NEU PRESS

Diş Hekimliği Dergisi

Vol: 6 Special Issue Year: 2024 Research Article e-ISSN: 2687-5535

https://doi.org/10.51122/neudentj.2024.116

Marginal Bone Loss and Clinical Evaluation of Angled Implants: A Retrospective Study

Beyza ÖZTAŞ[1*] Doğan Ilgaz KAYA[2]

[1] Res. Ass., Karamanoglu Mehmetbey University, Ahmet Kelesoglu Faculty of Dentistry, Maxillofacial Surgery, Karaman, Türkiye, beyzadonmez@kmu.edu.tr

[2] Ass. Prof., Karamanoglu Mehmetbey University, Ahmet Kelesoglu Faculty of Dentistry, Maxillofacial Surgery, Karaman, Türkiye, doganilgaz@kmu.edu.tr

Article Info

Article History

Received: 30.06.2024
Accepted: 04.09.2024
Published: 15.10.2024

Keywords:
Angled implant,
Dental implant,
Marginal bone loss.

ABSTRACT

Aim: The volume of the edentulous crest and its proximity to critical anatomical structures are important limiting factors for implant surgery. Surgical procedures with complications can be avoided by placing angled implants. The aim of this clinical study was to evaluate marginal bone loss and the complications of angled implants.
Materials and Methods: Fifty-eight dental implants were examined in 32 patients (16 females, 16 males) with cone beam computed tomography (CBCT) images from patients with angled implants and complete edentation. The marginal bone loss in angled implants that were functional for 15 to 30 months was evaluated according to factors such as implant angle, connection type, opposing arch restoration type and planning of superstructure restoration. Marginal bone loss measurements were recorded from CBCT sections.
Results: It was determined that 3.44% of the implants placed had an inclination of less than 15°, 75.86% had an inclination between 15° and 30° and 20.68% had an inclination of more than 30°. While there was no marginal bone loss on the mesial and distal surfaces, the average marginal bone loss was 0.66 on the buccal surfaces and 0.93 in the lingual region. Only one of the implants examined failed. No pain or infection was observed in any of the implants examined.
Conclusion: According to the results of this retrospective clinical study, further clinical studies with larger sample sizes are needed to evaluate angled implants supported by full arch fixed prostheses as a predictable and valid treatment method in the prosthetic rehabilitation of edentulous jaws.

Açılı Yerleştirilmiş İmplantların Marjinal Kemik Kaybı ve Klinik İncelenmesi: Retrospektif Çalışma

Makale Bilgisi

Makale Geçmişi

Geliş Tarihi: 30.06.2024
Kabul Tarihi: 04.09.2024
Yayın Tarihi: 15.10.2024

Anahtar Kelimeler:
Açılı implant,
Dental implant,
Marjinal kemik kaybı.

ÖZET

Amaç: Dişsiz kretin hacmi ve kritik anatomik yapılara komşuluğu, implant cerrahisinin önemli limitleyicilerdendir. Açılı implantlar yerleştirilerek komplikasyonlara sahip cerrahi işlemlerden kaçınılabilmektedir. Bu klinik çalışmanın amacı açılı yerleştirilmiş implantların marjinal kemik kaybını ve komplikasyonları değerlendirmektir.
Gereç ve Yöntem: Açılı implant yerleştirilmiş hastalardan konik ışınlı bilgisayarlı tomografi (KIBT) görüntüleri bulunan, tam dişsizliğe sahip 32 hastada (16 kadın-16 erkek), 58 dental implant incelenmiştir. 15 ila 30 aylık süre boyunca fonksiyonda olan açılı implantlarda meydana gelen marjinal kemik kaybının implant açısı, bağlantı tipi, karşıt ark restorasyon tipi ve üst yapı restorasyonunun planlanması gibi faktörlere göre değerlendirilmesi yapılmıştır. Marjinal kemik kaybı ölçümü KIBT'tan alınan kesitlerden kaydedildi.
Bulgular: Yerleştirilen implantların %3,44'u 15° den daha az eğimli, % 75,86'ı 15°- 30° eğimleri arasında, %20,68'i 30° den fazla eğimde olduğu belirlenmiştir. Mesial ve distal yüzeylerde marjinal kemik kaybı yokken bukkal yüzeylerde ortalama 0,66 lingual bölgede 0,93'dür. İncelenen implantların sadece bir tanesinde başarısızlık gözlenmiştir. İncelenen hiçbir implantta ağrı, enfeksiyon gözlenmedi.
Sonuç: Bu retrospektif klinik çalışmanın sonuçlarına göre, tam dişsiz çenelerin protetik rehabilitasyonunda, tam ark sabit protezlerle desteklenen açılı implantların öngörülebilir ve geçerli bir tedavi yöntemi olarak değerlendirilebilmesi için daha büyük örneklem büyüklüğüne sahip ileri klinik çalışmalara ihtiyaç vardır.

