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RESTORATION REMOVAL USING HIGH-SPEED HANDPIECES WITH OR WITHOUT THE FIBER-OPTIC LIGHT

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ABSTRACT

Background and Aim: The aim of this study was to evaluate the differences in cavity dimension changes associated with the removal of tooth-colored restorations using high-speed handpieces with or without fiber-optic light.

Materials and Methods: Five recently graduated dentists (6 months-1 year of professional experience) were assigned to remove 40 Class I composite restorations. Half of the restorations were removed using a high-speed handpiece with fiber-optic light, and the other half with a handpiece without light. Cavity dimensions changes were measured using a periodontal probe and a digital micrometer at nine defined regions of the tooth preparation. Measurements were recorded at two stages: before restoration removal and after removal (with/without fiber-optic light). Analyses were conducted to assess changes in cavity dimensions and the unnecessary removal of sound tissue. Statistical analysis was performed using the Mann-Whitney U test to compare non-normally distributed data between the two groups, with a significance level set at $p < 0.05$.

Results: Restorations removed with high-speed handpieces with fiber-optic light resulted in significantly less unnecessary cavity dimension changes compared to those removed without light ($p<0.05$). The use of high-speed handpiece with fiber-optic light demonstrated a statistically significant advantage in preserving the cavity integrity ($p<0.05$).

Conclusion: The use of high-speed handpieces with fiber-optic light significantly reduced unnecessary cavity dimension changes compared to those without light, demonstrating their potential to enhance precision and support minimally invasive dentistry.

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INTRODUCTION

Modern dentistry increasingly favors tooth-colored restorative materials due to their aesthetic advantages and the ability to perform more conservative cavity preparations. However, during the replacement of restorations, distinguishing between composite resin remnants and natural tooth structure becomes nearly impossible, especially when using water-cooled rotary instruments. Compared to amalgam restorations, the removal of tooth-colored restorations is associated with higher risks, including over-preparation, excessive removal of tooth structure, unnecessary weakening of structural integrity, and prolonged treatment durations.[1-5] Moreover, the difficulty in differentiating tooth-colored materials from natural tooth tissue may cause challenges such as reduced adhesive bond strength and/or marginal seal of the new restorations due to remnants of the old restoration.[6]

As the conventional removal procedures for tooth-colored materials become more complex, time-consuming, and less predictable, the need for innovative diagnostic approaches arises. Attempts to enhance visibility, such as the use of photochromic cavity liners[5] or selecting materials with significantly different shades,[7] have shown limited success. The intrinsic fluorescence of resin-based composites under UV light was first highlighted by forensic experts for its diagnostic potential, long before its use in dental applications.[8,9] Early studies suggested the use of UV light for examining cavities after restoration removal,[10] with subsequent research showing that most resin composite brands exhibit fluorescence levels higher than those of natural tooth tissues.[11,12] Techniques leveraging this property have been developed to improve the identification and removal of tooth-colored restorations, demonstrating increased accuracy and efficiency.[13]

However, while such advancements have shown potential, their integration into conventional dental practices is often limited by cost and accessibility challenges, particularly in regions with lower socioeconomic resources. Furthermore, their incorporation into preclinical student education poses additional challenges due to the complexity and cost of these technologies. Integrating fiber-optic light features into traditional dental handpieces enables clinicians to illuminate darker areas of the oral cavity, enhancing visibility during procedures. However, it remains uncertain whether these devices provide significant advantages in preserving healthy tooth structure and supporting minimally invasive dentistry, or if they merely function as an accessory with limited practical value.

Thus, the aim of this *in vitro* study is to evaluate the differences in cavity dimension changes associated with the removal of tooth-colored restorations using high-speed handpieces, with or without fiber-optic light. The null hypothesis of this study states that there is no statistically significant difference in cavity dimension changes between high-speed handpieces with and without fiber-optic light during the removal of tooth-colored restorations.

