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Bibliometric Analysis of Composite Resin Restorations From 2000-2020

Sultan Gizem Ülkü[1-a]*, Nimet Ünlü[1-b]

[1]Department of Restorative Dentistry, Faculty of Dentistry, Selcuk University Konya, Turkey
*Corresponding author

Research Article

ABSTRACT

Aim: To indentify the most effective actors(authors, countries, and journals) about composite resin restorations in the period 2000-2020.

Materials and Methods: An electronic research was conducted in the Scopus database by selecting the words 'composite resin' and 'restoration and English language, article and review types, dentistry field. Their bibliometric data including publication title, authorship, citation count, citation dentistry, year of publication, country and institution of origin, journal of publication, study design, and keywords were extracted and analysed.

Results and Discussions: To our knowledge, this is the first bibliometric article on composite resin restorations. This study provides information about authors, institutions and countries that contribute to significant improvements in composite resin restorations. From 2000 to 2020, there were 7118 articles published from 99 countries.Articles originate primarily from the USA and Brazil. Results indicate that the USA, Brazil, Germany, Turkey, the United Kingdom, Japan, Switzerland, Italy, Netherlands and India are the leading countries in composite resin restoration research and account for 51.8% of the total number of publications. The total number of citations are 158.404, corresponding to 22 citations per paper publication. During the time period examined, 776 hot articles and 228 classic articles on composite resin restorations were found. The journal with the most publications is 'Operative Dentistry'. The publishing houses of the top 10 journals are from 4 countries: USA(6), Netherlands(2),Germany(1),Japan(1). The most cited article within the boundaries of this study is Ferracane's article titled 'Resin composite-State of the art', which was published in Dental Materials in 2011 and received 913 citations.

Conclusions: This article is the first known bibliometric analysis of composite resin restorations. Studies on composite resin restorations are increasing in parallel with the increasing demand for aesthetics. The analysis of the most influential factors of these publications will give an idea for the studies to be done.

Keywords: Bibliometric Analysis, Composite Resin, Composite Restoration

[a] sltngzm@gmail.com   https://orcid.org/0000-0002-3699-0662   [b] nunlu@selcuk.edu.tr   https://orcid.org/0000-0002-6546-6368

Introduction

Significant improvements have been made in the field of restorative dentistry with the development of composite resin technology. While amalgam was the most commonly used restorative material in the 20th century, the use of amalgam was decreased due to the development of adhesive materials and the banning of amalgam-based materials in some countries due to concerns about mercury leakage.[1] Despite advances in composite resins, problems such as marginal incompatibility, marginal discoloration, fracture, microleakage, secondary caries, postoperative sensitivity and polymerization shrinkage are still disadvantages of composite restorations. The studies done in this area is important in order to overcome the negativity encountered in restorations and to obtain long-term restorations. Both the advances in composite resins and the importance of work in this area will provide further research and development opportunities in future studies on composite resin restorations.

The choice of appropriate restorative material when a tooth is restored is evidence-based and depends on the study of studies in which materials are used.[2] Studies evaluating the treatment preferences and management strategies of dentists in various countries were carried out and different results were revealed. These differences exist between countries as well as among dentists in each country.[3,4,5]

Nowadays, there is a wide literature on composite resin restorations with advances in composite technology. These studies need to be analysed in order to assess their impact on research and development in the field of composite resins. This effect can be evaluated by bibliometric analysis. In this respect, it is important to determine the basic research themes, which authors are interested in this subject and the contributions of institutions and countries working in this field, and to qualitatively evaluate the publications on composite restorations. Citation analysis, which examines the effect of research publication by examining citation data obtained by a scientific study, is the preferred method in bibliometry.[6,7]

Articles published recently may not have enough time to receive citations, and older articles may have higher citation counts, as the number of citations will accumulate over time. In this way, time bias is the disadvantage of citation analysis, but today it maintains its popularity in measuring the attribution effect of a paper.

The purpose of this study is to examine the articles on "composite resin restoration" published in the period from 2000 to 2020, thus creating an archive of articles on this subject. In this study, the list of journals, institutions and authors on composite resin restorations, citations, geographic distribution of institutions and authors, and publication statistics were examined. Effective performance parameters were selected in order to evaluate the contributions of countries, institutions and authors in a comparative way.

Materials and Methods

The words "composite resin" and "restoration" were searched in the Scopus database in the titles of "article title, abstract and keywords" between the years 2000-2020. The search results were filtered by selecting "English" language and "article" and "review" document type.

The most cited articles in the resulting list were evaluated in terms of title, author, region of the institute where the author is located, published journals and number of citations.

Results and Discussion

Articles published on any subject are cited due to their idea of change in practice and their relevance to future studies. The aim of our study was to perform a bibliometric analysis of articles published on composite resin restorations in the last 20 years. Our study determines and highlights the impact of recent developments on publications by providing the opportunity to historically review articles published on the relevant topic. Secondly, it presents scientific and clinical developments in this field and quantitative information

about authors, journals, countries. Finally, he created a group of articles on composite resin restorations.

There are some limits to the citation analysis we performed as a result of the search conducted through Scopus. Self-cited articles by the authors could not be excluded from this search. In addition, in our study, publications other than English language reviews and articles were not included in the analysis.

About composite resin restorations in the field of dentistry from 2000 to 2020; Except for 244 unidentified studies, 7118 articles were published in Scopus indexed journals from 160 research institutes from 99 countries.

General Statistics

In the period from 2000 to 2020, there are 7118 articles on composite resin restorations in Scopus indexed journals. The timeline of publications on composite resin restorations is shown in Figure 1. Although some fluctuations were observed in the period from 2000 to 2020, similar to the increase in demand for composite resin restorations, studies in this area have also increased. The number of articles published on the subject did not fall below 300 after 2006. Between 2000 and 2020, the least (274) articles on composite resin restorations were published in 2001, and the most (396) in 2018. While the majority of these publications (94.7%) are research article types, the remaining 373 publications are of the type of review (Figure 2).

Country Statistics

Except for the publications whose country is not defined, there are publications from 99 different countries. However, it can be said that most of the publications are from only a few countries. The main countries that publish on composite resin restorations are America with 1722 publications and Brazil with 1509 publications. These countries are Germany (692) and Turkey (566) is followed. The geographical distribution of the number of publications is shown in Figure 3. Excluding 244 unidentified publications, the publications made by the countries in the top 10 in terms of number of publications constitute 51.8% of the total publications.
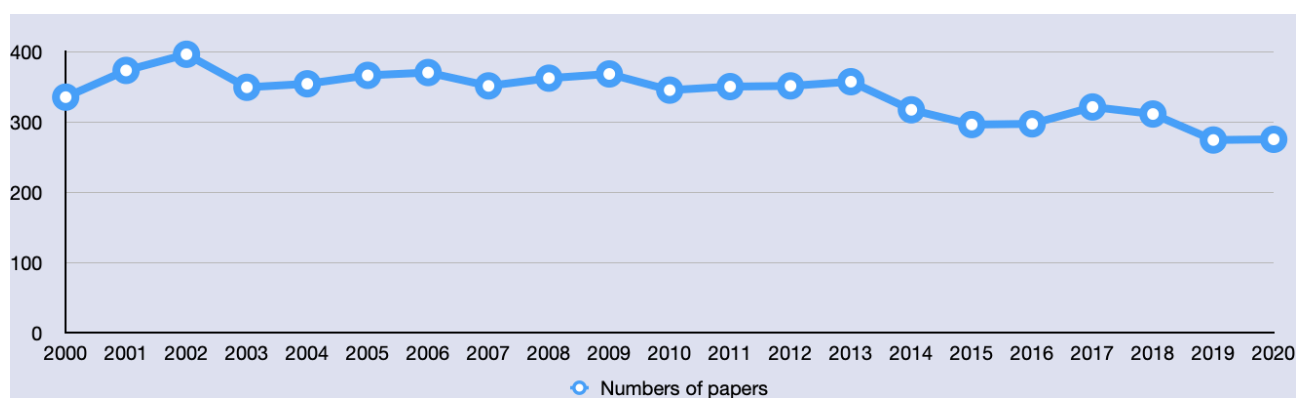
Figure 1. Timeline of publications and patents from 2000 to 2020.

Figure 2. Types of publications within the composite resin restoration from 2000 to 2020.

Figure 3. Geographical distribution of publications on composite resin restoration
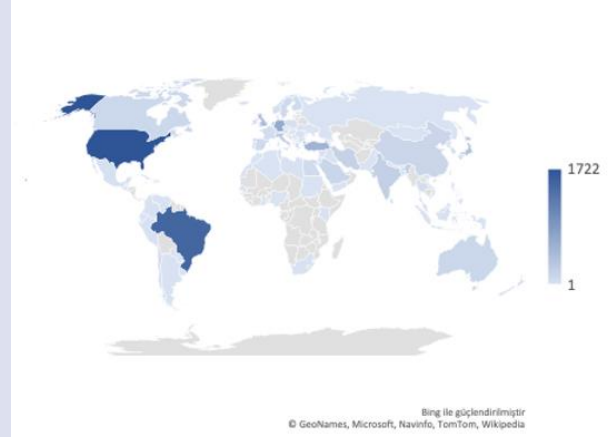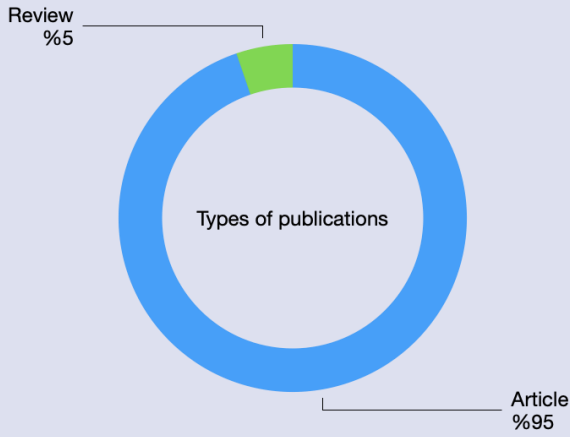
Table 1. Data of the journals that ranked in the top 20 in terms of the number of publications on the restoration of composite resin between 2000 and 2020.

Journal	Papers	IF	h- index	Country	CS(Cite Score)
Operative Dentistry	734	2.387	73	USA	3.9
Dental Materials	645	4.827	132	Netherlands	8
Journal of Dentistry	443	3.470	101	Netherlands	5.8
Journal of Prosthetic Dentistry	336	2.726	109	USA	4.4
American Journal of Dentistry	317	0.900	71	USA	1.5
Journal of Adhesive Dentistry	315	2.464	64	USA	3.6
Clinical Oral Investigations	234	2.903	69	Germany	4.4
Quintessence International	233	1.694	66	USA	2.3
Dental Materials Journal	215	1.545	50	Japan	2.6
Journal of Esthetic and Restorative Dentistry	215	1.986	52	USA	2.6
Dentistry Today	213	0.080	23	USA	0.1
Journal of Contemporary Dental Practice	192	0.670	38	USA	1.0
General Dentistry	184	0.45	30	USA	0.8
Journal of Oral Rehabilitation	115	2.580	84	England	3.8
Journal of The American Dental Association	110	2.803	112	USA	4.3
Journal of Prosthodontics	99	2.122	52	England	3.1
International Journal of Prosthodontics	98	1.550	88	USA	2.4
Journal of Endodontics	92	3.635	131	USA	6.2
Journal of Dental Research	90	4.914	158	USA	9.0
Pediatric Dentistry	86	0.742	62	USA	1.9

IF: (Impact Factor)

Journal Distribution

In our study, journals with the largest share in publications related to composite resin restorations were examined. The total number of journals in which the publications take place is 159. The average impact factor (IF) of the top 10 journals in terms of number of publications is 1.78 (0.09 - 4.827). The highest value of these journals in terms of citation score; In 2nd place is Dental Materials, which has a citation score of 8. The

citation score range of the top 10 journals is 1.5–8. Operative Dentistry" is the journal with the most articles with 734 articles. The publishers of the top 10 journals are from 4 countries: America (n=6), The Netherlands (n=2), Germany (n=1) and Japan (n=1). Detailed information about the top 20 journals in terms of the number of publications on the restoration of composite resin between 2000 and 2020 is given in Table 1.

Subject Distrubiton

Issues related to composite resin restorations are direct/indirect composite restorations, repair/replacement of direct/indirect composite resin restorations, adhesive systems, composites used in cad/cam system. When the article titles are examined; The word 'repair' is found in 192, 'renovation' 53, 'indirect restorations' 47, 'CAD/CAM' 154, 'adhesive system' 1.155. While the number of publications indicated as in vitro in the title is 531; There are 80 publications that are in vivo. Scopus was given in figure 4 of the distribution of subject categories in the research with the words 'composite resin' and 'restoration'. There are 7118 articles in the field of dentistry, which constitutes 79.2% of the total articles. In our study, 7118 articles in the field of dentistry were examined.
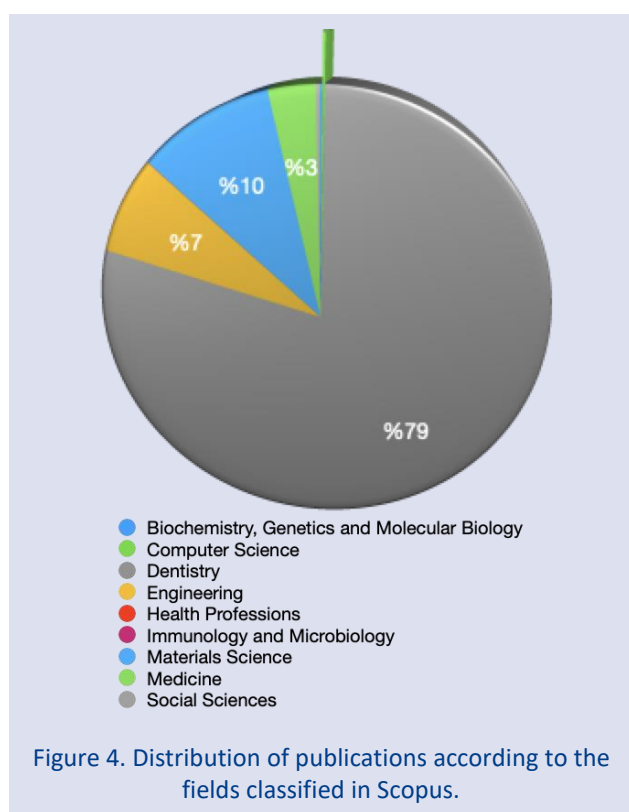
Figure 4. Distribution of publications according to the fields classified in Scopus.

Evaluation of Authors

The authors with the most publications are Tagami, Junji (Tokyo, Japan) with 90 publications and Reis, Alessandra (Ponta Grossa, Brazil) with 88 publications. The number of authors with a publication number of 20 or more is 108. They are followed by Loguércio, Alessandro Dourado (Ponta Grossa, Brazil), also from Brazil, with 84 publications.

When the author numbers of the publications are examined; the largest number of publications created by 4 authors. The relationship between the number of authors and publications is shown in Figure 5. The average number of authors per article is 4.15(1-24).

Institutional Statistics

Detailed information about the publishing institutions of composite resin restorations is shown in Table 2. It is seen that the studies carried out in this field are concentrated in several countries and institutes. So much so that the first four most cited articles belong to institutions in Brazil. 'Universidade de Sao Paulo - USP', which has the most publications on composite resin restorations, also has the most publications in the field of dentistry (8663). 'Universidade do Oeste de Santa Catarina', the institution with the fewest publications on dentistry (101), has 29 publications on composite restorations. While the number of citations of the publications in 45 institutes is over 50; the institutes ranked in the top 10 in terms of number of citations include 21.9% of the publications. Two of the research institutes in the top 10 contain the same number (126) publications (Tokyo Medical and Dental University and Ludwig-Maximilians-Universität München).

Article Citation

I-10 index is the number of publications containing more than 10 citations. In the period from 2000 to 2020, the i-10 index of the publications on composite resin restoration is 3591. Articles with more than 50 citations are called hot articles. There are 776 hot articles in the analysed time period. Articles exceeding 100 in terms of the number of citations can be named as "classic articles" on demand. These articles have historical reference importance in the development of the subject studied.[8,9] In our study, the number of citations of 228 articles is over 100. In other words, we can say that 3.2% of the total number of articles about composite resin restorations published between 2000 and 2020 is "classical articles". The most recent of these articles is the article titled "Wear, strength, modulus and hardness of CAD/CAM restorative materials" published in Dental Materials by Lawson *et al.* in 2016.

The number of citations per publication (CPP) can be used to evaluate the productivity of the research. 7118 articles were cited 158,404 times in total. The number of citations of the published articles is between 0 and 913. The average of citations is 22,254. The most cited work on this subject in the literature is Ferracane's article titled ''Resin composite - State of the art'', which was published in Dental Materials in 2011 and received 913 citations. It constitutes 0.57% of the total number of citations. When the articles with the same number of citations from the 100 most cited articles were accepted in the same order, three articles published in different years and 120 cited each took the last place. These; "Effect of different finishing techniques for restorative materials on surface roughness and bacterial adhesion" published in Journal of Prosthetic Dentistry (2010), ''Evaluation of dental restorative composites'' published in Dental Materials by Fong *et al.* (2005) containing polyhedral oligomeric silsesquioxane methacrylate "and" Crown fractures in the permanent dentition: Pulpal and restorative considerations'' by Olsburgh *et al.* (2002) published in Dental Traumatology. Among the first hundred articles, among the articles published in 2000, which is the oldest publication date of the period we examined, the most cited area is "In vivo degradation of resin-dentin bonds in humans" published by Hashimoto et al in the 'Journal of Dental Research' with 502 citations. Over 1 to 3 years.

Table 2a. Institutions publishing composite resin restoration

Institute name	Number of citations	Country	Number of publications
Universidade de Sao Paulo - USP	372	Brazil	8663
Universidade Estadual de Campinas	298	Brazil	4320
UNESP-Universidade Estadual Paulista	209	Brazil	4687
Universidade Federal de Pelotas	133	Brazil	1003
Tokyo Medical and Dental University	126	Japan	3458
Ludwig-Maximilians-Universität München	126	Germany	1145
University of Zurich	124	Switzerland	2331
Hacettepe University	109	Turkey	1261
Université de Genève	100	Switzerland	1144
Radboud University Nijmegen Medical Centre	95	Netherlands	1185
Universidade Federal de Santa Catarina	95	Brazil	900
Medical College of Georgia	91	USA	2061
Faculty of Life Sciences & Medicine	90	England	2861
University of Florida	89	USA	2067
Academic Centre for Dentistry Amsterdam	84	Netherlands	3097
The University of North Carolina at Chapel Hill	83	USA	3373
Charité – Universitätsmedizin Berlin	82	Germany	1175
Universidade Estadual de Ponta Grossa	80	Brazil	514
Turun yliopisto	78	Finland	1565
University of Tennessee Health Science Center	76	USA	917
University of Melbourne	76	Ausralia	1974
King's College London	75	England	2237
Universidade Federal de Uberlandia	75	Brazil	614
University of Birmingham	75	England	1396
KU Leuven	73	Belgium	1583
Umeå Universitet	73	Sweden	1307
Turku University Institute of Dentistry	72	Finland	1260
Oregon Health & Science University	71	USA	1535
University of Minnesota Twin Cities	71	USA	1788
Università degli Studi di Siena	69	Italy	674
Ege University	68	Turkey	910
The University of Hong Kong	66	China	2634
Christian-Albrechts-Universität zu Kiel	65	Germany	657
University of Washington, Seattle	64	USA	3797
Universidade Federal do Rio Grande do Sul	61	Brazil	1329
King Saud University	60	Saudi Arabia	1562
Københavns Universitet	59	Denmark	1390
Friedrich-Alexander-Universität Erlangen-Nürnberg	58	Germany	720
University of Southern California	55	USA	1933
National University of Singapore	54	Singapore	448
University of Toronto	52	Canada	3177
Universidade Federal de Santa Maria	52	Brazil	608
Nihon University	51	Japan	2173
UNC-CH Adams School of Dentistry	51	USA	2161
National University of Singapore, Faculty of Dentistry	51	Singapore	614
Departement Mondgezondheidswetenschappen	49	Belgium	351
Istanbul University	48	Turkey	947
Tufts University School of Dental Medicine	48	USA	1689
Selçuk University	47	Turkey	587
Gazi University	47	Turkey	910
Ankara University	46	Turkey	893
Klinikum der Universität Regensburg und Medizinische Fakultät	46	Germany	379
Osaka University	46	Japan	2008
University of Iowa	45	USA	2539
Universität Freiburg im Breisgau	45	Germany	834
Universiteit van Amsterdam	44	Netherlands	1490
Nova Southeastern University	43	USA	537
Alma Mater Studiorum Università di Bologna	43	Italy	1236
Universidade Federal Fluminense	41	Brazil	925
Aristotle University of Thessaloniki	41	Greece	1102

Table 2b. Institutions publishing composite resin restoration

Institute name	Number of citations	Country	Number of publications
University of Maryland Dental School	41	USA	996
New York University	41	USA	1556
National and Kapodistrian University of Athens	41	Greece	1644
Indiana University School of Dentistry	41	USA	1940
University of Texas Health Science Center at San Antonio	40	USA	3044
Herman Ostrow School of Dentistry of USC	40	USA	971
Universidade Federal do Rio de Janeiro	38	Brazil	1418
University of Bern	38	Switzerland	2652
University of Copenhagen, School of Dentistry	38	Denmark	1646
The University of Alabama at Birmingham	38	USA	1923
University of Texas Health Science Center at Houston	38	USA	1777
Universidad de Granada	37	Spain	854
Mashhad University of Medical Sciences	36	Iran	586
King Abdulaziz University	36	Saudi Arabia	707
Ondokuz Mayis University	36	Turkey	664
Universität Heidelberg	36	Germany	744
Shiraz University of Medical Sciences	36	Iran	506
Melbourne Dental School	36	Australia	623
Faculty of Biology, Medicine and Health	36	USA	901
University of Groningen	35	Netherlands	1138
National Institute of Standards and Technology	35	USA	456
Radboud University Nijmegen	34	Netherlands	1050
University of Michigan, Ann Arbor	34	USA	4018
Graduate School of Medicine, Dentistry and Pharmaceutical Sciences	34	Japan	922
Cairo University	33	Egypt	683
Tehran University of Medical Sciences	33	Iran	868
Chulalongkorn University	33	Thailand	673
Universidade Federal de Minas Gerais	33	Brazil	1603
University of Birmingham, College of Medical and Dental Sciences	33	England	374
NYU College of Dentistry	33	USA	1572
Case Western Reserve University	32	USA	1226
University of Groningen, University Medical Center Groningen	32	Netherlands	1074
Universidade Federal do Ceara	32	Brazil	505
Universidade de Passo Fundo	32	Brazil	281
Atatürk University	31	Turkey	523
Vrije Universiteit Amsterdam	31	Netherlands	1145
Seoul National University	31	South Korea	1624
Prince Philip Dental Hospital	31	China	954
Universität Regensburg	31	Germany	370
Forsyth Institute	30	USA	1484
The University of Adelaide	30	Australia	1898
Universidade de Pernambuco	30	Brazil	620
Baskent Universitesi	30	Turkey	489
University of Belgrade	30	Serbia	446
Faculdade Sao Leopoldo Mandic	30	Brazil	747
Universidade do Oeste de Santa Catarina	29	Brazil	101
The Ohio State University	29	USA	2248
Hebrew University of Jerusalem	29	Israel	1821
Universidad de Chile	29	Chile	630
Philipps-Universität Marburg	29	Germany	402
Cardiff University	29	England	1348
School of Dentistry	29	USA	607
Dalhousie University	28	Canada	715
Sichuan University	28	China	1534
Departement Beeldvorming & Pathologie	28	Belgium	539
University of G. d'Annunzio Chieti and Pescara	27-8	Italy	1138
Mahidol University	27	Thailand	551
West China School/Hospital of Stomatology Sichuan University	27	China	1393
Nippon Dental University	26	Japan	1102
University of Maryland, Baltimore	26	USA	1375

Table 2c. Institutions publishing composite resin restoration

| Institute name	Number of citations	Country	Number of publications
Tabriz University of Medical Sciences	26	Iran	363
Universidade Positivo	26	Brazil	337
State Key Laboratory of Oral Disease	26	China	1123
Yeditepe University	25	Turkey	421
Università degli Studi di Napoli Federico II	25	Italy	991
Okayama University	25	Japan	1016
KU Leuven– University Hospital Leuven	25	Belgium	622
Augusta University	25	USA	458
University College Cork Dental School & Hospital	24	İreland	352
UNMC College of Dentistry	24	USA	362
University Dental Hospital of Manchester	24	England	1267
Nagasaki University	24	Japan	797
School of Dentistry	24	Iran	388
Universidade Luterana do Brasil	23	Brazil	384
Tel Aviv University	23	Israel	1748
Universität Leipzig	23	Germany	418
Indiana University-Purdue University Indianapolis	23	USA	1016
Adelaide Dental School	23	Australia	1027
Humboldt-Universität zu Berlin	22	Germany	319
Hokkaido University	22	Japan	830
Isfahan University of Medical Sciences	22	Iran	567
Universidade Federal de Goias	22	Brazil	557
University at Buffalo, The State University of New York	22	USA	2083
Süleyman Demirel Üniversitesi	21	Turkey	370
Klinikum der Universität München	21	Germany	236
Universidade do Estado do Rio de Janeiro	21	Brazil	762
University of Tanta	21	Egypt	204
Universidade de Uberaba	21	Brazil	124
Pontificia Universidade Catolica do Rio Grande do Sul	21	Brazil	663
Rheinisch-Westfälische Technische Hochschule Aachen	21	Germany	592
Tufts University	21	USA	351
Tsurumi University	21	Japan	973
Texas A&M College of Dentistry	21	USA	2226
University of Illinois at Chicago	21	USA	2007
Wuhan University	21	China	853
Jordan University of Science and Technology	21	Jordan	650
School of Stomatology Wuhan University	21	China	755
Université de Paris	21	France	886
The University of Manchester	20	England	1059
Trinity College Dublin	20	Ireland	629
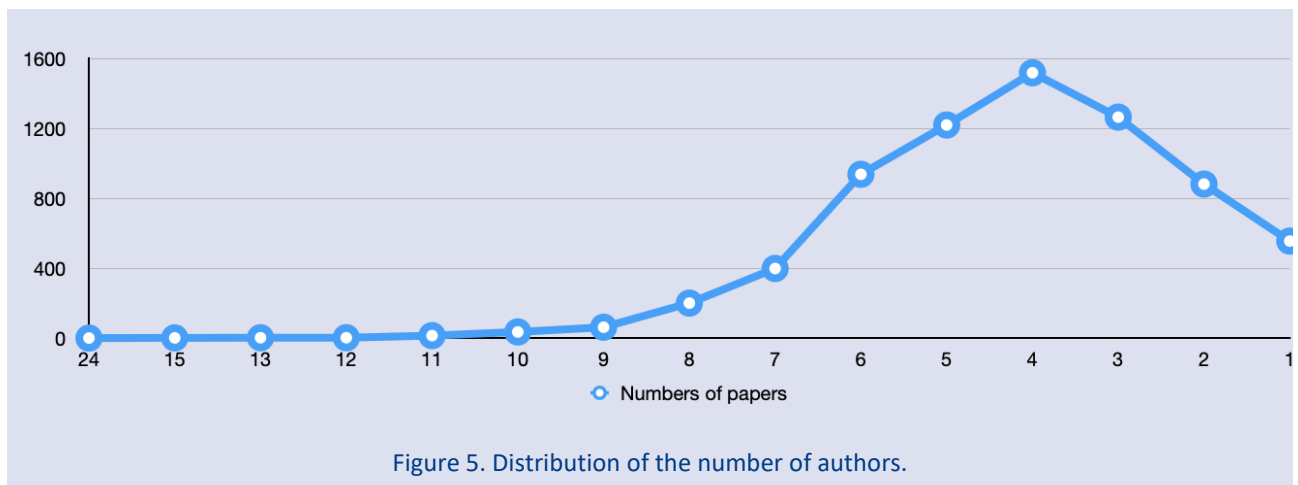
Figure 5. Distribution of the number of authors.

Table 3. Top 10 most cited articles

Author	Country	Year	NC	Journal	h index
Ferracane (Ferracane JL. Resin composite--state of the art. Dent Mater. 2011 Jan;27(1):29-38)	USA	2011	913	Dental Materials	66
Blatz (Blatz MB, Sadan A, Kern M. Resin-ceramic bonding: a review of the literature. J Prosthet Dent. 2003 Mar;89(3):268-74)	USA	2003	605	Journal of Prosthetic Dentistry	27
Mitra (Mitra SB, Wu D, Holmes BN. An application of nanotechnology in advanced dental materials. J Am Dent Assoc. 2003 Oct;134(10):1382-90)	USA	2003	571	Journal of the American Dental Association	11
Hashimoto (Hashimoto M, Ohno H, Kaga M, Endo K, Sano H, Oguchi H. In vivo degradation of resin-dentin bonds in humans over 1 to 3 years. J Dent Res. 2000 Jun;79(6):1385-91)	Japan	2000	502	Journal of Dental Research	32
Wiegand (Wiegand A, Buchalla W, Attin T. Review on fluoride-releasing restorative materials--fluoride release and uptake characteristics, antibacterial activity and influence on caries formation. Dent Mater. 2007 Mar;23(3):343-62)	Germany	2007	470	Dental Materials	36
Tay (Tay FR, Pashley DH, Suh BI, Carvalho RM, Itthagarun A. Single-step adhesives are permeable membranes. J Dent. 2002 Sep-Nov;30(7-8):371-82)	USA	2002	464	Journal of Dentistry	104
Demarco (Demarco FF, Corrêa MB, Cenci MS, Moraes RR, Opdam NJ. Longevity of posterior composite restorations: not only a matter of materials. Dent Mater. 2012 Jan;28(1):87-101)	Brazil	2012	454	Dental Materials	41
Pashley (Pashley DH, Tay FR. Aggressiveness of contemporary selfetching adhesives. Part II: etching effects on unground enamel. Dent Mater. 2001 Sep;17(5):430-44)	USA	2001	428	Dental Materials	118
Van Meerbeek (Van Meerbeek B, Peumans M, Poitevin A, Mine A, Van Ende A, Neves A, De Munck J.Relationship between bond-strength tests and clinical outcomes. Dent Mater. 2010 Feb;26(2):e100-21)	Belgium	2010	416	Dental Materials	81
Tyas (Tyas MJ, Anusavice KJ, Frencken JE, Mount GJ. Minimal intervention dentistry--a review. FDI Commission Project 1-97. Int Dent J. 2000 Feb;50(1):1-12)	Australia	2000	410	International Dental Journal	41

NC: Number of citations

The most recent article to date is the two articles published in 2015. These; `` Mechanical properties of resin-ceramic CAD / CAM restorative materials ''published by Awada and Nathanson in the Journal of Prosthetic Dentistry and 171 cited in Dental Materials, published by Nedeljkovic *et al.* with composites a material-based problem?''.

The total impact factor of the first 20 publications with the most citations is 1565, and the number of citations is 4.966. However, within the first 20 publications, there are 2 journals with the same number of citations (Dental Materials Journal and Journal of Esthetic and Restorative Dentistry, 215). The number of citations of the first 20 journals is in the range of 86-734, as can be seen, there is a significant difference between the number of citations of the first and 20th journal. The most cited 10 articles are shown in Table 3.

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Antibiofilm Evaluation of Two Different Denture Liners Incorporated with Zirconium Oxide Nanoparticles

Gulfem Ergun[1-a]*, Ayse Seda Ataol[2-b], Zeynep Sahin[3-c], Nurdan Sarac[4-d], Tuba Baygar[5-e], Aysel Ugur[6-f]

[1]Department of Prosthodontics, Faculty of Dentistry, Gazi University, Ankara, Turkey
[2]Zoom Dental Clinic, Çankaya, Ankara, Turkey
[3]Department of Prosthodontics, Faculty of Dentistry, Lokman Hekim University, Çankaya, Ankara, Turkey.
[4]Department of Biology, Faculty of Science, Mugla Sitki Kocman University, Mugla, Turkey.
[5]Material Research Laboratory, Research Laboratories Center, Mugla Sitki Kocman University, Mugla, Turkey.
[6]Section of Medical Microbiology, Department of Basic Sciences, Faculty of Dentistry, Gazi University, Ankara, Turkey
*Corresponding author

Research Article

ABSTRACT

Objectives: This *in vitro* study was purposed to examine the antibiofilm activity, weight change, and surface properties including glucose sorption, and roughness of novel nano-ZrO$_2$ incorporated denture liners.

Materials and Methods: Modified nano-ZrO$_2$ were added to silicone-based and acrylic resin-based prosthetic lining materials at two different concentrations (0.5% and 1%). The antibiofilm potentials of test groups against Candida albicans (*C. albicans*), Staphylococcus aureus (*S. aureus*), and Streptococcus mutans (*S. mutans*) were determined using 3-(4.5-dimethylthiazol-2-yl)-2.5-diphenyltetrazolium (MTT) method. Surface roughness, weight change, and glucose sorption of denture liners were also evaluated after modifying them with nano-ZrO$_2$.

Results: According to the antibiofilm activity results, 1% nano-ZrO$_2$ addition to silicon-based and acrylic resin-based denture liners resulted in 16.48% and 13.39% of biofilm inhibition for *S. aureus*, respectively. 1% nano-ZrO$_2$ addition to silicon-based denture liners also inhibited the *S. mutans* biofilm formation at an 8.16% rate. Nano-ZrO$_2$ addition to the test groups had no inhibition effect on *C. albicans* biofilm formation. Surface roughness decreased significantly once nano-ZrO$_2$ was added in acrylic resin-based test groups; however, addition of 0.5% nano-ZrO$_2$ increased silicone-based test group significantly.

Conclusions: To mitigate microbial biofilm problems caused by the use of denture liners addition of nano-ZrO$_2$ might be a promising method owing to its antibiofilm capacities especially against biofilms of *S. aureus* and *S. mutans*.

Keywords: Denture Liners, Glucose, Nanoparticles, Surface Properties, Zirconium Oxide

Zirkonyum Oksit Nanopartikülleri İlave Edilmiş İki Farklı Protez Astarlarının Antibiyofilm Değerlendirmesi

ÖZ

Amaç: Bu *in vitro* çalışma, güncel nano-ZrO$_2$ ilave edilmiş protez astarlarının antibiyofilm aktivitesi, ağırlık değişimi, glukoz emilimi ve pürüzlülüğü dahil yüzey özelliklerini incelemek amaçlanmıştır.

Gereç ve Yöntemler: Modifiye nano-ZrO$_2$ silikon esaslı ve akrilik rezin esaslı protetik astar malzemelerine iki farklı konsantrasyonda (%0,5 ve %1) eklendi. Test gruplarının *Candida albicans (C. albicans)*, *Staphylococcus aureus (S. aureus)* ve *Streptococcus mutans (S. mutans)*'a karşı antibiyofilm potansiyelleri, 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium (MTT) yöntemi kullanılarak belirlendi. Nano-ZrO$_2$ ile modifiye edildikten sonra protez astarlarının yüzey pürüzlülüğü, ağırlık değişimi ve glikoz emilimi de değerlendirildi.

Bulgular: Antibiyofilm aktivite sonuçlarına göre, silikon esaslı ve akrilik rezin esaslı protez astarlarına %1 nano-ZrO$_2$ ilavesi *S. aureus* için sırasıyla %16,48 ve %13,39 biyofilm inhibisyonu ile sonuçlandı. Silikon esaslı protez astarlarına %1 nano-ZrO$_2$ ilavesi de *S. mutans* biyofilm oluşumunu %8,16 oranında engelledi. Test gruplarına Nano-ZrO$_2$ ilavesinin *C. albicans* biyofilm oluşumuna inhibisyon etkisi olmadı. Akrilik esaslı test gruplarında nano-ZrO$_2$ eklendiğinde yüzey pürüzlülüğü önemli ölçüde azaldı, ancak %0,5 nano-ZrO$_2$ eklenmesi silikon esaslı test grubunu yüzey pürüzlülüğünü ise önemli ölçüde artırdı.

Sonuçlar: Protez astar kullanımından kaynaklanan mikrobiyal biyofilm problemlerini azaltmak için nano-ZrO$_2$ ilavesi, özellikle *S. aureus* ve *S. mutans* biyofilmlerine karşı antibiyofilm kapasiteleri nedeniyle umut verici bir yöntem olabilir.

Anahtar Kelimeler: Protez Astarları, Glikoz, Nanopartiküller, Yüzey Özellikleri, Zirkonyum Oksit.

[a] ergungulfem@yahoo.com   https://orcid.org/0000-0001-9981-5522   [b] sedaataol@gmail.com   https://orcid.org/0000-0003-3990-179X
[c] dtsahinzeynep81@gmail.com https://orcid.org/0000-0003-2459-2912   [d] nsarac@mu.edu.tr   https://orcid.org/0000-0001-7676-542X
[e] tubaygar@mu.edu.tr   https://orcid.org/0000-0002-1238-3227   [f] ayselugur@hotmail.com https://orcid.org/0000-0002-5188-1106

Introduction

In spite of the increasing health awareness of patients, the requirement for the use of removable denture is growing steadily.[1] Removable complete denture aims to replace the patient's missing teeth and soft tissue with hard acrylic dentures. Tolerance of the patient depends on how well the denture is fit in the mouth.[2] The thickness of patients' lining mucosa decreases due to resorption in the cases with highly resorbed ridge[3], thus the overlying thin mucosa cannot tolerate high chewing forces distributed by hard base material.[2] Soft denture liners are suggested to provide functional load distribution equally on the denture foundation area and to reduce local point pressures.[4] In addition, these materials improve the fitting tissue surface of the denture base and retention of the prosthesis.[5]

Tissue conditioners (TCs) are short-term soft liners. They usually consist of polyethyl methacrylate (PEMA) polymer powder and liquid components.[6] TCs are widely used in; the treatment of damaged mucosal tissues underlying poorly fitting dentures, in making dynamic impressions[7], for provisional relining of poorly fitting dentures and immediate dentures, and for tissue conditioning during implant healing.[8]

Denture liners can be classified as provisional or permanent depend on their duration of use, and as silicone rubber or acrylic resin regarding their composition. They can also be categorized depending on their polymerization method for instance heat, chemical or light cure.[9,10] There are some problems related to these materials: loss of resilience[5,6,11], change in color[5,6,9,12], porosity[5,9], water sorption and solubility[6,12], rough surface character[9], microbial adhesion and colonization.[11,13,14] In addition, the use of these materials harbor biofilm growth of fungal or bacterial pathogens, especially in geriatric patients with poor oral hygiene.[15]

Denture liners are easily colonized by pathogenic microorganisms.[13] The surface topography and the composition of material are the parameters that are directly associated with microbial adhesion to dental materials.[16] Denture liners are prone to microbial colonization due to degeneration and further degradation over time.[17,18] A rough surface supports microbial growth caused by the adhesion of microbial cells. This microbial growth occurs with the adhesive interactions between Candida species and oral bacteria (mostly *C. albicans* and *oral streptococci*).[19] Surface roughness is a significant surface property affects the adhesion of microorganisms on denture liners. As the surface roughness of denture liners increases, the accumulation of biofilm will also increase.[16] Biofilm adherence with its enzymatic activity leads to the degradation of liner materials and irritate the denture foundation area.[17]

Nanotechnology has an effective and fundamental role in developing the properties of dental materials.[20] The size, distribution, and morphology of nanoparticles are specific properties. Thanks to these properties, they show either completely new or improved features. Recently, new applications of nanoparticles are increasing rapidly.[21,22] Metallic nanoparticles exhibit improved reactivity and increased surface area. Therefore, the antimicrobial properties of these nanoparticles have been of interest.[20]

Nano-ZrO_2 has properties as high strength, high fracture toughness, excellent abrasion resistance, and superior chemical resistance. Due to these properties, it is added as a filler to the denture bases.[23] The addition of nano-ZrO_2 is recommended to improve the mechanical properties of PMMA.[24,25] Nano-ZrO_2 possesses excellent mechanical and chemical properties as well as antimicrobial properties.[26] Several studies have reported that it has antibacterial and antifungal effects on *C. albicans* and *S. aureus*.[26-28] It was reported that the antibacterial effect of nano-ZrO_2 on *C. albicans* may result from the active oxygen species produced by nano-ZrO_2. These produced active oxygen species disrupt the cell membrane of microorganisms.[27]

Numerous *in vitro* studies have been conducted focusing on different aspects of soft lining materials related to microbial and fungal colonization.[29-31] Among these studies include the use of denture cleaners[14,32], the addition of antimicrobial or antifungal agents[30,31], and the addition of fillers at low concentrations.[19,33] Although there are studies about the addition of nano-ZrO_2 to PMMA denture base[22,25,26], there is not enough information regarding the incorporating of nano-ZrO_2 into denture liners in the literature.[34]

The purpose of this *in vitro* research was to examine the antibiofilm activity of an acrylic-based tissue conditioner and a silicone-based soft denture liner combined with nano-ZrO_2. Additionally, the objective was to evaluate the impact of adding nano-ZrO_2 on glucose sorption, weight change, and surface roughness of two types of different denture liners. The null hypothesis of this study was that the addition of nano-ZrO_2 into denture liners would not affect the evaluated parameters.

Materials and Methods

The test materials used in this research study are presented in Table 1. ZrO_2 nano-powder (St. Louis, MO, USA average particle size of ≤100 nm) and silane coupling agent [3-aminopropyltriethoxysilane, (APTES, St. Louis, MO, USA)] were supplied by Sigma-Aldrich.

Surface functionalization of Nano-ZrO_2 Using a Silane Coupling Agent

The introduction of reactive groups to the surface of the filler was achieved by reaction of the silane coupling agent with nano-ZrO_2. Since the silane agent was cross-linked with the surface hydroxyl groups of nano-ZrO_2, the homogeneous distribution of nano-ZrO_2 fillers was ensured without agglomeration in the denture liners.

250 mg of nano-ZrO_2 and 5 mL pure toluene (≥99.7%, Sigma-Aldrich) were placed into a flask and then ultrasonicated at ambient temperature for 20 min. After that, this solution was placed into a flask equipped with a

magnetic stirrer (WiseStir MSH-20A, Germany) at speed 0-1500 rpm. The silane in the amount of 13.21 μL was added dropwise using a sterile syringe under a rapid stirrer. After the flask was covered by parafilm, the slurry was left for two days. The solvent (toluene) was removed from the slurry using a rotary evaporator (Büchi rotavapor R-210, Switzerland) under vacuum at 60°C rotary 150 rpm for 30 min. The modified nano-ZrO_2 particles were dried in a vacuum oven (BINDER vacuum drying Model VD 53, Tuttlingen, Germany) at 60°C for 20 hours and, then the nanoparticles were stored at room temperature before use.

The Fourier Transform Infrared Spectroscopy (FT-IR) measurements

Binding analysis showing before and after the modification step with the silane binding agent of nano-ZnO_2 was performed using FTIR (Nicolet iS5, Thermo Scientific, Madison, WI, USA) within wavelength the range of 450–4500 cm^{-1} obtaining by 40 scans. The spectrum peaks were recorded using OMNIC Spectra Software and then analyzed.

Preparation of test specimens

The two commercial denture liners materials were examined in this study. These materials were one silicone-based soft denture liner (Ufi Gel P; VOCO GmbH, Cuxhaven, Germany) and one acrylic-based tissue conditioner (Visco-gel, Dentsply DeTrey GmbH, Konstanz, Germany). Concentrations of nano-ZrO_2 added to the test materials are presented in Table 2. Three sub-groups were formed in each group including the control group [Ufi Gel P (UGP) / Visco-gel (VG)]. Two weight percentage of modified nano-ZrO_2 (0.5% and 1%) were used. These groups were tissue conditioner (Visco-gel) and soft lining material (Ufigel P) containing 0.5% and 1% modified ZrO_2 (respectively VG 1, VG 2, UGP 1, and UGP 2).

Modified nano-ZrO_2 and hexane solvent (Sigma Aldrich, St. Louis, MO, USA) was placed into a glass beaker, and then this solution was ultrasonicated (20 min) to provide nano-ZrO_2 particles to disperse well. After the incorporation of the catalyst of UGP test material into the solution, this mixture subjected to ultrasonication for 20 min. The hexane was removed from the mixture using an evaporator at the room temperature. The base of UGP was mixed with the composite including the catalyst and modified nano-ZrO_2. Before adding nano-ZrO_2 fillers to the VG test materials, nano-ZrO_2 particles were modified aforementioned method. The liquid of VG test material and modified nano-ZrO_2 was mixed with the powder of VG. According to the manufacturer's instructions, for UGP test materials, the obtained mixture was prepared in a weight ratio of 1:1 base to a catalyst, while for VG test materials, at a 3: 2.2 powder to liquid ratio.

Test methods
Glucose sorption and weight change

The glucose sorption test method was performed according to Muttagi and Subramanya.[35] Artificial saliva (AS) was prepared by mixing 0.400g NaCl, 0.400g KCl, 0.795 g $CaCl_2H_2O$, 0.69g NaH_2PO_4, 0.005g $Na_2S.9H_2O$, 1.0g urea, and 1000mL distilled water[36] was prepared. The pH of AS was adjusted to 7.00 with NaOH or HCl, and then the volume was increased to 1 L. Artificial saliva with glucose (G-AS) was obtained by adding 150 g of glucose to the AS with the same composition.