To cite this article: Öztaş B, Kaya DI. Marginal Bone Loss and Clinical Evaluation of Angled Implants: A Retrospective Study. NEU Dent J. 2024;6(Special Issue):60-9. https://doi.org/10.51122/neudentj.2024.116

***Corresponding Author:** Beyza ÖZTAŞ, *beyzadonmez@kmu.edu.tr*

INTRODUCTION

The use of implant-supported prostheses is increasing because they offer a permanent, successful and safe treatment option for patients with total and partial edentulism.[1] During implant placement, the treatment option is determined by looking at the quantity and quality of the alveolar crest. In cases with advanced resorption, maxillary sinus pneumatisation, the presence of a nasal cavity adjacent to the implant placement sites, and proximity of the lower alveolaris crest are characteristics of standard dental implant placement.[2,3] According to the original Brånemark System, implants should be placed at a parallel angle.[4] As stated in this system, patients with resorbed crests require long distal cantilever prostheses and bone augmentation to provide acceptable chewing capacity in the molar region with standard implant placement. However, cantilever extensions longer than 15 mm are known to be associated with increased implant failure rates.[5] Various treatment options, such as inferior alveolar nerve transposition and bone grafting techniques, can be used to avoid this problem.[6,7] These techniques have shown successful results in the long term. However, they cause various biological and technical disadvantages, such as morbidity at the graft recipient site, post-procedural discomfort, increased treatment time and difficulty of surgical procedure.[8]

Researchers have attempted to find suitable alternatives to the procedures described above to avoid the additional surgical procedures and complications that would be required to place standard straight implants in atrophic jaws.[9] In 1993, Dr Paulo Malo developed the "All-on-Four" concept, in which two parallel implants are placed on premaxilla and two implants are placed in the molar region at an angle of 35-40 degrees.[10] Angling the implants allows longer implants to be placed in the molar region. In addition, placing the implants in this way increases the contact surface of the implants and leads to successful results in implant stability. The coronal parts of the implants are shifted more distally and the distance between the two implants increases compared to straight implants. As a result, the cantilever length of prosthetic restorations is reduced or may even disappear completely. This results in a more uniform and balanced force distribution in the anterior-posterior direction.[11] Although researchers and clinicians have reported that angled implants have been used with varying success over time, the efficacy and suitability of angled implants, particularly for the treatment of patients with severely resorbed alveolar bones, is still a matter of debate.[2,8] The purpose of this study was to evaluate the marginal bone loss level and clinical success of angled dental implants placed in edentulous areas. This study was designed according to the hypothesis that angulated implants used in edentulous jaws would have minimal marginal bone loss and a low complication rate.

MATERIALS AND METHODS

This paper was carried out with the permission of the 'Mehmetbey University Non-Pharmaceutical and Medical Device Ethics Committee dated 26.03.2024, with the permission being obtained by following up on the patients who received implant treatment at the Ahmet Keleşoğlu Faculty of Dentistry (Decision No: 03-2024/06). The study was designed retrospectively and was conducted in accordance with the 1975 Helsinki Declaration, as revised in 2013.

This research with 16-30 months follow-up was performed on 32 patients (58 implants) with complete edentulism in the maxilla and/or mandibula, aged between 25 and 67 years (mean:56). Inclusion criteria were patients older than 18 years of age, patients with no systemic contraindications to surgery, patients with edented jaws, patients