MATERIALS AND METHODS

Sample Size Calculation

A power analysis was conducted using G*Power software (version 3.1) to determine the required sample size. With an alpha error probability of 0.05, a statistical power of 80% ($1-\beta = 0.80$), and an effect size of 0.8, the analysis indicated that a minimum of 36 specimens (18 per group) was required. Thus, a total of 40 specimens (20 per group) was included, slightly exceeding the minimum required sample size.

Cavity Preparation and Measurements

The preparation of 40 occlusal Class I cavities was performed on mandibular first molar plastic teeth (Frasaco APT, Tettnang, Germany) mounted in phantom head dental chair simulators. The procedures were carried out by five recently graduated dentists with 6 months to 1 year of professional experience with normal vision who underwent a standardized training program and calibration prior to the study. They were instructed to completely remove the restorations while avoiding unnecessary extension of the cavities. To minimize bias, all samples were randomly assigned to the dentists, and the procedures were conducted under identical conditions, including operatory dental chair light illumination in the same laboratory environment. The consistency of cavity preparations was verified independently to ensure standardization and accuracy. The flow chart of the study is presented in Figure 1.

The procedures were performed following routine standardized protocols under continuous water cooling, using a high-speed traditional handpiece (Alegra TE–95, W&H, Bürmoos, Austria). The occlusion preparations were performed using round and cylinder diamond burs (#G801-314-018-F, #G835R-314-010-4-F Diatech; Coltène/Whaledent, Altstätten, Switzerland). The cavities were standardized with an occluso-gingival depth of 2 mm and