Table 1. Test materials evaluated in the study

Materials (Code)	Material Type	Main Composition	Lot No.	Manufacturer
Visco-gel (VG)	auto-polymerized acrylic-based tissue conditioner	Powder: Polyethyl methacrylate Liquid: Ethanol, Butyl phthalyl butly glycolate, Dibutyl phthalate	1610000172	Dentsply DeTrey GmbH, Konstanz, Germany
Ufi Gel P (UGP)	auto-polymerized silicone-based soft denture liner	Modified polydimethylsiloxane and platinum catalyst	1645226	VOCO Gmbh, Cuxhaven, Germany

Table 2. Classification of test materials used in the study and percentages and amounts of powder, liquid and nano-ZrO_2 powder of these materials

Groups	nano-ZrO_2 conc. percentages	amounts of nano-ZrO_2 (mg)	amounts of powder or base (g)	amounts of liquid or catalyst (g or μl)
Group UGP 0 (Ufigel UGP 0)	0%	0 mg	0.1 g	0.1 g
Group UGP 1 (Ufigel UGP+nano-ZrO_2)	0.5%	1 mg	0.1 g	0.1 g
Group UGP 2 (Ufigel UGP+ nano-ZrO_2)	1%	2 mg	0.1 g	0.1 g
Group VG 0 (Viscogel)	0 %	0 mg	0.2 g	146.6 μl
Group VG 1 (Viscogel+nano-ZrO_2)	0.5%	1 mg	0.2 g	146.6 μl
Group VG 2 (Viscogel+nano-ZrO_2)	1%	2 mg	0.2 g	146.6 μl

Each of the 3 test specimens of the 6 groups (Group UGP0, UGP1, UGP2, and VG0, VG1, VG2) were submerged in 50 mL of G-AS and were shaken at 75 rpm for 20 minutes. Test specimens were removed from G-AS and excess saliva was wiped dry. After the test specimens were rinsed for 2 minutes with 20 mL of distilled water, they immersed in 50 mL AS for 6 hours. While the control group was kept in AS throughout the experiment, the other test specimens were taken from AS after 6 hours and then immersed in G-AS. The described procedure was repeated for all test specimens 3 times a day throughout 3 days. Both G-AS and AS were changed for each reading and every 24 hours, respectively.

The amount of glucose in the distilled water was determined with the Phenol sulfuric acid method.[35] The standard calibration curve was used to calculate the amount of glucose in the distilled water for all specimens. After every 24 hours, the amount of glucose in AS was calculated similarly. At the end of the third day, the test specimens which were divided into small pieces were placed in 100 mL of ethyl acetate. The specimens in the flasks were kept on a shaker for 4 hours to completely dissolve. The ethyl acetate solution was washed using 20 mL of distilled water every 30 minutes and this process repeated 5 times. The separating funnel separated the washed distilled water. This distilled water collected in the flask and then the glucose amount was calculated.

Antibiofilm Activity

Microorganisms and Culture Medias

Candida albicans (C. albicans) (ATCC 10239), Staphylococcus aureus (S. aureus) (ATCC 6538P), and Streptococcus mutans (S. mutans) (ATCC 25175) were purchased from the American Type Culture Collection (ATCC) and used as three standard strain organisms. S. aureus was cultivated in Nutrient Broth (NB) culture at 37°C; S. mutans was cultured in Brain Heart Infusion Broth (BHIB) under a humidified atmosphere of 5% CO_2 at 37°C and C. albicans strain was grown in Sabouraud Dextrose Broth (SDB) at 30ºC.

Disc specimens (5x1.5 mm dimensions; n=10) from per group were prepared to evaluate their antibiofilm activities. They were assigned into 3 subgroups concerning the added amounts of nano-ZrO_2 (Group 0: control, Group 1: 0.5% nano-ZrO_2 added, Group 2: 1% nano-ZrO_2 added). 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT) staining method was used to measure the biofilm inhibition rates of the denture liners incorporated with nano-ZrO_2. The disc-shaped specimens were incubated with microbial inoculum in Tryptic Soy Broth (TSB) supplemented with 5% D-Glucose for 72 h. Following the end of the incubation period, the specimens were washed twice with PBS. Then, these specimens were immersed in 5 mL PBS and sonicated for 5 min to remove the attached microbial biofilm layer. The sonicated solution was centrifugated. The pellet was suspended with 150 μL PBS in microplate wells. 50 μL MTT solution added to the wells for staining

the live microorganisms and incubated for 2 h at 37°C. The media was removed and 150 μL of dimethyl sulfoxide (DMSO) and 25 μL glycine buffer were added. The experiment was done in triplicate. The absorbances were read at 550 nm in a microplate reader (Multiskan GO UV/Vis Microplate Spectrophotometer, Thermo-Fisher Scientific, Rockford, IL, USA). Results compared with the control discs that were not containing nano-ZrO_2 and percentage of biofilm inhibition was calculated.[38]

Surface Roughness Test

For the surface roughness test, specimens with a diameter of 10 mm and a thickness of 1.5 mm were produced using a stainless-steel mould (n = 10). As the specimens were produced, the glass plate which approximately 0.009 μm, was placed under and above the stainless-steel mould and kept under vertical force. The surface roughness test of all specimens was performed with the profilometer device (SJ-210, Mitutoyo, Kanagawa, Japan) (cut-off wavelength of 0.8 μm and a speed of 0.5 mm/s). 3 different areas in the same direction for each specimen were measured. Average surface roughness (Ra) calculated.

Scanning Electron Microscope (SEM) Examination

Two test specimens from each group were randomly chosen for surface analysis under Scanning Electron Microscope (SEM) (Zeiss, SUPRA-55, Carl Zeiss NTS GmbH, Oberkochen, Germany). The selected specimens were made conductive under the vacuum of 10^{-1} mbar/Pa and a current of 10 mA in the gold-palladium coating unit (Quorum Q 150 R ES DC Sputter, Kent, UK) by coating with Au-Pd for 180 seconds. After coating, the SEM micrographs of specimens were taken at a magnification of x50, x100, x200. The surface morphological features for each subgroup's tissue conditioner and soft denture liner were visualized and then analyzed.

Statistical Analysis

Data were analyzed using IBM SPSS Statistics version 17.0 software (IBM Corporation, Armonk, NY, USA). The evaluation of continuous variables was first performed for homogeneity and normality by Levene and Shapiro-Wilk tests, respectively. Mann Whitney U test was used to determine the differences in continuous variables between test groups. However, in comparisons between more than two independent groups, the data were subjected to the Kruskal Wallis test. When the p-values were statistically significant according to the Kruskal Wallis test, the differences among all the combination groups were determined by Conover's multiple comparison test.

Friedman's test was used to evaluate whether the differences among measurement times in terms of both glucose concentrations in distilled water and weight of specimen were statistically significant or not. $p < 0.05$ was considered statistically significant. However, the Bonferroni correction was performed for all possible multiple comparisons to check Type I errors.

Results

FT-IR Analysis

FTIR spectra taken to confirm the covalent binding between the nano-ZrO_2 particles and the silane are shown in Figure 1.

In the transmittance spectrum of the silane, the two peaks at 1072 and 952 cm^{-1} were attributed to the asymmetric and symmetric stretching vibrations of Si-O-C bond, respectively. And the peak at 764 cm^{-1} correspond to the bending of Si-C bond. The absorption bands at 2884 and 2974 cm^{-1} arose from CH_3 symmetric and asymmetric stretching vibrations, respectively. The peak at 2927 cm^{-1} is due to the CH_2 asymmetric stretching vibration. In the transmittance spectrum of the silane modified nano-ZrO_2 particles, the strong peaks resulting from vibrations of Si-O-C bond were disappeared due to breaking of these bonds in the silane molecule. And two new strong peaks appeared at 1154 and 1225 cm^{-1}, which could be assigned to the stretching vibration of Si-O-Si and twisting vibration of CH_2, respectively. On the other hand, the peaks originating from the methyl group in silane molecule disappeared due to the removal of the methyl group as a result of the reaction. In addition, absorption of Zr-O-Si bond seemed to be overlapped with the strong absorption of Zr-O-Zr bond below 800 cm^{-1}. According to the peaks of these covalent bonds, we can say that the surface of the nano-ZrO_2 particles with the silane coupling agent has been successfully modified.

Glucose sorption and weight change

In all VG test groups for the first day, there was no statistically significant difference between the 6th hour, the 12th hour, and the 24th hour in terms of median glucose concentrations in the distilled water (VG0: $p = 0.050$, VG1: $p=0.097$, VG3: $p=0.050$). Likewise, as far as the comparison between the 6th hour, the 12th hour, and the 24th hour regarding median glucose concentrations in the distilled water for the first day, no statistically differences were found in all UGP test specimens (UGP0 and UGP1 $p = 0.050$, UGP2: $p = 0.097$) (Table 3). Besides, the glucose sorption of test groups was not statistically significant among all subgroups for all three days in artificial saliva ($p>0.05$) (Figure 2).

Among the VG0, VG1 and VG2 groups, respectively; there was no statistically significant difference according to the Bonferroni correction in terms of the median sample weight of 0 h, 24 h, 48 h and 72 h ($p>0.00625$). Similarly, no statistically significant difference could be determined among the sample weights of the UGP0, UGP1 and UGP2 groups that measured every 24 hours ($p>0.00625$) (Table 4).

Antibiofilm Activity

Biofilm inhibition rates of the nano-ZrO_2-incorporated denture liners are given in Table 5. In the pilot study, a 0.25% added nano-ZrO_2 group was excluded from the study because this group did not show antibiofilm activity against all microorganisms tested. The highest antibiofilm activities were observed against *S. aureus* for UGP2 and VG2 with 16.48% and 13.39% inhibition, respectively. The biofilm formation of *S. mutans* was only inhibited by UGP2 with an 8.16% inhibition rate. *C. albicans'* biofilm formation was not inhibited by any mixture of the nano-ZrO_2-denture soft liner.

Table 3. The concentration of glucose in distilled water according to follow-up time, hours and groups

	Day 1			Day 2			Day 3		
	6th h	12th h	24th h	6th h	12th h	24th h	6th h	12th h	24th h
Group 0 VG 0	116.47 (4.50)	131.47 (3.76)	143.67 (1.46)	132.17 (4.85)	126.37 (3.98)	114.39 (1.02)	154.38 (2.72)	144.55 (3.06)	132.74 (2.19)
UGP 0	97.89 (1.10)	102.68 (1.04)	116.58 (3.91)	122.37 (3.11)	115.67 (3.27)	108.67 (4.02)	131.22 (2.80)	122.35 (3.01)	115.08 (2.09)
Group 1 VG 1	107.69 (1.88)	111.48 (7.09)	126.47 (7.60)	128.17 (6.11)	119.87 (1.72)	117.59 (2.36)	165.74 (6.68)	141.32 (2.48)	123.57 (4.20)
UGP 1	103.68 (2.20)	107.59 (2.99)	119.54 (4.46)	113.67 (1.55)	114.59 (2.33)	103.28 (4.28)	135.48 (2.67)	127.49 (3.03)	125.67 (1.62)
Group 2 VG 2	109.36 (2.25)	117.49 (4.89)	131.27 (4.11)	145.36 (7.20)	137.86 (3.12)	120.03 (2.02)	171.28 (2.67)	156.31 (5.07)	141.28 (2.40)
UGP 2	103.68 (2.45)	103.58 (1.02)	124.01 (6.19)	129.98 (2.48)	130.25 (2.50)	119.32 (5.99)	139.67 (3.09)	128.74 (6.71)	124.69 (4.31)

Values are shown in the form of the median (distribution between quarters).

Table 4. Weight change of test specimens according to groups at certain time intervals

	0. hour	12. hour	48. hour	72. hour
Group 0				
VG	0.472 (0.007)	0.488 (0.010)	0.507 (0.009)	0.510 (0.007)
UGP	0.547 (0.012)	0.542 (0.007)	0.541 (0.004)	0.537 (0.008)
Group 1				
VG	0.490 (0.010)	0.501 (0.014)	0.500 (0.014)	0.497 (0.012)
UGP	0.549 (0.001)	0.557 (0.011)	0.559 (0.007)	0.560 (0.006)
Group 2				
VG	0.498 (0.015)	0.502 (0.014)	0.504 (0.012)	0.510 (0.011)
UGP	0.570 (0.005)	0.579 (0.019)	0.580 (0.005)	0.576 (0.013)

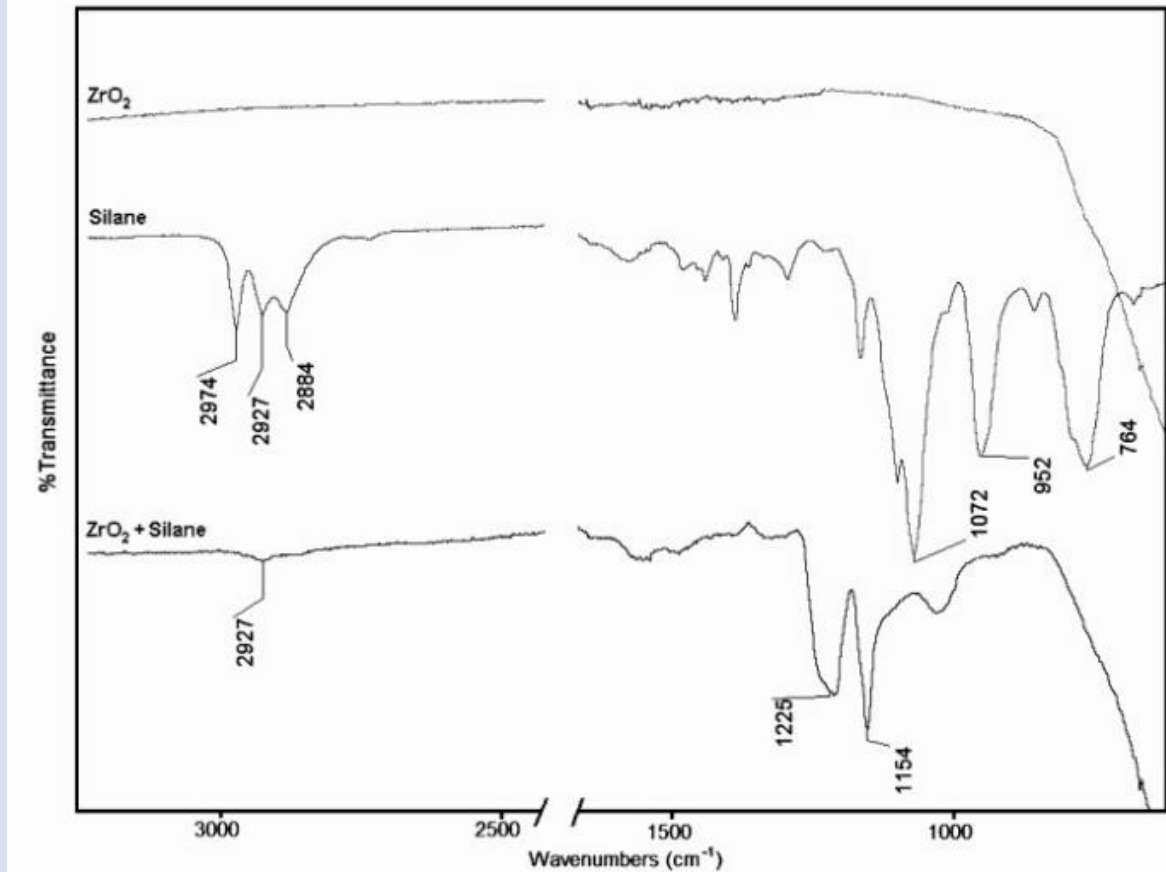Values are shown in the form of the median (distribution between quarters)

Figure 1. FT-IR spectrum of nano-ZrO$_2$ and modified nano-ZrO$_2$ with the silane coupling agent
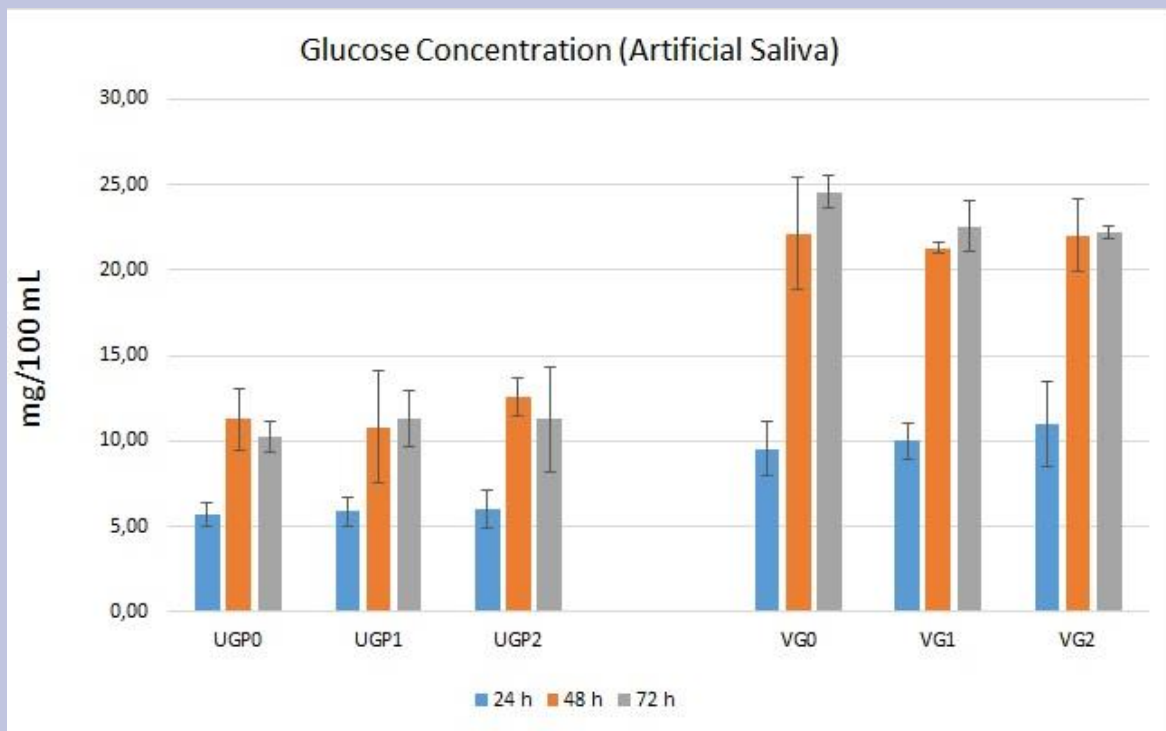

Figure 2. Glucose concentrations calculated in artificial saliva after certain time intervals

Table 5. Antibiofilm activity of denture liners incorporated with nano-ZrO$_2$

	Tested Materials						
	UGP + nano-ZrO$_2$				VG + nano-ZrO$_2$		
Group	Antibiofilm Activity (%) C. albicans	Antibiofilm Activity (%) S. aureus	Antibiofilm Activity (%) S. mutans	Group	Antibiofilm Activity (%) C. albicans	Antibiofilm Activity (%) S. aureus	Antibiofilm Activity (%) S. mutans
UGP0	Control (100% Biofilm) (0% Activity)	Control (100% Biofilm) (0% Activity)	Control (100% Biofilm) (0% Activity)	VG0	Control (100% Biofilm) (0% Activity)	Control (100% Biofilm) (0% Activity)	Control (100% Biofilm) (0% Activity)
UGP1	0.00	3.46	0.00	VG1	0.00	2.28	0.00
UGP2	0.00	16.48	8.16	VG2	0.00	13.39	0.00

Table 6. Mean values of surface roughness for the test materials

	VG	UGP	*p*-value †
Group 0	3.97 (1.29)[a,b]	0.29 (0.37)[a]	< 0.001
Group 1	1.74 (2.01)[a]	0.66 (0.76)[a,c]	0.004
Group 2	2.38 (2.50)[b]	0.44 (0.26)[c]	< 0.001
p-value ‡	0.012	0.020	

†A comparison between VG and UGP groups showed the results to be statistically significant according to the Mann Whitney U test and Bonferroni Correction ($p<0.0167$), ‡ Likewise, a comparison within VG and UGP groups showed the results were of statistical significance for $p<0.025$ according to the Kruskal Wallis test and Bonferroni Correction, a: The difference between group 0 and group 1 was statistically significant ($p<0.001$), b: The difference between group 0 and group 2 was statistically significant ($p=0.002$), c: The difference between group 1 and group 2 was statistically significant ($p=0.002$).

Surface Roughness Test

The results of surface roughness are shown in Table 6. Among the UGP and VG groups, there was a statistically significant difference according to the results of surface roughness (p<0.001). The UGP groups (incorporating with 0.5% nano-ZrO$_2$ and 1% nano-ZrO$_2$) had statistically lower values than those of the VG groups (respectively *p*=0.004; p<0.001).

In VG groups, the addition of nano-ZrO$_2$ (0.5% and 1%) significantly reduced the surface roughness of the test specimens (p<0.001 and p=0.002). Among the VG 1 and VG 2 test groups, no difference of statistical significance could be determined according to Bonferroni correction (p=0.050).

Among the UGP test specimens, there was a statistically significant difference in terms of surface roughness (p=0.020). UGP 1 group had statistically higher values than those of UGP 0 and UGP 2 groups (p<0.001 and p=0.002). There was no statistically significant difference between UGP 0 and UGP 2 test groups (p=0.098).

SEM Observation

SEM analysis indicated a rougher surface with the pits and fissures in Group VG 0 (Figure 3A), while the incorporation of nano-ZrO$_2$ for tissue conditioning test materials displayed relatively smooth surface due to the existence of nanoparticles (Figure 3B and 3C).

The surfaces of Group UGP 0 and UGP 2 were relatively smoother than UGP 1 (Figure 3D, 3E and 3F). In both test groups with zirconium oxide added, nano-ZrO$_2$ was observed in a globular-shaped throughout the liner surfaces (Figure 3B, 3C, 3E and 3F). In UGP 1 and UGP 2 groups nano-ZrO$_2$ well distributed without agglomeration or clusters within the soft denture liner (Figure 3E and 3F).

However, in VG1 and VG2 test groups, nano-ZrO$_2$ slightly agglomeration in the tissue conditioner matrix was observed (Figure 3B and 3C). The SEM images showed that the nanoparticles were successfully embedded without disrupting the matrix integrity.

Discussion

In this present study, nano-ZrO$_2$ were added into denture liners in an attempt to improve the antibiofilm properties of the liner against *C. albicans*, *S. aureus*, and *S. mutans*. The influence of nano-ZrO$_2$ addition on surface roughness, weight change, and glucose sorption of denture liners were also evaluated. The null hypothesis of our study, 'that the addition of nano-ZrO$_2$ into denture liners would not affect the evaluated parameters' has been partially rejected. Tissue conditioner and soft denture liner containing 1% nano-ZrO$_2$ were found to exhibit antibiofilm activity for *S. aureus*. The addition of nano-ZrO$_2$ did not affect *C. albican's* biofilm. Surface roughness (Ra) decreased significantly once nano-ZrO$_2$ was added in the VG group, but Ra increased in the UGP group.

Microbial colonization on the surfaces of denture liners is a clinically significant problem for dental applications.[15,38] There are studies about the incorporation of antimicrobial compounds to denture liners indicated that the antimicrobial effect was occurring in a dose-dependent matter.[39,40] Within the present study, nano-ZrO$_2$ addition into denture liners showed an antibiofilm effect against *S. aureus* biofilm formation for both silicone and acrylic-based resin denture liners. However, there was no inhibition effect on *C. albicans* biofilm formation. There was a difference between microorganisms to inhibit biofilm formation. This may also be related to the type of microorganism. The bacteria

have a thin and slack cell wall. On the flip side, *C. albicans* is a eukaryotic organism. The cell wall of *C. albicans* is thick and complex.[18] The lack of antibiofilm activity against *C.*

albicans in tested materials might be explained by the complexity and density of the cell wall structure of these microorganisms.
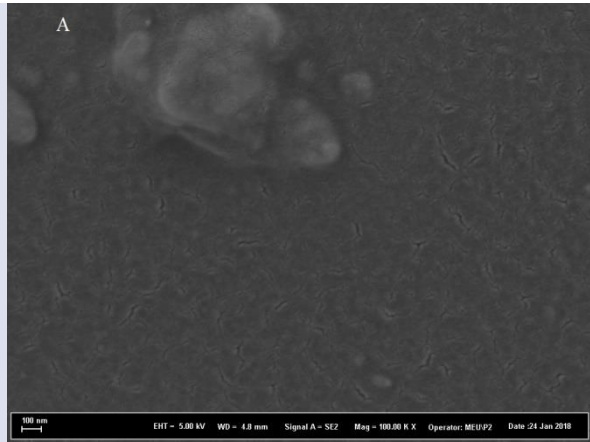
Figure 3(A). SEM image of specimen surface from Group VG 0 (control group)
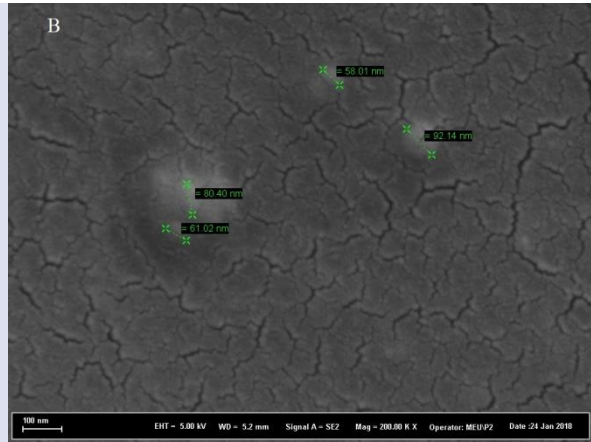
Figure 3(B). SEM image of specimen surface from Group VG 1 (0.5% nano-ZrO$_2$ added)
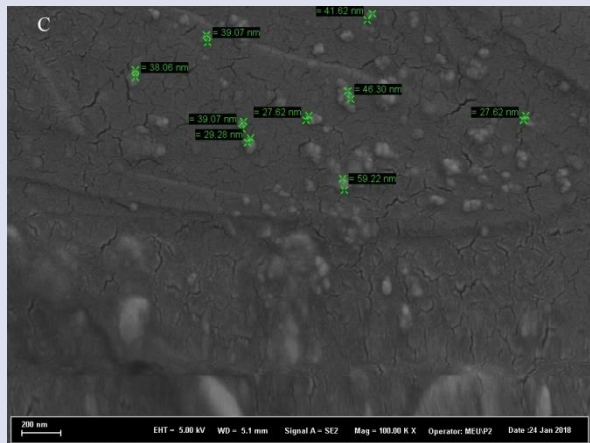
Figure 3(C). SEM image of specimen surface from Group VG 2 (1% nano-ZrO$_2$ added)
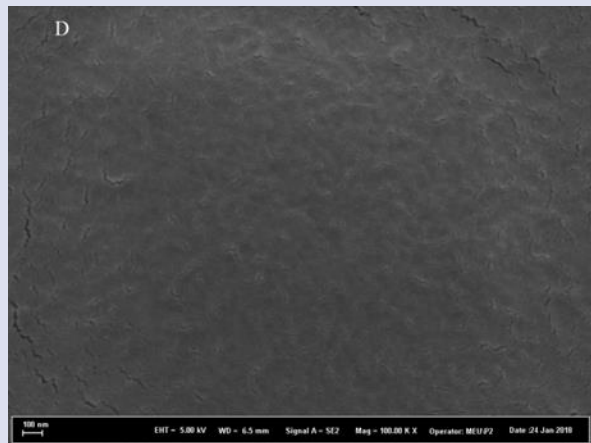
Figure 3(D). SEM image of specimen surface from Group UGP 0 (control group)
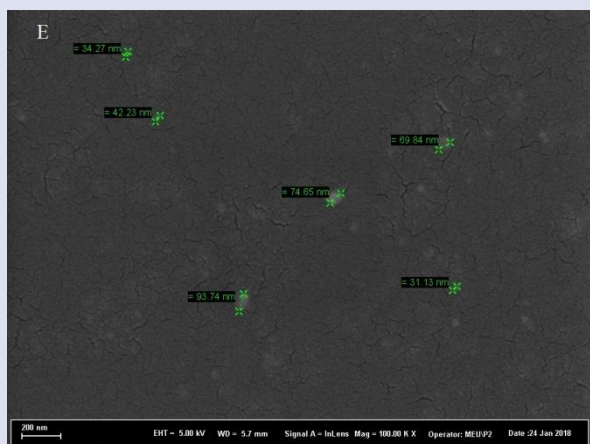
Figure 3(E). SEM image of specimen surface from Group UGP 1 (0.5% nano-ZrO$_2$ added)
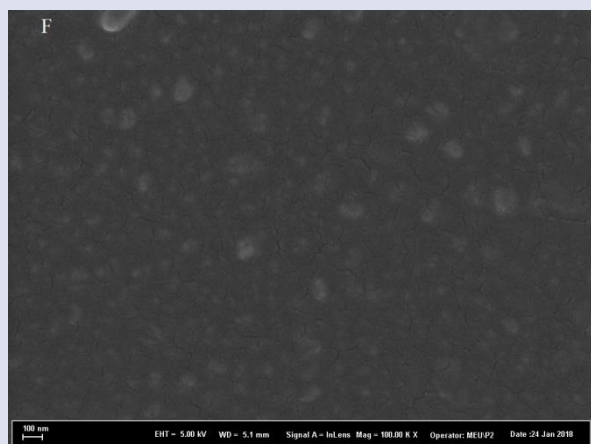
Figure 3(F). SEM image of specimen surface from Group UGP 2 (1% nano-ZrO$_2$ added)

Figure 3. SEM images of denture liner's surfaces

Our results infer that the antibiofilm activity of nano-ZrO$_2$ containing specimens against *S. aureus* was more effective than *S. mutans*. Both bacteria are Gram-positive

cells.[18] However, the time for these microorganisms to appear in the biofilm of denture wearers is different. *S. aureus* is associated with various infections containing

systemic diseases like septicemia, endocarditis, pneumonia.[38] ZrO_2 nanoparticles produce active oxygen species. They accumulate on the surface of *S. aureus* cells, actively inhibiting the growth of *S. aureus* cells.[27] On the other hand, *S. mutans* is a precursor of biofilm formation, so it might lead to denture stomatitis with *C. albicans*.[38] From this information point of view, it is important to found that 8.16% rate antibiofilm activity against *S. mutans* in UGP2 test specimens in our study.

Gad *et al.*[26] reported that the addition of 7.5% nano-ZrO_2 into cold-cured resin significantly caused a reduction in the amount number of *C. albicans*. In the present study, the addition of nano-ZrO_2 to denture soft liners was not found to be beneficial to decrease the *C. albicans* biofilm formation. This might be due to the applied dose of the nano-ZrO_2. Candida accumulation on denture materials may also vary depending on the type of material.[41] Jangra *et al.* [28] evaluated the antimicrobial effect of zirconia nanoparticles against bacterial strains (*E. coli* and *S. aureus*) and fungal strain (*Aspergillus niger*) and found it to be effective only against the *E. coli*. Gowri *et al.*[27] performed the synthesis of nano-ZrO_2 using Aleo vera gel extract via a biological method. They found that nano-ZrO_2 inhibits the growth of fungal strains and also show superior antibacterial activity against *E. coli* than *S. aureus*. Findings different from our study might be due to surface charge. In our study, the antibiofilm activity was examined and in these mentioned studies, antibacterial and antifungal activity was investigated which are different test methods.

Yasser and Abdul Fatah[34] investigated the antifungal effect of acrylic base soft denture liner material (Vertex™ Soft) with combined nano-ZrO_2. They concluded that this antifungal activity was enhanced with an increased duration of incubation in artificial saliva. The reason for the different antifungal activity in our study may be due to the denture liner polymerization method used. In addition, their study determined antifungal activity by disc diffusion test, while the antibiofilm activity of test specimens was examined by the MTT method in our study.

Although nano-ZrO_2 has the same surface geometry, different nanoparticle shapes may also affect antimicrobial activities.[26,28] Similarly, triangular silver nanoparticles exhibited superior biocidal activity against *E.coli* than rod- or spherically-shaped nanoparticles.[42] In our study, the SEM images of test materials were examined and the globular-shaped nanoparticle was observed. Also, future studies should be made by taking the TEM image of nano-ZrO_2 to better understand antibiofilm and antimicrobial efficiency.

Glucose is preferred by most cells as a source of carbon and energy, so the sensing and response of glucose are highly developed in most organisms.[43] *C. albicans* possesses glucose sensors.[35] The high-affinity glucose sensors in *C. albicans* respond even at very low levels of glucose (0.01%). *C. albicans'* sensing of sugar is essential to its colonization and show virulence optimally.[44] For this reason, in our study glucose absorption of the test specimens was evaluated by adding glucose to the

prepared AS. The SEM showed a relatively smooth surface due to the existence of nanoparticles for nano-ZrO_2 added VG test materials (Figure 3B and 3C). Nano-ZrO_2 might fill spaces of the surface layer, causing a smoother surface. These findings are in agreement with previous studies.[25,26] In addition, the SEM images showed that the nanoparticles were successfully impregnated with denture liner without disrupting the surface integrity (Figure 3B, 3C, 3E and 3F). The comparisons among all the tested subgroups in the current study displayed that glucose sorption levels were close to each other (Figure 2 and Table 3). This might be related to the surface texture of the test specimens. Likewise, based on the weight change results of test groups evaluated, no difference was determined (Table 4). This outcome could be explained by molecular weight or similar glucose uptake into test materials.

Analyzing the results of our study, that although no statistically significant difference was observed compared between test groups ($p>0.05$), glucose sorption values for all VG groups slightly more than those of UGP test groups. This may be related to the surface properties or roughness of the test materials.

The evaluation of surface roughness was performed according to the Ra value. This value shows the average of the peaks and depressions on the surface for the evaluated test material. In this study, surface roughness values of test materials were obtained numerical data ranging from 1.74±2.01 to 3.97±1.29 µm for VG groups and from 0.29±0.37 to 0.66±0.76 for UGP groups. In all subgroups, surface roughness values of UGP groups were lower than VG groups. These results may be related to the natural characteristics and composition of test materials. VG comprises acrylic polymers (polyethyl methacrylate) and an ester-based plasticizer (ethanol, dibutyl phthalate, phthalyl butyl glycolate).[45] UGP consists of modified polydimethylsiloxane and platinum catalyst, but no plasticizer.[6]

0.5% and %1 nano-ZrO_2 that are incorporated into tissue conditioner (VG) decreased the surface roughness of test materials. The addition of nano-ZrO_2 may have reduced the porosity of the VG group. This will also reduce void formation and microbial adherence. As a result, nano-ZrO_2 incorporated VG group might cause obtaining a denser less porous mix. Incorporation of this nano-ZrO_2 into tissue conditioner will also improve the surface structure of the material. However, within UGP groups, surface roughness values increased in the experimental group containing 0.5% nano-ZrO_2. Since UGP has cross-linking agents in its chemical structure, the nanoparticles may not be able to penetrate completely into the polymer. Silicone-based denture liner materials are chemically more stable than acrylic-based ones.[46]

The differences in surface roughness observed between silicone and acrylic-based materials may be related to the consistency of the materials.[47] The acrylic-based tissue conditioner (Visco-gel) used in our study has more flowing consistency than the silicone-based (Ufigel P). On the other hand, the application of acrylic-based

material (Visco-gel) is easier. The material is already more consistent until polymerized between the glass plate. Acrylic-based material (Visco-gel) is less able to reproducing the surface details between a smooth glass plate during specimen fabrication. This may result in higher roughness values. The increased surface roughness of the resins may promote the biofilm deposition and colonization of *C. albicans*, resulting in prosthetic stomatitis.[41,47] Furthermore, the characteristic features of denture liners such as absorption, irregularities and porosity have considerable effects on microbial adherence.[48] The result of surface roughness in our study allows us to infer, that the UGP 0 and VG 1 test groups may cause less microbial adhesion and microorganism-related prosthetic stomatitis.

The limitations of this research contain that the fact the oral environment simulating the clinical situation such as the aging process, thermocycling, the occlusal force was not imitated. Extremely smooth glass plates were used in the production of test specimens. This test condition does not reflect the clinical environment. On the other hand, the oral cavity includes multiple-strain biofilms but such mixed biofilm was not used in the present study. The adherence of microorganisms to the tested denture liners was not examined by microscopy. Modified test liners showed superior antibiofilm and surface properties compared to their commercial counterparts although a single polymerization method of test materials was investigated in this study with an insufficient dispersion of ZrO_2 nanoparticles. Further studies on the influence of adding various amounts of nano-ZrO_2 to denture liners in which different polymerization methods on antimicrobial, physical, and biocompatibility properties are essential for clinical use.

Conclusions

It was concluded, that to mitigate microbial biofilm problems caused by the use of denture liners addition of nano-ZrO_2 might be a promising method owing to its antibiofilm capacities especially against biofilms of *S. aureus* and *S. mutans*.

Acknowledgements

Conflicts of Interest Statement

The authors did not have any conflicts of interest in regards to this study.

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Cumhuriyet Dental Journal

Evaluation of the Impacts of Surgical Removal of Impacted Teeth on Alterations of the Mood with Beck Depression Inventory

Mustafa Sami Demirsoy[1-a], Aras Erdil[2-b]*, Sefa Çolak[3-d], Mehmet Kemal Tümer[4-e]

[1]Department of Oral and Maxillofacial Surgery, Faculty of Dentistry, Sakarya University, Sakarya, Turkey
[2]Department of Oral and Maxillofacial Surgery, Faculty of Dentistry, Uşak University, Uşak, Turkey
[3]Department of Oral and Maxillofacial Surgery, Faculty of Dentistry, Tokat Gaziosmanpaşa University, Tokat, Turkey
[4]Department of Oral and Maxillofacial Surgery, Faculty of Dentistry, Alanya Alaaddin Keykubat University, Antalya, Turkey
*Corresponding author

Research Article

ABSTRACT

Objectives: To determine whether the inflammatory complications following impacted third molar surgeries and varying surgical difficulties impact individuals' mood alterations.
Materials and Methods: A prospective, double-blind, observational study was designed with three study groups (slightly, moderate, and very difficult) constituted with surgical difficulty scores. The participants were evaluated preoperatively and postoperatively on the sixth hour, second and seventh days. The visual analog scale (VAS) and Beck depression scale (BDS) scores, maximal mouth opening, and swelling amounts were recorded.
Results: A total of 75 patients were enrolled and divided into three study groups with an equal number of participants.
The preoperative mean BDS scores of the study groups (slightly, moderate, very difficult) were 9.16, 7.16, and 8.12, and mean VAS scores were 2.86, 1.4, and 1.56, respectively. A significant correlation was observed between the surgical difficulty and the increased BDS scores on the second and seventh postoperative days. Significant correlations were observed between surgical difficulty and VAS scores and maximum mouth opening amounts on the second postoperative day. Also, postoperative swelling amounts were significantly affected by surgical difficulty on the postoperative second day. The impact of surgical difficulty and inflammatory complication-related factors on the postoperative BDS scores' increase was also evaluated, and the postoperative pain, trismus, swelling, and operation time correlated.
Conclusion: The surgical removal of impacted molar teeth has significant effects on alterations in mood. It would be beneficial to consider different aspects of the postoperative term that the patient will experience in third molar surgeries.

Keywords: Lower Third Molar, Inflammatory Complications, Beck Depression Inventory, Surgical Removal

Beck Depresyon Ölçeği ile Etki Dişlerin Cerrahi Olarak Çekilmesinin Ruh Durum Değişiklikleri Üzerindeki Etkilerinin Değerlendirilmesi

ÖZ

Amaç: Cerrahi üçüncü molar çekimleri sonrası oluşan enflamatuvar komplikasyonların ve farklı çekim zorluklarının bireylerin duygu durum değişikliklerine olan etkilerini belirlemek.
Gereç ve Yöntemler: Cerrahi zorluk skorlarına göre oluşturulan üç çalışma grubu (kolay, orta ve zor) ile prospektif, çift-kör, gözlemsel bir çalışma tasarlanmıştır. Katılımcılar preoperatif, postoperatif altıncı saat, ikinci ve yedinci günlerde değerlendirilmiştir. Vizüel analog skala (VAS) ve Beck depresyon ölçeği (BDS) skorları, maksimum ağız açıklığı ve şişlik miktarları kaydedilmiştir.
Bulgular: Çalışmaya dahil edilen 75 hasta her bir grupta eşit sayıda katılımcı yer alacak şekilde üç çalışma grubuna ayrılmıştır.
Çalışma gruplarının (kolay, orta, zor) sırasıyla preoperatif ortalama BDS skorları 9,16, 7,16 ve 8,12 iken ortalama VAS skarları 2,86, 1,4 ve 1,56'dır. Postoperatif ikinci ve yedinci günlerde BDS skorlarındaki artış ile cerrahi zorluk arasında anlamlı ilişki görülmüştür. Cerrahi zorluk ile VAS skorları ve maksimum ağız açıklığı miktarları arasında postoperatif ikinci günde anlamlı korelasyon gözlenmiştir. Ayrıca postoperatif ikinci günde cerrahi zorluk ile kaydedilen şişlik arasında anlamlı ilişki görülmüştür. Cerrahi zorluk ve enflamatuvar komplikasyonlarla ilişkili faktörlerin postoperatif BDS skorlarının artışı üzerine etkileri de incelenmiş ve artış ile postoperatif ağrı, trismus, şişlik ve operasyon süresinin korele olduğu gözlenmiştir.
Sonuçlar: Gömülü üçüncü molarların cerrahi çekimlerinin duygu durum değişikliklerine anlamlı etkileri vardır. Üçüncü molar cerrahilerinde hastaların deneyimleyeceği postoperatif sürecin farklı yönlerinin de değerlendirilmesi faydalı olacaktır.

Anahtar Kelimeler: Azı Dişi, Üçüncü, Enflamatuvar Komplikasyonlar, Beck Depresyon Envanteri, Cerrahi Çekim

[a] xdemirsoy@hotmail.com   https://orcid.org/0000-0001-8654-2799   [b] erdil.aras@gmail.com   https://orcid.org/0000-0002-9582-5114
[c] dr.sefacolak@gmail.com   https://orcid.org/0000-0002-0807-9089   [d] dr_kemaltumer@yahoo.com   https://orcid.org/0000-0002-6250-0954

Introduction

Most of the third molars do not follow regular eruption patterns and remain impacted.[1] Nearly half of the third molars cannot obtain a vertical position on the dental arch and remain impacted in the mesioangular position.[2] Most individuals require at least one impacted molar surgically removed at some point in their lives due to complaints related to them. Therefore, surgical removal of impacted third molars is one of the most common interventions performed by oral surgeons in an outpatient setting.[3]

Complications are observed after surgical extraction of third molars. Some of these complications are postoperative inflammatory complications such as swelling, pain, trismus, and mild bleeding. According to the literature, these complication rates range from 3 to 30%.[4] Although severe and persistent complications such as postoperative infection, mandibular fracture, inferior alveolar nerve damage, and alveolar osteitis can be observed, their frequency is rare.[5] Although the inflammatory complications due to tissue damage are tried to be controlled with local measures and pharmacological treatments, they cause a decrease in the quality of life of the patients and postoperative discomfort.[6] Although controversial, studies indicating a correlation between surgical difficulty and the severity of postoperative complications.[7–9] In the literature, the number of studies investigating the effects of different methods and pharmacological agents on quality of life in the postoperative period is increasing.[10–12]

The Beck depression scale (BDS), developed in 1961, targets the assessment of depression in psychiatric disorders.[13] BDS is one of the most widely used and empirically validated questionnaires for screening for depression.[14] The scale was derived from clinical observations of attitudes and symptoms commonly seen in depressed and non-depressed psychiatric patients. From these observations, 21 items were determined, and these items were graded between 0-3 points according to their severity. The lowest possible score is 0, and the highest score is 63.[13] Also, BDS is used to measure the depression level of adults with different disorders and symptoms.[15,16]

Although there are studies in the literature investigating the surgical stress during surgical removal of impacted teeth[17], postoperative quality of life[6], and the frequency of complications experienced[4], only one study investigated the difficulty of surgical extraction and the level of depression.[18]

This study aims to examine the alterations in the mood due to inflammatory complications after surgical removal of impacted third molars and investigate the impact of surgical difficulty on the inflammatory complications. The study's null hypothesis is that there will be a correlation between the surgical difficulty scores and the severity of inflammatory complications and alterations in the mood.

Material and Methods

Patients who had an appointment for surgical extraction of impacted mandibular third molars at the Oral and Maxillofacial Surgery Clinic in the Faculty of Dentistry, Tokat Gaziosmanpaşa University, were included in the study. The Helsinki Declarations were considered and followed through the study. The study protocol was approved by the Tokat Gaziosmanpaşa University, Clinical Research Ethical Committee before the inclusion of the patients (Protocol number: 19-KAEK-142). All patients signed the informed consent for participation in the study. The current study was conducted in accordance with TREND guidelines.[19]

Inclusion criteria were: patients aged between 18-65 years requiring surgical removal of one mandibular third molar. Exclusion criteria were: outside the targeted age range, systemic diseases (ASA II or higher), autoimmune diseases, immunosuppressed, malignancies, clinical conditions that contraindicate the surgical removal of third molars, and preoperative BDS scores above 20.

Surgical difficulty scores of the impacted third molars were determined according to the Pederson difficulty index[20], and the postoperative measurements regarding inflammatory complications were obtained by the same investigator (AE). According to the surgical difficulty index scoring, the mandibular third molars with 1, 2, 3, and 4 scores were determined as the slightly difficult group, those with 5, 6, and 7 scores as the moderately difficult group, and those with 8, 9, and 10 scores as the very difficult group. The determined scores were rechecked by another investigator independent of the study design. Third molar teeth were excluded from the study, which could not agree on the determining difficulty scores.

BDS was administered to the participants by an investigator (SC) who did not know surgical difficulty scores pre-and postoperatively. Also, the operating surgeon (MSD) was unaware of the scored surgical difficulty and BDS scores. All interventions were performed by the same investigator (MSD). In addition, the time from incision to completion of the operation in minutes was recorded by the operating investigator in all interventions. The study was designed as a double-blind, prospective clinical study, as the participants did not know their groups.

Inferior alveolar nerve, lingual nerve, and long buccal nerve blocks were administered with 40 mg/ml articaine ve 0.01 mg/ml epinephrine containing 2 ml local anesthetic solutions. In the slightly difficult group, mucosal flaps were elevated following a sulcular incision. In moderately and very difficult groups, the full-thickness flaps were raised as described by Alcântara et al.[21] In cases required, bone removal and tooth sectioning were performed using round carbide and flat fissure carbide burs. Third molars were removed with Bein elevators, and if a flap was elevated, the wound was sutured with 3-0 silk sutures.

All participants were prescribed the same postoperative medications (25 mg dexketoprofen

trometamol BID and chlorhexidine digluconate+ benzydamine hydrochloride mouthwash for seven days). In cases where bone removal was performed, antibiotics (500 mg amoxicillin and 125 mg clavulanic acid BID during seven days) were prescribed to the patients.