who would have required a bone grafting procedure for implant placement but who refused any bone grafting procedure and patients who had radiographic images immediately after the procedure and at follow-up sessions. Exclusion criteria included patients with bleeding problems, coagulation disorders, the presence of immune system diseases, uncontrolled diabetes mellitus, metabolic bone disease, patients who were pregnant or breastfeeding, and patients who had undergone radiotherapy to the maxillofacial region or had received chemotherapy within the last 12 years. The patients included in the study had angled dental implants performed in a two-stage procedure by the same surgeon (DIK). The angled placement of the implants was done free-hand, without using a guide. For this reason, cone beam computed tomography (CBCT) was taken after the procedure to check whether important anatomical structures close to the implant areas were damaged. Marginal bone loss was measured by two different maxillofacial surgeons (BO, DIK) using CBCT taken after the procedure and during the control session. In case of disagreement, it was re-evaluated and discussed, and the radiologist was consulted as a third researcher (SS). In case of disagreement, the measurements were re-evaluated and discussed, and the radiologist was consulted as a third researcher (SS). Consensus was achieved on the measurements. Radiological images were obtained with Kavo OP3d Pro (PaloDEx Group Oy, Tuusula, Finland) using the parameters of 90 kV, 8 mA exposure setting, exposure time 17.5-26.9 s, 13×15 cm field of view (FOV), and voxel size 0.320 mm. Calibration control was performed by comparing the actual length of the implant applied to the patient to the implant length measured on the radiograph. Marginal bone loss calculation was recorded by measuring the distance in mm between the implant neck level in the buccal, lingual, mesial and distal regions and the first point where the bone contacts the implant surface in cross-sectional sections taken from CBCT (Figure 1).

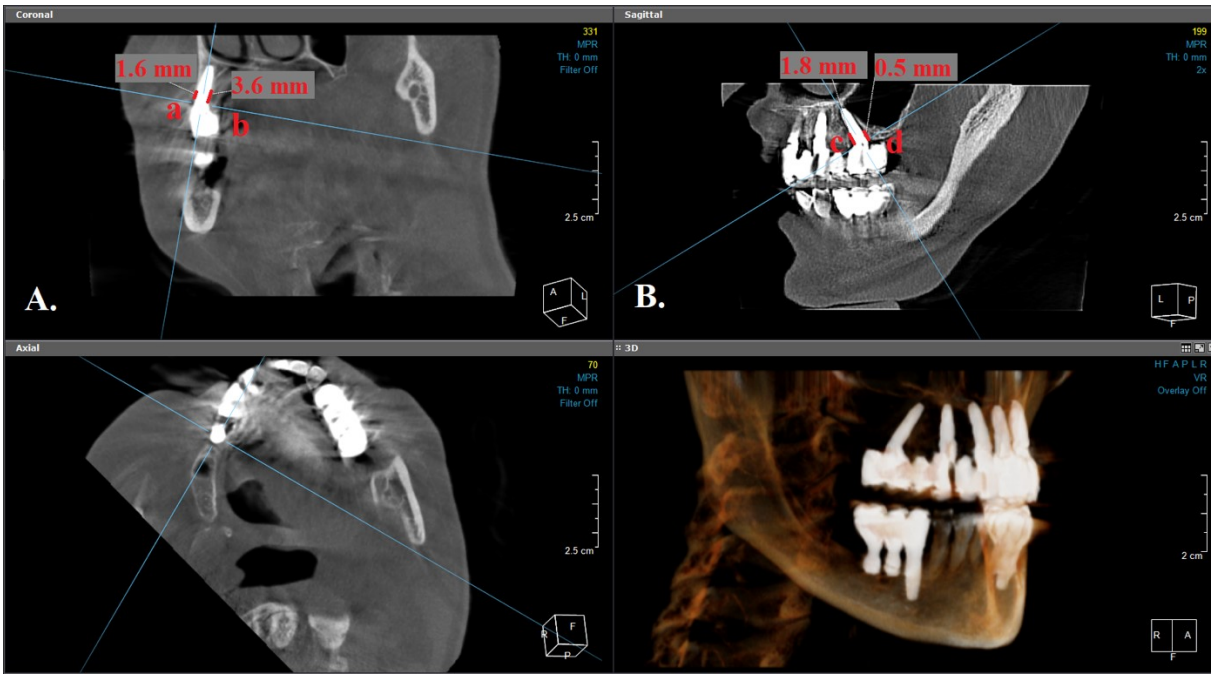

Figure 1. Marginal bone loss calculation was recorded by measuring the distance in mm between the neck level of the implant and the first point where the bone contacted the implant surface in cross-sectional sections taken from CBCT. A. In the coronal section, bone loss was measured in the buccal (a) and lingual (b) regions. B. In the sagittal section, bone loss in the mesial (c) and distal (d) regions was measured.