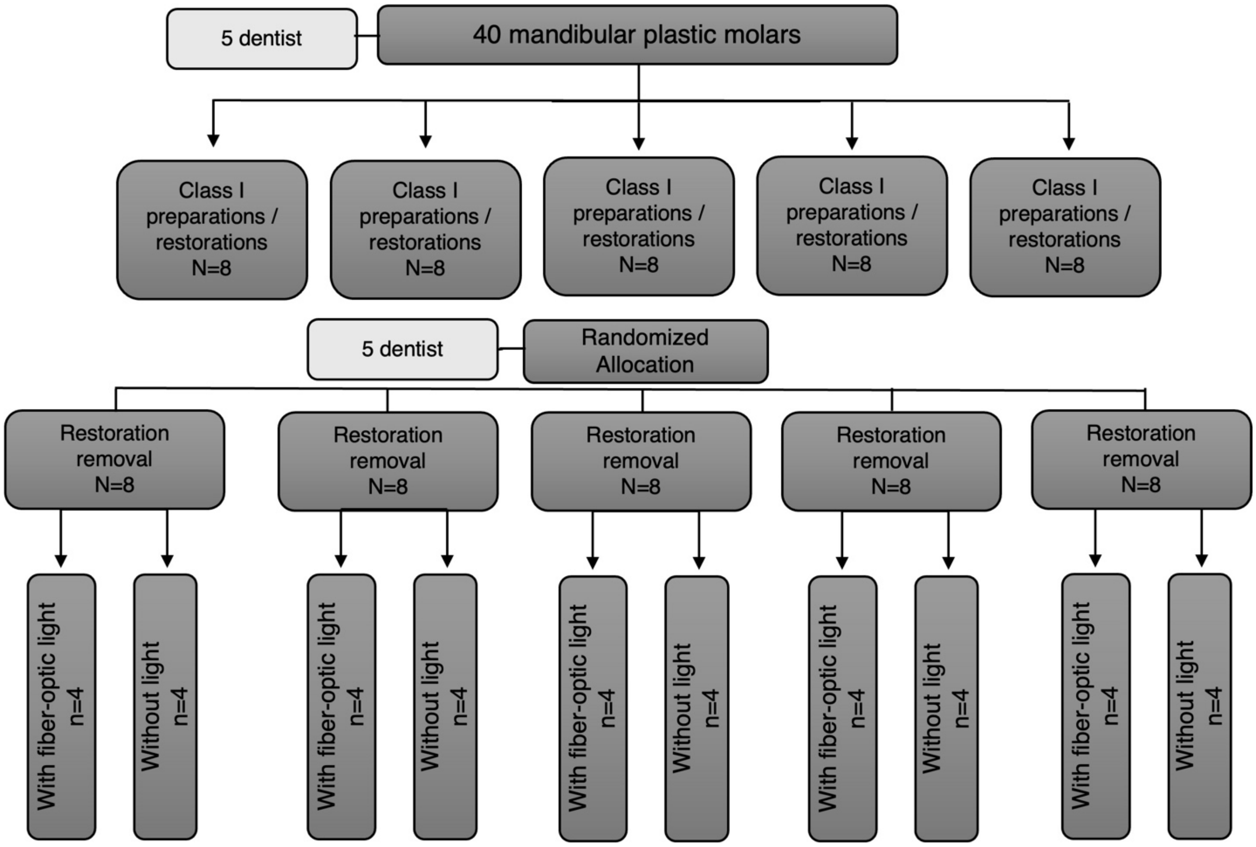

Figure 1. Flowchart of the study

a box-shaped configuration, with no beveling applied to the margins. All preparations were independently inspected by two experts to ensure consistency and adherence to the standardized dimensions.

Measurements of all prepared cavities were conducted using a periodontal probe (Hu-Friedy, Chicago, IL, USA), followed by validation with a digital micrometer (Digital micrometer, IP65, Mitutoyo MC, Tokyo, Japan) with a precision of ±0.01 mm, based on standardized testing principles for dental materials analysis.

Measurements were recorded at six occluso-pulpal regions: disto-buccal (DB), disto-lingual (DL), central fossa buccal (CB), central fossa lingual (CL), mesio-buccal (MB), and mesio-lingual (ML) edges, and three bucco-lingual regions: between the distal cusps (D), at the center of the central fossa (C), and between the mesial cusps (M). The cavity preparation procedures adhered to internal protocols to ensure consistency in occluso-gingival depth (2 mm) and box-shaped configuration. The initial measurements (M0) of cavity dimensions were then obtained.

Restoration Procedure

Following cavity preparation and measurements, the samples were rinsed with an air-water spray and dried using compressed air at a pressure of 2.5 kgf/cm² from a distance of 5 cm. Subsequently, the universal adhesive (Prime&Bond, Dentsply Sirona, Charlotte, NC, USA) was applied in self-etch mode for 20 s, in accordance with the manufacturer's instructions. The surfaces were then air-dried for 5 s using an air-water spray to ensure solvent evaporation and polymerized for 20 s using an LED curing light (Cromalux 1200, Mega-Physik, Rastatt, Germany) at a distance of 1 mm. The cavities were then restored with nanohybrid resin composite (Ceram-X Duo, Dentsply DeTrey, Konstanz, Germany) in increments no thicker than 2 mm using a hand instrument to ensure a gap-free application, with each layer light-cured for 20 s at a 1 mm distance.

The restorations were finished using bud-shaped fine-grit diamond bur (G368-314-016-3.5-F, Diatech; Coltène/Whaledent, Altstätten, Switzerland) under constant water cooling with a high-speed handpiece. The restoration surfaces were polished using silicon polishing system (KerrHawe HiLuster Plus; Kerr, CA, USA) with a low-speed handpiece-micromotor system (WE 56 Alegra Contra Angle Handpiece, AM 25 BC Micromotor, W&H, Bürmoos, Austria). Occlusal adjustments were performed by fine-grit diamond burs and verified with articulating paper.

Restoration Removal Procedure

The restored samples were randomly assigned to same five recently graduated dentists, with each dentist allocated eight samples. Care was taken to ensure that none of the dentists worked on restorations they had initially performed. Each student removed 4 restorations using a high-speed handpiece with fiber-optic light (Alegra TE-95 LQ, W&H, Bürmoos, Austria) and the other 4 restorations using a conventional high-speed handpiece without light (Alegra TE–95, W&H, Bürmoos, Austria). Prior to the procedures, all dentists completed a standardized training program and performed two trial preparations to ensure consistency. These trial preparations were independently evaluated by two experts. This experimental design simulated a clinical scenario where restorations are removed by a different clinician.