In order to monitor the pain, which is one of the postoperative inflammatory complications, the patients were asked to mark the severity of pain on a 1 cm equally spaced, 10 cm long visual analog scale (VAS) preoperatively, at the 6th hour, 2nd, and 7th days postoperatively. VAS scores were classified as mild pain in the range of 0-3 cm, moderate in the range of 3.1-6.9 cm, and severe pain in the range of 7-10 cm.

The amount of swelling was calculated by taking the average of the distance between the lateral canthus-angulus mandibulae and the distance between the lateral commissure-tragus of the operated side in millimeters on the preoperative, postoperative 2nd, and 7th days. The increase in swelling compared to preoperative measurements was calculated and classified as a percentage. According to this classification, an increase of less than 5% was considered mild, 5-10% was considered moderate, and more than 10% was considered severe swelling.

Maximum mouth openings of the participants were measured to determine the amount of trismus that occurred in the postoperative period compared to the preoperative period. The distance between the right upper and lower incisors was measured and recorded in millimeters on preoperative, postoperative 2nd, and 7th days. The decrease in maximum mouth opening compared to preoperative measurement was calculated and classified as a percentage. According to this classification, a decrease of less than 20% was considered mild, a decrease of 20-40% was considered moderate, and an increase of more than 40% was considered severe trismus.

The alterations that may occur in the mood of the patients who were evaluated with preoperative BDS due to inflammatory complications was tried to be determined by repeating the scale on the 2nd and 7th postoperative days. The total BDS scores, 0-10, were interpreted as no depression, 11-16 mild depression, 17-20 borderline clinical depression, 21-30 moderate depression, 31-40 severe depression, 41 and above severe depression.[16]

However, since the diagnosis of depression was outside the scope of the study and required expertise in the field of psychiatry, the BDS total scores above 10 were used to evaluate alterations in the mood.

The obtained data were analyzed IBM SPSS version 22 (IBM Corp; Armonk, NY, USA). The normal distributions of the obtained data were analyzed with the Shapiro-Wilk test. Also, validation was done with Skewness and Kurtosis values. The homogeneous distribution of variances was checked.

Preoperative mouth opening, preoperative swelling, maximum mouth opening on postoperative 2nd and 7th days, swelling on postoperative 2nd and 7th days, and postoperative 2nd day pain values were analyzed by Analysis of variance (ANOVA) test because they demonstrated normal distribution.

Preoperative BDS and pain scores, postoperative 2nd day BDS scores, postoperative 7th day BDS scores, mouth opening, and pain values were analyzed with the Kruskal Wallis test as they did not show normal distribution.

In addition, the chi-square test was used to compare grouped data of the study variables.

Finally, multiple linear regression analysis was utilized to determine the variables that significantly affected BDS scores. Independent variables were determined as patients' gender, pain, swelling, trismus, and surgical difficulties (slight, moderate, and very difficult). *p* values of less than .05 were considered significant.

Results

A total of 75 patients, 37 male and 38 female were included in the study. The mean age was 26 years with a standard deviation (SD) of 4.6 years. Participants were divided into three groups based on surgical difficulties, with an equal number of participants in each group (slightly difficult= 13 m, 12 f, moderately difficult= 12 m, 13 f, and very difficult group= 12 m, 13 f.). Descriptive statistics of the study population are presented in Table 1.

BDS Scores
Compared to the preoperative BDS scores, the mean scores of the patients in the slightly difficult group increased from 9.16±5.62 to 11.96±5.09, in the moderate difficulty group increased from 7.16±4.60 to 12.64±5.03, and in the very difficult group increased from 8.12±4.22 to15.68±3.91 on the second postoperative day.

Compared to the BDS scores on the second postoperative day, the patients' mean scores in the slightly difficult group decreased to 6.20±4.75, in the moderate difficulty group decreased to 9.64±5.33, and in the very difficult group decreased to 12.24±5.08 on the seventh postoperative day.

Median and range values of the BDS scores for the slightly difficult group on the preoperative, postoperative second, and seventh days were 11, 12, 4, and 19, 19, 17, respectively. For the moderate difficulty group, the same values were 6, 14, 11, and 16, 19, 18. For the very difficult group, the median and range values were 6, 14, 11, and 16, 19, 18.

On the second postoperative day, 16 patients in the slightly difficult group, 19 patients in the moderate difficulty group, and 24 patients in the very difficult group had BDS scores above 10. On the 7th postoperative day, the BDS scores of 7 patients in the slightly difficult group, 13 patients in the moderate difficulty group, and 18 patients in the very difficult group continued to be above 10

A statistically significant correlation was observed between the surgical difficulty and the alterations in the mood on the second and seventh postoperative days

(p=0.02 / p=0.008) and increases in the means of the BDS scores (p=0.015/p=0.001) (Table 2).

VAS Scores

Compared to the postoperative sixth hour mean VAS scores, on the second postoperative day, the scores of the patients in the slightly difficult group ranged from 2.86±2.16 to 2.90 ± 2.15, in the moderate difficulty group ranged from 1.40 ± 1.94 to 3.78±2.60, and in the very difficult group increased from 1.56±2.35 to 4.74±1.89.

Compared to the VAS scores on the second postoperative day, patients' mean sores in the slightly difficult group decreased to 0.28±0.50, in the moderate difficulty group decreased to 1.43±2.07, and in the very

difficult group decreased to 1.22±1.99 on the seventh postoperative day. Median and range values of the VAS scores for the slightly difficult group on the preoperative, postoperative second, and seventh days were 3, 3, 0, and 6, 7, 2, respectively. For the moderate difficulty group, the same values were 0, 3, 0, and 7, 10, 6. For the very difficult group, the median and range values were 0, 5, 0, and 8, 9, 7.

When the VAS scores were classified as mild, moderate, and severe, on the second postoperative day in the slightly difficult group, 16 patients had mild, 8 patients had moderate, and 1 patient had severe pain. In the moderate difficulty group, 13 patients had mild, 6 had moderate, and 6 had severe pain. In the very difficult group, 6 patients had mild, 14 had moderate, and 5 had severe pain.

Table 2. Comparison between the surgical difficulty and alterations in mood (BDS scores)

Variables		Surgical Difficulty			p values
		Slight (n=25)	Moderate (n=25)	Very (n=25)	
Postoperative 2nd day	(0< BDS<10)	9 (36%)	6 (24%)	1 (4%)	0.020*
	(BDS>10)	16 (64%)	19 (36%)	24 (96%)	
	Mean	11.96	12.64	15.68	0.015‡
	SD	5.08	5.03	3.91	
	SE	1.01	1.00	0.78	
Postoperative 7th day	(0<BDS<10)	18 (72%)	12 (48%)	7 (28%)	0.008*
	(BDS>10)	7 (28%)	13 (52%)	18 (72%)	
	Mean	6.20	9.64	12.24	0.001+
	SD	4.75	5.33	5.07	
	SE	0.95	1.06	1.01	
	Q1	3	4	11	
	Q2 (Median)	7	11	14	
	Q3	7.5	14	16	

*denotes p values obtained by chi-square (χ2), ‡ ANOVA, and + Kruskal-Wallis tests. SD:Standard deviation, SE:Standard error

Table 3. Comparison between the surgical difficulty and postoperative pain

VAS Score classes and Mean values		Slightly difficult	Moderate Difficulty	Very Difficult	Total (n)	p values
Postoperative 2nd day	Mild (0<VAS<3)	16 (64%)	13 (52%)	6 (24%)	25	0.019 *
	Moderate (3.1<VAS<6.9)	8 (32%)	6 (24%)	14 (56%)	25	
	Severe (7<VAS<10)	1 (4%)	6 (24%)	5 (20%)	25	
	Mean	2.9	3.78	4.74		0.018 ‡
	SD	2.14	2.59	1.88		
	SE	0.42	0.51	0.37		
	n	25	25	25	75	
Postoperative 7th day	Mild (0<VAS<3)	25 (100%)	18 (72%)	19 (76%)	25	0.042 *
	Moderate (3.1<VAS<6.9)	0	7 (28%)	5 (20%)	25	
	Severe (7<VAS<10)	0	0	1 (4%)	25	
	Mean	0.27	1.43	1.22		
	SD	0.49	2.06	1.99		
	SE	0.09	0.41	0.39		
	Q1	0	0	0		0.360 +
	Q2 (Median)	0	0	0		
	Q3	0.5	4	2.5		
	n	25	25	25	75	

* denotes p values obtained by chi-square (χ2), ‡ ANOVA, and + Kruskal-Wallis tests. SD:Standard deviation, SE:Standard error

On the seventh postoperative day, in the slightly difficult group, all patients reported mild pain; in the moderate difficulty group, 18 patients had mild, 7 patients had moderate pain, and in the very difficult group, 19 patients had mild, 5 patients had moderate, and 1 patient had severe pain.

A significant correlation was found between the surgical difficulty and the classification of postoperative VAS scores on the second and seventh days (p=0.019/p=0.042). While there was a significant relationship between the surgical difficulty groups and the mean VAS scores on the postoperative second day (p=0.018), no significant relationship was found on the postoperative seventh day (p=0.360) (Table 3).

Swelling

Compared to the preoperative measurements, the mean swelling amount of the patients in the slightly difficult group on the second postoperative day increased from 106.45±4.76 mm to 110.82±4.99 mm, in the moderate difficulty group increased from 106.86±7.56 mm to 115.42±6.36 mm, and in the very difficult group increased from 106.24±7.64 mm to 116.60±8.13 mm.

Compared to the second postoperative day, the mean swelling amounts of the patients in the slightly difficult group decreased to 107.28±4.77 mm, in the moderate difficulty group decreased to 109.96±6.27 mm, and in the very difficult group decreased to 109.88±7.25 mm on the seventh postoperative day.

Median and range values of the swelling amounts for the slightly difficult group on the preoperative, postoperative second, and seventh days were 106.5 mm, 111 mm, 108mm, and 16.5 mm, 18 mm, 20 mm, respectively. For the moderate difficulty group, the same

values were 107.5 mm, 116 mm, 111 mm, and 29.5 mm, 22.5 mm, 25 mm. For the very difficult group, the median and range values were 105 mm, 115 mm, 108 mm, and 27.5 mm, 31 mm, 26 mm.

When the increase in swelling amounts was classified as mild, moderate, and severe, on the second postoperative day, in the slightly difficult group, 18 patients had mild, 6 patients had moderate, and 1 patient had severe swelling. In the moderate difficulty group, 6 patients had mild, 12 moderate, and 7 patients had severe swelling. In the very difficult group, 12 patients had moderate, and 13 patients had severe swelling.

On the seventh postoperative day, in the slightly difficult group, all patients reported mild swelling; in the moderate difficulty group, 20 patients had mild, 4 patients had moderate, 1 patient had severe swelling, and in the very difficult group, 19 patients had moderate, and 6 patients had severe swelling.

A significant correlation was found between the surgical difficulty, the classification, and mean amounts of postoperative swelling on the second postoperative day. (p=0.000/p=0.007). However, there was no significance between the surgical difficulty and the mean and grouped swelling on the postoperative seventh day (p=0.073/p=0.225) (Table 4).

Trismus

Compared to the preoperative measurements, the mean amount of MMO in the slightly difficult group on the second postoperative day decreased from 44.24±3.19 mm to 31.68±5.62 mm, in the moderate difficulty group decreased from 43.76±3.60 mm to 28.88±5.53 mm, and in the very difficult group decreased from 42.88±4.17 mm to 25.16±6.32 mm.

Table 4. Comparison between the surgical difficulty and postoperative swelling (mm)

Swelling amount classes and Mean values		Slightly difficult	Moderate Difficulty	Very Difficult	Total (n)	p values
Postoperative 2nd day	Mild (<4.99%)	18 (72%)	6 (24%)	1 (4%)	25	
	Moderate (5<-<9.99%)	6 (24%)	12 (48%)	7 (28%)	25	0.000 *
	Severe (10%<)	0	12 (48%)	13 (52%)	25	
	Mean	110.82	115.42	116.66		
	SD	4.98	6.35	8.12		0.007 ‡
	SE	0.99	1.27	1.62		
	n	25	25	25	75	
Postoperative 7th day	Mild (<4.99%)	25 (100%)	0	0	25	
	Moderate (5<-<9.99%)	20 (80%)	4 (16%)	1 (4%)	25	0.073 *
	Severe (>10%)	19 (76%)	6 (24%)	0	25	
	Mean	107.28	109.96	109.88	109.04	
	SD	4.76	6.26	7.25	6.22	
	SE	0.95	1.25	1.45	0.71	
	Q1	104	104.5	104		0.225 +
	Q2 (Median)	108	111	108		
	Q3	110	114	116.5		
	n	25	25	25	75	

* denotes p values obtained by chi-square (χ2), ‡ ANOVA, and + Kruskal-Wallis tests. SD:Standard deviation, SE:Standard error

Compared to the second postoperative day, the mean amounts of MMO in the slightly difficult group increased to 43.36±2.64 mm, in the moderate difficulty group increased to 37.88±3.97 mm, and in the very difficult group increased to 35.28±5.40 mm on the seventh postoperative day.

Median and range values of the maximum mouth opening amounts for the slightly difficult group on the preoperative, postoperative second, and seventh days were 45 mm, 32 mm, 44 mm, and 15 mm, 20 mm, 11 mm, respectively. For the moderate difficulty group, the same values were 44 mm, 28 mm, 38mm, and 14 mm, 19 mm, 18 mm. For the very difficult group, the median and range values were 43 mm, 25 mm, 37 mm, and 13 mm, 23 mm, 19 mm.

When the trismus rates were classified as mild, moderate, and severe, on the second postoperative day, in the slightly difficult group, 6 patients had mild, 14 patients had moderate, and 5 patients had severe trismus. In the moderate difficulty group, 2 patients had mild, 13 patients had moderate, and 10 patients had severe trismus. In the very difficult group, 2 patients had mild, 7 patients had moderate, and 16 patients had severe trismus.

On the seventh postoperative day, in the slightly difficult group, all patients reported mild trismus; in the moderate difficulty group, 18 patients had mild, 6 patients had moderate, 1 patient had severe trismus, and in the very difficult group, 18 patients had mild, and 6 patients had moderate, and 1 patient had severe trismus. When the classified postoperative trismus rates were compared by surgical difficulty, a significant correlation was found on the second postoperative day (p=0.021) but not on the seventh postoperative day (p=0.072). A significant relationship was also found between the surgical difficulty and the mean amounts of MMO on the second (p=0.001) and seventh (p=0.000) postoperative days (Table 5).

The possible effects of gender, operation time, mouth opening and swelling amounts, VAS scores, and surgical difficulty (independent variables) on the change between preoperative BDS scores and postoperative second and seventh day BDS scores (dependent variable) were examined by multiple linear regression analysis. The analysis results revealed that operation time, MMO amounts, VAS scores, and surgical difficulty effectively increased BDS scores on the second postoperative day. On the seventh postoperative day, the analysis indicated that VAS scores had no effect, but MMO amounts, operation time, and surgical difficulty were effective. (R^2 = 0.311; Adjusted R^2 = 0.250; F= 5.118 (P = 0.000). R^2 = 0.299; Adjusted R^2 = 0.247; F= 4.831 (P = 0.000)) (Table 6).

Discussion

According to the present study results, postoperative inflammatory complications and surgical difficulties of impacted teeth affected mood alterations in patients who underwent surgical removal of impacted teeth. While the pain and operation time variables were effective on the BDS scores on the second postoperative day, swelling and trismus continued to affect the BDS scores on the seventh day. As such, the null hypothesis can be accepted despite the current limitations of the study.

Table 5. Comparison between the surgical difficulty and postoperative trismus (mm)

Trismus rate classes and Mean values		Slightly difficult	Moderate Difficulty	Very Difficult	Total (n)	*p* values
Postoperative 2nd day	Mild (<20%)	6 (24%)	14 (56%)	5 (20%)	25	
	Moderate (20< - <40%)	2 (8%)	13 (52%)	10 (40%)	25	0.021 *
	Severe (40%<)	2 (8%)	7 (28%)	16 (64%)	25	
	Mean	31.68	28.88	25.16		
	SD	5.62	5.53	6.31		0.001 ‡
	SE	1.12	1.10	1.26		
	n	25	25	25	75	
Postoperative 7th day	Mild (<20%)	25 (100%)	0	0	25	
	Moderate (20< - <40%)	18 (72%)	6 (24%)	1 (4%)	25	0.072 *
	Severe (40%<)	18 (72%)	6 (24%)	1 (4%)	25	
	Mean	43.36	37.88	35.28		
	SD	2.64	3.96	5.39		
	SE	0.52	0.79	1.07		
	Q1	41	44	45		0.000 +
	Q2 (Median)	44	38	40		
	Q3	45	37	39.9		
	n	25	25	25	75	

* denotes p values obtained by chi-square (χ2), ‡ ANOVA, and + Kruskal-Wallis tests. SD:Standard deviation, SE:Standard error

Table 6. Evaluation of Changes in Postoperative BDS Scores by Multiple Regression Analysis

Postoperative 2nd day							
Independent variables	B	SE	β	t Value	p values	95% Confidence Interval For B	
						Lower Bound	Upper Bound
Gender	-1.7512	1.4191	-0.1970	-1.2340	0.221	-4.583	1.081
Operation Time	0.2859	0.1324	0.4528	2.1597	0.034 *	0.022	0.550
Maximum mouth opening	-0.0330	0.0876	-0.0469	-0.3772	0.707	-0.208	0.142
Swelling	-0.1996	0.1102	-0.3123	-1.8108	0.075	-0.420	0.020
VAS scores	0.5325	0.2230	0.2769	2.3878	0.020 *	0.087	0.977
Surgical difficulty	0.2788	1.1335	0.0512	0.2460	0.806	-1.983	2.541
Postoperative 7th day							
Independent variables	B	SE	β	t Value	p Value	95% Confidence Interval For B	
						Lower Bound	Upper Bound
Gender	-4.9935	1.9786	-0.3921	-2.5238	0.014 *	-8.942	-1.045
Operation Time	0.4094	0.1708	0.4525	2.3970	0.019 *	0.069	0.750
Maximum mouth opening	-0.4276	0.1552	-0.3506	-2.7551	0.007 *	-0.737	-0.118
Swelling	-0.4837	0.1642	-0.4697	-2.9459	0.004 *	-0.811	-0.156
VAS scores	0.5956	0.3619	0.1610	1.6457	0.104	-0.127	1.318
Surgical difficulty	-0.7524	1.5111	-0.0965	-0.4979	0.620	-3.768	2.263

R^2= 0.311; Adjusted R^2=0.250; F=5.118 (P= 0.000). R^2= 0.299; Adjusted R^2= 0.247; F=4.831 (P= 0.000), B=unstandardised coefficients; SE=standard error of coefficients; β=standardised coefficients. * donates significant p values < 0.05.

Postoperative pain increased on the second postoperative day, correlated with surgical difficulty. However, there was no significant difference between the groups on the seventh postoperative day. Similarly, pain scores did not affect BDS scores on the seventh postoperative day. The postoperative pain, which decreased gradually in the short term, lost its effect on the patients mood changes. The most significant handicap of postoperative pain assessment is that it is subjective. The inability to objectively evaluate postoperative pain is one of the limitations of the present study. In addition, the follow-up period of the current study was one week postoperatively, which limited the evaluation of the long-term effects of postoperative pain. However, the fact that this complication did not show a significant difference between the groups on the postoperative seventh day is consistent with other studies in the literature.[22–25] Postoperative swelling did not differ significantly on the postoperative seventh day, as did postoperative pain. Again, it did not have a significant effect on BDS scores on the seventh postoperative day.

In the current study, preoperative surgical difficulty was assessed using the Pederson scale. It has been stated that the Pederson scale is helpful in determining surgical difficulty, and variables such as surgical difficulty, the severity of inflammatory complications, operation time, chewing ability are correlated.[9,20] Santana-Santos et al.[26] indicated that the prolongation of the operation time and the division of the tooth contributed to the formation of postoperative trismus. In the literature, it has been reported that the change in chewing ability due to trismus after mandibular third molar surgeries is up to 80%.[27] In the current study, all operations were performed by the same investigator, using the same techniques, in the same

setting, in order to standardize the effects of surgical difficulty. However, the duration of the operation in both postoperative evaluations and the persistence of trismus on the seventh postoperative day affected the BDS scores. Therefore, postoperative trismus can be considered as an unavoidable complication due to surgical difficulty. The effective management of this complication, which also has severe effects on quality of life in the postoperative period[6], should be considered.

Studies indicate that mandibular third molar surgeries have adverse effects on quality of life in the short-term postoperative period.[22,28,29] Similarly, in the current study, it was observed that depression scores were significantly affected during the one-week follow-up period. Although it has been reported that third molar surgeries have positive effects on oral health-related quality of life in the long term[30], their effects on the alterations in the mood are unknown. Although there are studies on evaluating the postoperative period with BDS in different specialties[31–33], these studies in the field of oral surgery are currently insufficient. The present study is the second study in the literature investigating the interaction between postoperative complications and alterations in the mood to the best of our knowledge.

This study did not observe any unexpected complications such as nerve damage, mandibular fracture, or infective complications. Therefore, the inability to evaluate the effects of such complications, which are more severe than inflammatory complications, on BDS scores is a limitation of the present study. In further studies, studies with more extended follow-up periods and evaluating the impacts of are needed such serious complications should be considered.

Conclusions

Inflammatory complications after surgical removal of impacted teeth can cause alterations in the mood of patients. It is essential to determine the factors that may exacerbate these complications during the preoperative evaluation process, inform the patients in this direction, and manage the postoperative process with more minor complications.

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None.

Conflicts of Interest Statement

No potential conflict of interest was reported by the authors.

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Cumhuriyet Dental Journal

Staining Susceptibility of Dental Composite Resins with Various Nano-Filler Technologies

Sakshi Sachdeva[1-a], Subhashish Das[2-b], Aasadur Rahaman Midday[3-c], Manuel S. Thomas[4-d]*, Prashanthi S Madhyastha[5-e]

[1]*Department of Orthodontics, Manipal College of Dental Sciences, Mangalore, Affiliated to Manipal Academy of Higher Education (MAHE), Manipal, Mangalore, Karnataka, India*

[2]*University of Colorado School of Dental Medicine, Aurora, Colorado, USA*

[3]*Department of Conservative Dentistry and Endodontics, SDM College of Dental Sciences and Hospital, Karnataka, India*

[4]*Department of Conservative Dentistry and Endodontics, Manipal College of Dental Sciences, Mangalore, Affiliated to Manipal Academy of Higher Education (MAHE), Manipal, Mangalore, Karnataka, India*

[5]*Department of Dental Materials, Manipal College of Dental Sciences, Mangalore, Affiliated to Manipal Academy of Higher Education (MAHE), Manipal, Mangalore, Karnataka, India*

*Corresponding author

Research Article

ABSTRACT

Objectives: The purpose of this study was to evaluate the color stability of polished composite resin material with different filler technologies.

Materials and Methods: Three composites were studied; Filtek™ Z350 XT (3M, ESPE, St. Paul, USA) [FXT] that has nano-cluster filler particles, Brilliant EverGlow™ (Coltene/Whaledent® AG, Altstatten, Switzerland) [BEG] which consists of submicron barium glass fillers and pre-polymerized fillers and Ceram.X® Sphere TEC™ (Dentsply, Konstanz, Germany) [CXS] with advanced granulated filler technology composite. Twenty standardized composite discs were prepared with each composite resin, and it was polished with Sof-Lex disks (3M, ESPE, St. Paul, USA). The baseline color was then recorded using a spectrophotometer (X-Rite PANTONE® iPro-2, Michigan). Eight samples from each group were then subdivided and immersed into freshly prepared solutions of turmeric, coffee, and four samples into distilled water for a total period of 3 hours/day for 30 days. Following this, the color was again recorded. The change in color (ΔE) was calculated, and the data obtained were subjected to Kruskal Wallis and Mann Whitney test.

Results: A significant difference was seen between the staining characteristics of CXS and FXT. The mean color change in the values was highest in Ceram.X that was clinically unacceptable (ΔE>3.3).

Conclusions: Though all composites revealed color changes after their immersion into the staining solutions, the amount of stain varied based on their constituents and filler characteristics.

Keywords: Color, Composite Resin, Filler Particles, Spectrophotometer, Staining.

[a] sakshisachdeva56@gmail.com   https://orcid.org/0000-0003-1315-1644   [b] drsdas21@gmail.com   https://orcid.org/0000-0002-8844-2529
[c] armidday@gmail.com   https://orcid.org/0000-0001-5830-6019   [d] manuel.st@manipal.edu   https://orcid.org/0000-0002-3042-0669
[e] prashanthi.madhyast@manipal.edu   https://orcid.org/0000-0002-7281-3753

Introduction

Beauty and aesthetics have been one of the most important concerns of people for many centuries. With this increasing demand for aesthetics in the field of smile designing/dentistry, the invention of composites has revolutionized treatment modalities. Composite resin has enabled dentists to perform restorations for patients on not only the anterior teeth but also on the posterior teeth with utmost perfection and ease. However, the color stability of these materials has been one of the most important criteria in determining the longevity and the success of restorations.[1] The quality of the resin restorations has improved greatly with the advent of new technologies in recent years. Composite resin has benefited with the development of smaller particle sizes, better bonding systems, curing refinements, and sealing systems, but color stability remains as an inherent challenge to the material.[2]

The discoloration of dental composites has a wide variety of reasons, both intrinsic and extrinsic. Whereas recent studies have shown no significant color changes in completely polymerized resins due to intrinsic factors post water storage.[3] Hence, discoloration due to extrinsic factors becomes the most significant one, although the etiology is multifactorial, staining due to coffee, tea, turmeric is a few of the causative factors being widely accepted in day-to-day life.[3] This discoloration is mainly caused by the adsorption of the colorant from the staining solutions or beverages on the resin-based restorations. This adsorption occurs mainly due to the surface roughness of a material, the types of resin matrix, and the dimensions of the filler particles. Discoloration of composite resins has been largely found as one of the major reasons for its replacement.[4,5]

Various composite resins have been developed with different physical properties mainly based on the filler particle size. The traditional ones being macrofilled, microfilled, small particle, and hybrid.[6] The newer ones in the market are nanocomposites. These materials are very versatile as they could be used for restoring both anterior and posterior teeth because of their better strength, handling, wear properties, and polishability.[7-9] Nanocomposites can be broadly sub-classified as nano-filled and nano-hybrid based on the filler technology used. Nano-filled composite resin consists nanoparticles and nanocluster filler particles. Whereas nano-hybrid composite contains larger filler particles in addition to the nanoparticles.[10,11] Various nano-hybrid composites are marketed with diverse filler technologies. The discoloration potential of these composites may vary depending on this.[12]

Aim of this study was to evaluate the color stability of various nanocomposite resin restorations having different filler particle technologies on exposure to staining agents.

Materials and Methods

Sample Preparation

Three composites that differ in their filler particle size and structure were selected for the study (Table 1). A total of 60 disks were made using a brass mold with a disk size of 2 mm height and 10 mm diameter. Twenty samples (n=20) were prepared from each of the composite resin groups using the mold. The mold was placed on a mylar strip and overfilled with composite resin, the top of the brass mold was again covered with a mylar strip and a glass slide. The composite was then polymerized completely for 20 seconds on one side and 20 seconds on the opposite side (LED- D Woodpecker Curing Light, 850mW/cm^2 -1000 mW/cm$^{2)}$). One side of the composite samples was polished using Sof-Lex disks as per manufacturer instructions (3M ESPE, St. Paul, MN, USA).

The non-polished side was marked with an indentation. The samples were stored in distilled water for 24hrs to ensure complete polymerization.

Staining Procedure

Twenty samples from each group were randomized into three subgroups. Those in subgroup A were immersed in staining solutions of turmeric. It was prepared by mixing 0.5g of turmeric (Everest, S. Narendra Kumar, and Co., Mumbai, India) in 500ml boiling water, simmer for 5 mins, and filtered. Samples in subgroup B were immersed in the coffee solution. This solution was prepared by adding 15g instant coffee powder (Bru, Brook Bond label, Hindustan Unilever, Ltd., Mumbai, India) in 500ml boiling water, simmer for 5 mins, and filtered. Samples in subgroup C were immersed in distilled water, acted as the control group. The samples were immersed in vials containing staining solution in a water bath at 37°C for 3 hours following which the samples were washed and kept in the water bath till the next day. Before immersion, the samples were taken out of the water bath and blotted with blotting paper to prevent dilution and then immersed again for 3 hours. The staining solutions were freshly prepared every day, and this process was repeated for 3 hours/day for 30 days. (Figure 1).

Staining Characteristics

The color of the samples was recorded at day 1 (T$_1$) before their immersion in the staining solutions, and finally, on Day 30 (T$_{30}$). The measurements were recorded using X-Rite i1 Pro Spectrophotometer with a Profile maker pro 5.0.1 software with D65 as the standard illumination under natural daylight conditions. The instrument was calibrated before use according to the manufacturer's instructions. Three readings were taken for each specimen at specific areas marked, and the mean of all the values, L*, a*, and b* were calculated.

Table 1. Composite resin materials used in the study

Composite resin	Code	Shade	Filler technology	Composition	Filler Volume (%)
Filtek™ Z350 XT (3M, ESPE, St. Paul, USA)	FXT	A2 Body	Nanocluster filler particles (Nano-filled)	bis-GMA, bis-EMA, UDMA, with small amount of TEGDMA Aggregated zirconia/silica cluster filler (0.6 -10μm); Silica (20nm); Zirconia (4-11nm)	63.3
Ceram.X® Sphere TEC™ (Dentsply, Konstanz, Germany)	CXS	A2	Advanced granulated nano-ceramic filler technology (Nano-hybrid)	Methacrylate modified polysiloxane Dimethacrylate resin Barium boron aluminum silicate glass (1.1- 1.5μm), Silicon dioxide (2-10nm)	59-61
Brilliant EverGlow™ (Coltene/Whaledent® AG, Altstatten, Switzerland)	BEG	A2	Submicron barium glass fillers, and pre-polymerized fillers (Nano-hybrid)	bis-GMA, TEGDMA, bis-EMA Pre-polymerized filler containing dental glass and nano-silica Colloidal nano-silica aggregated and non-aggregated Barium glass (20-1500 nm)	64

bis-GMA-Bisphenol A-glycidyl methacrylate; TEGDMA- Triethylene glycol dimethacrylate; bis-EMA- Bisphenol A-ethoxylate dimethacrylate; UDMA-Urethane dimethacrylate
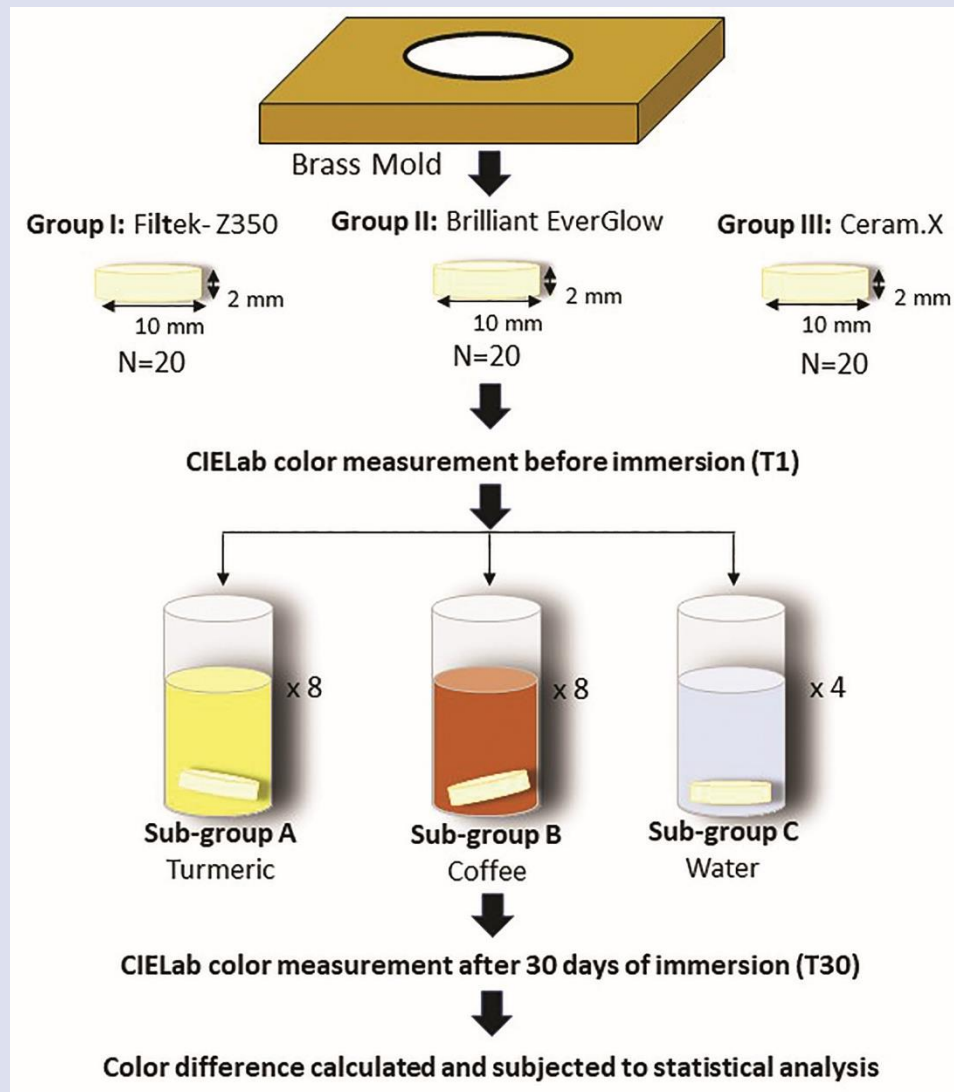
Figure 1. Schematic diagram of the experimental design

The L* value mainly refers to the lightness or the darkness of the object and ranges from 0 to 100, 0 being a perfect black to 100 being white. a* values show the shift between the color red and green. Positive $\Delta a*$ value shows a shift towards red, whereas negative value points towards a shift to green. On the other hand, b* value gives a range from yellow to blue, positive $\Delta b*$ value indicates a change towards yellow and negative towards blue.[13]

The total color difference (ΔE) that is the variation between the color at baseline, and after 30 days for each disk sample was calculated using the following equation: $\Delta E= [(\Delta L*)^2+(\Delta a*)^2+(\Delta b*)^2]^{1/2}$; where $\Delta L*= (L*_{30}- L*_1)$, $\Delta a*= (a*_{30}- a*_1)$, and $\Delta b*= (b*_{30}- b*_1)$.

Statistical Analysis

The change in color (ΔE) after 30 days was calculated, and the data obtained were subjected to Kruskal Wallis and Mann Whitney test using statistical software (SPSS for Windows, Version 11.0.0, SPSS Inc., Chicago, IL, USA). A p-value of less than 0.05 was set as statistically significant.

Results

The overall color change of the composite specimens in various staining solutions is shown in Table 2. ΔE value, which is obtained with the combination of L*, a*, and b* should be less than or equal to 1 in order to be inconspicuous. When this value is between 1 and 3, the color change is visually perceptible, and the value beyond 3.3 units in clinically unacceptable.[13,14]

All the three composite samples showed visually perceptible color change after immersion in the staining solution. The amount of color change was greatly affected by the group of composites used as well as the nature of staining solution used. In the turmeric staining solution, the mean color change seen was highest with Ceram.x ($\Delta E=3.63$). This value was statistically significant when compared to the other two composites. In the coffee staining solution, the mean color change of all the composite resins was higher than the clinically acceptable limit, with Ceram.x being significantly higher than the rest ($\Delta E=5.91$).

Table 2. Mean color changes (ΔE) of tested materials

Color parameter	Composite	Turmeric	p value	Coffee	p value	Distilled water	p value
Delta E	Filtek	2.02±0.61 [1.80] A	0.02	3.19±0.82 [3.49] A	0.02	0.87±0.06 [0.87]	0.56
	Ceram.X	3.34±0.53 [3.63] B		5.49±1.05 [5.91] B		1.04±0.78 [1.04]	
	Brilliant EverGlow	2.17±0.70 [2.28] A		3.84±0.75 [3.64] A		1.01±0.02 [1.01]	

Table 3. ΔL*, Δa*, Δb* values among restorative materials

Color parameter	Composite	Turmeric	p value	Coffee	p value	Distilled water	p value
Delta L	F	-1.40±0.66 [-1.50]	0.12	-2.56±0.59 [-2.60] A	0.01	-0.10±0.42 [-0.10]	0.24
	C	-2.54±1.18 [-2.80]		-5.15±1.18 [-5.45] B		-0.85±0.63 [-0.85]	
	B	-1.54±0.82 [-1.60]		-3.00±0.94 [-3.40] A		-0.50±.00 [-0.50]	
Delta a	F	-0.15±0.22 [-0.10]	0.06	-0.42±0.25 [-0.50] A	0.01	0.40±0.00 [0.40]	0.17
	C	-0.08±0.42 [-0.10]		-0.20±0.31 [-0.35] B		0.50±0.42 [0.50]	
	B	-0.54±0.24 [-0.60]		-0.72±0.17 [-0.70] A		-0.55±0.49 [-0.55]	
Delta b	F	-0.70±1.36 [-1.25]	0.56	-0.86±1.91 [-1.50]	0.14	-0.70±0.14 [-0.70]	0.09
	C	0.18±2.13 [0.20]		0.21±1.97 [-0.20]		0.35±0.21 [0.35]	
	B	-1.30±0.47 [-1.30]		-1.92±1.27 [-2.10]		-0.10±0.00 [-0.10]	

Same uppercase letters denote an insignificant difference between the same columns. The value in the brackets represents the median.

The Kruskal Wallis and Mann Whitney test results for ΔL*, Δa*, and Δb* are given in Table 3. ΔL* represents the change in brightness of an object. In the present study, there was a significant difference before and after the polishing and staining of the composite materials. The samples after staining had become dark. ΔL value was found to be highest for Ceram.x and lowest for Filtek. The Δa* value means a shift towards red, which, according to the values, was seen highest in Ceram x. The Δb*, which is a measure of a shift towards yellow, did not show any significant difference in the value. [Δa* value <0 means a shift towards green, and Δa* >0 means a shift towards red. Δb* value <0 the color of specimens shifts to blue and Δb*>0 means a shift towards yellow].

Discussion

The present study was based on the assessment of the color stability of 3 different nanocomposites with different filler technologies when subjected to the action of food colorants. Color perception is highly subjective and prone to individual variation. To match the restoration to the color of any tooth, Culpepper[15] has noted a disagreement not only between different dentists but also the same dentist at different occasions in shade matching the same tooth. Miller, *et al.*[16] have listed various parameters that can affect the apparent tooth color, the major ones being the time of the day, the light source used, and surrounding conditions. Therefore, to eliminate any subjectivity of color perception, a spectrophotometer was used in this study for color measurements, which made it possible to assess the color change.

Composite restorations, although being highly aesthetic, exhibit a disadvantage of discoloration over time. This discoloration may be due to intrinsic or extrinsic factors.[17] The intrinsic factors mainly include the choice of the material used along with the matrix properties and the interface between the matrix and the fillers. These factors directly affect the color of the restoration and can only be dealt with by changing the entire restoration. The extrinsic factors, on the other hand, are the exogenous sources such as food colorants, tobacco, and drinks.[18] The amount of color imbibed in the composite resin depends on the amount of water sorption the composite exhibits.[19] Studies have also shown that different surface finishing and polishing also affect the stain resistance property of the composite resin restoration.[20] Hence to negate this bias in the method of finishing and polishing composite resin, a common protocol with soflex discs was utilized for all the study samples.[21]

Coffee was chosen as one of the staining solutions in the present study because it has shown a high capacity of staining composite resin restorations and natural teeth.[22] Immersion of composite discs in a coffee solution for 30 days simulates two years of coffee consumption. The other staining solution used was turmeric. In the present study, maximum discoloration was seen in the composite discs immersed in coffee. This result is as per other studies.[23,24] The discs immersed in turmeric solution were significantly stained when compared to the control. However, the amount of color change was much less than that shown in the study by Malhotra, *et al* and Usha, *et al.*[1,25] This could be because, in our study, the samples were taken out from the staining solution, rinsed and dried before storing in distilled water. This procedure was to simulate the in-vivo condition of oral hygiene maintenance.

The dental composite resins are available in various technologies depending upon their molecular structure, i.e., the filler particle size as well as the amount of fillers present. In the present study, all three composites tested had nano-fillers. However, the nano-filler technology used

was different. Filtek[TM] Z350 XT is a nano-filled composite with non-aggregated as well as aggregated nano-filler clusters. The other two composites tested are nano-hybrid composites, which have small particle filler particles along with nano-sized filler particles. (Figure 2). These changes in filler size can affect the filler loading as well as the polishability. Thus, in turn, can affect the susceptibility of the composites to stains.[11,12]

In this study, Filtek[TM] showed the least amount of color change because of the presence of nano-filled technology that contains silica nanofillers and loosely bound nanoclusters made of silica/zirconia. This is said to provide better filler content along with high polishability.[22] The high polishability is attributed to the lightly agglomerated nanoparticles in the nanocluster that is only partially removed from the resin when subjected to finishing and polishing procedures. This will result in smaller surface irregularities.[12] Additionally, TEGDMA, a rather hydrophilic monomer, has been replaced with a hydrophobic resin combination of UDMA and bis-EMA. This could also be a contributing factor to the color stability of the nano-filled composite tested.[24,26]

In the final ΔE values, Ceram.X[TM] showed the highest mean color change in the turmeric solution (ΔE = 3.63) as well as in the coffee solution (ΔE= 5.91), both of which were clinically unacceptable. This nanoceramic hybrid composite contains spherical nanoparticles that are organically modified along with micro-sized glass fillers. The filler load in Ceram.X is lower than the other two composites tested. Lesser the volume of fillers, more will be the resin matrix (hydrophilic resin) available to absorb the stains. This could be one of the reasons why it showed increased staining.[27] Furthermore, the larger filler particles in this nanohybrid composites could also result in more surface irregulates after polishing.[27] Rough surfaces will adsorb stains more than smooth surfaces.

Brilliant EverGlow[TM] resin consists of silica glass particles, which increases the porosity of the biomaterial and, therefore, produces a higher level of surface roughness.[28] The composite resins that contain large filler sizes are more prone to discoloration due to the stains because of increased water sorption by the complex polymer network of the material.[12] The submicro-hybrid composite as the name suggests will have a combination of both small and large filler particles although few voids will be filled, but after the complete finishing and polishing, a large number of voids are left on the composite surface which eventually leads to greater water sorption and hence more discoloration.[29]
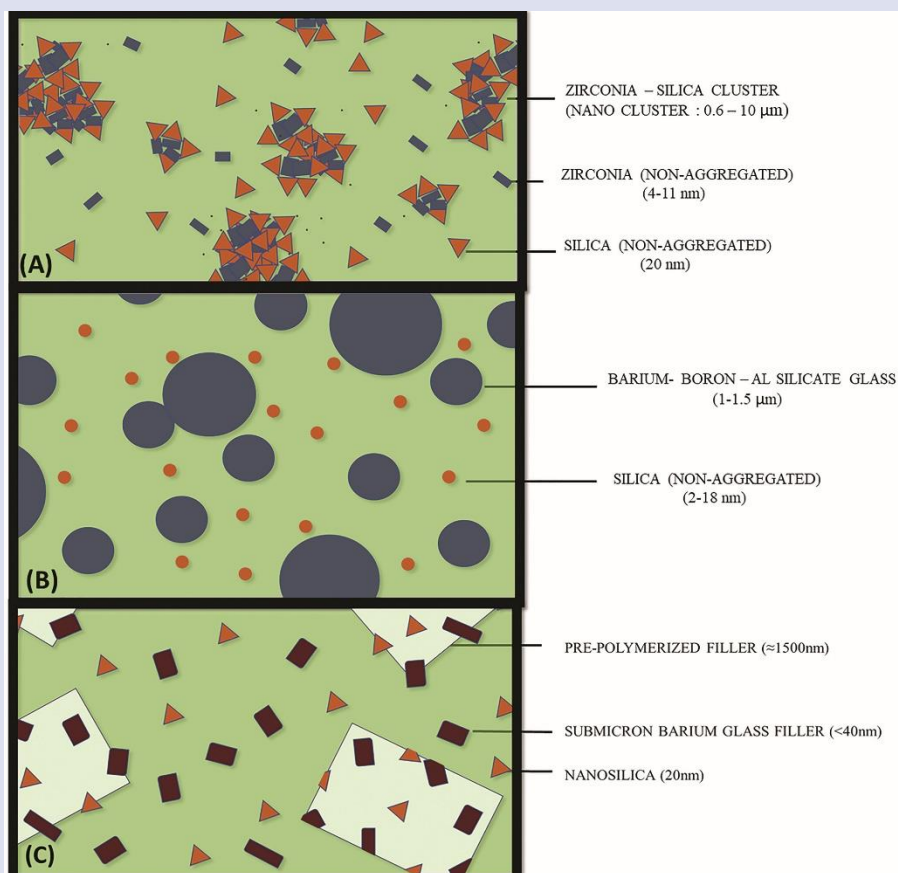

Figure 2. Filler particles and their distribution in the composites tested in this study; (A)Nano-filled composite with non-aggregated and aggregated filler Particles (B)Nano-hybrid composite with spherical filler particles (C)Nano-hybrid composite with pre-polymerized fillers and submicron filler particles

The filler load in Brilliant EverGlow is higher because it has incorporated pre-polymerized particles as filler as well. This could be the reason why this composite showed lower staining as compared to the other nano-hybrid composite. However, when compared to the nano-filled composite, the above-mentioned nano-hybrid composite showed more staining, though not statistically significant. This could be due to presence of more hydrophilic resins like TEGDMA.[30]

This study was done to identify the composite resin, which takes up the least amount of stain and hence can be used widely for a longer duration of time, providing better aesthetics. The results of this study give an insight into how different resin composites may behave when exposed to different dietary chromogens, thus affecting the clinician's choice of the material and the patients control of dietary habits. The present study only evaluated the in vitro effects of the different indigenous stains on the composite resins; however, in-vivo studies are required, which would take into consideration the effects of saliva and change of the pH of the oral cavity.