Implant angles were determined by calculating the angle between the long axes of two virtual implants placed using the implant planning program (OnDemand3D version 1.0.7462 software, Cypermed Inc., Seoul, Republic of Korea). (Figure 2)

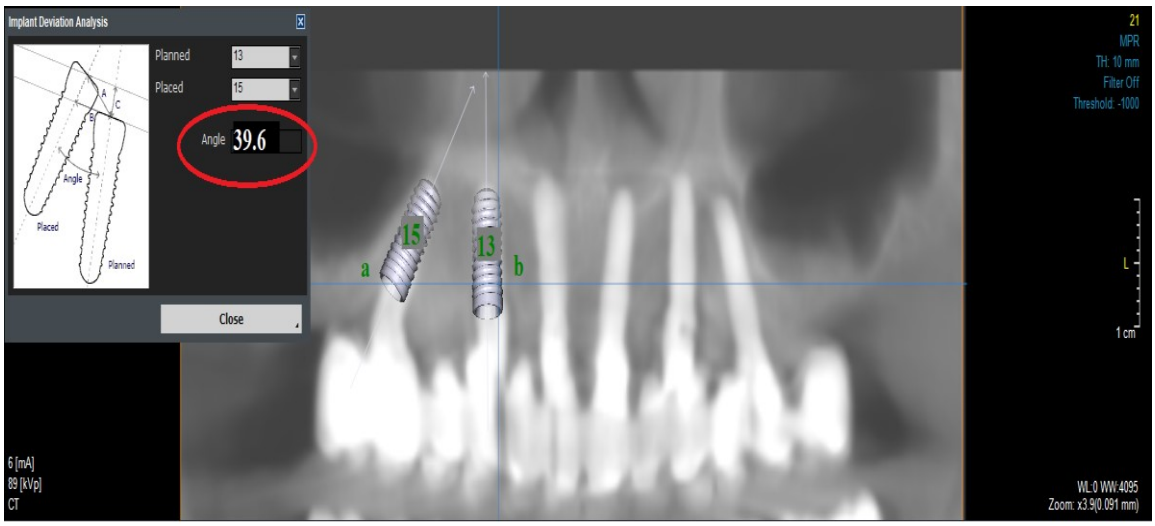

Figure 2: Implant angulation was determined by calculating the angle of the long axis of the two virtual implants (a, b) relative to each other using the tools in the implant planning programme (OnDemand).

An intraoral examination was performed to evaluate the clinical success criteria and possible complications of the implants. The criteria used to determine implant success were those proposed in the study of Buser et all.[13] and revised by Albrektsson and Zarb.[14] According to these criteria, the following conditions must be met for an implant to be successful: (1) Absence of sensory problems such as persistent pain, dysesthesia, or paresthesia at the implant site. (2) Absence of peri-implant infection with or without suppuration (inflammation). (3) Absence of implant mobility. (4) Absence of peri-implant bone resorption (>1.5 mm) within the first year after implant loading and persistent bone resorption (more than 0.2 mm/year) in subsequent years. Implants are considered successful if all of these criteria are met. In addition, other possible problems, such as soft tissue complications, significant bone loss, radiolucency (radiographic signs) around the implant and prosthesis-related complications, were recorded. An evaluation of the success rates and possible complications of implants was thus conducted.

Statistical analysis

Firstly, demographic variables are presented with percentages. Numerical variables are summarized with means and standard deviations. The qualitative variables are shown with frequencies and percentages. For each parameter to be evaluated, normality analysis and the Kolmogorov-Smirnov test were performed for homogeneity of variances. For parameters that did not show normal distribution, the non-parametric Mann–Whitney U test and Kruskal–Wallis test were applied. For all analyses, a statistical significance level of 0.05 was used. Statistical analyses were performed using the IBM SPSS Statistics 20.0 computer program (IBM Corp. Released, 2011). IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp., USA).

RESULTS

It was determined that 16 (50%) of the individuals included in the study were female and 16 (50%) were male. A total of 58 implants that were angled relative to the adjacent implant and met the inclusion criteria were identified (Table 1).

Table 1: Descriptive statistics

Sex			
Male		16(%50)	
Female		16(%50)	
The arch where the implant is inserted			
Maxilla		40(%68.9)	
Mandible		18 (%31.1)	
Insertion Angle (°)	26.2±6.1		24.9 [13-41.6]
Diameter of the implant (mm)	3.9±0.2		4.1 [3.5 -4.1]
Length of Implant(mm)	11±0.9		11 [10 -12]
Connection Type			
Multiunit		34 (%58.6)	
Cemented		24 (%41.4)	
Follow-up Period(month)	23.2±4.9		25 [16 -30]
Opposite Arc Condition			
Implant Mounted Restoration		40 (%68.9)	
Tooth		8 (%13.7)	
Crown and Bridge Restoration		10 (%17.4)	
Number of Superstructure Parts			
One Piece		42 (%72.4)	
2 Piece		12 (%20.6)	
3 Piece		4 (%7)	

Descriptive statistics are expressed as mean ± standard deviation or median [min -max] for numerical variables and (%) for categorical variables.