Conclusions

Among the dental composite resins tested, nano-filled composite showed better color stability than the nano-hybrid composites.

All the dental nanocomposites showed clinically unacceptable discoloration when immersed in coffee solution ($\Delta E>3.3$). Whereas, turmeric solution caused clinically significant staining only in the nano-hybrid composite with ceramic technology. ($p<0.05$).

Thus, filler shape along with filler volume as well as resin composition could all have played a role in the variations seen among the color stability of the nanocomposite resin tested in the current study.

Conflicts of Interest Statement

The authors have no conflicts of interests.

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Effect of Composite or Ceramic Thickness on the Polymerization Hardness of 5 Different Dual-Cured Resin Luting Cements

Gül Ateş[1-a]*, Nur E. Hersek[2-b]

[1]*Turkish Republic Ministry of Health, Directorate of Health Service. Ankara-Turkey*
[2]*Hacettepe University Faculty of Dentistry Department of Prosthodontics. Ankara-Turkey*
Corresponding author

Research Article

ABSTRACT

Objectives: The aim of the present study was to evaluate the influence of ceramic and composite thickness on polymerization hardness of five different dual-cure resin cements.

Materials and Methods: A total of 100 disc-shaped spacer, 10-mm in diameter and five varying thicknesses (1.0mm, 2.0mm, 3.0mm, 4.0mm, 5.0mm) were fabricated from ceramic and composite materials. Dual-cure resin cement specimens with 8-mm diameter were prepared using metal brass mold and activated by light beneath the composite and ceramic disc shaped spacers. A total of 100 specimens of five different dual-cure resins (RelyX, Variolink DC, NX3, Calibra Universal, Panavia F2.0) were prepared. Knoop hardness of each dual-cure resin cement was measured at five different point using a microhardness device with a 500 gm load, after 1 hr, 1 day, and 1 week polymerization. All data were statistically evaluated using one-way ANOVA.

Results: Multivariate analysis of variance revealed significant differences in hardness of specimens dual-cured under composite resin or ceramic spacers and different time intervals. Specimens cured through composite resin spacers showed less hardness values than ceramic spacers, with increasing thickness of the spacer. Also increasing the thickness of the composite or ceramic spacers produced a statistically significant decrease in microhardness of the dual-cure cements. Hardness values significantly reduced when composite spacers were thicker than 2 mm and ceramic spacers thicker than 3 mm.

Conclusions:. Dual-cured resin cements are needed to be improved to achieve sufficient degree of hardening under composite and ceramic restorations. Different commercially available brands have different polymerization properties.

Key words: Composite Inlay, Ceramic Inlay, Dual-Cure Resin Luting Cement, Microhardness.

Kompozit veya Seramik Kalınlığının 5 Farklı Dual-Cure Resin Yapıştırıcı Simanın Polimerizasyon Sertliği Üzerine Etkisi

ÖZ

Amaç: Bu çalışmanın amacı, seramik ve kompozit kalınlığının beş farklı dual-cure rezin simanının polimerizasyon sertliği üzerindeki etkisini değerlendirmektir.

Gereç ve Yöntemler: Seramik ve kompozit malzemelerden, 10 mm çapında ve beş farklı kalınlıkta (1.0 mm, 2.0 mm, 3.0 mm, 4.0 mm, 5.0 mm) toplam 100 adet disk şeklinde örnek hazırlanmıştır. 8 mm çapında dual-cure rezin siman numuneleri metal pirinç kalıp kullanılarak hazırlanmış ve kompozit ve seramik disk şeklindeki örnekler altında ışıkla polimerize edilmiştir. Beş farklı dual-cure rezin simandan (RelyX Universal, Variolink DC, NX3, Calibra Universal, Panavia F2.0) toplam 100 numune hazırlanmıştır. Her bir dual-cure rezin simanın Knoop sertlik değerleri, polimerizasyondan 1 saat, 1 gün ve 1 hafta sonra, 500 gr kuvvet uygulayan mikrosertlik ölçüm cihazı ile 5 farklı noktadan ölçülerek elde edilmiştir. Tüm veriler tek yönlü ANOVA kullanılarak istatistiksel olarak değerlendirilmiştir.

Bulgular: Çok değişkenli varyans analizi, kompozit veya porselen örnekler altında polimerize edilen dual-cure rezin simanların sertliklerinde, farklı zaman aralıklarında ölçüldüklerinde önemli farklılıklar olduğunu ortaya çıkarmıştır. Kompozit örnekler altındaki dual-cure rezin simanların, kalınlık arttıkça seramik örnekler altındaki dual cure rezin simanlara göre sertlik değerinin daha düşük olduğu gözlenmiştir. Ayrıca, kompozit veya seramik örneklerin kalınlığı arttıkça dual-cure rezin simanların mikrosertlik değerlerinde istatistiksel olarak anlamlı bir azalma olmuştur. Kompozit örnekler 2 mm'den kalın olduğunda ve porselen örnekler 3 mm'den kalın olduğunda sertlik değerleri önemli ölçüde azalmıştır.

Sonuçlar: Kompozit ve seramik restorasyonlar altında yeterli derecede sertleşme elde etmek için dual-cure rezin simanların iyileştirilmesi gerekmektedir. Piyasada bulunan markaların polimerizasyon özellikleri birbirinden farklıdır.

Anahtar Kelimeler: Kompozit İnley, Seramik İnley, Dual-Cure Rezin Yapıştırma Simanı, Mikrosertlik.

[a] atesgul2008@hotmail.com   https://orcid.org/0000-0002-1181-3045   [b] nhersek@hotmail.com   https://orcid.org/0000-0002-1734-1069

Introduction

Using dual-cure resin cements for indirect restorations such as ceramic and composite inlays are used widely during clinical practice. Dual-cured composite resin cements are ideal for bonding these restorations. The major advantage of these photo-activated materials is their ease of use. The working time is not a limitation, therefore excess luting material can be removed prior to curing.

Adequate cure of the resin-based cement is an important prerequisite for the stability and bio-compatibility of the restoration. Composite resin or ceramic inlays reduce the amount of the light reaching the bottom of the cavity and therefore compromise photo-activation of the luting material.[1-5] Dual-cure luting cements have been developed in order to combine the advantages of chemically and photo-activated materials. The chemical curing component is expected to ensure complete polymerization at the bottom of deep cavities, whereas photo-activation allows immediate finishing after exposure to the curing light. Many studies have revealed that the chemical curing mechanism alone is less effective than dual-curing and may be almost ineffective for some materials.[1,2,6-10]

The polymerization of dual-cured resin composite luting agents depends, on exposure time and the intensity of the light source [1-4,10-19] The shade of the restoration can also influence the polymerization[4,14,15]. Also, it has been reported that dual-cured resin composite luting agents are not sufficiently polymerized under thick and/or opaque ceramic or resin composite restorations.[3,4,10,11,13-24] It is therefore questionable where there is sufficient hardening of the dual-cured resin luting agents of different brands in those parts of a tooth reached by insufficient light intensity.[25,26]

The aim of the present study therefore was to evaluate the thickness of ceramic and composite resin inlays on the hardening of five commercially available dual-cure resin cements after 1 hour, 1 day and 1 week.

Materials and Methods

Composite Resin and Ceramic Disc Specimen Preparation

A total of 50 ceramic (Ceramco Finesse-Dentsply, York, USA) discs (diameter, 10 mm) were fabricated using leucite reinforced pressable glass ceramic, with lost wax injection moulding fabrication method. Ceramic disc thicknesses were 1.0 mm, 2.0 mm, 3.0 mm, 4.0 mm, 5.0 mm. Fifty composite resin (Tetric Ceram, Ivoclar Vivadent Shaan, Liechtenstein) discs were also fabricated at the same dimensions. Composite resin and ceramic disks 1.0-5.0 mm were used as spacers to simulate composite and ceramic inlays with different thicknesses and were constructed in A2 colors.

Preparation of Dual-Cure Resin Samples

A brass mold was used to polymerize the dual-cure luting cements under ceramic and composite spacers. Five dual-cure resin-based cements were selected for the study (Table 1). Dual-cure resin cement was placed in the hole 8 mm diameter and 1 mm depth, in a brass mold and covered with transparent filmstrip. Composite resin and ceramic spacers with different thicknesses were placed over the strip and dual-cure cements were polymerized through the disc using a visible light-polymerizing unit (Translux EC Heraeus Kulzer GmbH D-61273 Wehrheim-Germany) at a power density of 450 mW/cm^2 for 60 seconds.

Two specimens for each composite thickness were prepared, and they were separated to three groups for each time interval. In this way, 10 specimens were prepared for each dual-cure cement. The same procedure was repeated for ceramic spacers and a total of 100 samples were obtained. Specimens were stored at 37^{0}C until testing was done.

Surface Hardness Measurements of Dual-Cure Resin Samples

A Tukon microhardness tester (Acco Industries Inc, Wilson Instrument Division, Bridgeport, Conn.) with a Knoop indenter and 500 gm weight was used to determine the surface microhardness of each specimen after 1 hour, 1 day and 1 week. Five readings were obtained for each specimen, at each test interval with a total of 1500 readings. Mean Knoop Hardness numbers (KHNs) were calculated for each dual-cure luting cement. The results were analyzed statistically with multivariate analysis of variance (MANOVA) and Tukey tests were performed at the 95 % level of confidence.

Results

Specimens cured through composite resin spacers showed less hardness values than ceramic spacers (*P*<0.001). Also, hardness values decreased gradually with increasing thickness of the spacer. The mean microhardness values of five dual-resin cements are shown in figures 1-5. MANOVA revealed significant differences in KHNs among composite and ceramic spacers (P<0.001), different time intervals (P<.001) and between different spacer thickness (P<0.05).

For RelyX a decrease in the KHN from 58,83 to 19,32 (67%) occurred when the composite spacer thickness was 5 mm compared to curing without a spacer at the 1-week test interval. The value was 19,24 (67%) for the ceramic spacer. Significant decreases in KHNs of RelyX Universal occurred when the spacer thickness was more than 3 mm (Figure 1).

For Calibra, mean KHNs decreased from 48.89 to 40.94 (16 %) for composite and 31.71 (35 %) for ceramic, when the spacer thickness was 5 mm compared to the value obtained without a spacer at the 1 week test interval (Figure 2).

For NX3, mean KHNs decreased from 56.83 to 7.80 (86 %) for composite and 25.86 (56 %) for ceramic spacers with 5 mm thickness at the 1 week test interval (Figure 3)

Table 1. The five resin based dual-cure cements that were examined

Material	Manufacturer	Shades used	Filler Type	Filler Percentage
RelyX Universal	3M ESPE Dental Products, St. Paul, Minn. U.S.A	A1	Hibrit	82
Calibra Universal	Dentisply Caulk, Milford, Del. USA	Dark	Hibrit	65
NX3	Kerr Corporation, Orange, Calif. USA	Yellow	Mikrohibrit	68
Variolink DC	Ivoclar-Vivadent, Schaan, Liechtenstein	Warm	Mikrohibrit	71
Panavia F2.0	Kuraray America, Inc. NY. USA	Light	Hibrit	78

RelyX

	no spacer	1mm com	1mm cer	2 mm com	2 mm cer	3 mm com	3 mm cer	4 mm com	4 mm cer	5 mm com	5 mm cer
1 hour	47,72	31,1	37,92	28,17	38,5	26,99	36,34	18,58	23,16	13,62	9,05
1 day	55,87	46,99	57,7	45,58	50,35	32,6	47,51	19,05	26,68	16,69	15,41
1 week	58,83	55,22	64,76	46,68	50,97	36,61	49,5	19,25	31,69	19,32	19,24

Figure 1a. Mean KHNs of RelyX dual cured through resin composite and ceramic spacers and without a spacer at three test intervals.

Figure 1b. Comparison of Knoop hardness values of dual-cure polymerized RelyX Universal resin cement under composite and ceramic spacers of different thicknesses.

Calibra

	no spacer	1mm com	1mm cer	2 mm com	2 mm cer	3 mm com	3 mm cer	4 mm com	4 mm cer	5 mm com	5 mm cer
1 hour	31,56	16,36	16,82	22,6	16,61	20,82	16,14	19,35	23,15	17,13	18,31
1 day	44,85	25,09	24,17	31,91	23,89	34,51	27,22	34,36	38,48	33,55	31,01
1 week	48,89	27,03	25,03	41,19	25,13	34,95	28,91	39,33	39,84	40,94	31,71

Figure 2a. Mean KHNs of Calibra dual cured through resin composite and ceramicspacers and without a spacer at three test intervals.
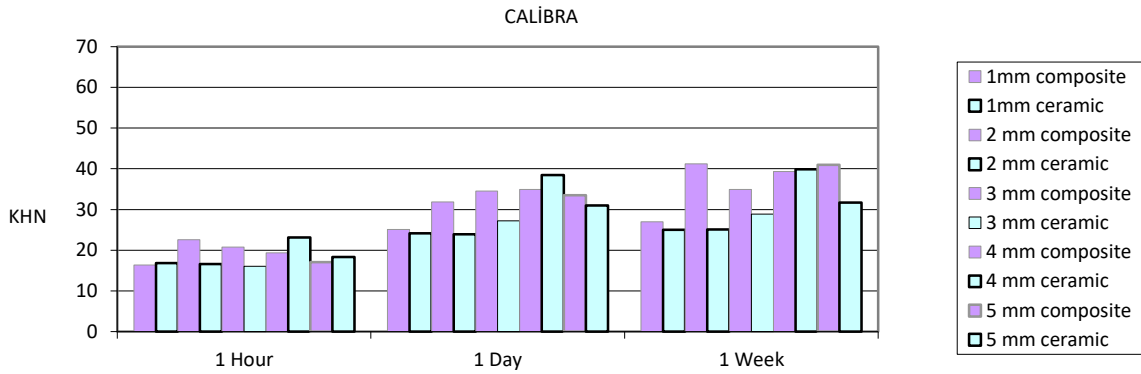
Figure 2b. Comparison of Knoop hardness values of dual-cure polymerized Calibra resin cement under composite and ceramic spacers of different thicknesses.

NX3	no spacer	1mm com	1mm cer	2 mm com	2 mm cer	3 mm com	3 mm cer	4 mm com	4 mm cer	5 mm com	5 mm cer
1 hour	46,72	26	47,63	20,2	37,57	20,57	39,93	7,73	29,7	7,05	26,9
1 day	57,87	37,79	55,48	27,1	50,52	28,04	50,78	7,77	43,85	6,47	37,88
1 week	56,83	39,5	51,3	32,01	46,96	29,88	48,44	10,35	42,5	7,8	25,86
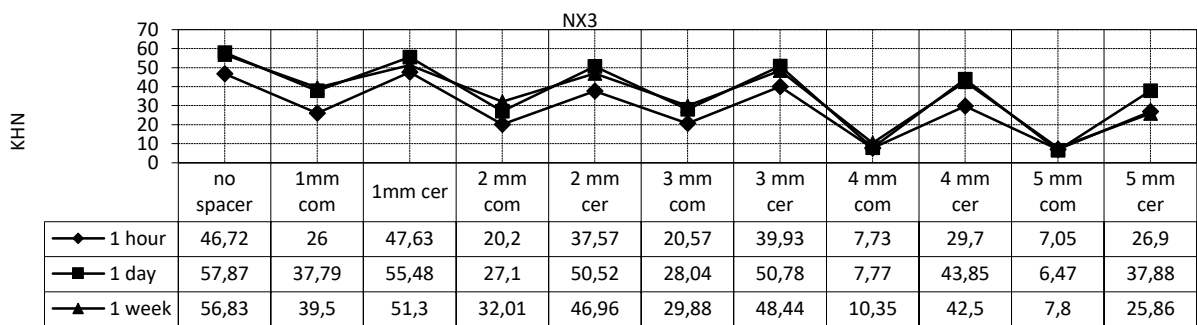
Figure 3a. Mean KHNs of NX3 dual cured through resin composite and ceramic spacers and without a spacer at three test intervals.
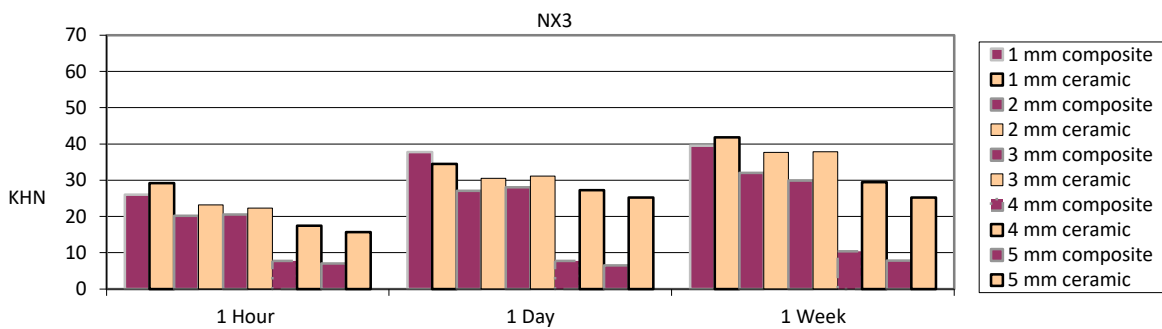
Figure 3b. Comparison of Knoop hardness values of dual-cure polymerized NX3 resin cement under composite and ceramic spacers of different thicknesses.

Variolink DC	no spacer	1mm com	1mm cer	2 mm com	2 mm cer	3 mm com	3 mm cer	4 mm com	4 mm cer	5 mm com	5 mm cer
1 hour	38,75	22,31	32,43	25,56	32,68	15,42	31,15	7,33	30,22	6,74	26,15
1 day	38,92	28,73	47,5	37,25	40,01	24,51	39,05	11,85	33	7,07	34,38
1 week	49,02	34,41	53,13	36,8	49,15	25,73	47,44	11,26	36,04	7,09	37,46
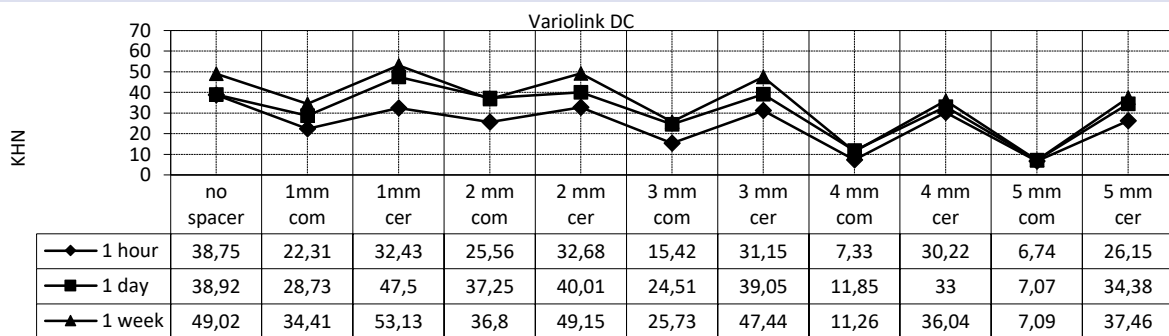
Figure 4a. Mean KHNs of Variolink DC dual cured through resin composite and ceramic spacers and without a spacer at three test intervals.
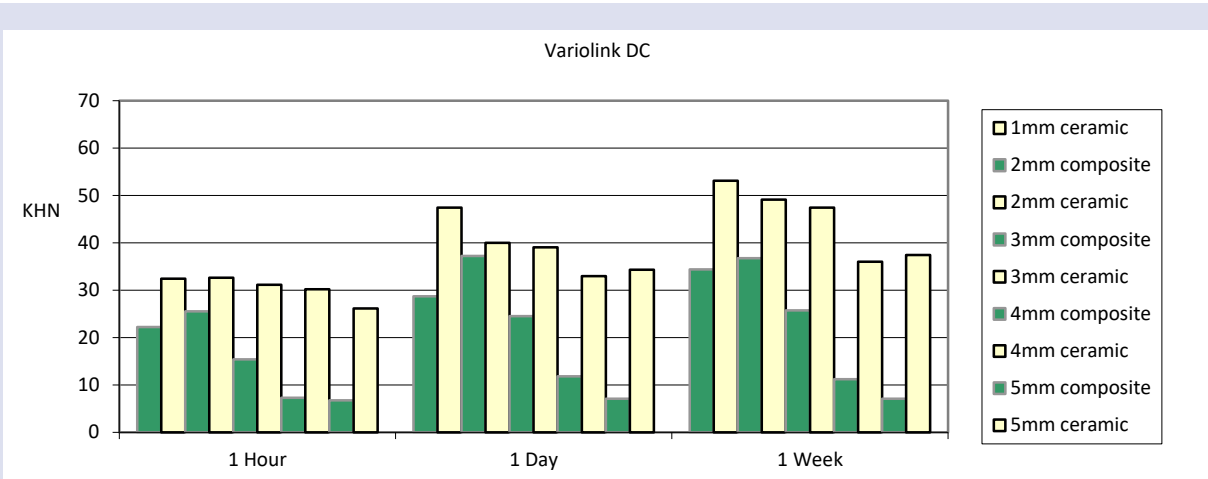
Figure 4b. Comparison of Knoop hardness values of dual-cure polymerized Variolink DC resin cement under composite and ceramic spacers of different thicknesses.

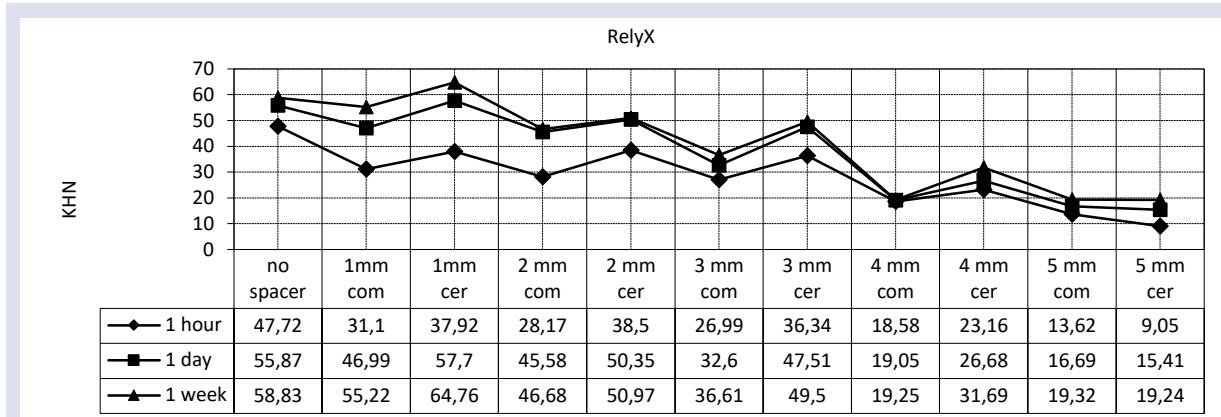|	no spacer	1mm com	1mm cer	2 mm com	2 mm cer	3 mm com	3 mm cer	4 mm com	4 mm cer	5 mm com	5 mm cer
1 hour	57,17	20,53	50,2	6,65	38,51	0	20,43	0	14,61	0	11,73
1 day	58,57	38,1	65,43	24,27	49,93	4,2	39,09	0	31,12	0	21,22
1 week	60,03	43,61	60,89	25,82	50,47	11,32	36,68	0	32,69	0	23,93
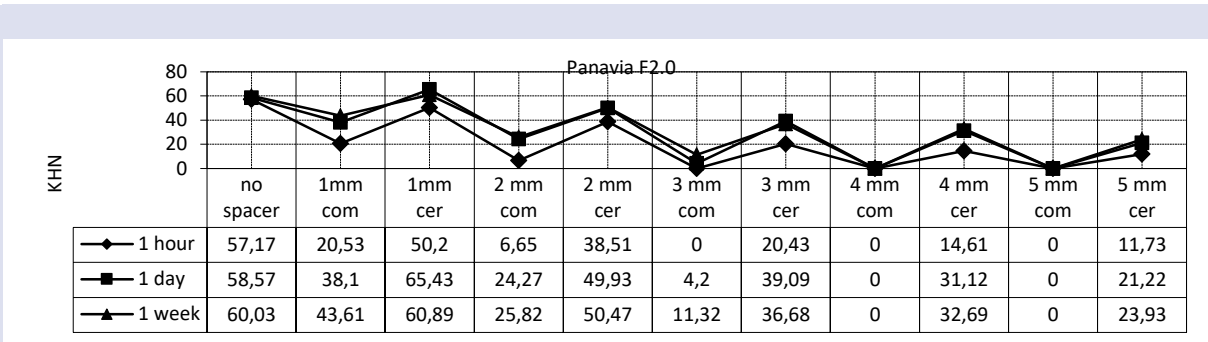
Figure 5a. Mean KHNs of Panavia F2.0 dual cured through resin composite and ceramic spacers and without a spacer at three test intervals.
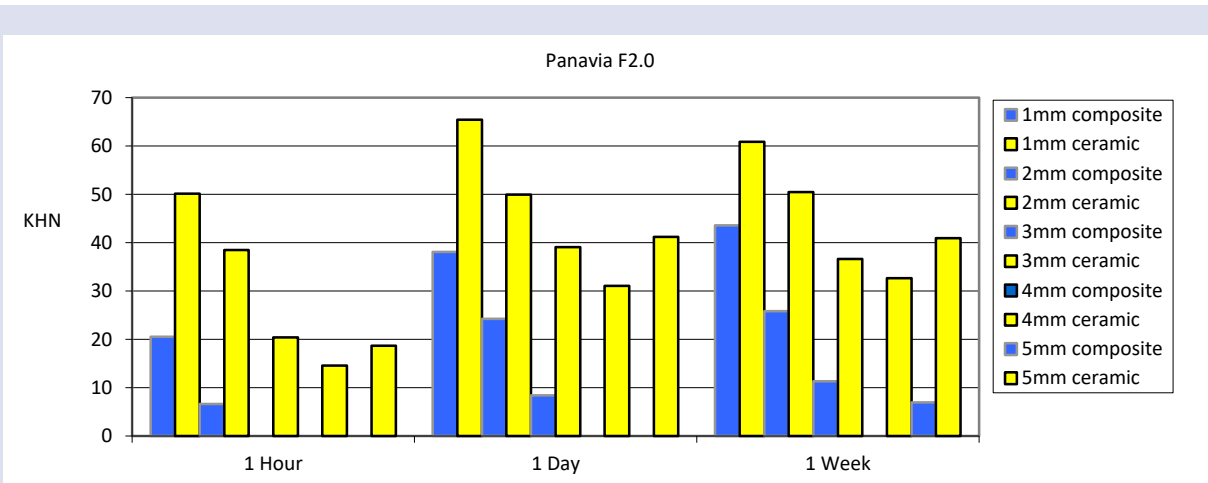
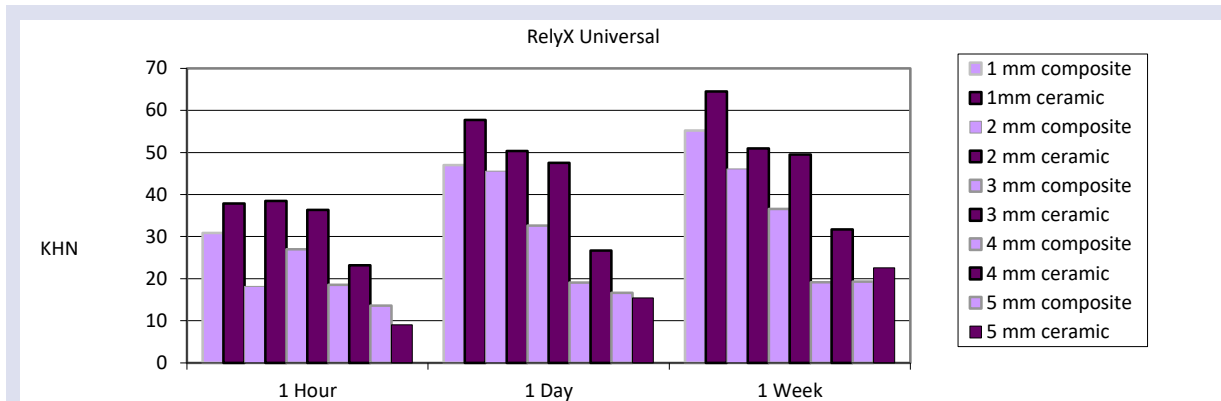
Figure 5b. Comparison of Knoop hardness values of dual-cure polymerized Panavia F2.0 resin cement under composite and ceramic spacers of different thicknesses.
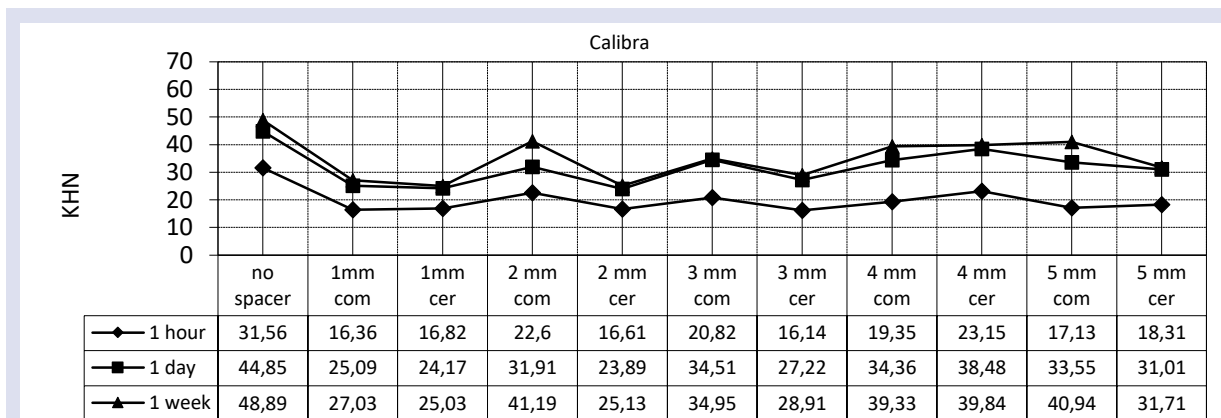
For Variolink, these values decreased from 49.02 to 7.09 (86 %) for composite and 37.46 (24 %) for ceramic spacers with 5 mm thickness at the 1-week test interval (Figure 4).

Significant decreases in KHNs of NX3 and Variolink occurred under composite and porcelain spacers more than 3 mm thickness.

For Panavia F2.0, surface hardness was not measurable under composite resin spacers more than 3 mm thickness. Mean KHNs decreased from 60.03 to 23,93 (60%) for ceramic spacers with 5 mm thickness at the one-week test interval (Figure 5). Panavia F2.0 showed highest KHNs under porcelain spacers compared to the other dual-cure cements.

Discussion

This study revealed that the thickness of ceramic and composite resin restorations effect hardening of the dual-cure resin cement. There are several factors that can influence the degree of polymerization of a dual-cure resin cement, such as shade, light unit and curing time. These factors were kept constant in our study to determine the influence of thickness and time only. Also the thickness of the spacers was between 1 and 5 mm, since the thickness of deep cavity restorations may be 5 mm or more. Statistically significant differences were found in the hardness of the specimens dual-cured through composite spacers versus ceramic spacers. The reason for these differences is most likely because of the way ceramic was more translucent than composite. Significant differences were also found in the hardness of specimens dual-cured through ceramic or resin composite spacers 2 to 3 mm in thickness or more the gradual reduction that occurred in KHNs with increasing spacer thicknesses could be attributed to attenuation of the light caused by the increasing opacity with the increasing spacer thickness. This attenuation may be caused by the light-absorbing characteristics of the restorative material (ceramic or composite resin). It is likely that the hardness achieved at 5 mm resulted mainly from the chemical-curing component of the cement instead of the light-curing component.

Dual-cured cements contain the peroxide/amin components found in chemical-cure systems in addition to the photosensitizer, camphoroquinone, used in light-cure materials. A slow–acting peroxide/amin system is used to achieve an extended working time and to adequately harden surfaces of the resin insufficiently exposed to light. The light –activated component provides rapid, initial hardening of the resin for stabilization of the restoration. Dual-cure initiator systems have been found to improve curing, solvent resistance and tensile strength of composites [14,15,24]

Knoop hardness measurements of the examined cements were recorded at varied times (1 hour, 1 day, and 1 week). From these findings, a relatively high degree of hardness was seen for specimens at 1 week test interval versus at other times test intervals. Even after 1 hour, dual-cured resin cements did not achieve adequate hardness. For this reason, it can be recommended not to stress bonding after cementation because the hardness at that time may be much lower than the maximum.

The KHNs of the examined cements can be sequenced in descending order as; RelyX, Variolink, NX3, Calibra, Panavia F2.0. Panavia F2.0 showed distinctly different pattern from other cements (Fig. 5). Its hardness values with no spacer were the highest values, but when composite spacer thickness was more than 2 mm, Knoop hardness measurements cannot be recorded, because the specimens were very soft. It may be attributed to its lower chemical curing component and greater dependence on light-activation. These findings conflict with the concept that the chemical-activated component will provide complete hardening of the cements in parts of the tooth not reached by the curing light. The attenuation of light by the tooth and restoration resulted in lower hardness and the chemical-cure component did not produce complete hardening. It can be recommended that Panavia F2.0 resin cement should be used under 1- or 2-mm thickness of ceramic restoration.

Calibra showed different pattern from other cements (Figure 2). In this study, the dark color of Calibra cement was used. As the spacer thickness increased, the KHN values also increased. It even reached higher hardness values under composite spacers compared to ceramic spacers. It may be attributed to its chemical curing components more than the light curing component. Also it can be said that it is not affected by the translucency of the ceramic spacer since the light activation component is low. Therefore, the polymerization hardness increased chemically over time, regardless of the thickness. Calibra is the cement with the lowest filling ratio among the cements we used (Table I). It may be possible to evaluate this cement as a chemically polymerized cement.

El-Badrawy and El-Mowafy[4] studied Knoop hardness values of seven different dual-cure resin cements through composite resin and ceramic spacers, under 1-6 mm. thickness. Also, in another study[22,23,24] they evaluated the effect of resin composite thickness on the hardness of eight different dual-cure resin composites. The results of these studies agree in general terms with our results, but the dual-cure cement brands were different, so there are some variabilities among the cements tested. The reason for these differences may be attributed to the formulations of the cements.

Complete polymerization of luting resin cement is essential for stability, and clinical success and longevity of the restoration. Decreased curing of resin cements caused by light attenuation significantly decreases the bond strength. The results of this study show that, currently available dual-cure resin cements cannot reach maximum hardness under 2 mm composite spacers and under 3 mm and more ceramic spacer thickness. From these findings it can be recommended that more work should be undertaken to improve the hardening of the currently available dual-cure resin cements so that maximum hardness can be achieved through the chemical curing component alone as efficiently as with the dual-curing component.

Conclusions

Within the limitations of this study, the following conclusions were drawn:

- 1.The polymerization potential of five commercially available dual-cure cements was found to vary greatly with brand.
- 2.Composite resin spacer obstructed light significantly more than ceramic resin spacer.
- 3.For most dual-cure resin systems tested, the hardness observed 1-hour postmix was significantly lower comparing 1-week values.

It can be recommended not to stress bonding after cementation because the hardness at that time is much lower than the maximum.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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Cumhuriyet Dental Journal

COVID-19 Related Knowledge among Dental Patients- A Questionnaire Survey

Zahra Janbani[1-a], Freshteh Osmani[2,3-b]*

[1]Master of Surgical Technology, Faculty Member, Faculty of Paramedical Sciences, Birjand University of Medical Sciences, Birjand, Iran
[2]Infectious disease Research Center, Birjand University of Medical Sciences, Birjand, Iran
[3]Department of Epidimiology and Biostatistics, Faculty of Health, Birjand University of Medical Science, Birjand, Iran
*Corresponding author

Research Article

ABSTRACT

Objectives: The novel coronavirus disease (COVID-19) is a serious pandemic that caused viral respiratory illness. Human behavior and knowledge assessment during the crisis are critical in the overall efforts to contain the outbreak. Therefore, we aimed to assess knowledge, and precautionary measures toward COVID-19 among a sample of dental patients in Iran.

Material & Method: This study was conducted among 270 attending patients to the dental clinics as a cross-sectional survey. They were asked to complete a standardized covid-19 knowledge questionnaire. This questionnaire includes 20 knowledge-based questions about covid-19. Along with this questionnaire, a checklist including five items about sociodemographic characteristics was completed by participants. After collecting the data, they were analyzed by descriptive statistical methods and chi-square test using SPSS software.

Results: The study was performed in February 2021. Results of this study showed 19.5%, 30.6% and 49.9% of respondents had poor, fair and satisfactory level of toward covid-19 respectively. Above 65% of the responders answered correctly to all questions. Men had poorer information statistical tests released that, knowledge had a significant association with educational level, age and monthly income amongst responders.

Conclusions: It was concluded that, their knowledge towards SARS-CoV-2 is generally good. Further steps need to be taken to educate the patient's about its transmission in a dental clinic. Also, training programs about mechanism of potential spread of COVID are suggested for the improvement of knowledge.

Keywords: COVID-19, Knowledge, Awareness, Dentistry

[a] ✉ drabedi05@gmail.com   (ID) https://orcid.org/0000-0002-1653-1432   [b] ✉ fereshteh.osmani@gmail.com (ID) https://orcid.org/0000-0000-7131-5112

Introduction

Patient safety plays an important role in improving the quality of patient care[1]. Infectious diseases are a substantial public health problem in many countries. In December 2019, the emerging coronavirus, which is now known as the Covid-19 and acute respiratory failure, appears in Wuhan City, China. The outbreak of Covid-2 has become a global health issue. Pneumonia has involved many countries and has infected many people around the world[2]. This virus caused the death of many people.

The virus is highly contagious and is spreading around the world. In Iran, since the first case of the Covid-19 virus was identified, the number of infected people has reached 245 in one week.[3] The available evidence indicates that asymptomatic patients can transmit the virus to others during the incubation period and infect them.[4] COVID 19 cases, like other diseases, are widely classified as suspected, probable, and confirmed. Assessing the symptoms of COVID-19 (suspected cases) is an early stage in the diagnosis and management of this disease. Person-to-person transmission (community outbreak) is currently ongoing in the country, so controlling the disease is essential to prevent its rapid spread across the country.[5,6]

A very high rate of spread and virus transmission induce health system for improving measures of COVID-19 prevention. One of the important factors for preventive measures is the awareness of people. Adherence to preventive and control measures is essential to ensure disease control. This commitment is highly dependent on public awareness. On the other hand, few studies have assessed the knowledge of the population regarding the COVID-19 outbreak.[7,8] Therefore, the present study aims to evaluate dental patient's viewpoint regarding CIVD-19 knowledge and its transmission.

Materials and Methods

This research is a cross-sectional descriptive-analytical study was conducted at Darolshafa Dental Institute, Birjand, Iran from July 2020 to August 2021, after obtaining ethical approval.

The data collection tool in this study was a standard questionnaire. This questionnaire was used to assess the knowledge of people referring to the dental clinic about

the Covid-19 virus. Likert's 3-point scale was used for the response of this questionnaire. Its reliability was obtained through Cronbach's α (α=0.73). Totally 270 patients fill the questionnaire. After checking these questionnaires, 16 cases were excluded due to incomplete information. In the first section of the questionnaire, sociodemographic information was asked, next section consisted of questions, which were designed to assess patient's knowledge regarding the COVID-19 pandemic. Including knowledge about the common route of COVID-19 transmission, personal protective equipment (PPE), its epidemiology and routes of transmission; practices regarding COVID-19 preventive methods. Validity, and interpretability of answers were modified based on the results of the pilot study. Questionnaire were scored as 0 and 1 for incorrect and correct responses, respectively. The questionnaire is attached.

Inclusion criteria for this study were having consent to participate in the study. Questionnaires completed with incomplete information were excluded from the study. The study population was all patients referred to the dental clinic of Birjand city since the beginning of the study.

Using the results of a similar study[9] and considering the 95% confidence interval and 20% accuracy and according to the following formula, 245 samples were obtained, which with a loss of 10%, 270 samples were considered for this study.

$$n = \frac{Z_{1-\alpha/2}^2 \cdot S^2}{d^2}$$

Statistical Analysis

After collecting information, data was entered into Spss software version 21. Categorical variables are expressed as frequency and percentage, and continuous ones are reported as mean and standard deviation (SD). All the associations were assessed using the chi-square or Fisher exact test. Two samples Independent t-test was used to assess the difference in patients' knowledge. The significance level was set at 0.05.

Results

Overall, 286 questionnaires were distributed among visitors to the dental clinic. Incomplete questionnaires were excluded. Finally, a total of 270 questionnaires were assessed with a response rate of 90.2%. Some of these drop out was due to that these patients were usually in hurry and unfortunately didn't accept to complete the questionnaire. The mean age was 31.6 ± 13.3 years. Regarding the source of covid-19 information, 41.9% reported that they gained their information from social media, (28.7%), obtained their information through TV, 19.8% from friends and relatives, and only 8.9% from a newspaper. 157 (58%) of the respondents were males while113 (42%) were females (Table 1). Their age was between 17 to 64 years old and it was distributed in 3 categories as follows: 17 to 34-years old 44(16.25%), 35 to 50 years old 142(52.5%), and 51 to 64 years old

84(31.25%). The monthly income variable is very substantial in awareness level. The current study showed that 2.75%, 24.5% and72.75% had primary education, high school, and college graduates respectively (Table 1). According to the correct answers among all age groups, a significant difference was observed (P<0.05). The maximum number of correct answers were reported in the 35-50 years old, so that, 88% of this group had the correct answers. While the percentage of correct answers in the other two groups (51-65 years and 17-34 years) was reported as 69% and 55.4% respectively (Table2). There was no significant difference incorrect answers by gender (P>0.05), so that, 91% of the males versus 87% of females gave the correct answers (Table3). Also, there was a statistically significant difference among monthly income groups (P<0.05). (Table2).
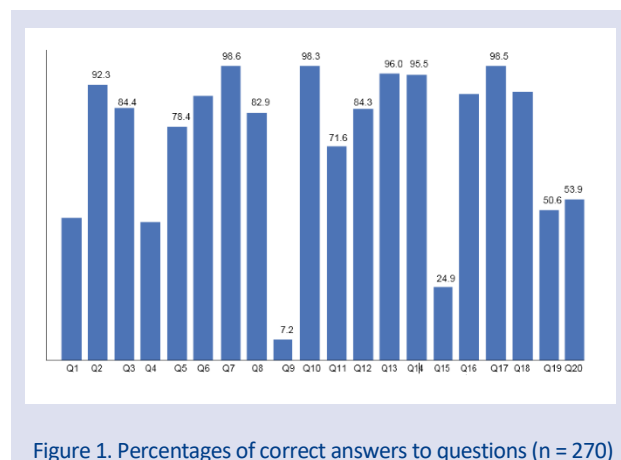
Figure 1. Percentages of correct answers to questions (n = 270)

Table 1. Frequency distribution of studied variables among respondents.

Variables	N	%
Gender		
Male	121	44.8
Female	149	55.2
Age (Years)		
20-34	44	16.25
35-50	142	52.5
51-65	84	31.25
Monthly Income		
Less than <30000000	22	8.1
30-50(m)	133	49.4
Above >50	115	42.5
Education		
Primary	8	2.75
High School	66	24.5
College	196	72.75

Education level had a substantial role in the COVID 19 awareness. The percentage of right answers increased with increasing the level of education. The college education respondents gave the highest number of correct answers (87%). While those with high school education (54%) and patients with primary education

(52%). So that, a significant difference was observed based on education level (P<0.05) (Table 3).

Also, the mean score of knowledge was 14.86±1.63, so that 49.8% of the responders had a high knowledge toward COVID-19 (Table 4).

Discussion

This study was conducted on the awareness of COVID-19 knowledge in Iran. This study shows that a relatively high proportion of dental patients had basic COVID-19 protection and their awareness regarding COVID 19 pandemic is acceptable. Although, some of them had a low level of knowledge.

Various studies have been conducted to assess the knowledge of dental health care providers regardingCOVID-19 recently[10,11]. Therefore, the knowledge of infectious diseases of dental patients is very important.

Results of this study show that education level and monthly income were significant factors in increasing the knowledge about COVID 19. The 35-50 years old respondents had also impacted the knowledge level positively. It can be due to that at this age, many of them are formerly involved in COVID 19 about prevention or treatment of the affected ones. In addition, the lowest level of knowledge was reported in the low monthly income group.

Various researches have evaluated the different levels of awareness about infectious diseases, such as severe acute respiratory syndrome and avian influenza[10,12]. Based on a literature search, any public study on knowledge regarding COVID 19 among the dental patients' population has not been found in Iran until now. So, this survey could provide baseline information for preventive measures to deal with future outbreaks[13,14].

Table2. Distribution of all answers among respondents by demographic variables

Variable	Yes	No	Don't know	Total	P value
Age					
20-34	24(55.4%)	17 (38.5%)	3 (6.1%)	44 (100%)	
35-50	125 (88%)	(12%) 17	0	(100%)142	0.034
51-65	58 (69%)	9(11%)	17 (20%)	84(100%)	
Monthly income(Rials)					
<30000000	18 (41%)	16 (37%)	9 (22%)	43(100%)	
30-50(m)	38 (65%)	18 (31%)	2 (4%)	58(100%)	
>50	142 (84%)	17 (10%)	10 (6%)	169(100%)	0.027
Gender					
Male	110 (91%)	8 (7%)	3 (2%)	121(100%)	
Female	130 (87%)	15 (10%)	4 (3%)	149(100%)	0.071
Education level					
Primary	4 (52%)	2 (26%)	2 (22%)	8(100%)	
High School	36 (54%)	22 (34%)	8 (12%)	66(100%)	0.001
College	170 (87%)	20 (10%)	6 (3%)	196(100%)	

Table 3. Association of Knowledge about COVID-19 with Demographic Variables

Variable	Knowledge About COVID-19		Significance	
	Mean	SD	Test Value	P-value
Age				
20-34	13.16	0.25	F=4.58	0.021
35-50	17.46	0.46		
51-65	12.65	0.77		
Monthly income(Rials)				
<30000000	13.58	0.14	F=3.71	0.042
30-50(m)	14.81	0.36		
>50	16.92	0.18		
Gender				
Male	14.25	0.34	T=0.18	0.31
Female	16.72	0.29		
Education level				
Primary	12.54	0.67		
High School	13.94	0.29	F=7.63	0.001
College	17.39	0.12		

Table 4. COVID-19 Knowledge Summary of the Respondents

Item	Number of Questions	Mean	SD	Knowledge level (in %)		
				Low	Moderate	High
Knowledge about COVID-19	20	14.86	1.63	19.5	30.6	49.9

The long latency period is a serious factor in COVID-19. Almost, half of the dental patients did not know the correct answer. Also, another important question that was answered incorrectly by the majority of respondents was the transmission medium. Regarding immunity against the COVID-19, most subjects chose no immunity. Although, it might compel short-term or moderate-term immunity in many individuals[15]. The questions were related to handwashing had fewer correct answers, which affirmed a less knowledge of handwashing may be among patients. Whereas, handwashing is acutely essential in controlling infectious diseases such as COVID-19. Hence, it should be considered seriously. The majority of the patients had received COVID-19 information from social media or websites, such as the Ministry of Health, and the WHO, while, a fifth receiving information from institutions meetings institutions. Former publications relieved that, the most important information source was those of television and newspapers. Currently, we can allege that social media have substituted with mass media easily. The results indicated that the majority of the responders reported antibiotics would not be beneficial in COVID-19 treatment, maybe due to that, they knew it is a viral illness. Although this rate of the correct answer was satisfactory, we recommend it should be higher.

In this study about two-fifths of them had poor knowledge about this infection. In line with this finding, another study showed that dental patients had low knowledge about HIV/AIDS[15-17]. Patients' education level is increasing as their concern for protection during treatment receiving rising[18]. In our survey, the educational level of dental patients was associated with their level of knowledge significantly. In addition, females got a little better knowledge score with no significant difference compared to males). This finding was similar to the results of other studies[19,20]

Many studies are investigating the knowledge levels of dental students about infectious diseases[21,22]. COVID-19 is a new disease that has spread rapidly and information about this disease is limited. To our best knowledge, no study has yet been made related to COVID-19 knowledge among dental patients. This study could investigate the knowledge regarding COVID-19 of dental patients at the dentistry clinic of Birjand, Iran.

The generalizability of our study was limited to the Iranian population, so, Future studies are required to conduct more accurate surveys. On the other hand, day by day, more facts are revealed about coronavirus. Hence, future studies can rely on more comprehensive and more technical surveys

Limitation

One of the limitations of the present study was that most of the questions in the questionnaire were related to knowledge and the apprehension of the dental patients towards covid-19 and fewer questions included related to the clinical aspect of covid-19 and its control measures. Although, a questionnaire-based study is a useful tool to obtain information regarding the opinions and experiences of participants efficiently[9,23]. In our study, we had a large sample for data analysis; but, some categories of the variables had a small sample size, which caused the imprecision of the results.

Conclusions

From the current study, it can be concluded that good Knowledge regarding Covid-19 was dominated among patients attending the dental clinic. The principal source of patients' information about Covid-19 was social media. Patients who attended dental clinics need to be trained with better knowledge via educational programs. It can be mainly through social media or TV programs, public places, etc. to increase public awareness. These programs can help to control infection through increasing awareness about the required protection measures. Also, the low-income group and low education level group have the least Knowledge level. Therefore, to prevent the COVID-19 pandemic from spreading, the health authorities should concentrate more on these groups.

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Appendix: Study questionnaire

No.	Questions	Yes	No	Don't know
1	COVID 19 is caused by a virus	-	-	-
2	The incubation period of COVID 19 is 5–14 days	-	-	-
3	COVID 19 is transmitted by infected persons	-	-	-
4	COVID 19 is transmitted by droplets in the air	-	-	-
5	COVID 19 is transmitted by droplets on surfaces	-	-	-
6	COVID 19 is transmitted by cough and sneeze	-	-	-
7	COVID 19 is transmitted by exhalation	-	-	-
8	COVID 19 has upper respiratory and lower respiratory symptoms	-	-	-
9	COVID 19 has gastrointestinal symptoms	-	-	-
10	COVID 19 has Fever and muscle pain	-	-	-
11	COVID 19 mortality rate is higher in elderly	-	-	-
12	COVID 19 can be prevented by wearing a mask	-	-	-
13	COVID 19 can be prevented by washing hands for 20 seconds	-	-	-
14	COVID 19 can be prevented by having a good immune system	-	-	-
15	COVID 19 can be prevented by balanced nutrition	-	-	-
16	COVID 19 can be prevented by Vaccine			
17	No drug treatment available for COVID 19			
18	COVID 19 patient needs a ventilator to survive			
19	Vitamin C is important in COVID 19 treatment			
20	Vitamin D is important in COVID 19 treatment			

Cumhuriyet Dental Journal

The Relationship Between Self-Reported Sleep/Awake Bruxism and Chronotype Profiles of Dental Students

Halenur Bilir[1-a]*, Burcu Yılmaz[2-b]

[1]*Department of Prosthodontics, School of Dentistry, Istanbul Medipol University, Istanbul/ Turkey*
[2]*Program of Dental Prosthesis Technology, Vocational School of Health Services, Bahcesehir University, Istanbul/Turkey*
*Corresponding author

Research Article

ABSTRACT

Objectives: The aim of this study is to evaluate the possible relationship between the presence/absence of the self-reported sleep and/or awake bruxism and the chronotype profiles of dental students.

Materials and Methods: The dental students of Istanbul Medipol University and Istanbul Medeniyet University participated in this study in the fall semester of the 2020-2021 academic year. Along with a form requiring students 'demographic data, an 11-item questionnaire evaluating sleep quality and self-reported sleep and awake bruxism, and a 19-item Morningness-Eveningness Questionnaire (MEQ) determining the chronotypes were applied. The significance level was set at p≤ 0.05 for statistical analysis.

Results: 171 students (female:128, 74.9%; male:43, 25.1%) participated in the study. The mean age was 22.3±2.2. There was no statistical difference between the presence or absence of the bruxism types and the chronotype profiles of the students. The sleep quality in the students with sleep bruxism was statistically lower than in other types of bruxism. The participants with sleep bruxism were statistically more likely to have difficulty concentrating on their daily activities than the participants with other types of bruxism.

Conclusions: There is no relationship between the presence or absence of the bruxism types and the chronotype profiles. However, sleep bruxism negatively affects both sleep quality and focusing on the daily activities.

Keywords: Bruxism, Circadian Rhythm, Dentistry.

Diş Hekimliği Öğrencilerinin Kendi Bildirdikleri Uyku ve Uyanıklık Bruksizm Varlığının Kronotip Profilleri ile İlişkisinin Değerlendirilmesi

ÖZ

Amaç: Bu çalışmanın amacı diş hekimliği fakültesinde eğitim gören öğrencilerin kendi bildirdikleri uyku ve/veya uyanıklık bruksizmi varlığı veya yokluğu ile kronotip profilleri arasındaki olası ilişkinin değerlendirilmesidir.

Gereç ve Yöntemler: Bu çalışmaya 2020-2021 eğitim-öğretim dönemi güz yarıyılında İstanbul Medipol Üniversitesi ve İstanbul Medeniyet Üniversitesi'nde eğitim gören diş hekimliği öğrencileri katılmıştır. Demografik verilerle birlikte uyku durumlarını ve kendi bildirdikleri uyku ve uyanıklık bruksizmini değerlendiren 11 soruluk bir anket ile kronotip profillerini belirleyen 19 soruluk sabahçıl-akşamcıl anketi uygulanmıştır. İstatistiksel analiz için anlamlılık düzeyi P≤ 0.05 olarak ayarlanmıştır.

Bulgular: Çalışmaya 171 öğrenci (kadın:128, %74,9; erkek:43, %25,1) katılmıştır. Yaş ortalamaları 22,3±2,2'dir. Öğrencilerin kendi bildirdikleri uyku ve/veya uyanıklık bruksizmi varlığı veya yokluğu ile kronotip profilleri arasında istatiksel olarak fark yoktur. Uyku bruksizmi olanlarda uyku kalitesi diğer bruksizm türlerine göre istatiksel olarak daha düşüktür. Uyku bruksizmi olanların günlük aktivitelere odaklanmada zorluk yaşamaları diğer bruksizm türlerine sahip olanlara göre istatiksel olarak daha yüksektir.

Sonuçlar: Bruksizm varlığı veya yokluğu ile kronotip profilleri arasında bir ilişki yoktur. Ancak uyku bruksizmi hem uyku kalitesini hem de günlük aktivitelere odaklanmayı olumsuz yönde etkilemektedir.

Anahtar kelimeler: Bruksizm, Sirkadiyen Ritim, Diş Hekimliği.

[a] halenurbilir@gmail.com   https://orcid.org/0000-0002-1753-6747   [b] burcu9yilmaz9@gmail.com   https://orcid.org/0000-0003-0730-179X

Introduction

Bruxism is a repetitive muscular activity of the masticatory system characterized by grinding or clenching of the teeth during sleep and/or wakefulness.[1] Its etiology is multifactorial and is associated with various psychological factors, especially personality traits such as anxiety and susceptibility to stress.[2,3] According to current literature, stress plays an important role in the pathogenesis of bruxism. The presence of bruxism is a relatively easy clinical symptom to detect and indicates the presence of stress.[4]

The human body is regulated by an internal clock whose health and adaptive skills are essential. This internal clock controls their daily rhythms, sleep/wake cycles, behavior, and physiological functions (such as temperature, melatonin secretion-light/dark cycle, cortisol levels, cellular replication, and digestion). This biological clock repeats cyclically (every 24 hours) and is expressed by the Latin term circadian, which means about one day.[5] The endogenous circadian rhythm is personal and therefore the daily cyclical system in humans differs from person to person. The chronotype refers to the circadian rhythm differences between individuals.[6] In other words, it is a feature that reflects the preference for what activities to do at different times of a day.[7,8]

There are three different chronotype profiles: the morning-type, the evening-type and the intermediate-type. 1) The morning-type: These individuals reach the optimal mental and physical performance in the early hours of the day and when they wake up and go to sleep early. 2) The evening-type: These individuals perform best towards the end of the day and when they wake up and go to the bed late. 3) The intermediate-type: These individuals do not have a clear morning-type or evening-type profile and therefore adapt more quickly to the variation in the circadian cycle.[5]

Many mental health-related conditions have also been associated with the chronotype used to describe the interindividual differences in the daily activity patterns and the sleep-wake cycles.[9,10] The modern lifestyles of these individuals require more adaptation to daily activities that do not fit their chronotype profiles. Therefore, inappropriate circadian cycles lead to inconsistencies between the social and biological clocks that determine sleep and wakefulness.[11] Also, reducing sleep times for social life causes a lack of sleep on workdays. This negatively affects daytime functioning and performance in general, and more effort is required to perform tasks.[12,13] Therefore, it was thought that performing tasks that are not compatible with the chronotype profiles could potentially lead to higher stress levels and ultimately trigger bruxism.[14]

The examining of the chronotype profiles and their possible association between the presence or absence of sleep and/or awake bruxism will provide a deeper understanding of the pathophysiology of bruxism. The aim of this study is to examine the possible relationship between the presence or the absence of the self-reported sleep and awake bruxism and their chronotype profiles. The null hypothesis of this study is that there is no relationship between the presence or the absence of bruxism and the chronotype profiles. The second null hypothesis of the study is that bruxism types do not affect sleep quality.

Materials and Methods

This study was carried out with the approval of the Istanbul Medipol University Ethics Committee (Date: 06/08/2020, Decision no: 10840098-772.02-E.34488). A questionnaire was uploaded to Google Forms. The sample size of the study was calculated using a power analysis (G*Power 3.1.9.2, Düsseldorf, Germany) that an alpha error probability of 0.05 and a power of 95%. Power analysis (effect size = 0.352) showed that at least 125 students should be included in the study. 356 dental students studying at Istanbul Medipol University and Istanbul Medeniyet University were invited to the study in the fall semester of the 2020-2021 academic year. 171 of them responded to the entire questionnaire.

On the front page of the questionnaire, detailed information about the study was given to the participants, and the consent form was placed in this section. The participants were informed that they could contact the researchers if there were any difficulties in understanding and completing the questionnaire. The questionnaire consisted of 11 items to obtain demographic information (*e.g.* gender and age), sleep condition, the presence or absence of sleep and/or awake bruxism, and 19 items from the Morningness-Eveningness Questionnaire (MEQ), which was used to determine the chronotype profile of the participants. The questionnaire consisting of 11 items was created by compiling questions from studies of Serra-Negra *et al.*[15] and Paesani *et al.*[16]. Firstly, the questions were translated into Turkish by two experienced educators. Then, the clarity of the questions was pretested with 15 PhD students. After the pretest, the questionnaire was finalized by the educators who conducted this study.

The Questionnaire for the Assessment of the Sleep Condition

In this survey, it was evaluated whether the participants had difficulty in focusing on the daily activities due to sleep duration, sleep quality, drug use for sleeping and not sleeping well. A similar questionnaire was used in a previous study by Serra-Negra *et al.*[15]

The Questionnaire for the Assessment of Sleep and Awake Bruxism

To evaluate the sleep or awake bruxism of the participants, a questionnaire including the following questions was applied:[15,16]

- Have you been told that you clenched your teeth while sleeping at night?

- Have you noticed that you are clenching and grinding your teeth at night while you are asleep?
- In the last 6 months, has your jaw locked when you woke up?
- Have you had pain in your face when you woke up in the last 6 months?
- Do you grind your teeth during the day?

The questionnaire consisted of "yes" and "no" answers. In the evaluation of this questionnaire, it was accepted that the participant who answered "yes" to at least one of the questions 1, 2, 3 and 4 had probable sleep bruxism, and the "yes" answer of a participant to question 5 was considered to have probable awake bruxism. The participants who answered "yes" to at least one of the questions 1, 2, 3, 4 and question 5 were considered to have both probable sleep and probable awake bruxism. It was decided that those who answered "no" to all questions did not have bruxism.

The Morningness-Eveningness Questionnaire (MEQ)

The Morningness-Eveningness Questionnaire (MEQ) consisted of 19 items answered with a 5-point Likert-type scale (ranging from "never" to "always") to rate the frequency of events. The sum of the answers to the questions provided a total score that determined the chronotype profile of the individuals, and this total score ranged from 16 to 86. The scores less than or equal to 41 indicated the evening-type, while scores between 42 and 58 indicated the intermediate type. The participants with scores higher than or equal to 59 were considered as the morning-type.[17]

Statistical Analysis

Data were analyzed with the IBM SPSS V23. The conformity to normal distribution was examined by Kolmogorov-Smirnov and Shapiro-Wilk. The chi-square test was used to compare the categorical data. The categorical data were presented as frequency (percentage). The significance level was taken as $p<0.050$.

Results

171 dental students participated in this study. 128 (74.9%) of the participants were female and 43 (25.1%) were male. The mean age of the students was 22.3 ± 2.2. 15.2% (n=26) of the participants was the 1st grade, 17.5% (n=30) of them was the 2nd grade, 6.4% (n=11) of them was the 3rd grade, 15.2% of them (n=26) was in the 4th grade and 45.7% (n=78) were in the 5th grade (Table 1).

14.6% (n=25) of the participants had self-reported sleep bruxism, 9.3% (n=16) of them had self-reported awake bruxism, 39.8% (n=68) of them had both self-reported sleep and awake bruxism. In 36.3% (n=62) of the participants, none of the bruxism types were observed. 4% (n=7) of the participants had the morning-type chronotype profile, 53.9% (n=92) of them had the intermediate-type chronotype profile, and 42.1% (n=72) of them had the evening-type chronotype profile. As can be seen in Table 2, there was no statistically significant relationship between the presence or absence of the bruxism types and the chronotype profiles (P=0.815).

Table 1. The distribution of groups with the sleep bruxism, the awake bruxism, both the sleep and the awake bruxism, and no bruxism type, by sex and grade

	The sleep bruxism (n=25)	The awake bruxism (n=16)	Both the sleep and the awake bruxism (n=68)	No bruxism (n=62)	P¹
Sex					
Female	16 (%64)	12 (%75)	53 (%77.9)	47 (%75.8)	0.585
Male	9 (%36)	4 (%25)	15 (%22.1)	15 (%24.2)	
Grade					
1	3 (%12)	2 (%12.5)	8 (%11.8)	13 (%21)	
2	5 (%20)	1 (%6.3)	9 (%13.2)	15 (%24.2)	
3	1 (%4)	0 (%0)	4 (%5.9)	6 (%9.7)	0.146
4	2 (%8)	2 (%12.5)	16 (%23.5)	6 (%9.7)	
5	14 (%56)	11 (%68.8)	31 (%45.6)	22 (%35.5)	

¹Chi-square test

Table 2. The comparison of groups with the sleep bruxism, the awake bruxism, both the sleep and the awake bruxism, and no bruxism according to the chronotype profiles

	The sleep bruxism (n=25)	The awake bruxism (n=16)	Both the sleep and the awake bruxism (n=68)	No bruxism (n=62)	P¹
The morning-type	0 (%0)	0 (%0)	4 (%5.9)	3 (%4.8)	
The intermediate type	13 (%52)	8 (%50)	37 (%54.4)	34 (%54.8)	0.815
The evening-type	12 (%48)	8 (%50)	27 (%39.7)	25 (%40.3)	

¹Chi-square test statistic

Table 3. The comparison of the answers to the questions about the sleep status of the groups with the sleep bruxism, the awake bruxism, both the sleep and the awake bruxism, and no bruxism type

	The sleep bruxism (n=25)	The awake bruxism (n=16)	Both the sleep and the awake bruxism (n=68)	No bruxism (n=62)	P^1
How many hours do you sleep?					
8 hours or more	10 (%40)	8 (%50)	24 (%35.3)	25 (%40.3)	0.739
Less than 8 hours	15 (%60)	8 (%50)	44 (%64.7)	37 (%59.7)	
How do you find your sleep quality?					
Good	9 (%36)[a]	13 (%81.3)[b]	36 (%52.9)[b]	46 (%74.2)[ab]	0.001*
Bad	16 (%64)[a]	3 (%18.8)[b]	32 (%47.1)[b]	16 (%25.8)[ab]	
Do you use medication to sleep?					
Yes	0 (%0)	0 (%0)	2 (%2.9)	2 (%3.2)	0.728
No	25 (%100)	16 (%100)	66 (%97.1)	60 (%96.8)	
Do you have trouble concentrating on daily activities because you are not sleeping well?					
No	6 (%24)[a]	10 (%62.5)[b]	24 (%35.3)[ab]	35 (%56.5)[ab]	0.006*
At least once a week	19 (%76)[a]	6 (%37.5)[b]	44 (%64.7)[ab]	27 (%43.5)[ab]	

[1]Chi-square test statistic, a-b: There is no difference between groups with the same letter. (*P <0.05)

As can be seen in Table 3, the sleep quality depended on the types of bruxism (P=0.001). The rate of good sleep quality in those with sleep bruxism was 36%, and this rate was lower than the groups with awake bruxism, both sleep and awake bruxism. The sleep quality of those who did not have any type of bruxism did not differ from other types of bruxism. The difficulty in concentrating on the daily activities of those who did not sleep well depended on the types of bruxism (P=0.006). While the rate of having difficulty concentrating on daily activities at least once a week was 76% in those with sleep bruxism, this rate was 37.5% in those with awake bruxism, and the other groups did not differ.

Discussion

In this study, the relationship between the bruxism types and the chronotype profiles of dental students, and the effects of bruxism types on the sleep condition were evaluated. According to the results obtained from the study, there was no statistically significant difference between the presence or absence of the bruxism types (sleep bruxism, awake bruxism, both sleep and awake bruxism) and the chronotype profiles (the morning-type, the intermediate type, the evening-type). Therefore, the first null hypothesis of the study, that there was no relationship between the presence or absence of the bruxism types and the chronotype profiles, was accepted. Since the presence of sleep bruxism affected the sleep quality and made it difficult to concentrate the daily activities, the second null hypothesis of the study, the hypothesis that the bruxism types did not affect the sleep condition, was rejected.

According to the consensus report published in 2013, the presence of bruxism was graded as "possible", "probable", "definite".[1] In the consensus updated in 2018, the diagnoses of sleep and awake bruxism were handled separately. The same rating was used for both groups.[18] It has been reported that in order to determine the presence of "definite" sleep bruxism, the presence of sleep bruxism should be determined according to the presence of sleep bruxism according to the

polysomnography data in addition to the clinical observation and the presence of self-reported sleep bruxism. In the "definite" awake bruxism, it has been reported that the presence of awake bruxism by the participants and the presence of awake bruxism should be determined according to electromyography data in addition to the clinical observation. In the studies with a large number of participants, the determination of bruxism in this way is both expensive and difficult in the practice, and it has been reported that the determination of "possible" bruxism, which the participants self-reported, is appropriate in both consensuses. In this study, according to the consensuses on the evaluation of bruxism published in 2013[1] and 2018[18], the presence of "possible" bruxism was determined by self-reported questionnaires.

In the determination of the chronotype profile, the "Morningness-Eveningness Questionnaire" consisting of 19 items, developed by Horne *et al.*[17] in 1976, was used. This questionnaire, which consists of the Likert type questions, was frequently used to determine the chronotype profiles. The translation of the scale into Turkish and the reliability studies were carried out by Pünduk *et al.*[19] in 2005.

It has been reported that the rate of bruxism in the general adult population ranges from 8% to 31.4%.[20] Studies have shown that the rate of bruxism in university students is higher than in the general population.[21,22] This is thought to be due to their higher stress levels.[4] In this study, the rate of those with only sleep bruxism was 14.6%, the rate of those with only awake bruxism was 9.3%, and the rate of those with both sleep and awake bruxism was 39.7%. While the rate of sleep bruxism in all participants was 54.3%, the rate of awake bruxism in all participants was 49.1%. In the study conducted by Serra Negra *et al.*[21] with dental students, the rate of sleep bruxism was 21.5%, and in the study by Aguiar *et al.*[23] it was 24%. The reason for these differences may be the cultural factors, the differences of the populations and increased the stress factors since this study was conducted during the COVID-19 pandemic period.

In this study, there was no gender difference between sleep bruxism, awake bruxism, both sleep and awake bruxism, or no bruxism. At least one type of the bruxism was seen in 63% of the female participants and 65% of the male participants. Although sleep bruxism was more common among the females than the males in the studies conducted by Serra Negra et al.[15] and Yıldırım et al.[24], they reported that sleep and awake bruxism were not affected by gender in a systemic review prepared by Manfredini et al.[25] in line with the present study.

When the chronotype profiles of the participants are examined, as in the previous studies[15,26], the majority has the intermediate-type profile. As in the study of Serra Negra et al.[15], no correlation was found between the chronotype profiles and sleep and awake bruxism. It is recommended to confirm this situation with data obtained as a result of examining the situation in large populations by increasing the number of samples in future studies.

In this study, it was observed that the sleep quality of students with sleep bruxism was statistically lower than those with awake bruxism and both sleep and awake bruxism. Consistent with the current study, the studies with the dental students in Brazil[21] and Saudi Arabia[27] also reported that sleep bruxism leads to poor sleep quality.

This study had some limitations. One of them was determined as the presence or absence of bruxism according to the students' self-reports as "possible" bruxism. The future studies should confirm the "definite" presence of bruxism by polysomnography for sleep bruxism and the EMG values for awake bruxism, together with the self-reports of the participants and the clinical observations of the clinicians. Another limitation was that the results obtained may not overlap with the general population, as the study was conducted only on dental students. Further epidemiological studies involving adults are recommended for the future studies.

Conclusions

Within the limitations, the following results were obtained from this study:

- There is no relationship between the presence or absence of bruxism types and chronotype profiles.
- Sleep bruxism negatively affects sleep quality and focusing on the daily activities.

Acknowledgements

Conflict of Interest

The authors declare no conflict of interest.

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Cumhuriyet Dental Journal

Effect of Adhesive on Micro Shear Bond Strength of a New Bioactive Restorative Material on Normal and Caries-Affected Dentine

Ezgi Sonkaya[1-a]*, Zehra Süsgün Yıldırım[1-b]

[1]Department of Restorative Dentistry, Faculty of Dentistry, Cukurova University, Adana, Turkey
*Corresponding author

Research Article

ABSTRACT

Objectives: Activa BioActive-Restorative is defined as a self-adhesive dual-cured resin-modified glass ionomer. The suggested application method includes only conditioning to the dentine with acid and keeps bonding optional. This study aims to evaluate the micro shear bond strength in the presence and absence of the bonding agent application after acid conditioning for different dentin surfaces.

Materials and Methods: 30 posterior molars having occlusal decay were used. The dentin surfaces involving normal dentin (ND) and caries affected dentin (CAD) were prepared and prepared three groups: Activa BioActive-Restorative with only 10 seconds of acid application (Act), Activa with acid and bonding application (Act B), GC G-aenial universal posterior composite with acid and bonding application. A total of 6 groups were formed, as each group had normal and caries-affected dentin surfaces. Universal test machines were used to calculate micro shear bond strength at a crosshead speed of 0.5 mm/min, and failure modes were checked by stereomicroscope. One-way ANOVA and Student t-test was applied for statistical analysis.

Results: There was no statistically significant difference between test results of each group neither for ND nor for CAD. There was no statistically significant difference between μ-SBS values of the ND and CAD subgroup for any of the groups. Adhesive failure dominated the other failure modes.

Conclusions: There is no difference between adherence of the material to ND and CAD. Acid application is sufficient for adequate bonding. However, an optional bond application can be recommended, especially for dentin cavities.

Keywords: Micro Shear Bond Strength, Bioactivity, Adhesion

Yapıştırıcının Normal ve Çürükten Etkilenen Dentin Üzerindeki Yeni Bir Biyoaktif, Restoratif Materyalin Mikro Kaydırma Bağ Dayanımı Üzerine Etkisi

ÖZ

Amaç: Activa BioActive-Restorative, self-adeziv, dual-cure, rezin ile modifiye edilmiş bir cam iyonomer olarak tanımlanır. Materyalin uygulama talimatlarında asit kullanılması önerilirken, bonding ajan kullanılması opsiyonel olarak kullanıcıya bırakılmıştır. Bu çalışma, farklı dentin yüzeyleri için asitleme sonrası bonding ajan uygulama ve uygulamama durumlarında mikro makaslama bağlanma dayanımını değerlendirmeyi amaçlamaktadır.

Gereç ve Yöntemler: 30 adet okluzal çürüğü olan molar diş kullanıldı. Normal ve çürükten etkilenmiş dentin içeren düz dentin yüzeyleri hazırlandı ve rastgele üç gruba ayrıldı (n=10): İlk gruba sadece 10 saniyelik asit uygulamasıyla Activa BioActive-Restorative (Act) uygulandı, ikinci gruba asit ve bonding ajan uygulaması ardından Activa uygulandı (Act B), üçüncü gruba asit ve bonding ajan uygulaması ardından GC G-aenial Universal posterior kompozit uygulandı. Her bir diş üzerinde hem normal hem çürükten etkilenmiş dentin yüzeyleri olduğu için toplamda 6 grup oluşturuldu. Bağlanma değerlerini hesaplamak için 0,5mm/dk hızında universal test cihazında makaslama bağlanma dayanımı testi uygulandı ve kırılma modları stereomikroskop ile belirlendi. İstatistiksel analiz için One-way ANOVA ve Student t testi uygulandı.

Bulgular: Gruplar kendi aralarında normal ve çürükten etkilenmiş dentin için test edildiğinde istatistiksel olarak anlamlı bir fark bulunmadı. Her üç grup için normal ve çürükten etkilenmiş dentin alt grubunun μ-SBS değerleri arasında istatistiksel olarak anlamlı bir fark yoktur. Örneklerde en fazla adeziv kırılma gözlendi.

Sonuç: Malzemenin normal ve çürükten etkilenen dentine bağlanması arasında fark yoktur. Yeterli bağlanma için asit uygulaması yeterlidir. Ancak özellikle dentin kavitelerinde isteğe bağlı bir bond uygulaması önerilebilir.

Anahtar Kelimeler: Mikro makaslama Bağlanma Dayanımı, Biyoaktivite, Adezyon.

[a] esonkaya@cu.edu.tr   https://orcid.org/0000-0001-9773-0955   [b] susgunzehra@gmail.com   https://orcid.org 0000-0002-1717-8214

Introduction

The most important purpose of restorative dentistry is to clean a carious lesion and restore the anatomy, function, and aesthetics of the tooth with the most appropriate restorative material. With the advancing technology, new concepts in minimally invasive dentistry have been discovered and new materials supporting them have been found.[1] Despite successful advances in the composition and adhesion of resin composites, materials science has always maintained its innovative perspective and worked to develop permanent fluoride-releasing restoration materials.[2] There are many fluoride-releasing materials on the market, but most of them do have not as strong mechanical properties as permanent composite resins. Recent innovations are the production of restorative resin composites with strong mechanical properties or claimed bioactivity.[3]

Repair, reconstruction, and regeneration are aimed with these special materials used. Bioactive materials, in the most general definition, are compounds that create a chemical bond between tissue and material by creating a special biological response when applied to living tissues.[4] Bioactive materials can strengthen the tooth structure by creating natural remineralization by releasing the calcium and phosphate minerals they contain.[5] At the same time, they cover the material and tooth surface with a hydroxyapatite layer to prevent the formation of secondary caries.[6]

Activa BioActive-Restorative is a bioactive composite resin and leads to more fluoride than glass ionomers residual. It claims to contain a shock-absorbing rubberized ionic-resin component and sol-gel derived bioactive glass (BAG) fillers in the bioactive resin matrix[4]. It does not contain BPA derivative monomers such as Bisphenol A, Bis-GMA.[7] Studies have shown bioactive materials have acceptable diametral tensile strength and flexural strength values[8], microleakage[9], and wear resistance.[10] Although the number of long-term randomized clinical studies conducted specifically to address the self-adhesion success of the material is insufficient, these studies have shown inconsistent results. One of these studies claimed that fillings applied with Activa showed 98% acceptable performance, while another study found that fillings showed a very high failure rate.[11,12] This composite is placed in the cavity with a dual barrel automix syringe.

Phosphoric acid conditioning is recommended. A bonding agent may or may not be applied. Although there are multiple reasons for the high failure rate, the main factor is thought to be the weak initial bond at the filling-tooth interface.[12] Clinical results and manufacturer's instructions gave researchers the idea that Activa self-adhesion ability should be studied. A considerable amount of literature has not been published on these. The objectives of this research are to determine whether using a bonding agent is necessary or not in Activa adhesion, *in vitro*, by calculating micro shear bond strength in comparison to a conventional composite. Our null hypothesis is that when a bonding agent is not applied, it is also showed adequate micro shear bond strength as a conventional composite.

Materials and Methods

The present *in vitro* study was undertaken in Cukurova University Faculty of Dentistry from May 2021 to August 2021 and was authorized by the Non-Invasive Clinical Research Ethics Committee of Cukurova University No. 44 dated May 21, 2021. The present study applies to the CRIS guidelines. Extracted carious human molars (n=30) were kept in 0.2% sodium azide solution added phosphate-buffered saline. Later, they were embedded in epoxy resin until the tooth enamel was exposed. To access normal dentin's (ND) and caries-affected dentin's (CAD) flat surfaces, their enamel was trimmed horizontally. 30 molars with moderately involved occlusal caries in the dentin were used according to Mount's classification and ICDAS II classification.

Caries detecting dye (Snoop, Pulpdent Corp, USA) was used to clearly define the difference between ND and CAD. Red caries detector dye was applied with 10 seconds interval (sec) to the dentin surface, rinsed, and then dried. Three different colors were observed after the procedure: dark-red, pink, and yellow respectively denoting caries infected, caries affected, and normal dentin. Caries-infected dentin was removed partially by a round steel bur. The dentin surface was flattened using 600-grit silicon carbide paper for 10 sec. Samples (n=30) were unplanned divided into 3 different groups according to tested restorative materials (n=10) (Table 1).

Table 1. Tested materials

Material	Chemical composition	Brand
Activa Bio-Active Restorative	Modified diurethane, other methacrylate monomers, modified polyacrylic acid, silica, amorphous, sodium flouride	Pulpdent Corp, Watertown, MA, USA
GC G-aenial Universal posterior composite	Urethane dimethacrylate, Inorganic and Pre-polymerized filler, Fluoroaluminosilicate, Silica, Trontium and Lanthanoid fluoride	GC Corp. Tokyo, Japan
Gel Etchant	37,5 % orthophosphoric acid gel	Kerr, CA, USA
Optibond All in One	Glycerol phosphate dimethacrylate, acetone, water, ethanol, Triethylene Glycol Dimethacrylate, ytterbium fluoride, photo initiators, accelerators, stabilizers, water	Kerr, CA, USA

Group 1: According to the manufacturer of Activa Bioactive-Restorative's instruction, dentin was etched with acid gel for 10 sec and then washed with water for 15 sec, air-dried slightly (Kerr, USA). Then, Activa BioActive-Restorative (Act) was applied (Pulpdent Corp, USA). It was placed with an applicator gun and polymerized for 20 sec (Valo, Ultradent Products Inc, USA) after allowing it to settle for three-four sec. Its full polymerization continued for three-four minutes.

Group 2: Dentin was etched with acid for 10 sec and washed with water for 15 sec, air-dried slightly. Then, the bonding agent (OptiBond All-In-One, Kerr, USA) was applied to the entire dentin during 20 sec and dried during 5 sec and polymerized for 10 sec. Then, Activa BioActive-Restorative was applied. It was placed with an applicator gun and polymerized for 20 sec after allowing it to settle for three-four sec. Its full polymerization continued for three-four minutes.

Group 3: Two-step total etching procedure was applied for a conventional composite. The dentin surface was etched with acid for 10 sec and then washed for 15 sec, air-dried slightly. Then, the bonding agent was applied to the dentin for 20 sec, dried for 5 sec and polymerized for 10 sec. Then, GC G-aenial Universal posterior composite was applied and polymerized for 20 seconds.

Starch tubes (pasta, Oba Pasta, Turkey) were applied for the application of the restorative material. The tubes were 1 millimeter (mm) in diameter-1 mm in height. One starch tube was placed for each dentin substrate (ND and CAD).[13] Microcylinders were left a room temperature for 24 hours to entire polymerization. During this time, the starch tubes softened, and the softened tubes were removed with a scalpel tip. All specimens were tested immediately. Universal test machines (MOD Dental MIC-101, Esetron Smart Robototechnologies, Turkey) were used to calculate micro shear bond strength. This machine utilizes a chisel-shaped metal blade inserted parallel to the dentin surface into the composite-dentin interface at crosshead speed of 0.5 mm/min until the stick's failure.[14]

The micro shear bond strength (μ-SBS) was calculated to the equation:

$$s = p / \pi . r^2$$

(s=μ-SBS (MPa), p=load at sample failure (N), π=3.14, r=radius of bonded sample (mm^2)).

Each fractured stick was controlled using a stereomicroscope (Leica Microsystems, Germany) at 50× magnification and was classified into the following failure types:

Type 1: Adhesive link between dentin and material or cohesive in adhesive

Type 2: Cohesive in dentin or resin

Type 3: Mixed.[15]

Statistical Analysis

The normality of the data was controlled with the Kolmogorov-Smirnov test. Two-way ANOVA was used. One-way ANOVA was applied to show the significant difference and a Student t-test was applied to determine the bond strength values among the tested restorative material bonded to normal or caries affected dentin. In all statistical analyses, the level of significance was determined as 95%. All statistical analyses were finalized using SPSS Statistics 23.

Results

The mean±standart deviation of all experimental group is shown in the tables (Table 2-3). No significant difference was observed between test values of each group neither for normal dentin (p:0.065; p > 0.05) nor for caries-affected dentin (p:0.110; p > 0.05).

No significant difference was observed between μ-SBS values of the ND and CAD subgroup for any of the groups (Act p:0.933; Act B p:0.684; GC p:0.863; p>0.05). According to pairwise comparison results, μ-SBS Act B and μ-SBS GC values are higher than μ-SBS Act values.

Regarding the percentages of observed failure modes, adhesive failure dominated the other failure modes (adhesive at dentin side) (Figure 1).

Discussion

A relatively new material character in restorative dentistry is bioactivity. Bioactive materials can be used with or without an adhesive agent. How Activa bonds to the dentin are not fully clear. This bonding is thought to be a combination of chemical interaction, and micromechanical infiltration. The ionic interaction between the carboxyl group of the material and the hydroxyapatite of the tooth provides chemical bonding. The self-etch feature of the material creates porosity on the tooth surface, also creates surface roughness in the dentin, and these provide micromechanical bonding.[16] The manufacturer suggested the use of acid and expressed the dentin-bonding procedure as optional. Therefore, in this study, the bonding of Activa to dentin with acid and applying acid + bond as compared with the bonding of a conventional composite.

Table 2. μ-SBS (in MPa) of the Tested Materials

	Materials			
	Activa Bio-Active Restorative only acid (Act)	**Activa Bio-Active Restorative acid+bond (Act B)**	**GC posterior acid+bond**	**P-value**
ND (Normal dentin)	10.42±7.82^A (Ptf/tnt:3/10)	18.24±10.21 ^{A} (Ptf/tnt:0/10)	22.55±10.90 ^{A} (Ptf/tnt:0/10)	0.065
CAD (Caries-affected dentin)	10.11± 5.52^A (Ptf/tnt:3/10)	20.48±13.74 ^{A} (Ptf/tnt:0/10)	21.66±11.75 ^{A} (Ptf/tnt:0/10)	0.110
P-value	0.933	0.684	0.863	

Ptf/tnt: Pre-test failures/total number of tested samples. ^{A} Same superscript uppercase letter denotes an insignificant difference.

Table 3. Boxplot For µ-SBS (in MPa) of the tested materials. Median and 25–75% quartiles are displayed within the boxes.
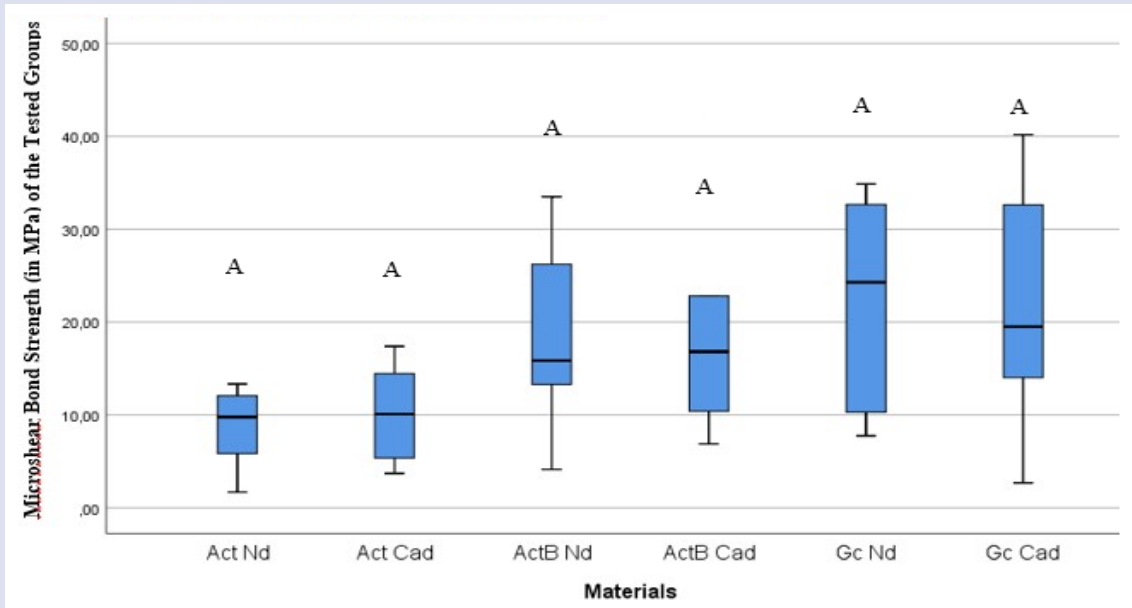
A Same superscript uppercase letter denotes an insignificant difference
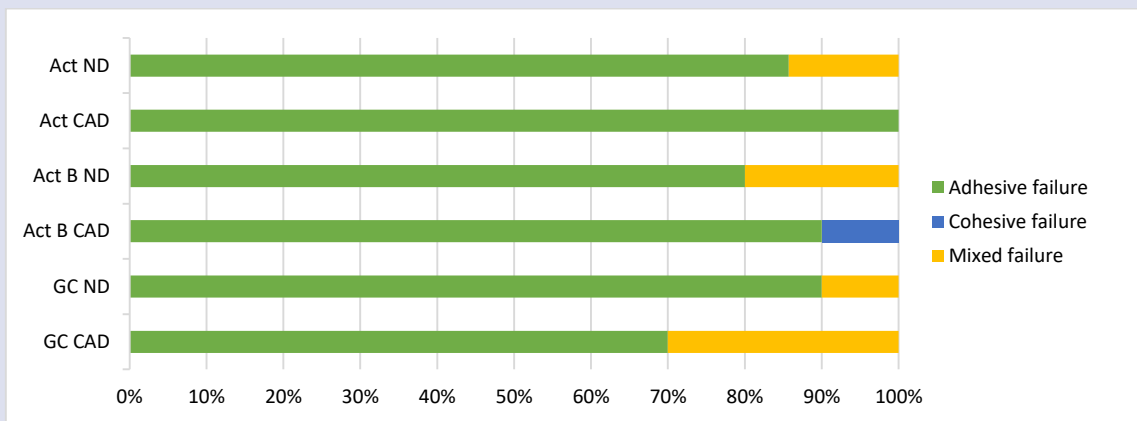

Figure 1. Percentage of failure modes in groups.

The current laboratory-based study is built on the hypothesis that Activa Bio-Active Restorative (Act) without bonding agents shows adequate bond strength in CAD and ND compared to conventional composites. The suggested hypothesis is not rejected.

The durability and adhesive strength evaluation of Activa and conventional composite was performed using the µ-SBS test as it is simple and easy to apply with broad acceptability and cost-effectiveness.[17]

Restoration prior to surface treatment on the enamel and dentin plays a major role in increasing the durability of resin-based restorations. With the introduction of the etching technique by Bonoucore is considered the most effective method to improve adhesive bonding for conditioning the tooth surface.[18] The dentin surface which was conditioned with the total-etch technique and conventional composite applied to show the highest bond strength in ND and CAD (22.55± 10.90 MPa, 21.66± 11.75 MPa, respectively) compared to all test groups, as expected. However, no significant difference was detected between the groups. This outcome can be explained using 37% phosphoric acid, which completely dissolves the smear layer and demineralizes intratubular and peritubular dentin and that would lead to hybridization and resin tags formation.[19]

Initially, in the current study, only Act-applied specimens were prepared without any preliminary preparation on the dentin. However, since all sample composites placed in this group were dropped, the group had to be excluded from the sample space. Thereupon, by following the manufacturer's instructions, Activa composite with 37.5% phosphoric acid was applied instead. There were only 3 failures in the acid-applied groups. These losses are quite significant for a material where the manufacturer promises a strong resin-hydroxyapatite complex and low microleakage.[20] However, no significant bond strength difference was noticed between the Act group in which we applied only

acid and the Act B groups in which we applied acid and bond. However, higher micro shear bond strength results were obtained from Act B groups which we applied bond. Although the bond application on flat dentin surfaces did not show a significant difference, it was found to be applicable. François *et al.* in one of their 2021 article argued that Act had poor self-adhesion to normal dentin without surface pretreatment (4.4 MPa) even though the manufacturer claimed that Act provides high micromechanical and chemical adhesion.[15] Another finding of François's study is that all-new resin-containing fluoride-releasing materials applied to dentin with an adhesive agent have higher µ-SBS values.[21] The findings of the current study are also consistent with Benetti *et al.*'s findings. They also observed losses on the non-pretreatment surface of the enamel and obtained the highest bond strength results in the acidified group. The loss of the material on the dentin surfaces was experienced in group that did not undergo pretreatment and group that were only etched. Thus, measurement of these samples could not be made. On the other hand, the Act group applied to the dentin with acid+bond did not differ significantly from the control group. However, it is claimed that in hemi spherically shaped cavities where dentin has not been pretreated, the fact that the material is surrounded by enamel has a positive effect on bonding. However, in cases where the cavity borders are placed on the dentin, if the dentin has not been pre-treated, losses are higher in restorations due to the large volumetric shrinkage of Active.[3] The reason why we experienced loss in our samples may be that we are on the flat dentin surface. Again, the Benetti study showed that the bond to enamel was higher.[3] François *et al.* stated that in 2021, the manufacturer's instructions wrote that bonding agent application is mandatory in cavities with low retention, and it can be used optionally in retentive cavities. The reason why we experienced sample losses in our study may be our non-retentive cavity, flat dentin.[21] In the light of these findings, the use of bonding agents is supported, especially if Activa is to be applied in non-retentive cavities.

Caries-affected and caries-free dentin affects the bond between the restorative material and dentin. Because caries affected dentin are exposed to increased collagenolytic activity, the connection with the restorative material deteriorates.[22] The use of only caries-free tooth surfaces to investigate material-dentin bonding *in vitro* studies doesn't entirely mimic the clinic.[23] Although some research has been carried out on bonding strength of both normal and caries affected dentin for some bonding systems and dental composite[24,25], no studies have been found which assess the bond strength of Activa to ND and CAD. Therefore, we aimed to test this condition. In the present study, all examined groups did not show significant difference bond strength to normal and caries-affected dentin. The reason for this may be the occlusion of the tubules due to the precipitation of calcium phosphate crystals in the carious-affected dentin. These precipitates may affect the chemical binding of ions in

Activa with hydroxyapatite crystals in dentin. This may explain why the tested material content recorded different bond strengths in studies on normal and caries-affected dentin.[26,27]

Ozduman *et al.* evaluated the bond strength of indirect pulp-coating materials to caries-affected dentin on dentin surfaces disinfected with and without chlorhexidine. Tricalcium silicate-based materials, whether disinfected with chlorhexidine or not, have been found to have lower shear bond strength than resin-modified glass-ionomer bioactive cement (Activa Bioactive).[28]

Besides these *in vitro* studies, van Dijken *et al.* did in randomized controlled clinical trials, an annual failure rate of 24.1% was found in Activa restorations in which were applied only after phosphoric acid gel etching. The main causes of restoration losses were postoperative symptoms, secondary caries, and loss of restoration. It was concluded that this loss rate was unacceptable in Class II cavities and further studies using adhesive ought to be repeated.[12] Alrahlah showed bioactive materials acceptable flexural and diametral tensile strength. However, the hardness was below the expected value. They found that Activa Bulk Fill is a potential material for dentin replacement, but a restorative material must be applied over Activa.[8]

The percentage of adhesive failure between the restorative material and the dentin surface was very high. However, there was no significant difference between failure groups.