Of the implants placed, 4 were Straumann® (Straumann, Switzerland), 4 were Medentika® (Medentika, Germany) and 50 were NucleOSS (NucleOSS, Türkiye). Forty of the implants were in the maxilla and 18 were in the mandible. The average angle of the examined implants was 26.2±6.1 (min 13˚ max 41.6˚), the average length was 11±0.9 (min 10 mm, max 12mm) and the average diameter was 3.9±0.2 (min 3.5 max 4.1). Thirty-four (58.6%) of the restorations were multiunit and 24 (41.4%) were of the cemented type. The mean follow-up period of the implants examined was determined as 23.2±4.9 months. Prosthetic restorations of implants placed in completely edentulous mouths were delivered in one piece (72.4%), two pieces (20.6%) and three pieces (7%). It was observed that 1 of the 58 implants examined did not osseointegrate after 3 months; therefore, this implant was renewed, while the remaining 57 implants were successful according to the success criteria of Buser and his team.[12] It was observed that two implants underwent restoration renewal due to abutment implant connection screw fracture at the end of 14 months. Cheeping was observed in the prosthetic restorations of 8 of the 32 patients examined. While no pain or infection was observed in any of the 32 patients studied, decementation was observed in the restorations of 6 participants.

In the comparison of the marginal bone loss of angled implants placed in the maxilla or mandible, no statistically significant difference was found between the two groups ($p>0.05$). When the implants examined were grouped according to their placement angles as <15°, 15-30° and >30°, no statistically significant difference was found between the marginal bone loss in the groups ($p>0.05$) (Table 2).

When the implants were classified according to the connection type with the prosthetic restoration (multiunit/cemented abutment) and the changes in marginal bone levels were examined, no statistically significant difference was found ($p>0.05$).

Table 2: Descriptive statistics for the amount of marginal bone loss

	Implant Surfaces			
	Buccal	**Lingual**	**Mesial**	**Distal**
Location Arc				
Maxilla	0.48±1.19	0	0	0
Mandible	1±1.3	0.3±0.6	0	0
p values	0.295*	0.365*	0	0
Insertion Angle				
<15°	0	0	0	0
15-30°	0.8±1.3	0.07±0.3	0	0
>30°	0.2±0.6	0.1±0.4	0	0
p values	0.652**	0.609**	0	0
Connection Type				
Multiunit	0.7±1.2	0.1±0.4	0	0
Cemented	0.5±1.3	0	0	0
p values	0.711*	0.616*	0	0
Opposite Arc Condition				
Implant Mounted Restoration	0.3±0.8	0.05±0.2	0	0
Tooth	1.5±1.7	0.4±0.8	0	0
Crown and Bridge Restoration	1.3±1.8	0	0	0
p values	0.138**	0.266**	0	0
Number of Superstructure Parts				
One Piece	0.5±1.1	0.1±0.4	0	0
2 Piece	1.1±1.7	0	0	0
3 Piece	0	0	0	0
p values	0.545**	0.674**	0	0

Mann Whitney U * Kruskal Wallis ** Descriptive statistics are presented as mean ± standard deviation.

When marginal bone loss was compared with the prosthetic restoration of the implant placed at an angle in occlusion according to the opposing arch condition (tooth, fixed crown bridge restoration, implant-supported restoration), no correlation was found. ($p>0.05$) There was no statistical difference between the number of pieces of the prosthetic restoration and marginal bone loss ($p > 0.05$) (Table 3).

Tablo 3: Descriptive statistics for the amount of marginal bone loss

	Implant Surfaces			
	Buccal	**Lingual**	**Mesial**	**Distal**
Follow-up Period(month)				
12-19 month	0.2±0.6	0.1±0.4	0	0
20-27 month	1.3±1.5	0.1±0.4	0	0
28-36 month	0	0	0	0
p value				
12-18 month / 26- 36 month	0.562**	0.473**	0	0
12 -18 month / 19 -25 month	**0.010****			
19 -25 month / 26 -36 month	0.113**			

Kruskal Wallis ** Descriptive statistics are presented as mean ± standard deviation. P value in bold indicates a statistically significant difference ($p<0.05$).