The limitation of the study:

This *in vitro* research was not performed using the standard method of thermocycling with cyclic loading to simulate the intraoral environment for checking the microleakage at the tooth- restoration interface. Mode of failure analysis information by taking SEM images is also important in micro shear tests. However, further research by conducting *in vivo* studies could authenticate these results.

Conclusions

It was found that the bond strength of the materials evaluated was not significantly influenced by applying additional bonding agents in Activa Bio-Active Restorative composites in sound dentin and caries affected dentin. However, an optional bond application can also be made, especially in dentin cavities. Further *in vivo* studies should be conducted.

Acknowledgments

Conflict of Interests

The authors declare that they have no conflict of interest.

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The Evaluation of Body Dysmorphic Disorder in Adult Orthodontic Patients

Fatemeh Masoumi[1-a], Sajjad Shirkhouii[2-b], Mahdiye Asghari[3-c*]

[1]*Department of Orthodontics, School of Dentistry, Guilan University of Medical Sciences, Rasht, Iran*
[2]*School of Dentistry, Guilan University of Medical Sciences, Rasht, Iran.*
[3]*Postgraduate resident of Orthodontics, School of Dentistry, Guilan University of Medical Sciences, Rasht, Iran.*
*Corresponding author

Research Article	**ABSTRACT**
  License ![CC BY NC] *This work is licensed under Creative Commons Attribution 4.0 International License*	***Introduction:*** The present study aimed to evaluate body dysmorphic disorder (BDD) in orthodontic patients. Also, the relation between demographic factors and BDD was investigated. ***Materials and Methods:*** This descriptive-analytical cross-sectional study was performed on 320 patients referring to the dental clinic. Participants were excluded if they had craniofacial syndromes, visible physical inabilities, mental diseases such as depression and OCD, and required orthognathic surgery. The YBOCS-BDD was used to assess BDD. Fisher's exact test was applied using SPSS Version 24 at the significance level of 0.05. ***Results:*** 47.5% of patients were normal and 34.4% had mild BDD and 17.2% had moderate BDD, and only 0.9% of the patients had severe BDD. A significant relation was found between gender and BDD, and between marital status and BDD. The relation of age and severity of BDD was not statistically significant. ***Conclusion:*** BDD disorder in orthodontic patients was more common in women and single people. In this regard, it is recommended that cosmetic clinicians be careful in accepting patients with a history of mental and personality problems, multiple and frequent esthetic surgeries, and if necessary, persuade and refer the patient to a psychiatrist and counselor to prevent the consequences. ***Keywords:*** Body Dysmorphic Disorder, Orthodontics, Anxiety Disorder.

[a] mahdiyeasghari92@gmail.com   https://orcid.org/0000-0002-0795-1947   [b] sf.masoumi@yahoo.com   https://orcid.org/0000-0002-2490-4739
[c] drsajjadshirkhouii@yahoo.com   https://orcid.org/0000-0001-5932-0015

Introduction

Body Dysmorphic Disorder (BDD) is a mental disorder characterized by preoccupation with slight or imagined defects or flaws in appearance.[1-2] The prevalence of BDD is reported to vary from 0.7-2.4% in the general population and 13-15% in patients who refer to cosmetic clinics.[3-5] BDD has neurobiological, psychological, and sociocultural backgrounds.[6-7] BDD as a chronic disorder can cause social fear, anxiety, depression, and anger, and may interfere with patients' daily activities as they spend a lot of time thinking about their body defect.[2,8-10]

BDD patients are distressed about their appearance and have an unrealistic image of their bodies.[11] The patients with BDD usually seek cosmetic procedures instead of psychological help to suppress the distresses and concerns caused by their distorted body image.[12-13] Usually, as the BDD patients get a cosmetic procedure on their obsessed body part, their obsessions shift to another body part, and their unrealistic expectations are not satisfied often.[14-16] Most patients are often obsessed with skin, nose, tooth, and breast.[5,8,17] As BDD patients are obsessed with their teeth, they may consult orthodontics for dentofacial aesthetic treatments.[18-19] Therefore, orthodontists should be aware of the symptoms of BDD, recognize potential BDD patients, and

refer them for psychological and psychiatric help.[11,18] This study identified the prevalence of BDD in orthodontic patients.

Materials and Methods

In this descriptive-analytic cross-sectional study the prevalence of BDD was assessed in adults undergoing orthodontic treatment. The study was approved by the ethics committee of the Guilan University of Medical Sciences (GUMS) (IR.GUMS.REC.1398.431).

320 patients older than 18 years were included in the study at the dentistry faculty of GUMS. Participants were excluded if they had craniofacial syndromes, visible physical inabilities, mental diseases such as depression and OCD, and required orthognathic surgery. After explaining the aims of the current study, the participants signed a written consent and were given an anonymous questionnaire.

Gender, age and marital status were recorded. Other data were collected using Yale-Brown Obsessive-Compulsive Scale Modified for Body Dysmorphic Disorder (YBOCS-BDD) questionnaire. Previous studies have assessed the validity of this questionnaire. In this paper, the reliability of the questionnaire was estimated

to be 74.4% using the Cronbach alpha coefficient. The questionnaire was a 10- item, semi-structured, rater-administered measure which had 5 choices for each question. According to the answer, a score of 0 to 4 was given to each question. The total score was measured by summing up each question's score and ranged from 0-40. The BDD was considered as normal if the total score was less than 10 and as mild if the total score varied from 10 to 15. The total score of 16 to 25 determined the moderate BDD. And, the total score of 26 and higher was the cut point to determine severe BDD.

All the data was analyzed using SPSS® software version 24 (IBM, Armonk and North Castle, NY, USA). Fisher's exact test was applied at the significance level of P=0.05.

Results

The data of 320 patients was analyzed. The mean age of participants was 26.87±5.91. Data distribution is presented in Table 1.

Participants' Answer to YBOCS-BDD Questionnaire is presented in table 2 in detail.

The analysis of data using Fisher's Exact Test showed that the relation of gender and marriage status with the severity of BDD was significant. (P value=0.018 and P value= 0.017, respectively) So that, BDD was more severe in females and single patients. While the relation of age and severity of BDD was not statistically significant. (P value= 0.086) (Table 3)

Using t-test, a significant relation was found between gender and the mean BDD score of participants. (P value= 0.004) So that, the mean score of BDD was higher in females. The same significant relation was reported between marriage status and the mean BDD score. (P Value= 0.001) So that, BDD had a higher mean score in single participants compared to married participants. Also, the relation of age and the mean BDD score of participants was significant statistically. (P= 0.001) So that, as participants were older, the mean BDD score was lower (Table 4).

Discussion

In this study, the frequency of BDD was assessed in 320 participants referring to the dental clinic of the University of Medical Sciences.

According to the results of the current study, most participants were normal in terms of BDD. 34.4% and 17.2% of participants had mild and moderate BDD respectively. And, 0.9% of participants were diagnosed with severe BDD.

In the study of Esmaeili et al.[21], the prevalence of BDD in orthodontic patients was 19.3%. In another study, it was claimed that one out of four patients, had at least one mental distress disorder and the annual prevalence of this disorder was 17.7%.[22] Yassaei et al.[23] stated that the prevalence of BDD was 5.5% among orthodontic patients. In 2006, Hepburn et al.[24] reported the prevalence of BDD among orthodontic patients to be 7.5%.

In accordance with the previous studies, the prevalence of BDD was significantly more in females compared to males in the current study. Veale et al reported the prevalence of BDD to be 3 times more in females compared to males.[25] Esmaeili et al.[21] also found the prevalence of BDD to be 30 times more in females. Yassaei et al.[23] found the same results.

In the current study, as the patients were older the prevalence of BDD was lower. Yassaei et al.[23] stated that as patients are younger the prevalence of BDD and the possibility of undergoing orthodontic evaluation increases. while Sathyanarayana et al.[26] found no significant relation between BDD and age. The difference in demographic features of patients in these studies may explain the divergence results.

BDD was more frequent in single patients in the current study. In contrary to the study, the results of Esmaeili et al.[21] showed a significant relation between married patients and BDD. As Gasemnejad et al.[27] had previously stated that BDD was significantly influenced by stress and stress was significantly higher in married participants. This finding explains why BDD was more frequent in married patients in the studies of Esmaeili and Gasemnejad.[21,28] Abramowitz et al.[29] found that the prevalence of BDD was more in single participants for having a higher level of stress, as married patients get more mental and social support compared to single participants. Phillips et al. and Yassaei et al.[23,29] reported the same findings.

Patients with BDD are usually not aware of the psychological origins of this disorder and seek cosmetic treatments. Orthodontics, oral maxillofacial surgeons and plastic surgeons face these patients first. So, these specialists should be educated about BDD and should refer the potential BDD patients to a psychiatrist so that the disorder is diagnosed and treated professionally by medication and behavior therapy. Awareness on BDD and its consequences is necessary for orthodontists, refer the patient to a psychiatrist to prevent them from seeking unnecessary and repeated treatments that are usually not satisfying to them. History of previous unnecessary cosmetic treatments can guide orthodontics toward the diagnosis of a potential BDD patient.

Table 1. Data distribution of participants

Variables		Percent (Number)
Gender	Female	50% (160)
	Male	50% (160)
Marriage status	Single	72.2% (231)
	Married	27.8% (89)
Age	18-30 years old	78.4% (251)
	>30 years old	21.6% (69)

Tables 2. Participants' Answer to YBOCS-BDD Questionnaire

Questions	Choices	Percent (Number)
Question 1: Time spent thinking about the body defect	None	36.6% (117)
	Mild (less than 1 hr/day)	37.5% (120)
	Moderate (1-3 hrs/day)	16.9% (54)
	Severe (greater than 3 and up to 8 hrs/day)	4.7% (15)
	Extreme (greater than 8 hrs/day)	4.4% (14)
Question 2: Interference due to thoughts about the body defect	None	27.8% (89)
	Mild: slight interference with social, occupational, or role activities, but performance not impaired.	50% (160)
	Moderate: definite interference with social, occupational, or role performance, but still manageable	19.7% (63)
	Severe: causes substantial impairment in social, occupational, or role performance	2.2% (7)
	Extreme: incapacitating.	0.3% (1)
Question 3: Distress associated with thoughts about the body defect	None	23.4% (75)
	Mild: not too disturbing.	45.6% (146)
	Moderate: disturbing.	25.9% (83)
	Severe: very disturbing.	2.8% (9)
	Extreme, disabling distress.	2.2% (7)
Question 4: Resistance against thoughts about the body defect	Makes an effort to always resist, or symptoms so minimal doesn't need to actively resist.	51.2% (164)
	Tries to resist most of the time	25.3 (81)
	Makes some effort to resist.	19.4% (62)
	Yields to all such thoughts without attention away from these thoughts attempting to control them but yields with some reluctance.	3.1% (10)
	Completely and willingly yields to all such thoughts.	0.9% (3)
Question 5: Degree of control over thoughts related to the body defect	Complete control, or no need for control because thoughts are so minimal.	22.2% (71)
	Much control, usually able to stop or divert these thoughts with some effort and concentration.	38.4% (123)
	Moderate control, sometimes able to stop or divert these thoughts.	32.5% (104)
	Little control, rarely successful in stopping thoughts, can only divert attention with difficulty.	6.6% (21)
	No control, experienced as completely involuntary, rarely able to even momentarily divert attention.	0.3% (1)
Question 6: Time spent in activities related to the body defect	None	35.6% (114)
	Mild (spends less than 1 hr/day)	38.8% (124)
	Moderate (1-3 hrs/day)	19.1% (61)
	Severe (spends more than 3 and up to 8 hours/day)	5.3% (17)
	Extreme (spends more than 8 hrs/day in these activities)	1.2% (4)
Question 7: Interference due to activities related to the body defect	None	36.2% (116)
	Mild: slight interference with social, occupational, or role activities, but performance not impaired.	43.4% (139)
	Moderate: definite interference with social, occupational, or role but still manageable.	16.9% (54)
	Severe: causes substantial impairment in social, occupational, or role performance.	2.5% (8)
	Extreme: incapacitating.	0.9% (3)
Question 8: Distress associated with activities related to the body defect	None	32.2% (103)
	Mild: only slightly anxious if the behavior prevented.	41.2% (132)
	Moderate: reports that anxiety would mount but remain manageable if the behavior is prevented.	21.2% (68)
	Severe: prominent and very disturbing increase in anxiety if the behavior is interrupted.	4.1% (13)
	Extreme: incapacitating anxiety from any intervention aimed at modifying activity	1.2% (4)
Question 9: Resistance to compulsion	Makes an effort to always resist, or symptoms so minimal doesn't need to actively resist.	40.6% (130)
	Tries to resist most of the time.	27.8% (89)
	Makes some effort to resist.	27.5% (88)
	Yields to almost all of these behaviors without attempting to control them, but does so with some reluctance.	2.2% (7)
	Completely and willingly yields to all behaviors related to body defects.	1.9% (6)
Question 10: Degree of control over a compulsive behavior	Complete control or control is unnecessary because symptoms are mild.	24.7% (79)
	Much control, experiences pressure to perform the behavior, but usually able to exercise voluntary control over it.	45.9% (147)
	Moderate control, strong pressure to perform the behavior, can control it only with difficulty.	23.1% (74)
	Little control, very strong drive to perform the behavior, must be carried to completion, can delay only with difficulty.	5.3% (17)
	No control, drive to perform the behavior experienced as completely involuntary and overpowering, rarely able to even momentarily delay activity.	0.9% (3)

Table 3. Severity of body dysmorphic disorder based on gender, marriage status, and age by YBOCS-BDD Questionnaire in percent (number)

Severity of BDD*	Based on gender		Based on marriage status		Based on age		Total
	Female	Male	Single	Married	18-30 years old	> 30 years old	
Normal	40.6% (65)	54.4% (87)	42.4% (98)	60.7% (54)	44.6% (112)	58% (40)	47.5% (152)
Mild	36.3% (58)	32.5% (52)	36.4% (84)	29.2% (26)	34.7% (87)	33.3% (23)	34.4% (110)
Moderate	21.2% (34)	13.1% (21)	19.9% (46)	10.1% (9)	19.5% (49)	8.7% (6)	17.2% (55)
Severe	1.9% (3)	0% (0)	1.3% (3)	0% (0)	1.2% (3)	0% (0)	0.9% (3)

*Body Dysmorphic Disorder

Table 4. The mean Body Dysmorphic Disorder score of participants according to gender, marital status, and age

Variables		Mean score ±SD	P value
Gender	Female	11.03±5.82	0.004
	Male	9.21±5.32	
Marriage status	Single	10.87±5.75	0.001
	Married	8.17±4.84	
Age	18-30 years old	10.5±6.68	0.001
	>30 years old	8.5%±17.08	

Conclusions

The results of the current study showed that BDD was more frequent in females, single participants, and at younger ages. Increasing awareness about psychological symptoms of BDD and assuring of patient's mental health, seems to be essential for surgeons. Orthodontists and surgeons should be careful about patients with a history of frequently repeated surgeries and should refer the patients to a psychiatrist if needed.

Conflict of Interest

None

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Morphometric Analysis of Mandibular Notch in Dry Human Mandibles- A Surgeon's Guide to the Masseteric Nerve Block

Priyadarshini A[1-a], Ashok Kumar Jyothi[2-b], Thotakura Balaji[3-c*], Prabhu K[4-d], Vaithianathan Gnanasundaram[5-e]

[1]Chettinad Dental College and Research Institute, Chennai, Tamil Nadu India.
[2]Department of Anatomy, Basaveshwara Medical College, Chitradurga, Karnataka, Chennai, Tamil Nadu, India
[3]Department of Anatomy, Chettinad Hospital and Research Institute, Chettinad Academy of Research and Education, Chennai, India
[4]Department of Anatomy, Sri Balaji Medical college and Hospital, Chennai, Tamil Nadu India
[5]Department of Anatomy, Chettinad Hospital & research Institute, Chettinad Academy of Research & Education, Chennai, Tamil Nadu, India
*Corresponding author

Research Article

ABSTRACT

Background: The mandibular notch allows the passage of masseteric vessels and nerves to the deep aspect of the masseteric muscle. The existing data gives a fairer idea in locating the masseteric nerve but does not consider much of the various shapes and sizes of the masseteric notch into account. Hence the present study analyses the various size and shapes and depths of the mandibular notch to achieve a more accurate method for masseteric nerve block. Thus, this investigation intends to examine the morphology and morphometry of mandibular notch in the mandibles of the South Indian people.

Methods: The morphometric parameters of the mandibular notch were examined in 102 dry mandibles of the peoples of South India. The morphometric parameters were estimated by a digital vernier caliper and data was analyzed statistically.

Results: The results of this study showed a round-shaped mandibular notch to be the most frequent type on the right side (43.1%) whereas it was 25.5% on the left side. The length and depth from gonion to notch showed a substantial variance between right and left bone respectively, but with respect to the width of the notch, no significant difference was observed.

Conclusions: This study demonstrates that population-specific and side-specific variations may be present in the mandibular notch measurements. Knowledge on variations in incisura mandibularis is of significance in maxillofacial surgeries and reconstructive operations.

Keywords: Mandibular Notch, Masseteric Vessels, Masseteric Nerve Block, Morphometry.

a ✉calmpriya14@gmail.com   https://orcid.org/0000-0003-4136-8787   b✉jyothiashok.anatomist@gmail.com https://orcid.org/0000-0003-4453-9262
c ✉balajianat@gmail.com   https://orcid.org/0000-0003-1515-9818   d✉prbanu75@gmail.com https://orcid.org/0000-0002-7687-4527
e ✉vaithi316@gmail.com   https://orcid.org/0000-0002-4571-159X

Introduction

The mandibular notch is a gap facing superiorly and backward on the upper margin of the ramus of the mandible, it is alternatively known as incisura mandibulae or sigmoid notch.[1] It separates the coronoid process and the condylar process. The incisura mandibulae act as a passage for the masseteric vessels and nerve to reach the internal surface of the masseteric muscle.[1] Morphometric and morphological investigations of the mandibular notch have been extensively reviewed; however, there is a gap in the literature with respect to the Indian population. The morphometry of sigmoid notch is variable among various population groups, viz. Japanese and Chinese.[2] Besides, the shape of the notch also differed widely in literary reports, viz: round, sloping, wide, triangular, and quadrilateral.[1,3,4] The mandibular notch is clinically important for surgical and reconstructive operations, as it helps maxillofacial surgeons in their surgical procedures and treatment within this region.[1,5,6] Various bony landmarks of the mandible are studied extensively for their neuro-osseous relationships. Some common neuro-

osseous relationships are the inferior alveolar nerve in the mandibular canal, auriculotemporal nerve behind and laterally towards the neck of the condyle of the mandible, etc. The mandibular nerve block is commonly performed in most dental procedures.[7]

The lingual nerve block is performed during teeth extraction, buccal[8], auriculotemporal, inferior alveolar, and mental nerves are blocked during various reconstructive surgeries. The inferior alveolar nerve block is performed in teeth extraction[9] and implant procedures, etc. One such neuro-osseous relationship is the masseteric nerve in the mandibular notch. The masseteric nerve block is performed in individuals with mandibular dislocation, facial reconstructive procedures[10–12], etc. Existing studies describe the mandibular notch as a gap[13] facing upwards and slightly backward occupying the upper border of the mandibular ramus.[14] The mandibular notch has also been described as a gap between the coronoid process and mandibular condyle[15,16] and the shape of the notch is based on these two processes.[1]

Since mandibular notch contains masseteric nerve laterally[17] and masseteric artery medially along with masseteric vein[18] and masseteric muscle is the ideal site for performing masseteric nerve block.[19] Previous studies describe a method for a masseteric nerve block as visualization of the width of ramus mandible by grasping anterior and posterior borders with thumb and the middle finger. The zygomatic arch is first identified by the index finger and the finger is moved downwards until it reaches midway. The thumb and middle finger coincide with the bottommost point of the mandibular notch.[20] The needle was introduced behind the index finger.[4] The existing methods described above give only a fairer idea in locating the masseteric nerve and lacks precision. In addition, these methods do not consider the various shape and sizes of the masseteric notch into account. Hence the present study analyses the various size and shapes and depths of the mandibular notch to achieve a more accurate method for masseteric nerve block.

Materials and Methods

The present study was carried out on 102 dry human mandibles obtained from the Department of Anatomy, Chettinad Hospital, and Research Institute, Chennai, irrespective of age and sex[21], including both right and left side and measured width, depth, and shape of the mandibular notch.

Measurement of Width

The mandibular notch width was measured from the tip of the condyle to the tip of the coronoid directly from the dry mandibles by means of digital vernier calipers (Figure 1).

Measurement of Depth

The depth of the mandibular notch was measured from two reference points. In the first method, the bone was traced on a sheet of paper before the measurement (Figure.2). After constructing the images on a sheet of paper, two horizontal lines were drawn, one passes through the tip of the condyle (Line A), and the other passes through the lowest point of the mandibular notch (Line B). A vertical line (line C) was drawn joining the above two lines to measure the depth of the notch from the condylar tip.

In the second method, the depth of the mandibular notch was measured from the mandibular angle, for this, A line from the posterior border of the ramus of the mandible was extended downwards vertically and a horizontal line is extended from the inferior border of the mandibular body. The point of intersection was considered as the angle of the mandible, and a transverse line was drawn along this point of intersection. Further, a vertical line (Line D) was drawn from line C extending upwards connecting the upper two horizontal lines (A and B) described in the previous method. The length of line D is the distance from the angle of the mandible to the lowest point on the notch (Figure 2&3).

The Shape of Notch

Mandibular notch shapes were directly observed from the bone and categorized as round, wide, and sloping[5], according to the classification provided in previous studies.[15] All the measurements were expressed in millimeters (mm).

Figure 1. Representative photograph while taking various measurements of mandibular notch with digital vernier calipers.
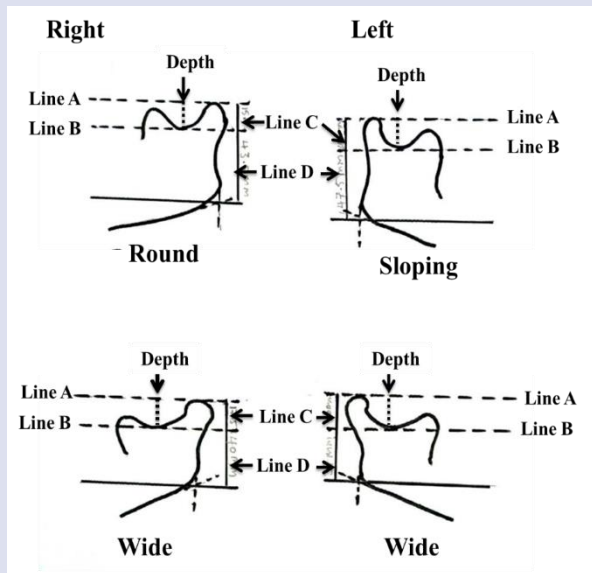
Figure 2. Schematic diagram showing different types of mandibular notches for measuring the depth.
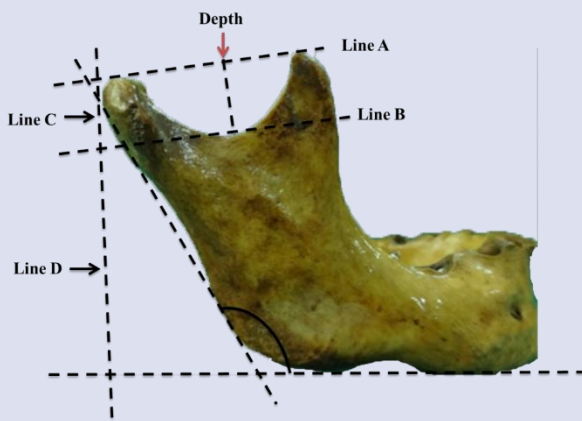

Figure 3. Photograph showing different measurements of the mandibular notch including depth (line C), width of the mandibular notch (line A), and the distance from the angle of the mandible to the mandibular notch (line D).

Statistical Analysis

The data were evaluated by SPSS software (IBM, USA, ver. 21). Student t-test was employed and results were expressed as the Mean ± Standard deviation (S.D). A value of $p<0.05$ was considered significant.

Results

Based on our observation and measurements of the mandibular notches, configurations were divided into five types: type I - Round, type II - Triangular, type III - Wide, type IV - Sloping, and type - V Quadrilateral. Minor variations were observed on both sides among these shapes. Type I mandibular notches exhibited rounded outline (Figure. 4A), it was observed as a smooth curve representing less than half of a circle bounded by the same extensions of condyle with its neck and coronoid

processes, the frequency of Type I was 43.1% on the right bone whereas it was 25.5% on the left bone (Table 1).

In type II mandibles the concavity of the notch in anatomical position was opened upward and forward, whereas, in this position, the body of the mandible was parallel to the ground; the notch was directed upwards and backward. In this type, the coronoid process was shorter than the mandibular condyle, this type was found to be 7.8 % on the right mandible and 27.5 % on the left mandible of total samples (Table 1).

The type III (wide) notches (Figure. 4B) also exhibited a proportionately shorter coronoid process than other types and the summit of it was directed forwards and upwards instead of upward direction, the frequency of wide type was 27.5% on right bone and 21.6% on left bone. The sloping (type IV) notch (Figure. 4C) exhibited more length measuring from the mandibular neck to a maximum depth of notch as compared to a length extending from summit of the coronoid process to maximum depth of the notch, the sloping type was 5.9% and 17.6% in right and left side respectively (Table 1). The quadrilateral (type V) is almost similar to the Type I (rounded) shape but with the bottom of the notch being like a straight line instead of curved, this type was 15.7% and 7.8% in right and left mandibles respectively (Table 1).

The minimum width of the mandibular notch on the right side was 18.91mm whereas it was 17.94 mm on the left side, on another hand the maximum width was 35.6 mm and 35.6 mm on right and left sides respectively. The minimum depth of the mandibular notch was 11mm on both sides whereas the maximum depth was 24 mm and 23 mm in right and left sides respectively. The minimum measurement from gonion to the mandibular notch was 31mm on the right side 27 mm on the left side, while the maximum distance was 52.50 mm on the right mandible 52mm on the left mandible (Table 2). The depth and length from gonion to notch showed a substantial variation between right and left (p=0.41), (p= 0.43) respectively, but no significant difference was observed on either side with respect to the width of the notch (Table 3).

Discussion

Morphological changes in body structures occur as a result of developmental variations caused by genetic factors or as a result of functional changes that take place during the process of growth.[22,23] The goal of this study was to look at the morphology and morphometry of the mandibular notch in the mandibles of South Indians. Our study results demonstrate that the most prevailing shape of the sigmoid (mandibular) notch on the right side was the round shape whereas it was triangular on the left side. The next prevalent shape was the wide type on the right side and the round type on the left side. The least frequent is the sloping type on the right side and the quadrilateral shape on the left side. Hence, these findings showed side specific variation as well as opposing the earlier findings[1] in which the triangular shape was most frequent in the

Iraqi population, while Shakya *et al.*, and Sahithi *et al.*[4,5], found that the sloped (45.5 %) and wide (43.5 %) shapes were most frequent in the North and South Indian population groups respectively. However, Shakya *et al.*[4], demonstrated that the wide-shaped (44.2%) mandibular incisures were most prevalent in individuals older than 30 years in South India. The selected South African population groups reported a smaller mandibular notch than the Japanese and Chinese population groups.[2] Therefore, it may be hypothesized that population-specific variations exist concerning the morphometry of the mandibular

notch. The sub-zygomatic triangle is bounded above by the zygomatic arch, posteriorly by the temporomandibular joint, and below and anteriorly by the frontal branch of the facial nerve.[24] This is a rapid and minimal invasive site for identification of masseteric nerve. A masseteric nerve is one of the important donor nerves in facial reconstruction procedures.[25] This is an imaginary triangle through which the physicians locate the masseteric nerve. Emerging surgical techniques insist us to depend on physical parameters from the surface or bony prominences.

Figure 3. Photograph showing different types of mandibular notch. A)Round type B) wide type C) Sloping type.

Table 1. Frequency of different shapes of the mandibular notch.

Type of mandibular notch based on the shape	Right		Left	
	Frequency	Percentage (%)	Frequency	Percentage(%)
Round	44	43.1	26	25.5
Triangular	8	7.8	28	27.5
Wide	28	27.5	22	21.6
Sloping	6	5.9	18	17.6
Quadrilateral	16	15.7	8	7.8
Total	102	100	102	100

Table 2. Minimum and maximum values of mandibular notch measurements.

Parameters	Minimum		Maximum	
	Right	Left	Right	Left
Mandibular notch width	18.91	17.94	35.60	36.60
Mandibular notch depth	11.00	11.00	24.00	23.00
Distance from angle	31.00	27.00	52.50	52.00

Table 3. Morphometric measurements of the mandibular notch, values were denoted Mean ± SD

Parameters	Right (Mean ± SD)	Left (Mean ± SD)	t – value	P-value
Mandibular notch width	25.92±4.20	25.10±4.35	1.692	0.097
Mandibular notch depth	16.24±2.58	16.93±2.84	2.099	0.041
Distance from angle	40.96±5.01	40.16±5.09	2.077	0.043

p-value <0.05 considered as significant.

Mintz *et al.*[7], proposed that the knowledge of the shape of the mandibular notch is helpful during maxillofacial surgeries and the coronoid process of the mandible makes an exceptional donor graft site for orbital floor deformities repair. Morphological shapes of the mandibular incisure are valuable for the maxillofacial surgeon in the management of chronic dislocations of

the mandible using a new miniplate that was reported by Cavalcanti & Vasconcelos.[26] These may lead the physicians to be independent of intra-operative procedures to identify the masseteric nerve. The present study also gives a numerical value through which masseteric nerve location may be made easier. The shortcomings of the sub-zygomatic triangle method

include difficulty in locating the nerve in zygomatic bone fracture cases and temporomandibular joint fracture cases and accident cases involving facial damage. In the present study, measuring the depth of mandibular notch and also measuring the notch from the angle of the mandible exhibited statistically significant values. The above measurements proposes a more reliable method in locating the masseteric nerve.

The dimensions of the mandibular notch were not observed in previous studies, and hence its importance was seldom explained. In the current study, the average width and depth of mandibular notch were calculated which helps in locating the masseteric nerve more precisely.[27] The mean depth of the mandibular notch and the mean distance from the angle of the mandible to the mandibular notch showed a statistically significant difference between right and left bones. The mean measurement of the notch from the angle of the mandible is very useful in achieving masseteric nerve block in patients with condylar fractures. Through the human lineage of evolution, the form of the notch is claimed to be species distinctive, with each ancestor having a unique pattern in Homo sapiens.[28] This necessitates a more thorough examination of the shape of the notch in various ethnic groups.

Conclusions

This study reveals that side-specific variations are present in the size and shape of the mandibular notch. Knowledge of the depth of the mandibular notch is significant during maxillofacial surgeries and reconstructive operations. Since prevalent shapes differ on both sides, side-specific variations should be taken into account. The present study was conducted only in 102 human dry mandibles, further studies with a larger sample need to be conducted to strengthen the accuracy of the present study.

Conflicts of Interest Statement

No conflicts of interest

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Cumhuriyet Dental Journal

Risk Factors Associated with Periodontal Diseases among Yemeni Adult Patients

Abdullah G. Amran[1-a]*, Mohammed Nasser Alhajj[2,3-b], Zaihan Ariffin[2-c], Abeer A. Al-Sosowa[1,-4-d], Ehab A. Abdulghani[5-e], Nadhem M. Sallam[6-f], Osamah M. Almekhlafi[7-g]

[1]Department of Periodontology, Faculty of Dentistry, Thamar University, Dhamar, Yemen.
[2]Prosthodontics Unit, School of Dental Sciences, Universiti Sains Malaysia, Health Campus, Kelantan, Malaysia.
[3]Department of Prosthodontics, Faculty of Dentistry, Thamar University, Dhamar, Yemen.
[4]Department of Periodontics, School of Stomatology, Lanzhou University, Lanzhou, China.
[5]Department of Orthodontics, School of Stomatology, Lanzhou University, Lanzhou, China.
[6]Department of Pediatric and Preventive Dentistry, Faculty of Dentistry, Thamar University, Dhamar, Yemen.
[7]Private Dental Clinic, Dhamar, Yemen.
*Corresponding author

Research Article

ABSTRACT

Objectives: This study aimed to investigate the possible risk factors associated with periodontal diseases among adult patients in Yemen.

Methods: The study population comprised of 805 patients attending the teaching dental hospital in Dhamar city, Yemen. The first part of the investigation was an interview including age, gender, systemic diseases, pregnancy, as well as tooth brushing, smoking, and Qat chewing habits and dentist interval visits. The second part was clinical examination including the periodontal parameters. Data were analyzed and presented in terms of frequencies, percentages or means and standard deviations, as appropriate. Chi-squared test was used for associations and Mann-Whitney U test was used for differences. Regression analysis was utilized for the determinants of the periodontal disease. A P-value<0.05 was considered significant.

Results: The bivariate analyses revealed significant differences between the independent variables (proposed risk factors) groups in relation to the periodontal parameters except for systemic disease in relation to gingival index (GI) and bleeding index (BI), visiting dentist in relation to calculus index (CI), BI, and gingival recession (GR), and pregnancy in relation to plaque index (PI), GI, CI, and BI. The regression analyses revealed that the age, smoking, and brushing teeth are significant determinants for all periodontal parameters. Whereas, systemic disease was a significant determinant for GR, and sex for BI.

Conclusions: Age, brushing teeth and smoking are the significant determinants of periodontal health. Education about the side effects of bad habits as well as maintaining good oral hygiene should be implemented.

Keywords: Periodontal Health, Risk Factors, Teeth, Oral Hygiene, Yemen.

[a] drimran2006@yahoo.com   https://orcid.org/0000-0003-0533-1688
[c] zaihan@usm.my   https://orcid.org/0000-0001-7712-8959
[e] ehab.yosfy@gmail.com   https://orcid.org/0000-0002-3392-4248
[g] dr.osamah.sp@hotmail.com   https://orcid.org/0000-0003-1342-4016
[b] m.n.alhajj@hotmail.com   https://orcid.org/0000-0003-4477-3024
[d] a.a.alsosowa@gmail.com   https://orcid.org/0000-0003-2274-5014
[f] nazimsallam35@gmail.com   https://orcid.org/0000-0003-0340-4193

Introduction

Periodontal disease is a complex polymicrobial inflammatory process/condition spread worldwide and can experienced by up to 90% of populations.[1,2] The disease is multifactorial in origin; it can affect all ages, particularly adult individuals, and include all pathological conditions such as gingivitis and periodontitis.[3] Gingivitis is a reversible inflammation of soft tissue (gingiva) with the absence of attachment loss which is recognized by changing in color and/or by bleeding on gentle probing within the gingival sulcus or pocket orifice. If gingivitis is left untreated, the disease may extend into alveolar bone causing pathological periodontal pocket formation, loss of periodontal attachment, and chronic destruction of the tissues that surround and support the teeth; the condition is characterized as periodontitis.[4,5] Both gingivitis and periodontitis are initiated primarily by dental plaque and are influenced by the inflammatory and immune responses of each individual.[6] People with poor oral hygiene are more affected by excessive accumulation of soft and hard deposits which can eventually result in caries, gingivitis and periodontitis.[7] Despite of periodontal disease is mainly induced by dental biofilm, it can be modified by several factors including age, sex, genetic, habits (such as: smoking, Qat chewing, faulty brushing technique), and iatrogenic factors.[8,9] Some epidemiological studies in the literature have clearly demonstrated that the prevalence, extent and severity of periodontal disease are seen to increase with age.[10,11] However, other studies suggested that the rate of periodontal destruction is the same throughout adulthood up to 70 years; and concluded that age may not be considered as a risk factor for people under 70.[12,13] Prevalence and severity of periodontal disease may be associated with gender with more affected males than females.[14] However, other studies showed a

high prevalence of periodontal disease among pregnant women.[15,16] One recent cross-sectional study among Yemeni adult population concluded that females has more prevalence for gingival recession and periodontitis, but males have more teeth affected by gingival recession and furcation involvement[17]. Several studies suggested that tobacco smoking is a known risk factor that affects the oral environment and ecology, vascularization of the periodontium, immune and inflammatory responses and the healing potential of the periodontal connective tissues.[18,19] Certain systemic diseases have also been associated with an increased risk of attachment loss and can adversely affect host defense systems.[20,21] The relationship between oral hygiene and systemic illnesses (such as diabetes mellitus, bacterial pneumonia, and cardiovascular disease) is a bidirectional, which means that negligence of one can aggravate the disease in the other.[22,23] Moreover, some habits can cause or exacerbate the periodontal disease. In Yemen, Qat chewing is most commonly used as social chewing habit. Qat or Gat (*Catha edulis*) is a natural stimulant from the *Catha edulis* plant, originated in the flowering evergreen tree or large flowering shrub of Celastraceous family, which grows mainly in Yemen and other regions as Ethiopia, Somalia, Kenya, Saudi Arabia, and Madagascar.[24,25] Most of the population in these countries used to chew its leaves for its stimulating and euphoric effects attributed to cathinone, an amphetamine-like stimulant.[26,27] Fresh Qat leaves are placed on the buccal cavity on one side or sometimes in both sides and chewing continuously for several hours to extract the juice.[28] The chewing process may take up to 6 hours or more causing a drying effect on the oral mucosa, and its users tend to consume a great quantity of fluids.[29] Qat chewing is prevalent among Yemeni people, with a higher prevalence in males than females.[30] There are several oral and dental disorders have been associated with the long-term Qat chewing such as keratotic white lesions, mucosal pigmentation, plasma cell stomatitis, tooth loss, teeth attrition and discoloration, gingival recession, periodontal diseases, and temporomandibular joint disorders.[31,32] Some studies among Yemeni adult population found a positive relationship between the frequency and duration of Qat chewing and severity of periodontal diseases.[8,33,34] Investigation of the different factors which might be associated with the individual's dental health problems is of utmost importance to explore the effect of these factors on the community health and to build up the appropriate preventive measures. The objective of the present study, therefore, was to evaluate some possible risk factors that may be associated with periodontal health status among adult Yemeni patients.

Materials and Methods

This was a cross-sectional study comprised of Yemeni adults randomly recruited from patients attending the teaching hospital of the Faculty of Dentistry in Dhamar city, seeking for dental treatment or check-up. The sample was consecutively recruited during the academic year 2018/2019. A total of 805 adult dental patients were recruited. The inclusion criteria included age of 18 and above, and having ≥ 20 teeth, while fully edentate patients and those having complete dentures were excluded. Before commencing the study, ethical approval was obtained from Research and Ethics Committee, Faculty of Dentistry, Thamar University (Ref#: 2018003). Before commencing the study, aims of the study were explained to all participants and they were asked to give their written or verbal consent to participate. Data was collected by interview and clinical examination as follows:

- Interview: A specially-designed questionnaire was used to include the important information that would assess to detect the possible association between periodontal health status and some risk factors such as age, gender, systemic diseases, pregnancy, as well as brushing teeth, smoking, Qat chewing habits and visit to the dentist.

- Clinical examination: Examination of all permanent fully erupted teeth, excluding the third molars, was performed. Dental plaque and gingival inflammation were measured by PI and GI, respectively on a scale of 0-3.[35,36] The presence or absence of supra- and/or subgingival calculus (CI) was determined.[37] BI, which was introduced by Ainamo and Bay (1975)[37], was performed through gentile probing of the orifice of the gingival crevice. If bleeding occurred within 10 seconds, a positive finding was recorded and the number of positive sites was recorded, and then expressed as a percentage of the number of sites examined. GR was measured from cementoenamel junction (CEJ) to the gingival margin in millimeters at six sites per tooth (mesiobuccal, midbuccal, distobuccal, mesiolingual, midlingual, and distolingual) using a 0.4 mm periodontal probe (Hu-Friedy's WHO-style probe, Hu-Friedy Inc., Chicago, IL, USA). The measured recession was then classified according to Miller's classification.[38] In case when the CEJ was covered by calculus or lost due to carious lesions, the location of such junction was estimated on the basis of the adjacent teeth. All clinical parameters were measured under sufficient illumination.

Statistical Analysis

Data was entered into a spreadsheet (MS Excel 2016), coded and transferred to analysis software program (SPSS v25; IBM Corp.). Results were presented in terms of frequencies and percentages or means and standard deviations, as appropriate. Chi-squared and Man Whitney U tests were used for differences between categorical variables and between continuous variables, respectively. Regression analysis models were used to further explore the effect of the different factors on the periodontal parameters. A P-value <0.05 was considered significant.

Results

The study investigated a total of 805 dental patients with mean age 29.2±9.6 years old, ranging from 16 to 60 years. Most of the participants were ≤30 years (68%), males (75%), with no systemic disease (92%), non-smokers (77%), Qat chewers (75%), not brushing their teeth (73%), non-regular dental attendants (76%), and non-pregnant (for women; 96%). More details regarding the characteristics of the study sample are presented in Table 1.

There were highly significant differences between age groups concerning the plaque index, gingival index, calculus index, gingival recession (P<0.001), and bleeding index (P=0.009); with individuals of >30 years having higher values than their counterparts. Males demonstrated significantly worse periodontal conditions compared with females. However, there were no significant differences in periodontal condition between females with and without pregnancy (P>0.05). Subjects with systemic diseases demonstrated significant differences in plaque index, calculus index, and gingival recession compared with healthy individuals (P=0.004, P=0.005, P<0.001; respectively). Highly significant differences in periodontal condition (P<0.001) were found between subjects in relation to brushing teeth, chewing Qat, and smoking. Similarly, there were

differences in periodontal condition between subjects who visit a dentist or not with statistical significance only in plaque index and gingival index (P<0.001, P=0.002, respectively). More details are presented in Tables 2 and 3.

The results of the linear regression analyses revealed that age, smoking, and brushing teeth had a highly significant effect on plaque index and gingival index (P<0.001, P=0.002, P<0.001, respectively. In contrast, there was no evidence that gender, systemic diseases, chewing Qat, and visiting dentist influence these indices. Related to the gingival recession classification, age, systemic diseases, smoking, and brushing teeth significantly impacted the periodontal conditions (P<0.001, P=0.003, P<0.001, P=0.038, respectively), whereas gender and chewing Qat had no significant effect (Table 4).

Moreover, the logistic regression analysis revealed a significant impact of age on calculus (P=0.001) and bleeding (P=0.013) indices. However, gender affected only the bleeding index (P<0.001). Subjects who practice teeth brushing were 0.6 and 0.5 less likely to have calculus and bleeding, respectively. Whereas subjects who smoke were 1.8 and 1.9 more likely to have calculus and bleeding, respectively (Table 5).