According to the results of the study, the relationship between marginal bone loss at the 36-month follow-up was found to be of low statistical significance ($p<0.05$). Marginal bone losses evaluated in the 12-19/20-27/28-36 follow-up periods did not show statistically significant differences on the lingual, mesial or distal surfaces ($p>0.05$). Marginal bone loss on the buccal surface differed significantly between 20-27 and 28-36 months ($p=0.010$).

DISCUSSION

Pneumatization of the maxillary sinus and inferior alveolaris nerve can create anatomical limitations due to bone loss in toothless jaws, which can create difficulties when placing standard implants. This challenge increases the incentive to use angled implants, an alternative surgical technique.[14] While angled implants are applied mesially or distally to the borders of the maxillary sinus in the maxilla, they can be placed in the area between the mental foramen in the mandible. These angled implants are used to overcome anatomical difficulties and increase implant stability.[15] This approach aims to minimize anatomical restrictions caused by bone loss, reduce patient discomfort and costs and optimize the treatment process.[16] In this study, the clinical success of implants and marginal bone loss after fixed prosthetic restoration loading were evaluated in patients who had angled implants placed for different reasons.

The survival rate of the implant is an important success parameter in implant treatment. In the current study, 1 out of 58 angled implants evaluated had implant loss, resulting in a survival rate of 98.3%. A single implant loss occurred before the prosthesis was loaded and an angled implant was re-placed in the adjacent area. No loss was observed in the implant loaded with the prosthesis. Charcnavic et all. found implant loss in 82 (1.63%) of the 5029 angled implants they examined in a meta-analysis.[17] This data showed results compatible with the present study. Similarly, Pomares et all.[18] and Maló et all.[19,20] reported a survival rate of 93%–100% during their follow-up period in their studies on angled implants. Considering these studies, angled dental implants can be regarded as a good alternative in the long term due to their low risk of complications in atrophic jaws and high survival rates.

Marginal bone loss around dental implants plays a critical role in determining the effectiveness of implant treatment.[21] A review of the literature reveals that periapical and panoramic radiographs are frequently used to determine marginal bone loss.[22] Periapical radiographs taken with the parallel technique are considered to be a reliable measurement method for detecting marginal bone loss.[23] However, conventional two-dimensional (2D) intraoral radiographs are inadequate for buccal/lingual bone imaging.[22] When compared with different marginal bone loss measurement methods in vitro and in vivo, CBCT has been reported to be quite accurate in measuring buccolingual width.[23,24]

In this research study, a retrospective study was designed using postoperative cone beam computed tomography (CBCT) images to evaluate the relationship of angled implants with adjacent anatomical structures and adjacent implants.

Barnea et all. found that the degree of angulation was significantly associated with marginal bone loss for angled implants.[25] Each additional 10˚ of implant angle was associated with 0.6 mm of marginal bone loss. Rosen and Gynther recorded a 97% success rate with the placement of 103 curved implants in a study with up to 12 years of follow-up.[26] The mean marginal bone loss was 1.2 mm. These authors produced angled implants in resorbed jaws as an alternative to bone grafting. In this study, no significant difference was observed in the evaluation of implants with different angles in terms of marginal bone loss.

In the control sessions of the patients included in the study, porcelain fracture was the most common condition compared to other factors. In a prospective study conducted by Krennmair et all., they found porcelain fractures in the prostheses of 10 out

of 24 patients following prosthetic restorations supported by angled implants.[27] Chochlidakis K. et all.[28] also examined the proretic complications of implant-supported restorations in their study and stated that the most common situation encountered was porcelain fracture in prostheses. In this study, porcelain fractures were detected in 8 of the 32 patients examined. This result may be due to the lack of standardization in the clinical and laboratory processes of the restoration or the fact that it was not applied by the same physician, which seems to be consistent with the literature.[28]

Marginal bone losses evaluated in the follow-up periods in the study did not show statistically significant differences on the lingual, mesial or distal surfaces. This result was found to be supported by other studies in the literature.[17,26] However, marginal bone loss on the buccal surface differed significantly at 20-27 and 28-36 months, which may be associated with inadequate buccolingual bone thickness.

Repeated CBCT scans may lead to an increase in the total radiation dose, which may increase health risks in the long term.[29] In addition, repeated CBCT scans may increase radiation exposure, which may not be clinically necessary in most cases.[30] As stated in our study, since implants were applied without using a guide, CBCT scans were performed immediately after the procedure to check whether important anatomical structures were damaged. In addition, a single CBCT image is used in control sessions if the physician requires it. In our study, only patients who had CBCT records taken at two different periods were evaluated.

Cone beam computed tomography images may vary depending on technical parameters. Artifacts may occur in the images due to scattering from high-density metal around the dental implant, which may pose difficulties in measuring accuracy.[21] Incorrect measurements may be made as a result. Our study has some limitations and these need to be addressed in future research. First of all, longer follow-up periods are needed to better understand the long-term results of angled implants. Secondly, to confirm the findings of the present study and improve the generalizibility of the results, future studies ought to be carried out with larger sample groups.

In measurements using CBCT, artifacts originating from high-density materials may affect measurement accuracy. Standardization of imaging protocols and the use of advanced image processing techniques may help to overcome this problem. Variability in prosthetic restoration techniques and lack of standardization in clinical and laboratory processes are also significant limitations. The frequent occurrence of prosthetic complications, such as porcelain fracture, in our study is evidence of this. Standardization of prosthetic procedures and ensuring consistency among different practitioners may increase the reliability of results.

CONCLUSION

Within the limitations of the study, angled dental implants can be used successfully in cases requiring additional surgical bone augmentation with insufficient alveolar bone height to accommodate long dental implants. In conclusion, although angled implants appear to have a high success rate in the short term, longer follow-up periods, larger sample groups, standardized imaging and prosthetic procedures wouldincrease the reliability and validity of future studies.

Ethical Approval

The necessary ethical approval for this study was received by the Karamanoğlu Mehmetbey University Non-Pharmaceutical and Medical Device Ethics Committee (Decision no: 03-2024/06).

Financial Support

No financial support was received from any institution or organization for this study.

Conflict of Interest

The authors deny any conflicts of interest related to this study.

Author Contributions

Design: BÖ, DIK, Data collection or data entry: BÖ, Analysis and interpretation: DIK, BÖ, Literature review: BÖ, DIK, Writing: BÖ.

REFERENCES

1. Lemos CA, Ferro-Alves ML, Okamoto R, Mendonça MR, Pellizzer EP. Short dental implants versus standard dental implants placed in the posterior jaws: a systematic review and meta-analysis. J Dent. 2016;47:8-17.
2. Malo P, de Araújo Nobre M, Lopes A, Moss SM, Molina GJ. A longitudinal study of the survival of All-on-4 implants in the mandible with up to 10 years of follow-up. J Am Dent Assoc. 2011;142:310-20.
3. Chrcanovic BR, Kisch J, Larsson C. Analysis of technical complications and risk factors for failure of combined tooth-implant-supported fixed dental prostheses. Clin Implant Dent Relat Res. 2020;22:523-32.
4. Ramezanzade S, Aeinehvand M, Khurshid Z, Keyhan SO, Fallahi HR, Abbasi A. Treatment options for oral rehabilitation of the atrophic maxilla: a literature review. Avicenna J Dent Res. 2023;15:122-33.
5. Schmid E, Roccuzzo A, Morandini M, Ramseier CA, Sculean A, Salvi GE. Clinical and radiographic evaluation of implant-supported single-unit crowns with cantilever extension in posterior areas: a retrospective study with a follow-up of at least 10 years. Clin Implant Dent Relat Res. 2021;23:189-96.
6. Vinci R, Teté G, Lucchetti FR, Capparé P, Gherlone EF. Implant survival rate in calvarial bone grafts: a retrospective clinical study with 10-year follow-up. Clin Implant Dent Relat Res. 2019;21:662-8.
7. Eshaweirf E, Sougei A. Short dental implants versus standard dental implants placed in the posterior jaws. Int J Med Arts. 2023;5:3572-82.
8. Gherlone EF, D'Orto B, Nagni M, Capparè P, Vinci R. Tilted implants and sinus floor elevation techniques compared in posterior edentulous maxilla: a retrospective clinical study over four years of follow-up. NATO Adv Sci Inst Ser E Appl Sci. 2022;12:6729.
9. Del Fabbro M, Pozzi A, Romeo D, de Araújo Nobre M, Agliardi E. Outcomes of fixed full-arch rehabilitations supported by tilted and axially placed implants: a systematic review and meta-analysis. Int J Oral Maxillofac Implants. 2022;37:1003-25.
10. Asawa N, Bulbule N, Kakade D, Shah R. Angulated implants: an alternative to bone augmentation and sinus lift procedure: a systematic review. J Clin Diagn Res. 2015;9:ZE10-ZE13.
11. De Vico G, Bonino M, Spinelli D, Schiavetti R, Sannino G, Pozzi A, et all. Rationale for tilted implants: FEA considerations and clinical reports. Oral Implantol. 2011;4:23-33.
12. Buser HP, Dula K, Lang NP. Tissue integration of non-submerged implants: 1-year results of a prospective study with 100 ITI hollow-screw and hollow-cylinder implants. Clin Oral Implants Res. 1990;1:33-40.
13. Albrektsson T, Zarb GA. Determinants of correct clinical reporting. Int J Prosthodont. 1998;11:355-61.
14. Agliardi E, Panigatti S, Clericò M, Villa C, Malò P. Immediate