Table 1. Characteristics of the study sample

		Frequency	%
Age	≤30	547	68
	>30	258	32
Sex	Male	605	75
	Female	200	25
Systemic Diseases	Yes	63	8
	No	742	92
Smoking	Yes	182	23
	No	623	77
Chewing Qat	Yes	601	75
	No	204	25
Brushing Teeth	Yes	217	27
	No	588	73
Visit Dentist	Yes	196	24
	No	609	76
Pregnancy (N= 200)	Yes	7	4
	No	193	96
Calculus Index	No	270	34
	Yes	535	66
Bleeding Index	No	206	26
	Yes	599	74
Gingival recession	No recession	281	35
	Class I	331	41
	Class II	112	14
	Class III	48	6
	Class IV	33	4
Age (Mean±SD)		29.2±9.6	
Plaque index (Mean±SD)		1.6±0.6	
Gingival index (Mean±SD)		1.4±0.6	

Table 2. Differences between risk factors in relation to plaque index and gingival index

		Plaque index			Gingival index		
		Mean±SD	Diff. (95% CI)	Pᵃ	Mean±SD	Diff. (95% CI)	Pᵃ
Age	≤30	1.6±0.6	-0.3 (-0.4,-0.2)	<0.001	1.3±0.5	-0.3 (-0.4,-0.2)	<0.001
	>30	1.8±0.6			1.6±0.6		
Brushing Teeth	Yes	1.3±0.6	-0.4 (-0.5,-0.3)	<0.001	1.2±0.6	-0.3 (-0.4,-0.3)	<0.001
	No	1.8±0.6			1.5±0.5		
Gender	Male	1.7±0.6	0.1 (0.0,0.2)	0.013	1.5±0.5	0.2 (0.1,0.3)	0.001
	Female	1.5±0.7			1.3±0.7		
Systemic Diseases	Yes	1.9±0.7	0.2 (0.1,0.4)	0.004	1.5±0.7	0.1 (0.0,0.3)	0.093
	No	1.6±0.6			1.4±0.6		
Visit Dentist	Yes	1.4±0.6	-0.3 (-0.4,-0.2)	<0.001	1.3±0.6	-0.1 (-0.2,0.0)	0.002
	No	1.7±0.6			1.4±0.6		
Chewing Qat	Yes	1.7±0.6	0.2 (0.0,0.3)	<0.001	1.5±0.5	0.2 (0.1,0.3)	<0.001
	No	1.5±0.7			1.3±0.7		
Smoking	Yes	1.9±0.6	0.3 (0.2,0.4)	<0.001	1.6±0.6	0.3 (0.2,0.4)	<0.001
	No	1.6±0.6			1.4±0.6		
Pregnancy	Yes	1.4±0.6	-0.2 (-07,0.3)	0.260	1.6±0.7	0.4 (-0.2,0.9)	0.260
	No	1.6±0.7			1.3±0.7		

ᵃMann-Whitney U test

Table 3. Differences between risk factors in relation to calculus index, bleeding index, and gingival recession

		Calculus index		P*	Bleeding index		P*
		No	Yes		No	Yes	
Age	≤30	208 (38.0)	339 (62.0)	<0.001	155 (28.3)	392 (71.7)	.009
	>30	62 (24.0)	196 (76.0)		51 (19.8)	207 (80.2)	
Brushing Teeth	Yes	101 (46.5)	116 (53.5)	<0.001	88 (40.6)	129 (59.4)	<0.001
	No	169 (28.7)	419 (71.3)		118 (20.1)	470 (79.7)	
Gender	Male	169 (27.9)	436 (72.1)	<0.001	114 (18.8)	491 (81.2)	<0.001
	Female	101 (50.5)	99 (49.5)		92 (46.0)	108 (54.0)	
Systemic Diseases	Yes	11 (17.5)	52 (82.5)	.005	10 (15.9)	53 (84.1)	.071
	No	259 (34.9)	483 (65.1)		196 (26.4)	546 (73.6)	
Visit Dentist	Yes	68 (34.7)	128 (65.3)	.728	58 (29.6)	138 (70.4)	.158
	No	202 (33.2)	407 (66.8)		148 (24.3)	461 (75.7)	
Chewing Qat	Yes	165 (27.5)	436 (72.5)	<0.001	117 (19.5)	484 (80.5)	<0.001
	No	105 (51.5)	99 (48.5)		89 (43.6)	115 (56.4)	
Smoking	Yes	32 (17.6)	150 (82.4)	<0.001	20 (11.0)	162 (89.0)	<0.001
	No	238 (38.2)	385 (61.8)		186 (29.9)	437 (70.1)	
Pregnancy	Yes	5 (71.4)	2 (28.6)	.445	2 (28.6)	5 (71.4)	.456
	No	96 (49.7)	97 (50.3)		90 (46.6)	103 (53.4)	

		Gingival recession					P*
		No recession	Class I	Class II	Class III	Class IV	
Age	≤30	216 (39.5)	243 (44.4)	61 (11.2)	17 (3.1)	10 (1.8)	<0.001
	>30	65 (25.2)	88 (34.1)	51 (19.8)	31 (12.0)	23 (8.9)	
Brushing Teeth	Yes	96 (44.2)	95 (43.8)	15 (6.9)	9 (4.1)	2 (0.9)	<0.001
	No	185 (31.5)	236 (40.1)	97 (16.5)	39 (6.6)	31 (5.3)	
Gender	Male	174 (28.8)	284 (46.9)	91 (15.0)	34 (5.6)	22 (3.6)	<0.001
	Female	107 (53.5)	47 (23.5)	21 (10.5)	14 (7.0)	11 (5.5)	
Systemic Diseases	Yes	8 (12.7)	25 (39.7)	15 (23.8)	6 (9.5)	9 (14.3)	<0.001
	No	273 (36.8)	306 (41.2)	97 (13.1)	42 (5.7)	24 (3.2)	
Visit Dentist	Yes	64 (32.7)	96 (49.0)	21 (10.7)	8 (4.1)	7 (3.6)	.096
	No	217 (35.6)	235 (38.6)	91 (14.9)	40 (6.6)	26 (4.3)	
Chewing Qat	Yes	171 (28.5)	280 (46.6)	91 (15.1)	37 (6.2)	22 (3.7)	<0.001
	No	110 (53.9)	51 (25.0)	21 (10.3)	11 (5.4)	11 (5.4)	
Smoking	Yes	16 (8.8)	84 (46.2)	54 (29.7)	17 (9.3)	11 (6.0)	<0.001
	No	265 (42.5)	247 (39.6)	58 (9.3)	31 (5.0)	22 (3.5)	
Pregnancy	Yes	1 (14.3)	2 (28.6)	3 (42.9)	1 (14.3)	0 (0.0)	.035
	No	106 (54.9)	45 (23.3)	18 (9.3)	13 (6.7)	11 (5.7)	

* Chi-Square test

Table 4. Multiple Regression analysis of the risk factors for plaque index, bleeding index, and gingival index

	Plaque index			Bleeding index			Gingival recession		
	B	(95% CI)	P	B	(95% CI)	P	B	(95%CI)	P
Age	0.2	(0.1,0.3)	<0.001	0.2	(0.1,0.3)	<0.001	0.5	(0.3,0.6)	<0.001
Sex	0.0	(-0.2,0.1)	0.847	0.0	(-0.2,0.1)	0.516	0.0	(-0.3,0.2)	0.798
Systemic Diseases	-0.1	(-0.2,0.1)	0.267				-0.4	(-0.7,-0.1)	0.003
Smoking	-0.2	(-0.3,-0.1)	0.001	-0.2	(-0.3,-0.1)	0.001	-0.5	(-0.7,-0.4)	<0.001
Chewing Qat	0.0	(-0.2,0.1	0.557	-0.1	(-0.2,0.1)	0.265	-0.1	(-0.3,0.2)	0.541
Brushing Teeth	0.3	(0.2,0.4)	<0.001	0.3	(0.2,0.4)	<0.001	0.2	(0.0,0.3)	0.038
Visit Dentist	0.1	(0.0,0.2)	0.143	-0.1	(-0.2,0.0)	0.093			

Table 5: Multiple Regression analysis of the risk factors for calculus index and bleeding index

	Calculus index				Bleeding index			
	B	S.E.	Exp(B)	P	B	S.E.	Exp(B)	P
Age	-0.6	0.2	0.5	0.001	-0.5	0.2	0.6	0.013
Sex	0.5	0.3	1.6	0.091	1.1	0.3	2.9	<0.001
Systemic Diseases	0.6	0.4	1.8	0.105				
Smoking	0.6	0.2	1.8	0.01	0.6	0.3	1.9	0.016
Chewing Qat	0.5	0.3	1.7	0.071	0.1	0.3	1.1	0.644
Brushing Teeth	-0.4	0.2	0.6	0.012	-0.7	0.2	0.5	<0.001

Discussion

This study assessed the effect of established risk factors on five periodontal parameters. Our results found highly significant differences between age groups regarding plaque index, gingival index, calculus index, gingival recession, and bleeding index. These results are similar to previous studies [39,40], where older participants were found to have poorer oral health. The combined impact of exposure to risk factors may result in increased vulnerability to periodontal destruction with aging throughout a lifetime.[41] In the study by Garanayak et al.[42], a strong positive correlation was found between age and plaque deposition and gingivitis. Other studies[43,44] also demonstrated that the prevalence of gingival recession is age-dependent.

In the current study, similar to previous publications[45,46], males demonstrated a greater risk of developing worse periodontal conditions compared with females. Sanadi et al [47] assessed the oral hygiene of 209 dental students and found gender differences, reflecting a greater incidence of gingival disease in males than in females. This may be related to the behaviors of oral health and hygiene status, which is affected by lifestyle factors. Despite our data reported that gender had an impact on bleeding index only, this result is similar to previous study.[48] However, it is in contrast to the findings of the study of Chen et al.[49], which reported gender as a strong determinant for most of the oral health determinants.

Some studies[50,51] have reported that the increased level of sex hormones during pregnancy may cause a significant elevation in gingival inflammation (gingival index and bleeding index) in pregnant women, but with no significant differences in plaque scores. These findings are similar to our findings concerning plaque index, while dissimilar to the gingival index and bleeding index. These

differences may be related to the small sample size of pregnant women in our study.

According to the current findings, systemic diseases had no significant impact on the periodontal condition, although there were differences in plaque index, calculus index, and gingival recession between individuals with and without systemic diseases. In contrast, Jepsen et al.[52] found that some types of systemic diseases had a negative effect on the apparatus of periodontal attachment with a high prevalence of gingival recessions. Furthermore, Albandar et al.[53] reported that some systemic disorders can directly affect periodontal inflammation by altering the immune response of the host to periodontal infection, resulting in significant loss of periodontal attachment and alveolar bone. Furthermore, systemic diseases can activate host metabolic alterations, affecting the different tissues of the periodontal apparatus. The differences between these findings may be due to the differences in the systemic disorders that had been examined. In our study, a small number (8%) of systemic diseased patients were found, including different types of diseases, which will not clearly reflect the effect of the systemic diseases on periodontal health. Moreover, no more details about the types of systemic disease were included in the analysis due to the small number of diseased patients and to avoid the decrease in power analysis.

Similar to previous studies[54,55], the results of our study revealed that brushing teeth had a highly significant effect on oral health with highly significant differences in periodontal condition between subjects who brush their teeth or not. On the other hand, some studies[56,57] reported that brushing teeth improperly leads to trauma and abrasion of the gingiva that causes wear at the cemento-enamel junction resulting in supporting

periodontium destruction progression to gingival recession.

The findings of the present research proved worse periodontal health among Qat chewers compared to non-chewers. This result is in agreement with other studies.[58,59] In fact, the substantial destructive impact on the periodontium of Qat chewing is not a bacterial risk factor, but it is a mechanical risk factor. Since there was no scientific evidence to prove the fact that pathogens among Qat chewers caused periodontal infections. In the development of periodontal diseases, in particular attachment loss, pocket depth, and gingival recession, Qat chewing habits can be considered a mechanical risk factor.[59] However, other reports were not consistent with our findings[60,61] Likewise, interestingly, Al-hebshi and Al-Ak'hali[62] concluded a positive impact of Qat on the health of the gingiva. They found lower mean PI, GI, and BOP scores in Qat chewers compared with non-chewers. Differences between these results might be related to the differences in the sample size.

Tobacco smoking is a common behavior that has serious health consequences. While tobacco use was once known as a habit, it is now considered nicotine dependence and a chronic relapsing medical condition (International Classification of Diseases, Tenth Revision).[63] It is well known that smoking has a significant adverse impact on the periodontal supporting tissues.[64] Furthermore, Banihashemrad et al.[65] assessed the effect of smoking on the gingival recession of the buccal and palatal surfaces of all teeth and found a relationship between gingival recession and smoking, possibly through changes in immune response and topical changes, such as decreases in gingival circulation. This finding was in concurrence with our results. It is promoted that smoking may cause a change in the subgingival biofilm composition with an increase in the prevalence of the periodontal pathogen.[66] Moreover, smoking had been involved in slowing the recruitment of neutrophils and migration into periodontal tissues, accordingly compromising the acute immune response.[67] This would increase the aggression threshold needed to activate the inflammatory cascade in the periodontal tissue. Also, smoking was proposed to change the balance of neutrophil activities to a more destructive nature.[68] In contrary to the current study, Holde et al.[69] concluded that smoking decreases the tendency of gingival bleeding. The underlying mechanisms of smoking's impact on bleeding of the gingiva are somewhat unclear. There is limited evidence that smoking promotes human gingival vasoconstriction.[70]

The result of the present study revealed that the subjects who visited the dentist had less plaque and gingival index; which is in line with that of Chen et al.[49], who found that more dental visits are good predictors of better gingival status.

Although the study could clearly demonstrate the effect of some risk factors on the periodontal health, some limitations should be acknowledged. The sample size was limited to one dental school. Frequency of teeth brushing and Qat chewing as well as types of systemic diseases were not included in the analysis. Therefore, further large-scale studies including more patients and more variables are recommended to further confirm the current findings of the study.

Conclusions

Within the limitations of the present study, it can be concluded that the prevalence of periodontal disease among Yemeni patients was high. Older age, smoking, and non-brushing teeth are the significant determinants for worse periodontal condition. Initiatives and preventive programs should be implemented in the dental schools to educate people about the adverse effects of bad habits as well as the importance of maintaining good oral hygiene.

Acknowledgment

Conflicts of Interest

The authors declare no conflicts of interest.

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Cumhuriyet Dental Journal

Reattachment of Fractured Tooth Fragments Using Modified Over Contour Technique: 2- Case Report

Uzay Koç Vural[1,a,*]

[1]Department of Restorative Dentistry, School of Dentistry, Hacettepe University, Ankara, Turkey
*Corresponding author

Case Report

ABSTRACT

Crown fractures of the teeth especially in anterior region are common forms of dental trauma. If the fractured tooth fragment is available after dental trauma, reattachment of the fragment to the remaining tooth substrate may provide maintenance of the optical properties and shape of the natural tooth conservatively, as well as psychological benefits to the patients, relatively short chair-time, predictable treatment outcome and low-cost. This case report summarizes coronal fractures of two upper central incisors that was successfully reattached using resin composite and modified over contour technique.

Keywords: Reattachment, Fractured Tooth, Over Contour Technique, Case Report.

Modifiye Over Kontur Tekniği ile Kırık Diş Parçalarının Yeniden Dişe Yapıştırılması: 2- Olgu Sunumu

ÖZ

Özellikle ön bölgede yer alan dişlerin kuron kırıkları dental travmalardan sonra sık karşılaşılan bir durumdur. Dental travma sonrası kırık diş parçası mevcutsa, parçanın kalan dişe yeniden yapıştırılması, doğal dişin optik özelliklerinin ve şeklinin korunmasının yanı sıra, hastayı psikolojik olarak rahatlatan, nispeten kısa tedavi süresi, öngörülebilir tedavi sonucu ve düşük maliyeti ile konservatif bir tedavi seçeneğidir. Bu vaka raporunda, travma sonucu kırılmış iki üst santral dişin kırık parçalarının rezin kompozit ve modifiye edilmiş over-kontur tekniği kullanılarak başarılı bir şekilde yeniden yapıştırılması özetlenmiştir.

Anahtar Kelimeler: Yeniden Yapıştırma, Kırık Diş, Over-Kontur Tekniği, Vaka Raporu

[a] uzay.koc@hacettepe.edu.tr   https://orcid.org/0000-0002-8764-2174

Introduction

Dental trauma in the mouth effects aesthetic, mastication and phonation and cause psychological and physiological impairment due to the traumatic aspect in the facial area and changing the patient's lifestyle.[1] Crown fractures of the anterior teeth mostly seen in children and/or adolescents, and the upper incisor teeth are the most often injured in accidents due to their vulnerable position in the mouth[2-4], whereas the lower central incisor and the upper lateral incisors are less frequently affected.[5] Although a single tooth is usually affected after traumatic dental injuries, multiple tooth injuries are not rare. However, in many countries, treatment of traumatized teeth has not been a priority for many peoples, unfortunately. It should be kept in mind that, treatment of a traumatized tooth is extremely important in terms of quality of life and for the prevention of undesirable challenges at long-term.[2,6]

The treatment and prognosis of traumatized and fractured teeth depend on a series of factors, such as the degree, location, level and type of fracture, the condition of soft and periodontal tissues, and the requirement of root-canal treatment.[7] Another important factor in the success of the reattachment therapy is storage time and storage media of the fractured tooth fragment out of the oral cavity. Since these factors, mentioned above, can cause changes in the color of enamel and dentin, there may be a color mismatch between the reattached tooth fragment and the remained tooth substrate. The lack of an aesthetically satisfying appearance may impair the social interactions of school children and affect the self-confidence of young people.[8,9]

When the tooth fragment is available, a conservative treatment option for fractured anterior teeth is reattachment, which offers some advantages over

conventional prosthetic indirect restorations or composite layering techniques.[9-12] In reattachments cases, the fracture line is crucial for the reattachment of the fragment; if it is continuous and regular, it will be easier to adapt[13] otherwise, reattachment of the tooth fragments can be more complicated in the presence of irregular fracture line with or without multiple fragments.

These 2-case reports aimed to present clinical application steps of reattachment therapy of upper central incisors after coronal fractures as well as the interventions done for functional and aesthetic adjustments using modified over contour technique.

Materials and Methods

Case Descriptions

A female patient at the age of 15, acquired a horizontal fracture in the upper right central incisor tooth in the cervical third, and another horizontal fracture in the middle third vestibule-palatine in the upper left central incisor tooth. Both fractures were in vestibule-palatine direction. The etiology of the tooth fracture was direct frontal trauma due to the fall, at home. The patient has no medical history. On extra- and intra- oral examination, no bruises or abrasions on the soft tissues were detected. The patient's admission time to the clinic after trauma is 24 hours. Periapical radiograph observations indicated no signs of any root fracture and periapical pathology. The two tooth fragments were found at the accident site, and kept in milk.

Clinical Examination

Case 1. The horizontal fracture was localized at the cervical third of the right upper central incisor tooth. The patient was diagnosed as a horizontal vestibule-palatine fracture including two-thirds of the clinical crown, and the tooth fragments were completely detached (Figure 1a). Clinical observations indicated the pinkish color of the dental pulp was reflected from the incisal edge of the tooth, but there was no visible bleeding (Figure 1b). The patient reported to have severe hypersensitivity. At pre-op time, electric pulp testing (Kerr Vitality Scanner 2006, SybronEndo, Orange, CA, USA), thermal testing (air-water syringe), tactile tests (palpation and percussion), as well as the predictors of inflammation and self-reported patient history was taken. Periapical radiography was obtained to assess the level of the dental fracture and the need for root-canal therapy. The radiography indicated no periapical pathology at the beginning. The insertion of the both tooth fragments were not presented good positional stability indicating missed tooth fragments (Figure 2a).

Case 2. The horizontal fracture was localized at the almost middle of the left upper central incisor tooth. The diagnosis was a horizontal vestibule-palatine fracture covering half of the clinical crown, and the tooth fragments were completely detached. The patient

reported to have hypersensitivity but not severe. Radiography observations and the insertion of the fragment were similar to the Case 1. Clinical check-ups were done after one week and 3- months.
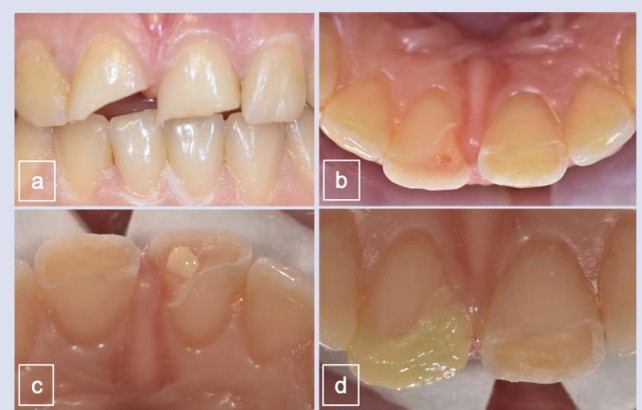

Figure 1. Indirect pulp capping
a. pre-operative view (buccal), b. pre-operative view (palatal), c. calcium hydroxide, d. glass ionomer cement

Treatment Plan

Case 1. For indirect pulp-capping, the area was irrigated with sterile saline solution and dried gently with sterile cotton pellets for indirect pulp capping. The reflected pinkish area was covered by calcium-hydroxide (Dycal; Dentsply Caulk, Milford, ME, USA) (Figure 1c). Then, a conventional glass ionomer cement (Figure 1d) was inserted throughout the incisal edge. The tooth was left undisturbed for 1 month then, the patient re-visited the dental clinic. After tooth vitality and physiologic mobility were guaranteed, the teeth were isolated with a rubber-dam (Optradam, Ivoclar Vivadent, Schaan, Lichtenstein). Since reattachment of the fragments to the tooth substrates confirmed missed tooth fragments, color of resin composite to be used was detected under ambient lighting conditions. The removal of the glass ionomer cement was started from peripheral area under water cooling. Previously inserted calcium hydroxide cement and a thin layer of glass ionomer cement were left. Enamel surfaces were totally exposed but the dentin surfaces were not. The disinfected fractured tooth fragment and remained tooth structures were selectively acid-etched by 37% orthophosphoric acid for 30 s on the enamel margins[14], rinsed and gently dried with cotton pellets. A universal adhesive system (Solare, GC, Tokyo, Japan) was applied according to the manufacturer's recommendations onto the substrate and tooth fragment. No additional groove or bevel preparation was done due to the missing tooth fragments. Approximately a 1mm thick resin composite (A2 and AO2) (G'aenial A'chord, GC, Tokyo, Japan) was placed on the palatal side of the substrate and un-cured. Subsequently, the tooth fragment was reattached, positioned and light-irradiated with a light-curing unit (Elipar Freelight 2, 3M ESPE, St. Paul, MN, USA,1000 mW/cm2)) for 20 s. Then the gap between substrate and tooth fragment was filled incrementally. After the restoration, the preparation

extended 2.5 mm coronally and apically from the fracture line, with a depth of 1 mm (Over contour technique, Figure 2d-j) by round-ended diamond finishing bur and then beveled. This created a slightly over contoured tooth surface. After etching and bonding as mentioned previously, the resin composite was placed by layering technique (G'aenial AO2, Gaenial A'chord A2, GC, Tokyo, Japan). The re-attachment and restoration steps were summarized in Figure 2a-j.

The polishing was done with polishing discs (Sof-Lex, 3M, St. Paul, MN, USA) in a decreasing order.

Case 2. It was decided to reattach of tooth fragments of left upper central incisor tooth immediately. The same protocol was followed mentioned above for re-attachment, except indirect pulp capping step. Photographs were obtained during the clinical application steps, after obtaining written consent from the patient.

Patient was instructed to prevent heavy loading of the anterior teeth. Post-operative period was uneventful.[15]

Figure 2. Reattachment steps of fractured tooth fragment and clinical application of over contouring technique
a. clinical view of the gap between the tooth and the fractured tooth fragment, b,f. acid-etching, c,g. bonding, d,e. over contouring, h. incremental composite layering, j. polishing

Figure 3. Clinical view of reattachment therapies at recalls
a. pre-operative stage, b. reattachment of left upper central incisor tooth, c. reattachment of right upper central incisor tooth, d. 3- month post-operative stage

Discussion

Traumatic injuries of permanent anterior teeth are a common problem especially seen in the first and second decades of life because of increased physical activities of this age-group.[4,16]

A proper dental restorative treatment after traumatic dental injuries is crucial for preventing biological and sociopsychological impacts.[8] A series of treatment options can be preferred for the restoration of traumatized teeth, varying from biological restorations to indirect prosthetic approaches. As the treatment and prognosis for each case is unique, treatment (chipping / bulk) and its level, availability for reattachment and conditions of the dentin tubules. In the literature, different reattachment methods present a perfect alternative treatment option for anterior fractured teeth since their natural anatomic form, contour, color, surface texture, translucency, incisal coverage, function and contribution to phonation are maintained.[4,17]

Although Demarco *et al.*[18] stated that the degree of bevel and the used material for the reattachment were not sufficient enough to catch the natural fracture resistance of the intact tooth, some alternative techniques were reported in the literature. Additionally, some authors advocate preparation of the tooth surfaces before and/or after bonding.[11, 17, 19] Reis *et al.*[20] indicated that a simple reattachment without any additional preparation of the neither fragment nor tooth can improve approximately one third (37.1%) of the fracture resistance of intact tooth while over contour 97.2%. Similarly, Abdulkhayum *et al.*[19] reported excellent fracture strength recoveries after over contour and/or internal groove techniques were employed. In light of the current literature, it was decided to use a slightly modified over contour technique in the present cases. The modification, employed in these cases, aimed first to promote the fracture strength of the reattached tooth and secondly to improve color match among substrate, resin composite and tooth fragment since the esthetic aspects of the restoration are equally important due to the high psychosocial and emotional impact on individuals' quality of life. After 3- month, reattachment interventions were clinically successful in line with the current literature, in these two cases. Exact color match was maintained and fragments were stayed reattached. This may be due to the reattachment technique and adhesive system, employed. However; there were some factors contributed to render reattachment procedures difficult. The main difficulty during reattachment was that there was a gap between the substrate and the fractured tooth fragment due to the missing pieces. This gap made it difficult both reattaching of the fractured tooth fragment exactly and maintaining the color harmony among fractured tooth fragment, remained tooth structures and resin composite. Although Andreasan *et al.*[21] recommended when the fragment is missed or inappropriate for reattachment, composite resin restoration should be preferred instead. However, it was decided that the master piece should be kept in
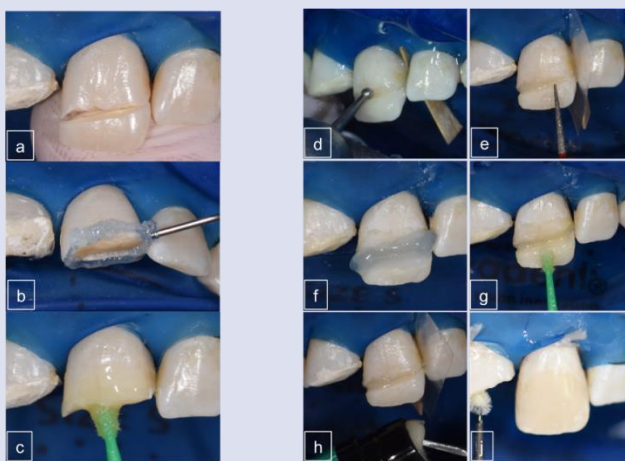
the mouth in the present two cases, considering the patient's age, aesthetic need, and long-term sustainability of the aesthetics.

However, it should be noted that reattachment of tooth fragment(s) doesn't finalize the process since aesthetic, biological or functional adjustments/ interventions can be required over time. A wide variety of factors are effective on the survival of a reattached tooth in the oral cavity. Patient collaboration and awareness of the limitations of the applied treatment are extremely important for maintaining long lasting restorations.[22]

Conclusions

After 3- month, reattachment of fractured tooth fragments using modified over contour technique were clinically successful.

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None

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Can Acids Produced From Probiotics Demineralize the Tooth and Cause Progression of Caries: A Critical Review

Swagata Saha[1-a], Aditi Chopra[1-b*], Shobha U Kamath[2-c], Karthik Sivaraman[3-d]

[1]Departmehnt of Periodontology, Manipal College of Dental Sciences, Manipal, Manipal Academy of Higher Education, Manipal, India
[2]Department of Biochemistry, Kasturba Medical College, Manipal, Manipal Academy of Higher Education, Manipal, India
[3]Departmehnt of Prosthodontics Crown and Bridge, Manipal College of Dental Sciences, Manipal, Manipal Academy of Higher Education, Manipal, India
*Corresponding author

ABSTRACT

Background: Probiotics are known to provide various health benefits to the host in adequate concentrations. Lactobacilli, Propionibacterium, and Bifidobacterium are common "Lactic Acid-producing bacteria (LAB)" present in various probiotic formulations. These probiotic bacteria release large amount of organic acids, mainly acetic acid, lactic acid, and propionic acid, into their surrounding environment. Increased concentration of these inorganic and organic acids can reduce the saliva's critical pH to below 5.5, and can initiate demineralization of the tooth surface. Thus, the present review aims to critically appraise the existing evidence on this emerging clinical perspective and double edged nature of the probiotic bacteria, and explain as to how probiotic supplements can increase the risk of enamel demineralization and tooth decay.

Results: *Lactobacilli* and *Bifidobacterium* are associated with rampant caries in preschool children and progression of caries. All probiotics were found to be acidogenic in nature as they reduced the pH of the saliva, and eroded the enamel. Probiotics release extracellular polysaccharides that help in plaque formation and can cause leaching of essential elements like calcium and phosphorous from the enamel surface. The lactic acid-producing efficiency of probiotics is increased when combined with supragingival plaque.

Conclusions: Acids released from probiotic bacteria can reduce the critical pH of the oral environment and play an important role in initiating enamel demineralization and progression of caries.

Keywords: Probiotics; Lactobacilli; Tooth; Caries; Enamel; Demineralization; Oral health; Acid; Critical pH.

Probiyotiklerden Üretilen Asitler Dişi Demineralize Edebilir ve Çürüklerin İlerlemesine Neden Olabilir mi?: Kritik Bir İnceleme

ÖZ

Arka plan: Probiyotikler, yeterli konsantrasyonlarda konakçıya çeşitli sağlık yararları sağlayan canlı mikroorganizmalardır. Lactobacilli, Propionibacterium ve Bifidobacterium, çeşitli probiyotik formülasyonlarda bulunan yaygın "Laktik Asit üreten bakterilerdir (LAB)". Bu probiyotik bakteriler, çevrelerine büyük miktarda organik asit, özellikle laktik asit, asetik asit ve propiyonik asit salgılarlar. Bu inorganik ve organik asitlerin artan konsantrasyonu tükürüğün kritik pH'ını 5,5'in altına düşürebilir ve diş yüzeyinin demineralizasyonunu başlatabilir. Bu nedenle, bu gözden geçirme, ortaya çıkan bu klinik perspektif ve probiyotik bakterilerin çift kenarlı doğası hakkındaki mevcut kanıtları eleştirel olarak değerlendirmeyi ve probiyotik takviyelerin emaye demineralizasyonu ve diş çürümesi riskini nasıl artırabileceğini açıklamayı amaçlamaktadır.

Bulgular: Lactobacilli ve Bifidobacterium, okul öncesi çocuklarda yaygın çürükler ve çürüklerin ilerlemesi ile ilişkilidir. Tüm probiyotikler, tükürüğün pH'ını düşürdükleri, emayeyi demineralize ettikleri ve aşındırdıkları için asidojeniktir. Probiyotikler, plak oluşumuna yardımcı olan ve kalsiyum ve fosfor gibi temel elementlerin emaye yüzeyinden sızmasına neden olabilecek hücre dışı polisakkaritleri serbest bırakır. Supragival plak ile birleştirildiğinde probiyotiklerin laktik asit üreten verimliliği artar.

Sonuçlar: Probiyotik bakterilerden salınan asitler, ağız boşluğunun kritik pH'ını düşürebilir ve emaye demineralizasyonunun ve çürüklerin ilerlemesinin başlatılmasında önemli bir rol oynayabilir.

Anahtar Kelimeler: Probiyotikler; Lactobacilli; Diş; Çürük; Emaye; Demineralizasyon; Ağız sağlığı; Asit; Kritik pH.

[a] ta1995@yahoo.co.in   https://orcid.org/0000-0002-2343-5977   [b] aditi.chopra@manipal.edu https://orcid.org/0000-0003-4805-5943
[c] shobha.kamath@manipal.edu   https://orcid.org/0000-0002-9896-0872   [d] karthik.s@manipal.edu   https://orcid.org/0000-0002-1512-6488

Introduction

Probiotics are known to provide various health benefits to the host upon intake in adequate concentrations.[1-2] The microorganisms present in probiotic formulations include Bifidobacterium longum, *Lactobacillus reuteri*, Lactobacillus acidophilus, *Lactobacillus rhamnosus*, *Streptococcus thermophiles, and Saccharomyces boulardil*.[3] Probiotics are commercially available in the forms of fermented milk, lozenges, tablets, powders, yogurt, chewing gums, liquid, syrups, and chips.[4-6] In the last decade, probiotic consumption has rapidly increased around the globe. According to the 2012 National Health Interview Survey (NHIS), probiotic consumption was found to be common with around 4 million U.S adults (1.6 percent) reportedly consuming probiotics in the preceding 30 days. With a rapid increase in the awareness and consumption of probiotics supplements, probiotics are among the most commonly consumed dietary supplement and superfood across the globe.[5]

Probiotic supplements are commonly prescribed to manage gastrointestinal, vaginal, urogenital, oropharyngeal, and atopic disorders.[5-7] In dentistry, probiotic bacteria are used as an adjunct to mechanical periodontal debridement, to treat oral and periodontal diseases. Probiotics can inhibit or replace the pathogens in the oral cavity and inhibit plaque formation. Probiotic bacteria also release various antimicrobial substances that can prevent attachment of primary coloniziers to the tooth surface, and reduce biofilm formation.[5-7] For example, probiotic can replace the primary colonizers such as *Streptococcus mutans*, *Streptococcus salivarius,* and *Actinomyces* viscosus and reduce the risk of caries and gingival inflammation.[7-20]

Although the role of probiotics in treating caries, halitosis, periodontal and peri-implant diseases is established, there is an emerging perspective that probiotic supplements could demineralize the tooth surface, and increase the risk of tooth decay.[21-31] This perspective is based on the acidogenic and aciduric nature of probiotic bacteria.

Probiotic microorganisms, particularly Bifidobacteria, *Lactobacilli*, and *Propionibacterium,* are classified as "Lactic Acid-producing bacteria" (LAB), as they release high amounts of organic acids in their surrounding environment.[28-33] Probiotics also produce extracellular polysaccharides (EPS) that aid in plaque formation, and in turn increase the overall acidity of the biofilm. Beighton *et al*. (2005) and Faraz *et al*. (2019) confirmed the strong acidogenic nature of probiotic bacteria and stated that 'lactic acid-producing bacteria,' may be a risk factor for demineralization of the enamel surface".[34-36] Since existing literature primarily focus on the ability of probiotics to replace the cariogenic pathogens, the demineralizing and erosive potential of probiotics are often ignored. Thus, the present review aims to explore this emerging clinical perspective and double edged nature of the probiotic bacteria. The paper is of paramount importance to the public, dentists, food scientists, and pharmaceutical companies, as it highlights the mechanisms, and existing evidence which confirm that probiotics may detrimental effect on the health of the enamel.

Methodology, Search Strategy, and Data Collection Process:

The following search strategy was used in following database: PubMed, Scopus, Web of Science database, Open Science and Dentistry for searching the relevant articles: (Probiotic* OR Probiotic supplements OR probiotic supplementation* OR Lactobacilli OR Bifidobacterium OR Propionibacterium) AND (Tooth OR Teeth OR Caries OR Decay OR Demineralization OR Enamel Loss OR Non-carious cervical lesion OR Erosion OR Roughness OR Strength OR Critical pH OR Lactic Acid). All articles up to July 2021 were included. The search strategy was modified accordingly in Scopus, Web of Science, ProQuest (Dentistry and Open access) to search for relevant articles. The cross-reference of all studies was searched to include any relevant data. Articles written in English language only were included. Two reviewers independently performed the initial screening for including the relevant articles.

All in-vitro, animal and in-vivo studies (randomized, quasi-randomized and non-randomized clinical trials, cross-sectional, prospective, retrospective, and observational studies) were included. The data from all the articles was compiled and presented as a narrative synthesis.

Results and Discussion

The search yielded 7055 articles in PubMed, 48 in Scopus, 1405 in Web of Science, 1027 in Open Sciences and dentistry, and 308 in ProQuest Health & Medical Complete (Proquest Medical Library). Of all the articles, only 40 were included for the review. Of the 40 articles, 13 articles directly explained the effects of probiotics and their role in decreasing the critical pH and progression of caries (Table 1a, b). The studies showed that probiotics can increase the acidity of the oral cavity and can induce erosive changes in the enamel.

Two main mechanisms that were found to be associated with increased demineralization of enamel surface and risk tooth decay were: *a) Increased acid production, b) Increased production of Exopolysaccharide (EPS)*

a) Increased Acid Production From Probiotic Microorganisms

Due to their capability to produce copious amounts of lactic acid, and other short-Chain fatty acids (SCFA) like acetic acid in their environment, Lactobacilli are considered as one of the most important cariogenic pathogens.[19,20] In 1998, Lankaputhra and Shah reported that lactic acid (780 – 3276 µg/ml), acetic acid (58-75 µg/ml), and pyruvic acid (6 – 22 µg/ml) are the most common organic acids produced by probiotic bacteria.[28]

Table 1a. Studies confirming the role of probiotics in reducing the critical pH, increasing the acidity of oral cavity.

A/Y	NP/PB	Aims and Objectives	Methodology	Results and Conclusion
A1	1	Lactobacillus salivarius was checked for its cariogenicity in rats	Six groups were infected with L. Salivarius with and without Streptococcus mutans.	L. salivarius proliferated and caused significant amount of dental caries within 5 days of infection. Higher caries score was observed in rats superinfected with both L. salivarius and S mutans and than those infected with either S. Mutans or L. salivarius alone. An inherent cariogenic activity was seen in relation to L salivarius strain after adherence to the tooth surface.
A2	2	Determine the profile of the bacterial species related to carious lesions in permanent and deciduous teeth, and variation with state of disease.	Plaque samples were collected from 39 healthy patients (control group). Plaque was collected from 51 subjects with high caries rate from healthy enamel with either whitespot lesions, or deep-dentinal lesions. The 16S rRNA was sequenced to the bacterial species.	197 bacteria with 22 new phylotypes were identified. In individuals having *S. mutans*, additional species of *Atopobium*, Lactobacillus, and *Propionibacterium* were noted in significantly amounts compared to *S. mutans*. These species played an crucial role in caries progression.
A3	3	To evaluate the presence of Bifidobacterium in root carious lesions.	Bifidobacterium was assessed in active carious lesions of the root, remineralizing lesions and healthy root surfaces.	*Bifidobacteria* was isolated from all soft active carious lesion on the root, five plaque samples collected from sound exposed root surfaces, and, 13 of 15 leathery lesions. The proportion of *Bifidobacteria* was significantly higher in infected dentin of carious lesions, and least in the plaque obtained from healthy root surfaces.
A4	2	The reduction in the pH level upon use of 14 different probiotics and dairy bacterial strains containing xylitol, lactose glucose, sorbitol, sucrose was assessed.	The pH levels were recorded for 30 mins at time intervals of 5, 10, 15, and 30 mins. Acid levels were measured after addition of different sugars (glucose, sucrose, lactose), and sugar alcohols (xylitol, sorbitol) to the fermentation medium.	The reduction in pH was dependent on sugar or sugar alcohol and the bacterial strain involved. The decrease in pH was fastest with glucose. After 5 min the pH was below 5 for all strains tested. None of the Bifidobacteria fermented sugar alcohols. All the strains were found to be acidogenic.
A5	1	To assess the mechanisms of probiotic bacteria and sum up the overall effects on the oral environment.	The role of salivary pellicle, attachment of bacteria, and the activation of peroxidase system was evaluated. The levels of Streptococcus gordonii, Streptococcus mutans, Aggregatibacter actinomycetemcomitans, and Helicobacter pylori were used noted	Probiotic bacteria affected the oral microbiota based on the specific nature of strain or species. Probiotics are acidogenic in nature. Probiotics may use either sugar alcohol or sugar for forming acid.
A6	4	To evaluate and compare the bacterial profiles for extensively carious teeth and healthy teeth in young permanent dentition.	Dental plaque was obtained from intact enamel in healthy subjects and from subjects with dental caries. The plaue was collected from the sound enamel; white spot lesions; carious/cavitated lesions; carious dentin. The compoistion of bacteria was noted from healthy and carious teeth using 16S rRNA genes.	*Lactobacillus* was the most prevalent species observed in increased caries. The Lactobacilli count increased markedly with progression of caries. The count of Propionibacterium FMA5 was not found to be high, but it was associated with the progression of caries. In contrast, S.mutans was not significantly associated with caries progression. The bacterial diversity reduced with progression of caries with the following species reduced in count: Capnocytophaga gingivalis, Campylobacter rectus, Corynebacterium matruchotii, Lachnospiraceae sp. C1, Eubacterium IR009, *Streptococcus gordonii; Streptococcus mitis; S.pneumoniae-S.infantis* group, and Streptococcus cristatus.
A7	1	To characterize two probiotic *Lactobacillus reuteri* strains, ATCC PTA 5289 and ATCC 55730, from a cariogenic perspective	Evaluation for adhesion and biofilm formation was done on saliva-coated hydroxyapatite. Arginine metabolism was estimated by measuring Ph values in the presence of glucose and arginine.	ATCC 55730 strains of Lactobacilli was found in low levels in both adhesion and biofilm formation compared to ATCC PTA 5289 strain. Both strains were found to be arginolytic and raised the pH in the presence of arginine.

Table 1b. Studies confirming the role of probiotics in reducing the critical pH, increasing the acidity of oral cavity.

A/Y	NP/PB	Aims and Objectives	Methodology	Results and Conclusion
A8	3	Bifidobacteria concentrations in caries-free and caries-active children were compared.	Salivary samples from 22 clinically caries free children and 38 caries-active children. Children were tested for levels of *Lactobacilli, Bifidobacteria, Streptococci mutans,* and yeasts	Bifidobacteria were isolated in 9% of the children without caries compared to 95% in children with active caries lesions. The nature of diet with level of sugar intake, frequency of consumption of sugar, and nature of oral hygiene practice were found to have a significant corelation to levels of Bifidobacteria in saliva.
A9	1	To assess the effect of lactobacilli present in the probiotic on lactic acid production in plaque.	*L. reuteri* and *L. plantarum* were added to the supragingival plaque which was obtained from 25 young healthy adults. The prodiction of lactic acid was evalauted after fermentation utilizing xylitol or fructose. 18 subjects were instructed to consume lozenges containing probiotic lactobacilli (*L. reuteri* DSM and ATCC PTA 5289), or placebo for two weeks. The concentration of lactic acid in supragingival plaque samples was compared at baseline and at 2 weeks. Salivary counts of Streptococci mutans and Lactobacilli were estimated .	Plaque with *L. reuteri* formed less lactic acid compared to *L. plantarum* and controls. Fructose induced more lactic acid concentrations compared to xylitol. No significant difference was noted for lactic acid production at 2 weeks compared to baseline in any of the groups. No significant changes were observed in relation to levels of S mutans. The levels of lactobacilli count increased significantly in the test group.
A10	5	Estimated the oral Lactobacilli levels among Japanese preschool children with differing prevalence of caries; and (2) to reveal the traits of these isolated *Lactobacillus* species.	Samples were collected from 74 preschool children with varied caries progression in Japan. The resistance to acidic environments and saliva-induced agglutination rate were measured.	High prelevance of dental caries was observed in preschool children with *Lactobacillus* (*L.*) *salivarius* or *Strepto coccus mutans* strains. The growth ability of L. Salivarius in acidic environment co-related positively with the scores of caries in the pre-school children with L. Salivarius strain.
A11	6	Compared the effectiveness of probiotic enriched yogurt extract and traditional yogurt extract in inhibiting dental enamel demineralization and promoting its remineralization.	60 caries-free human premolars divided into three groups comprising 20 teeth were checked for *in-vitro* demineralization. At a pH of 4.8, probiotic enriched yogurt extracts and traditional yogurt extracts was added and evaluated by confocal laser scanning microscopy and atomic absorption spectrophotometer.	Traditional yogurt has more inhibitory effect than probiotic enriched yogurt on dental enamel demineralization. The amount of calcium released into the solutions post emersion was more for probiotic groups (367.75 pg/ml) compared to the non-probiotic group (238.30 pg/ml). The difference was least for the traditional Non- probiotic group.
A12	1	To assess and compare the lactic acid-producing ability of L. Plantarum, and L. Acidophilus, in the presence or absence of dental plaque.	26 samples of Supragingival plaque with and without L.acidophilus and L.plantarum from three control groups and two test groups were collected. The concentration of the lactic acid was determined after acid production with sucrose.	The lactic acid production was greatest for the plaque group and least for L plantarum group. The lactic acid-producing ability of pure suspensions of L. .plantarum and L. acidophilus increased when mixed with the supragingival plaque.
A13	7	To evaluate the erosive activity on tooth enamel resulting from intake of six probiotic drinks.	48 extracted premolars, caries free, and not having hypocalcifications were used in the study to assess the erosive activity. Parameters like overall acidity, pH, weight loss of the tooth, and the rate at which calcium is released were noted when premolars were exposed daily for 5mins over a period of 1 week.	Probiotic drinks exhibit low erosive activity. Use of probiotics did not result in any calcium loss from tooth enamel although pH was seen to be lowered. All the tested samples showed continued weight loss of minerals for over 7 days' exposure.

A/Y: Author/year; *NP/PB:* Nature of Probiotics/ Probiotic bacteria
A1: Matsumoto *et al.,* 2005; A2: Aas *et al.,* 2008; A3: Mantzourani *et al.,* 2008; A4: Haukioja *et al.,* 2008; A5: Haukioja *et al.,* 2009; A7: Jalasvuori *et al.,* 2012; A8: Kaur *et al.,*2013; A9: Keller and Tweetman, 2012; A10: Shimada *et al.,* 2015; A11: Singh and Doyle, 2016; A12: Faraz *et al.,* 2019; A13: Zulkapli *et al.,* 2020,
1: Lactobacilli; 2: Lactobacilli and Bifidobacteria; 3: *Bifidobacteria; 4: Lactobacillus , Propionibacterium; 5:* Lactobacillus; 6: Probiotic yogurt (Mother Dairy B-Active) containing Lactobacilli; 7: Different probiotic drinks;
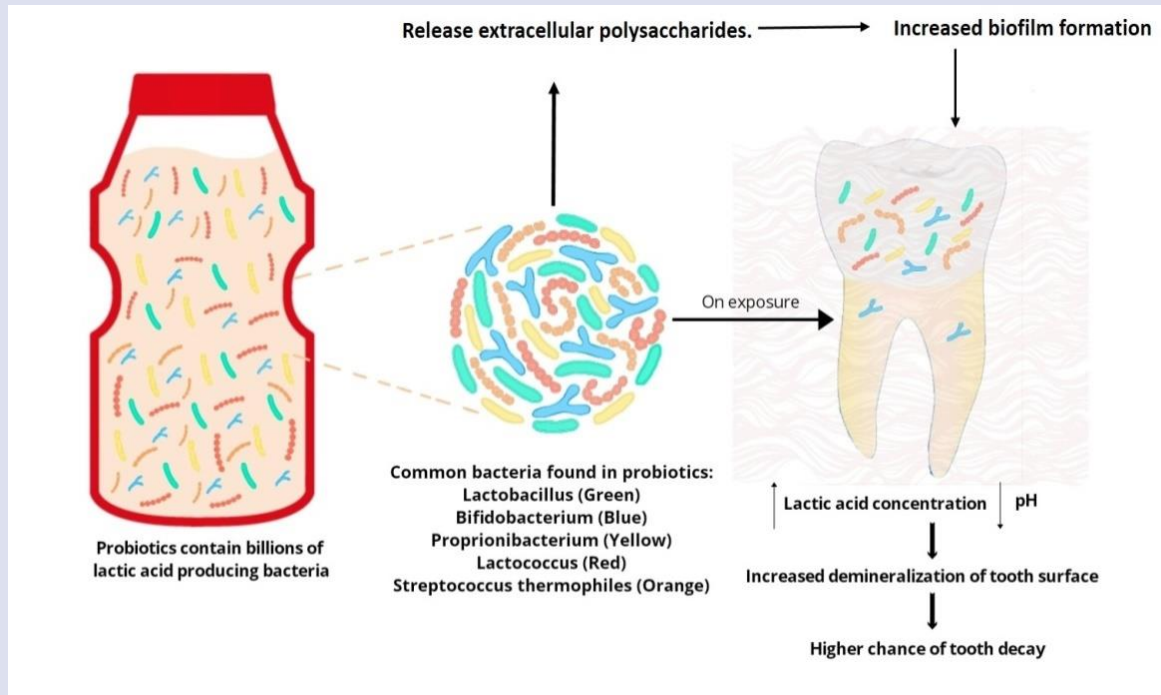
Figure 1. Schematic representation of the effect of probiotics on the Tooth surface: Probiotic supplements contain live microorganisms, particularly Lactobacilli, Propionibacterium, and Bifidobacteria.
These microorganisms are classified as "Lactic Acid-producing bacteria" (LAB) as they release many organic acids using the glycolysis pathways in their surrounding environment. The increased acidic environment and alteration in microbiota induce structural and environmental changes that make the tooth susceptible to caries.

Increased acid production can lower the critical pH and increase the risk of enamel demineralization, microerosion, softening of the enamel and tooth decay.[24-36] The areas of demineralization are prone for caries formation as bacteria can easily colonize these demineralized areas and penetrate the dentin. This role of lactic acid in enamel demineralization can be explained by the classic 'chemoparasitic theory (acidogenic theory)', which states that 'the pathogenic microorganisms utilize the fermentable carbohydrates in the oral cavity to increase the production of formic acid, lactic acid, and succinic acid reducing the pH of the oral cavity.[4] The theory also stated that any 'extrinsic factors such as diet can influence the demineralization process in the oral cavity. Intake of dietary acid through food or drink, along with microbial attack from existing bacteria in the mouth, can induce structural and environmental changes in the enamel'.[4,22-32] Therefore, an increase in the overall acidity of the saliva and alteration in the microbiome should be considered the root cause for change in the critical pH value of the oral cavity. Marsh *et al*. (2003), in their ecological plaque hypothesis, stated that the demineralization of enamel could be attributed to any species, conditions, or habit, which can increase the acidic load in the oral environment, and thus should be considered as a risk factor for caries.[30-36] Moreover, since recent studies have shown that probiotics can colonize the oral cavity and integrate into the biofilm, the effect of probiotic on the tooth surface should be explored.

There is sufficient evidence linking the probiotic bacteria such as *Lactobacilli* and *Bifidobacterium* with demineralization of tooth and progression of caries.[37-53] High levels of *Lactobacilli* have been isolated from initial to deep carious lesions.[51] However, there is contradicting data pertaining to the salivary *Lactobacilli* levels after probiotic usage, with few studies reporting no effects[54], while others reporting a statistically significant increase in counts of salivary *Lactobacilli* after probiotic comsumption.[20,24-26] Matsumoto *et al*., 2005, evaluated the ability of *Lactobacillus salivarius* to cause caries when infected with and without *S. mutans* and observed that *Lactobacillus salivarius* can 'establish itself in the buccal cavity and induce dental caries as early as five days'. Additionally, the caries score of rats superinfected with *S. mutans* and *Lactobacillus salivarius* was considerably greater than those infected with either S.mutans or *Lactobacillus salivarius*. This was linked to the propensity of *Lactobacillus salivarius* to cling to the saliva-coated hydroxyapatite and its 'inherent cariogenic activity'.[24] Studies have also correlated the role of probiotic-containing Bifidobacteria or *Lactobacilli* to the *Streptococci mutans* count in saliva.[8-22] Studies have shown that the decline in the *Streptococci mutans* count in the saliva was not dependent on the demineralizing potential of the product or strain used.[15-23] In a recent systematic review and meta-analysis, Wang *et al*. (2021) concluded that "there was no statistically significant decrease in *Lactobacilli* and *Streptococcus mutans* counts in saliva in people consuming probiotics with

Bifidobacterium[57]. *Bifidobacterium* was not found to be effective in reducing *Lactobacillus* and Streptococcus mutans count in the saliva or dental plaque, nor in reducing the incidence of caries in deciduous teeth. Thus, further investigations should be carried out regarding the suitability of *Bifidobacterium* to prevent dental caries.

Numerous papers have documented a positive correlation between salivary *Bifidobacterium* species, particularly *B. dentium and B. longum,* active root carious lesions and restored tooth surfaces.[10,11,51-55] The ability of *Bifidobacterium* to persist and proliferate in the acidic environment of carious lesions could be attributed to their 'ability to preserve pH despite extracellular acidification, durability of cell membrane, and intracellular alkaline production. It also contributes to their ability to proliferate in carious lesions even in the presence of *Streptococci* and *Lactobacilli*.[54] Therefore, based on this evidence, the role of *Bifidobacterium* in inducing inflamed gums, carious lesions, endodontic infections, and infected human dentin should not be ignored.[52-55] Mantzourani *et al*. (2008) observed that high proportion of *Bifidobacteria* in the infected dentine from soft lesions (7.88 +/- 1.93) compared to those in leathery lesions ((1.61 +/- 0.91) and in plaque from sound exposed root surfaces (0.05 +/- 0.39).[53]

Studies have shown that the progression of demineralization and caries are higher when acid drinks are involved, along with the presence of cariogenic bacteria.[37,38] Therefore, even if *Lactobacilli* may not trigger the onset of caries, acid produced from probiotic strains can certainly induce demineralization and increase the risk of caries progression.[38] Dental caries has been observed in gnotobiotic rats inoculated with *Lactobacillus casei* alone, in the sulcular regions, without any plaque accumulation.[39-43] However, the acidity of the plaque increases in the presence of the probiotic bacteria.[28,32,35,36] Ahmed *et al*. (2019) evaluated "the lactic acid-producing ability of *Lactobacillus acidophilus* and *Lactobacillus plantarum,* with and without dental plaque." and concluded that the efficiency of acid production increased on combination with supragingival plaque.[35] Approximately 0.35 µg/dl amount of acid was found to be produced by Lactobacillus plantarum after fermentation of sucrose and glucose.[35] A reduction in pH was observed by Hedberg *et al.* on fermentation of sucrose and glucose at 5.2-6.8 pH by *Lactobacillus plantarum*.[42] The fall in the pH is also linked with the creation of antimicrobial substances. Few of these antimicrobial substances have also been associated with the buffering action, and innate defense mechanisms.

A small number of in-vivo studies that have established that 'continuous administration of probiotic drinks can cause superficial loss of calcium and phosphorous from enamel, and increase the risk of carious and erosive lesions formation'.[35-48] A recent study by Singh and Dole (2016) showed that traditional non-probiotic yogurt has more protective effects than probiotic enriched yogurt in preventing enamel demineralization.[50] Zulkapli *et al*. (2020) compared the erosive effects of different probiotic drinks and concluded that all probiotic drinks can lower the pH to below 5.[52] However, they exhibited low erosive activity as a consequence of the buffering action caused by the the high calcium content in the drink. Although no calcium loss was noted, steady loss in weight was measured over 7 days, except on repetitive exposure on days 3 and 5. It should be noted, however, that the extent of demineralization will be depend on the overall acidity of the drink, residence of the probiotic bacteria in oral cavity, and the nature of acids produced by the oral bacteria.[35]

Increased EPS Production

Apart from increased acid production, lactic acid bacteria (LAB) also extravasate large amounts of extracellular polysaccharides(EPS) that have been linked with increased acid production. EPS are 'long-chain polysaccharides consisting of repetitive units of sugars or sugar derivatives secreted into their surroundings in form of loose slime. The EPS commonly secreted by probiotic bacteria include mannose, galactose, glucose, N-acetyl galactosamine , N-acetylglucosamine, and rhamnose. The rate of biofilm formation is increased by EPS by providing the essential molecules needed for acid production. Studies have proven that cariogenic bacteria using the glycolysis pathway can convert the galactose and glucose to lactate, formate, and acetate and produce acids. The lactate is subsequently converted into lactate ions which react with enamel hydroxyapatite to initiate the release of calcium and phosphate ions. The accumulation of EPS even favors the proliferation and firm anchorage of other bacteria to the enamel surface that can increase the growth of the cariogenic biofilm. *Streptococcus mutans* and *Streptococcus sobrinus* can utilize the dextran present in the EPS for biofilm formation.[40] The fructans and glucans, commonly added in probiotic formulations, have shown to affect the adhesion of *Actinomyces viscosus, Streptococcus gordonii, Streptococcus mutans,* and *Streptococcus sobrinus,* to the hydroxyapatite, apart from other cariogenic bacteria, thereby contributing to dental plaque formation and increased risk of tooth decay.[40-45]

Conclusions and Future Perspectives

In conclusion, 3D modeling may affect the surgeons preoperative decision-making processes, especially regarding the operation duration, osteotomy boundaries/defect size and complication risk. In complex cases, this novel methodology can be utilized in order to provide a better surgical outcome both for the surgeons and the patients. The findings of this preliminary study need validation on larger sample groups, with addition of 3D printing process to the present test protocol.

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Cumhuriyet Dental Journal

Blended Learning in Undergraduate Dental Education

Supriya Bhat[1-a]*, Medhini Madi[2-b]

[1]Department of Oral Medicine and Radiology, A.B Shetty Memorial Institute of Dental Sciences, Nitte (Deemed to be University), Mangalore, 575018, Karnataka, India

[2]Department of Oral Medicine and Radiology, Manipal College of Dental Sciences, Manipal, Manipal Academy of Higher Education, Manipal, 576104, Karnataka, India.

*Corresponding author

Reviews

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ABSTRACT

The Dental education sector has witnessed a lot of innovations in the past decade. Technology has played an important role in achieving this revolution such that the student can pursue the learning process at any given time and place beyond the geographical limits. The most frequently used approach is the concept of blended learning, which is an amalgamation of face-to-face and online modes of education. Thus, its role in ensuring the learning process to students all over the world despite the COVID 19 pandemic is innumerable. Hence, this review was conducted to explore how different dentistry fields have adopted this approach as a useful tool to impart dental education. The PUBMED database was used to retrieve the articles about the same using the search terms "Blended Learning" AND "dental education". The majority of the studies showed a positive response and a higher level of satisfaction in comparison to conventional teaching. However, certain studies also indicated no significant improvement in knowledge compared to conventional methods. Conventional methods will definitely continue to be the mainstay as certain themes cannot be dealt with otherwise. In such cases, blending online as well as traditional methods would give beneficial results while preserving the feel of the live personal interaction.

Keywords: Dental Education, Graduate, Educational Technology, Curriculum Innovation.

[a] dr.supriyabhat@gmail.com   https://orcid.org/0000-0002-4380-0214   [b] medhini.madi@gmail.com   https://orcid.org/0000-0002-5484-5960

Introduction

The scenario of dental education has witnessed numerous innovations incorporated to suit the requirements of a technological era. In the 21st century, the field of education demands that facilitators design diverse and novel approaches to stay akin to various pupils at any moment and at any place.[1] The most frequently used approach is the concept of blended learning (BL), which is an amalgamation of face-to-face and online modes of education.[2] It involves direct and indirect instruction, collaborative guidance and, individualized computer-aided learning.[3]

The traditional system of education definitely has its perks as it involves the much-needed face-to-face sessions and human touch. Only the face-to-face approach meets the affective objectives along with psychomotor and cognitive.[3] The COVID - 19 pandemic gave way to abrupt closure of Universities. This brought the traditional education system to an unprecedented complete halt owing to the impositions of lockdowns and difficulties in maintaining social distancing at schools. This paved the way to creating blended learning techniques as a mainstay in order to avoid the discontinuation of the teaching-learning process. More and more innovative blended learning resources were created involving technology to capture the attention of the students.[4] Learning can be made more effective via

this approach by eliminating the obstacles of time and duration. It enables the use of innovative methods of teaching and student-centered education.[5] E- learning is on the rise and reinforces learning by students in distinct ways while enabling a flexible environment.[6]

The term E-learning is universal; and encloses electronically compatible learning and teaching, which may or may not be online. It can be delivered either in the classroom or out of the classroom. It accomplishes self-paced or instructor-led learning involving variety of media in diverse forms like images, text, animation, audio and, video.[7] In this review, we explore about the different fields of dentistry and the way they have adopted the blended learning techniques as a useful tool to impart dental education. The PUBMED database was used to retrieve the articles pertaining to the same using the search terms "Blended Learning" AND "dental education". Full-text articles pertaining to undergraduate dental education were selected for the purpose of this review.

Blended learning has been defined by Rowe *et al.* as the systematic integration of online and face-to-face engagement to support and enhance meaningful interaction between students, teachers and resources.[8] It is context-dependent. A successful application of the approach in one domain may not be beneficial in another.[9] According to a meta-analysis conducted by Means *et al.* on

the effectiveness of online and blended learning, a course can be rendered "blended" when at least 25% of its content is made available online. In order to design a program, all the available media and technology should be considered, and their usage should be enhanced in order to meet the requirements of the learner.[10]

Blended Learning Models

A variety of blended learning models that are a combination of synchronous and asynchronous paterns are given below.

- Synchronous Physical Formats
- Synchronous Externally Directed Learning Formats
- Online Live e-learning formats that are Self-Paced and Asynchronous

Synchronous physical formats comprise of Instructor-led classrooms and lectures, Hands-on laboratory and workshop sessions, and Hands-on clinical training.

Synchronous Externally Directed Learning formats include virtual classrooms, webinars, broadcasts/podcasts, instant messaging, and e-meetings while self-paced online live e-learning formats include Documents and web pages, Web/computer-based training modules, Assessments/tests/surveys, Recorded live events, Online streaming and discussion fora, Simulated experiences, Job aids, and electronic performance support systems.[10] (Figure 1)

Blended learning provides the feel of a traditional classroom where there can also be scope for face to face interaction in the case of virtual live classes. The benefits of the virtual classroom are incomparable as the learning process can happen at any given time and place. The cyberspace is a forum where meetings happen with co-students and teachers beyond the geographical boundaries. Online audios and videos are available which utilisethe latest means of technology and explain variety of concepts in a manner appealing to students and are simple to understand. A webinar is an important tool which is an ICT supported format. It facilitates student participation in topics of their choice virtually. Various softwares are available which enable them to present their academic paper online and simultaneously participate in discussion via video conferencing. Online assessments are a vital part of the blended concept and are very useful in the transition of the evaluation system which is more formative, transparent, and quick. Hence all the above features blended together form the basis of blended learning.[3]

Blended Learning for Undergraduate Teaching in Various Branches of Dentistry

In dentistry, virtual learning and blended approach have been specifically reviewed in radiology as it involves working with digital images, and is quite apt for virtual viewing. It can also be utilized to assess the learners understanding of the subject, especially the anatomy of the oral structures and differentiating their appearance in a normal and a pathologic phenomenon, thus aiding to arrive at a diagnosis.[11]

A study conducted by Pacheco-Pereira C *et al.* on assessing the confidence of students in the interpretation of dental images subsequent to a blended learning approach revealed that the module had a positive impact. The students also mentioned the significance of including the detailed history of the patient along with findings of clinical examination as part of their image interpretation exercise.[12]

SYNCHRONOUS PHYSICAL FORMATS	Instructor-led classrooms and lectures, Hands-on laboratory and workshop sessions and Hands-on clinical training.
SYNCHRONOUS EXTERNALLY DIRECTED LEARNING FORMATS	Virtual classrooms, webinars, broadcasts/podcasts, instant messaging and e-meetings
ONLINE LIVE E-LEARNING FORMATS THAT ARE SELF-PACED AND ASYNCHRONOUS	Documents and web pages, Web/computer-based training modules, Assessments/tests/surveys, Recorded live events, Online streaming and discussion fora, Simulated experiences, Job aids and electronic performance support systems

Figure 1. Showing the Variety of Blended Learning Models.

Kavadella A *et al.* performed a study to evaluate the effectiveness of blended learning module for imparting oral radiology to undergraduate dental students as compared with that of a conventional method. They found that students' attitude towards the blended approach was positive, and they performed better than their counterparts in the traditional group in the evaluation test post the course. The authors also concluded that it could be included in the curriculum of undergraduate teaching of dental students for oral radiology.[13]Eachempati *et al.* conducted a study to analyze the impact of blended education in order to reinforce dental pharmacology during clinical years. Online sessions and face to face discussions replaced the traditional teaching hours in this study. Each session had a quiz, MCQ, or case scenario which addressed themes from dental pharmacology associated with orofacial pain and oral lesions. Their findings suggested that blended education can be effectively amalgamated into the undergraduate curriculum, and would also be agreeable when they move from preclinical to clinical years. The researchers also felt that the process was flexible and time-efficient.[14]

Nijakowski K *et al.* conducted a study to check the efficacy of blended learning in Conservative Dentistry and Endodontics amongst the undergraduate students (4th year) during the COVID 19 pandemic. The theory classes were conducted using online learning portals. And the practicals were performed with patient involvement following appropriate protocol. The students were very optimistic about the blended learning method and wanted the same to continue even after the pandemic.[15] Similar positive attitudes of the students was observed in a study conducted by Maresca C *et al.* where students learned and demonstrated the skills better than that of the traditional group.[16]

Bock *et al.* devised blended education units for lectures of oral and maxillofacial surgery. The students were pleased with the method and were specifically impressed with the operative videos displayed in the course of the lectures, which were a part of the module. A survey conducted by them post the module revealed that the majority of the students use online learning tools and actually preferred learning this particular way. They also concluded that integrating a blended approach with curriculum could meet the demands of the students of the present era, and thus help in the transition of long lectures into interesting and impactful ones.[17]

Retrouvey *et al.* were one of the earliest with a blended learning module in Orthodontics way back in 2008 with methodologies comparable to this day. Their main objective was bridging differences amidst theoretic information and clinical competencies using interactional multimedia programs. They also highlighted that these could be useful learning tools within and beyond the confines of the classroom. This was very well accepted by the students who could bring about the learning process at their own pace as well as knowledge application by indulging in various exercises of the program.[18]

A randomized trial was conducted by Bains *et al.* comparing parallel groups of electronic learning, face-to-face, and blended training among orthodontic undergraduates to evaluate the efficacy as well as student attitudes towards the approach. They inferred that Blended learning was more effectual when compared to other modes in delivering cephalometric education to undergraduates.[19]

Jeganathan S *et al.* conducted a randomized control trial on using blended modules supplementing instructor-guided seminars for undergraduate teaching in orthodontics. Though the method was successful and the students accepted it, they did not find any significant improvement in knowledge in the blended approach as compared to the traditional approach. And the level of satisfaction was similar for both approaches.[20]This meant that the blending approach could be as efficacious as traditional education and could be a good option to be slowly introduced as a mainstay into the current curriculum, especially in topics where the traditional approach cannot be used. Also, a study conducted on varying attitudes towards disabled people in undergraduate Special care dentistry program using blended approach stated that it did not cause a significant improvement in the attitudes of students.[21]This could be due to the simple reason that blended learning may not be beneficial in some domains.[9]

Ariana *et al.* conducted a study to compare the scores of dental students in histopathology after teaching the students using blended learning and compared them with those who received traditioal methods of training. The students who have had exposure to blended methods scored considerably better than those who had traditional methods alone. Their findings concluded that online tools for learning namely virtual microscopy and other innovative and interactive sources utilized for imparting pathology can be used to improve the performance, confidence, competence level and satisfaction among students.[22] A Blended learning approach utilized by Park *et al.*[23] in Dental Anatomy was well accepted by the students.

Reissmann *et al.* conducted a study evaluating the blended learning concept for a preclinical course of prosthodontics. The module is composed of three major components-key principles, additive information, and training outcome tests. Footages of the practical demonstration were uploaded online for the students to view. Also learning objective tests along with learning content were incorporated too. The evaluation of the students post this exercise was highly satisfactory.[24] Faraone *et al.* conducted a study using the blending techniques as a part of teaching pre-clinical prosthodontics. They wanted to test the hypothesis that this kind of approach would help establish competence in both pre-clinical as well as didactic learning. And that it required less supervision in comparison to the traditional approach.

Table 1. Showing the blended learning approaches followed in various programs of under graduation

Author	Year	Program	Method	Result
Retrouvey et al [18]	2008	Orthodontics	Bridging differences amidst theoretic information and clinical competencies using interactional multimedia programmes	Positive Well accepted by the students who could bring about the learning process at their own pace Efficient tool beyond the confines of the classroom
Bains et al [19]	2011	Orthodontics	Comparing electronic learning, face-to-face and blended training among undergraduates	Effectual when compared to other modes in delivering cephalometric education
Kavadella A et al [13]	2012	Oral Radiology	Effectiveness of blended learning module for imparting oral radiology to undergraduate dental students as compared with that of a conventional method.	Positive On evaluation, students performed better than conventional counterparts
Faraone et al. [25]	2013	Preclinical Prosthodontics	Test the hypothesis that BL would help establish competence in both pre-clinical as well as didactic learning	Positive Students performance was good and they were satisfied too.
Maresca C et al. [16]	2014	Preclinical Endodontics	Check if students who experienced BL demonstrated better manual skills & knowledge in comparison to traditional approach	Students learnt and demonstrated the skills better than that of traditional group
Phadraig et al. [21]	2015	Special care dentistry	Assessing changing attitudes towards disabled people using BL	No significant improvement in the attitudes of students
Park et al. [23]	2015	Dental Anatomy	Promotion of student centered learning with flipped classroom	Positive with respect to the synergistic and innovative mode of BL
Reissmann et al. [24]	2015	Preclinical Prosthodontics	Evaluating the blended learning concept	Positive Student evaluation post the feedback was highly satisfactory
Eachempati et al. [14]	2016	Dental Pharmacology	Analyse the impact of blended education in order to reinforce dental pharmacology during clinical years	Positive Can be effectively amalgamated into the undergraduate curriculum, agreeable when they move from preclinical to clinical years. Flexible and Time efficient
Ariana et al. [22]	2016	General Pathology	Compare the scores after teaching the students using BL with those who received traditional methods of training.	Positive Virtual microscopy can be used to improve the performance, confidence, competence level and satisfaction among students
Bock et al. [17]	2018	Oral and Maxillofacial Surgery	Implement students' requests for new teaching methods	Positive Aid in transition of long lectures into interesting and impactful ones
Pacheco-Pereira C et al. [12]	2019	Oral Radiology	Assessed the confidence of students in interpretation of dental images subsequent to a blended learning approach	Positive
Jeganathan S et al. [20]	2020	Orthodontics	Randomised control trial on using blended modules supplementing instructor guided seminars	Positive Accepted by students No significant improvement in knowledge in blended approach as compared to the traditional approach
Nijakowski K et al. [15]	2021	Conservative Dentistry and Endodontics	Check the efficacy of blended learning amongst final year students during the COVID 19 pandemic.	Positive The students wanted the same approach to continue even after the pandemic

The course material was made available online. Thus, it was possible to blend the conventional delivery of teaching material with an asynchronous method involving virtual lecture presentations and online demonstrations. Students were satisfied with blended learning and they concluded that with the help of a technological environment, this approach facilitated student- focused learning with the enhancement of didactic and laboratory skills.[25]

Advantages of Blended Learning

As the mode of instruction is online and is technology based, teachers have the creative freedom to use various strategies to explain a concept. The learning process of the students is unhindered while maintaining social interaction and the feel of traditional learning. Students become technologically sound and gain confidence which strengthens their professionalism. It also provides ample scope for communication.[3] It is possible to incorporate the benefits of personal communication in an offline classroom along with electronic learning. Thus, novel methods of instruction can be used to reach all potential learners regardless of the location and at any given time.[5]

Limitations

The main limitation is that no matter how realistic, simulating an environment created by traditional learning, especially face-to-face interaction will be challenging. Training of practical skills cannot be undertaken online. Technical obstacles can also be another limitation especially in case of an unstable internet connection or poor connectivity. Since students are learning from home, there will be higher chances of distraction, which can be a hindrance to the learning process.[26]

Future Perspective

The advancements in e-learning and technology have paved the way for an innovation in education enabling it to be individualized (adaptive learning), reinforcing interaction between the learners (collaborative learning) and revolutionizing the part of teacher from disseminator to facilitator.[27] The forthcoming e-learning packages may have scenario-based content and the difficulty level of the modules will be more as learners develop proficiency. Thus, the experience is personalized for every learner and will be more fascinating. The Face-to-face approach will continue by interactive lectures and networking events. Hence the blended approach will help us establish professionals in health care with the perfect harmony between knowledge, behaviour, and skills.[28] Predicting the future is not easy but the current trends may continue for a period of time and it is our duty as healthcare professionals to ensure that it is used wisely to avail the maximum benefits.[29]

Conclusions

The field of education is changing at a faster space and we often need to make the changes in our system of instruction in order to suit the requirements of the current generation of students. From the above review, it is clear that this approach has been accepted by the students as they found it innovative and highly satisfactory in comparison to traditional learning. However, certain studies also indicated that there was no significant improvement in knowledge in comparison to conventional methods. Conventional methods will definitely continue to be the mainstay as certain themes cannot be dealt otherwise. In such cases, blending online as well as traditional methods would give beneficial results, while preserving the feel of the live personal interaction. Undergraduate dental training also requires considerable interaction with the patient, which can only be possible by interaction but someamount of the training pertaining to the same could be imparted in a blended manner. In cases where blended learning gives a better edge over the conventional, it should be definitely implemented. Implementing this process is not an easy task as well. It needs a substantial amount of time and enormous efforts to design and create the modules, and also to capture the interest of the students. The transition should be gradual and with more and more methods incorporated and timely feedback by the learners would definitely help in establishing the foothold of blending concepts in the annals of the education sector.

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Cumhuriyet Dental Journal

Oromandibular Dystonia: An Update for Dental Professional

Shruthi Hegde[1-a]*, Vidya Ajila[2-b]

[1]*Department of Oral Medicine and Radiology, AB Shetty Memorial Institute of Dental Sciences (ABSMIDS), Deemed to be University, Mangalore, India.*
Corresponding author

Reviews

ABSTRACT

Oromandibular Dystonia (OMD) is a type of focal dystonia which affects the masticatory, cervical, facial, eyelid, laryngeal, and pharyngeal muscles. OMD patients may consult dentists with involuntary movement or spasm of the lips, tongue, involuntary jaw opening or closing, changes in the occlusion, slurred speech, drooling of saliva, difficulty in mastication, swallowing, and speaking. Due to the uncommon occurrence of OMD, this condition may be misdiagnosed and may lead the patients to exposure to unnecessary treatments. Thus, thorough knowledge regarding the features of OMD is essential for the dentists. This review will present the diagnosis and management of OMD, focusing on its signs and symptoms.

Keywords: Oromandibular Dystonia, Botulinum Toxin, Oral Appliances.

[a] drshruthihegde@yahoo.co.in   https://orcid.org/0000-0002-0744-5593   [b] drvidyaajila@nitte.edu.in   https://orcid.org/0000-0002-5744-9322

Introduction

Dystonia is a neurological disorder which is manifested as sustained involuntary muscle contractions leading to abnormal repetitive movements in various body parts.[1,2] Clinical presentation varies depending upon the affected musculature, severity and distribution.[3] The causative factor for this condition may be hereditary, birth-related, reaction to certain drugs, physical trauma, infection or poisoning.[4] According to the affected regions, dystonia can be categorized as focal, segmental, multifocal, and generalized.

Oromandibular Dystonia (OMD) is a type of focal dystonia which affects the masticatory, cervico-facial, eyelid, pharyngeal and laryngeal muscles.[5] OMD can have symptoms of involuntary movement/spasm of the lips, tongue, lip pursing involuntary jaw opening or closing. Muscle hyperactivity and resulting fatigue can cause muscle pain. Other symptoms noticed in orofacial region are dysphagia, dysphonia, deviation of the mandible, subluxation of the temporomandibular joint and intraoral soft-tissue trauma. Change in the occlusal relationship, excessive drooling, problems with mastication, swallowing, and speech may be noticed.[3,5-7] Due to the uncommon occurrence of OMD, this condition may be misdiagnosed and it may lead to unnecessary treatments. OMD patients may consult dental professionals with intraoral presentations and involuntary movements of jaw.

The aim of the present study was to perform a systematic review of the literature over the past 10 years in "PubMed" and "Science Direct" database for studies, case reports and reviews addressing signs and symptoms of OMD, diagnostic criteria and dental management of these patients.

Methods

This systematic review was prepared in accordance with the Preferred Reporting Items for Systematic Reviews and Meta Analyses (PRISMA) statement (Figure 1).[8]

Search Strategy

Literature search was carried out in "PubMed" and "Science Direct" database with search terminology "oromandibular dystonia" and "dental treatment". Data available from 2010 to 2020 were selected. English-language articles were chosen for the study. Review articles, clinical studies, single case reports and case series containing information regarding clinical features, diagnosis and management were included. In addition, the reference list of these articles was searched and those considered important were selected, as well. Only full text available was selected. Our search resulted in a total of 101 articles. In which 49 articles from PubMed database and 52 articles from Science Direct database. In our review 76 articles were excluded after reading the

title, abstract and duplication. Articles submitted to full-text analysis for eligibility were 25 of them. Out of which 21 articles fulfilled eligibility criteria. Studies included in final review for summarizing clinical features and management strategies used were 12 of them.

Results

Out of 12 studies included for final review following data were extracted: author, publication year, number of cases reported, age, gender, clinical features, treatment summary and outcome (Table 1).[4,7,9-17] The data was tabulated and the results recorded. Total of 89 patients with OMD were reported in 12 articles. Total of 44 female patients (49%) and 45 male patients (51%) were reported in the included studies. Age of the affected individuals ranged from 25 to 84 years. Out of 89 patients 82(92%) of them were treated with botulinum toxin A. Out of 8 studies reported use of botulinum toxin A for their patients, 6 studies reported improvement, one study reported complete improvement and in one study outcome was not reported. Other treatment modalities reported were dental prosthesis, occlusal stabilization appliance, occlusal splint, physical therapy and drugs such as baclofen, analgesics, anticholinergics, carbamazepine. All the studies reported improvement of symptoms.

Discussion

This systematic review was performed to evaluate clinical features, diagnostic criteria and dental management of cases reported with OMD from 2010 to 2020. Uncommon encounter of dental professionals with OMD patients in dental office may pose difficulty for diagnosis and treatment plan. Therefore, present review focuses on detailed discussion of the clinical features, etiology, classification, diagnosis, differential diagnosis, treatment and dental consideration of OMD patients.

According to the American Academy of Oral Medicine, OMD is a movement disorder associated with uncontrolled contraction of the affected muscles, leading to abnormal posture and functional difficulties, including psychosocial withdrawal.[18]

OMD is a rare condition. The incidence has been reported as 3.3 cases per million persons and prevalence is around 6.9 per 100,000 people. This systematic review also revealed only 89 reported cases of OMD over past 10 years. The onset of symptoms is usually seen in the age group of 40 to 70 years. In our study reported age range was 25 to 84 years. According to the literature women are commonly affected than men.[9,19] However, this review slight male predominance (51%) was noted.
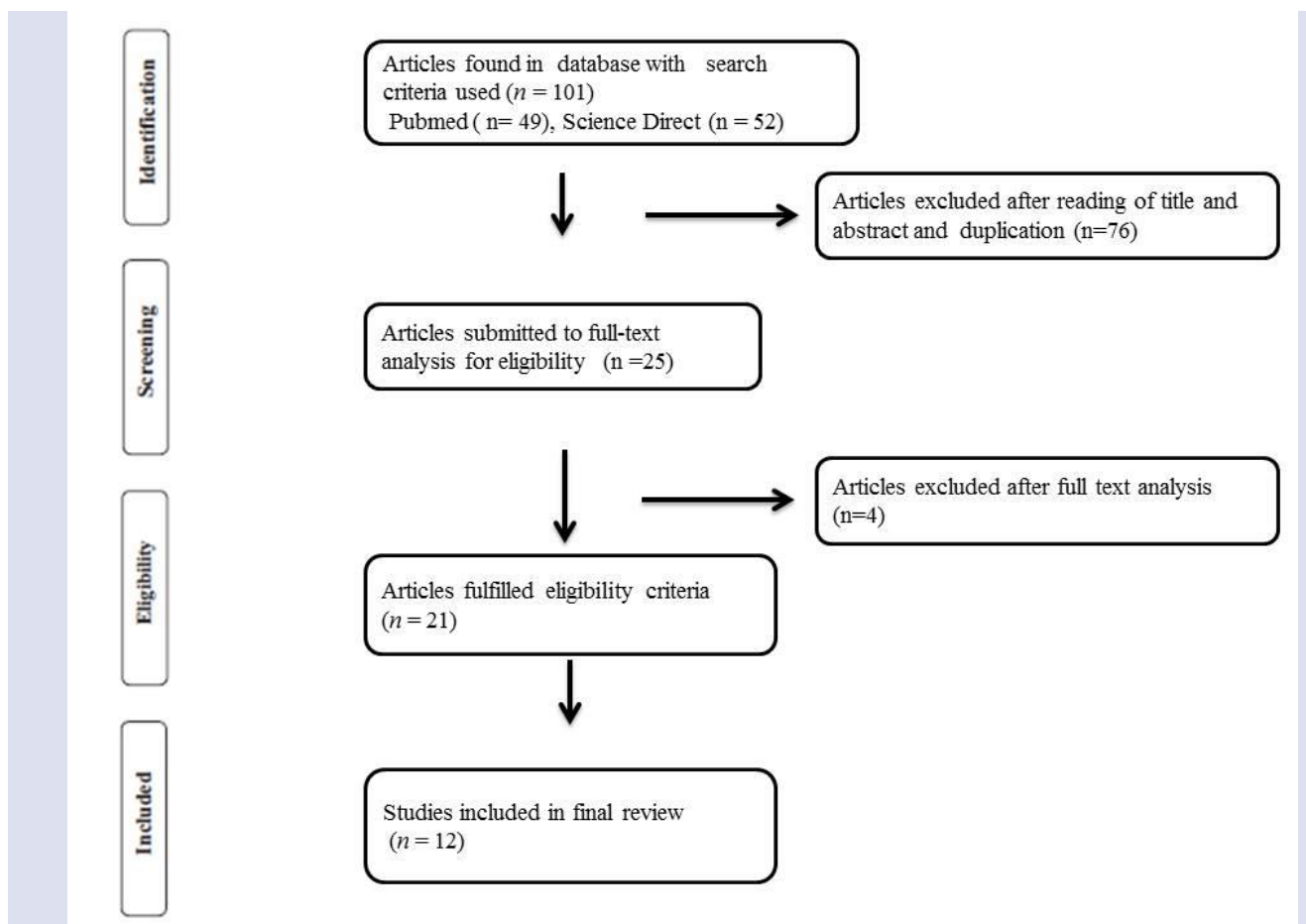

Figure 1. Search Strategy used according to PRISMA statement[8]

Table 1. Summary of Oromandibular dystonia cases reported in the last 10 years with clinical features, treatment protocols used and outcome

SN	Author year	NP	Age and sex	Clinical features	Summary of treatment protocol used	Outcome
1	Schneider R et al. (2011)[9]	1	60/Female	Abnormal speech and lisping involuntary movement of mandible, lips, and tongue	Dental prosthesis	Slight improvement of the symptoms but not complete resolution.
2	Jang SM et al. (2012)[4]	2	59/ Female	Abnormal jaw protrusive movement after dental extraction, severe dental attrition, unstable occlusion	Botulinum toxin A injection 30 units per muscle via an extraoral approach	Improvement
			57/ Female	Involuntary jaw tremor, limitation of mouth opening, and protrusive tongue movements following the extraction	Baclofen, analgesics, and occlusal stabilization appliance	Improvement
3	Bakke M et al. (2013)[10]	21	13 Female and 8 Male patients; age range 27-78years with mean age 56.7±12.7 years	Primary and secondary dystonia (13 focal, 7 segmental, 1 multifocal). Problems with mastication and swallowing, hyposalivation, dental attrition, and other dental problems	Intramuscular injection with botulinum toxin Details not reported	Not reported
4	Watt E et al. (2013)[3]	1	41/ Male	Involuntary oromandibular contractions	Removable dental appliances - Acrylic block/Splint	Provided beneficial effects
5	Pellecchia MT et al. (2014)[11]	1	53/ Female	Feeding difficulties Jaw opening dystonia	Botulinum toxin Injection 80 units of onabotulinum Toxin A in each lateral pterygoid muscle with EMG guidance Trihexyphenidyl (up to12 mg/day).	Effective in relieving jaw opening dystonia Improved tongue protrusion dystonia
6	Khan J et al. (2015)[12]	1	77/Female	Involuntary movements of the jaw, Preauricular pain during jaw Function, pain of the mandibular elevator muscles, Persistent twisting of lips, tongue movements	Temporary soft appliance was provided to protect the dentition initially later replaced with hard acrylic appliance 70 units of botulinum neurotoxin lateral pterygoid and orbicularis oris muscles	Reduction of 40% in involuntary Movements Reported complete improvement
7	Van Pelt-Sprangers MJ et al. (2015)[13]	1	56/Female	oromandibular dystonia due to capecitabine	Capecitabine discontinued anticholinergic drug	Improvement
8	Pedemonte C et al. (2015)[14]	30	Male Patients 18 to 65 years	Post-traumatic oromandibular dystonia bruxism, muscle pain, and involuntary muscle contraction	Use of Onabotulinum toxin A infiltration	Signs and symptoms decreased
9	TA Teemul et al. (2016)[15]	6	Female patients 45 to 82 years	Involuntary posterior mandibular movements during mastication, Movements of mandible and tongue, Bruxism, Chronic bilateral dislocation of the TMJ,	Botulinum toxin A 25U to affected masticatory muscles in majority of cases	Improvement
10	Gn S (2017)[7]	1	27/ Female	spontaneous, intermittent, unilateral paroxysmal, severely painful involuntary spasmodic contractions on the right half of face which lasted for 3–5 minutes, repetitive throughout the day	Carbamazepine 200mg BD dose	Complete absence of dystonic movements with improved quality of life
11	Yoshida K (2017)[16]	18	15 Female and 3 Male, mean age: 49.7 ± 16.0 [SD] years, age range: 25to 84 years)	dysarthria, masticatory disturbance, and muscle pain due to prolonged restricted mouth opening	Fifteen patients were treated by injecting botulinum toxin (Botox) into their masseter and temporal muscles. Bilateral coronoidotomy and masseter muscle stripping under general anesthesia combined with muscle relaxation	Overall Improvement in the patients' symptoms of 80.2%
12	Sude A et al. (2020)[17]	6	3/Female 3/Male The mean age 62 years (range 52-80 years)	Jaw Pain, teeth attrition, hyposalivation, and masseter hypertrophy	Botox injection affected muscles, Self-care, Physical therapy, Oral appliance, Health psychology	Improvement

SN: Sl Number; NP: Number of patients

Mastication and tongue muscles are most frequently affected in OMD causing involuntary jaw opening/closing movements, jaw deviation, tongue thrusting, lip pursing. Hyperactivity of muscles and masticatory muscle fatigue causes muscle pain. Orofacial region is affected with involuntary movements, soft-tissue trauma, dysphagia and dysphonia. Change in the occlusion and slurring of speech may be observed in some patients. Other symptoms such as excessive drooling, breathing difficulties, and sense of foreign material in the throat were reported. Symptoms are mild initially and become more evident over time.[12] The symptoms may be triggered by certain activities such as talking, mastication and also stress.[1] Due to OMD, damage to dental restorations, dentures, fracture of teeth, excessive dental wear can be seen in patients along with trauma to the lips, gums, and tongue.[1,20] This review revealed involuntary movements, bruxism, jaw pain, masticatory disturbance as common clinical presentation of individuals with OMD.

Bakke *et al.*[10] reported functional and clinical characteristics of 21 OMD cases in 2013. According to them different types of jaw movements were common. They noticed dystonic electromyography activity in anterior digastric muscle (62%) temporal and lateral pterygoid muscles (48%). Issues with mastication and swallowing were commonly found in their study. Other problems associated were hyposalivation, dental attrition, fractured filling, lack of molar support, denture adaptation.[10]

Dystonia can be classified according to etiology, anatomical location and age of onset.[15,20-22]

Classification of dystonia is described in Table 2. Etiology of OMD is not well known.[1] OMD can be classified as primary and secondary in nature. Dystonia is classified as primary if it is inherited or occurs in the absence of other clinical symptoms. Dystonia associated with another known disease is classified as secondary.[19]

The diagnosis of OMD is clinical. Due to its manifestation in various forms and severity, diagnosis of this condition is complicated. Even though this is a rare pathological entity in dental office, the dentist should be familiar with the symptoms to avoid misdiagnosis. A thorough medical history, clinical and neurologic examinations, and investigations such as electromyography is essential for the diagnosis of OMD.

Underlying pathology should be ruled out by magnetic resonance imaging of the brain and spinal cord. Preceding the onset of OMD, intermittent, involuntary jaw movements with interference of speech and mastication may be noticed by patients.[18,20]

Clinical examination should be carried out in relaxed position of jaw and during voluntary movement. This is essential as signs of OMD may not be there throughout. Lateral pterygoid, temporalis, masseter and anterior digastric muscles are commonly involved and muscles may be tender on palpation and hypertrophied**.**[20]

OMD mimics number of dental and medical conditions. Misdiagnosis results in progression of symptoms, incorrect treatment and iatrogenic harm. The differential diagnosis with TMJ disorders (condylar dislocation, bruxism), hemifacial spasm and psychological disorders is necessary. OMD induced bruxism usually stops while sleeping whereas idiopathic bruxism happens during sleep.[20]

OMD can be difficult to discriminate from neurological movement disorders. In Parkinson's disease tremor affects the jaw, mouth or tongue, and can cause clicking of teeth or eating difficulties. Observation of tremor occurrence timing may help to discriminate between the two. Parkinson's exhibits as a "rest" tremor (closed mouth position or open relaxed) and often stops with activities such as mouth opening or talking, whereas voluntary movements usually aggravate OMD.[20] Patients suspected with OMD should be referred to the appropriate health care provider for further evaluation and management.

There is no cure for OMD. Therapeutic management focusses on reducing the dystonic movements, improving patient's aesthetics, masticatory capabilities, swallowing function, and speech. The literature review suggests pharmacotherapy, botulinum toxin type A (BTX) injections, fabrication of occlusal appliances, surgery (peripheral and/or central), chemo denervation, physiotherapy, and occupational therapy as potential treatment options.[1,18,19] Various medications such as anticholinergics, antiparkinson drugs, anticonvulsants, dopamine receptor antagonists, levodopa and lithium were used in the management of OMD.[1]

Table 2. Classification of Dystonia 15,20-22

Classification criteria	Classification subgroup
Anatomical	• Focal: affecting just one part of the body, such as the lower face • Segmental: affecting two contiguous parts such as the lower face and neck • Multifocal: affecting two non-contiguous parts such as the lower face and foot • Generalised: involving the trunk and at least two other sites
Age of onset	• Early onset (infancy, childhood, and adolescence): Mostly secondary dystonia, due to genetic (DYT 1 mutation) or metabolic causes. • Adult onset (21–40 years of age): Idiopathic • Late adult onset (over 40 years of age): mostly idiopathic, few as part of neurodegenerative disorder.
Etiology	• Primary: Idiopathic, Inherited, Familial with genetic predisposition • Secondary: Peripheral trauma, Complication of operation, Diseases of the brain (Neurodegenerative disorders, Cerebral infarction) Drug-induced

Botulinum neurotoxin is the most effective treatment for symptomatic OMDs. Botulinum toxin type A injection is considered as highly effective treatment modality and it is safe. It blocks acetylcholine release at the presynaptic junction which produces transient weakening of the muscle activity. BTX injections have showed 90-95% response rate.[22] Teemul *et al.*[15] reported six patients treated with botulinum A toxin. They used extra oral approach wherein needle was directed through the sigmoid notch. A 40 mm needle of 21-gauge was used and mandibular condyle was identified by palpation on opening the jaw. The needle was inserted to 35-37mm depth from the surface of the skin which is the common position of the lateral pterygoid. They reported that their approach provided benefit for most patients. The injection effect lasted for 7-10 days. Patients were reviewed every three months and injections were repeated every 3-6 months. This systematic review presents the use of botulinum toxin in 8 studies involving 82 patients, which shows that majority of studies used botulinum toxin A for management of OMD. Improvement was noticed in Jang *et al.*[4], Pellecchia *et al.*[11], Pedemonte *et al.*[14], Teemul *et al.*[15], Yoshida[16], Sude *et al.*[17] studies. In Bakke *et al.*[10] study, outcome was not reported. Only Khan *et al.*[12] reported complete improvement. Khan *et al.*[12] first used appliance to protect the dentition which showed 40% reduction in involuntary movement followed by botulinum neurotoxin.

Other treatments include muscle afferent block using intramuscular injection of anaesthetic and alcohol.[22] Pellecchia *et al.*[11] reported a case of drug induced OMD and stated that anticholinergics drugs were effective in relieving tongue dystonia and combination of botulinum toxin injections and anticholinergics were helpful in treating mandibular dystonia.

Dental appliances such as bite block is used for treating OMD. It is custom made for each patient to help stability of jaw and position. Facial appearance, articulatory precision and hyperactive movement's improvement was observed with bite block therapy.[19] Watt *et al.*[3] reported a patient who presented with a 'sensory trick' that is patient symptoms were alleviated by occluding on a pen in between his premolar teeth. Watt *et al.*[3] constructed dental appliances to mimic that effect which was helpful for their patient.

Yoshida[16] suggested coronoidectomy as an effective procedure for patients with severe trismus and ineffective botulinum injection or muscle afferent block therapy. Operative therapies such as peripheral and central nervous system procedures are generally a last resort.[22]

OMD patients may present different clinical conditions to dentists with features of involuntary jaw movements and functional difficulties. Occlusal disturbance and denture retention issues challenge prosthetic treatment. Control of hyposalivation, prevention of dental attrition and fracture of dental restorations due to involuntary jaw movements is essential. Dystonic phenomena complicate dental care, therefore adaption to these special circumstances is required.[12] Jang *et al.*[4] reported two cases of OMD following extraction of lower posterior teeth. It is very important for the dental professional to be familiar with oromandibular dystonia, as it can develop after dental treatment. This condition is often misdiagnosed as a dental problem which may cause significant functional and psychosocial disability.

Conclusions

Oromandibular dystonia is a very rare clinical entity encountered by dental professionals. Diagnosis is very important for the prompt treatment. Since it presents with various forms and different degrees of severity, OMD poses a challenge for dental professionals. Diagnosis requires thorough knowledge and multiple investigations.

Acknowledgements

Conflicts of Interest Statement

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