rehabilitation of the edentulous jaws with full fixed prostheses supported by four implants: interim results of a single cohort prospective study. Clin Oral Implants Res. 2010;21:459-65.

15. Ata-Ali J, Peñarrocha-Oltra D, Candel-Marti E, Peñarrocha-Diago M. Oral rehabilitation with tilted dental implants: a meta-analysis. Med Oral Patol Oral Cir Bucal. 2012;17:7.

16. Sharaf MA, Wang S, Mashrah MA, Xu Y, Haider O, He F. Outcomes that may affect implant and prosthesis survival and complications in maxillary fixed prosthesis supported by four or six implants: a systematic review and meta-analysis. Heliyon. 2024;10:e24365.

17. Chrcanovic BR, Albrektsson T, Wennerberg A. Tilted versus axially placed dental implants: a meta-analysis. J Dent. 2015;43:149-70.

18. Pomares C. A retrospective clinical study of edentulous patients rehabilitated according to the “all on four” or the “all on six” immediate function concept. Eur J Oral Implantol. 2009;2:55-60.

19. Maló P, Rangert B, Nobre M. All-on-4 immediate-function concept with Brånemark System implants for completely edentulous maxillae: a 1-year retrospective clinical study. Clin Implant Dent Relat Res. 2005;7:1-94.

20. Maló P, de Araújo Nobre M, Lopes A, Francischone C, Rigolizzo M. “All-on-4” immediate-function concept for completely edentulous maxillae: a clinical report on the medium (3 years) and long-term (5 years) outcomes. Clin Implant Dent Relat Res. 2012;14:1-50.

21. Pelekos G, Acharya A, Tonetti MS, Bornstein MM. Diagnostic performance of cone beam computed tomography in assessing peri-implant bone loss: a systematic review. Clin Oral Implants Res. 2019;29:443-64.

22. González-Martín O, Oteo C, Ortega R, Alandez J, Sanz M, Veltri M. Evaluation of peri-implant buccal bone by computed tomography: an experimental study. Clin Oral Implants Res. 2016;27:950-5.

23. Misch KA, Yi ES, Sarment DP. Accuracy of cone beam computed tomography for periodontal defect measurements. J Periodontol. 2006;77:1261-6.

24. Li F, Jia PY, Ouyang XY. Comparison of measurements on cone beam computed tomography for periodontal intrabony defect with intra-surgical measurements. Chin J Dent Res. 2015;18:171-6.

25. Barnea E, Tal H, Nissan J, Tarrasch R, Peleg M, Kolerman R. The use of tilted implants for posterior atrophic maxilla. Clin Implant Dent Relat Res. 2016;18:788-800.

26. Rosén A, Gynther G. Implant treatment without bone grafting in edentulous severely resorbed maxillas: a long-term follow-up study. J Oral Maxillofac Surg. 2007;65:1010-6.

27. Krennmair S, Seemann R, Weinländer M, Krennmair G, Piehslinger E. Immediately loaded distally cantilevered fixed mandibular prostheses supported by four implants placed in both fresh extraction and healed sites: 2-year results from a prospective study. Eur J Oral Implantol. 2014;7:73-84.

28. Chochlidakis K, Einarsdottir E, Tsigarida A, Papaspyridakos P, Romeo D, Barmak AB, et all. Survival rates and prosthetic complications of implant fixed complete dental prostheses: an up to 5-year retrospective study. J Prosthet Dent. 2020;124:539-46.

29. Aanenson JW, Till JE, Grogan HA. Understanding and communicating radiation dose and risk from cone beam computed tomography in dentistry. J Prosthet Dent. 2018;120:353-60.

30. Pauwels R. Cone beam CT for dental and maxillofacial imaging: dose matters. Radiat Prot Dosimetry. 2015;165:156-61.