Subsequent to the restoration removal, the samples were examined by two independent experts to ensure consistency. Measurements were conducted using the same procedure applied in the initial measurements, with all measurements performed by a blinded researcher to avoid bias. The measurements were categorized into M1 (with fiber-optic light handpiece) and M2 (without light handpiece) values.

To determine dimensional changes and evaluate the preservation of tooth structure, the final measurements were subtracted from the baseline cavity dimensions (M0). The analysis focused on occluso-pulpal and bucco-lingual measurements to assess the effects of the two handpiece types.

To further minimize bias, the five dentists performing the removal procedures and the researcher conducting the measurements were blinded to group assignments. All measurements were conducted by a single researcher and reviewed by two independent experts to ensure consistency and accuracy.

Statistical analysis involved calculating the differences between the baseline measurements (M0) and the post-removal measurements using a high-speed handpiece with fiber-optic light (M1-M0) and without light (M2-M0) for each specimen. Δ represents the dimensional change calculated as the difference between baseline (M0) and post-removal measurements (M1 or M2), (Dimensional change at the disto-buccal region [ΔDB], dimensional change at the disto-lingual region [ΔDL], dimensional change at the central fossa buccal region [ΔCB], dimensional change at the central fossa lingual region [ΔCL], dimensional change at the mesio-buccal region [ΔMB], dimensional change at the mesio-lingual region [ΔML], dimensional change between the distal cusps [ΔD], dimensional change at the center of the central fossa [ΔC], dimensional change between the mesial cusps [ΔM]).

Statistical Analysis

The normality of the data distribution was assessed using the Shapiro-Wilk and Kolmogorov-Smirnov tests. Since the data did not follow a normal distribution, the Mann-Whitney U test was applied to compare differences between the two groups (with fiber-optic light and without light). Measures of central tendency were evaluated using median values. All statistical analyses were performed using SPSS software version 20.0 (IBM Corp., Armonk, NY, USA), and a p-value of <0.05 was considered statistically significant.

RESULTS

The influence of high-speed handpieces with and without fiber-optic light on the preservation of healthy tooth structure was analyzed through dimensional changes (Δ) at specific regions.

Table 1 presents the mean±SD, median, minimum, and maximum values of cavity dimension changes following the removal procedures with and without fiber-optic light. Statistical significance was set at $p<0.05$.

Occluso-pulpal Measurements

Significant differences were observed in ΔDB, ΔCB, ΔCL, and ΔMB ($p<0.05$), where the handpiece with fiber-optic light demonstrated superior preservation of healthy tooth structure. The largest reduction in dimensional change was noted at ΔMB. No statistically significant differences were observed in ΔDL and ΔML ($p>0.05$).

Bucco-lingual Measurements

For the bucco-lingual regions, a significant difference was observed in ΔM ($p<0.05$), indicating better preservation of tooth structure achieved by the fiber-optic light handpiece. However, no significant differences were detected in ΔD and ΔC ($p>0.05$).

Table 1. Mean±SD, median, minimum, and maximum values of cavity dimensions changes following removal procedures with and without fiber-optic light.

Removal		Δ DB	Δ DL	Δ CB	Δ CL	Δ MB	Δ ML	Δ D	Δ C	Δ M
With Fiber-optic Light (M1-M0)	Mean±SD	0.16±0.21	0.18±0.1	0.15±0.09	0.1±0.64	0.07±0.06	0.18±0.23	0.16±0.08	0.12±0.1	0.11±0.09
	Median	0.1*	0.2	0.1*	0.1*	0.1*	0.15	0.15	0.1	0.1*
	Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Max	1.0	0.4	0.4	0.2	0.2	0.8	0.3	0.4	0.3
Without Light (M2-M0)	Mean ±SD	0.28±0.17	0.25±0.15	0.23±0.13	0.19±0.13	0.19±0.11	0.19±0.1	0.21±0.12	0.18±0.14	0.23±0.15
	Median	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Max	0.7	0.5	0.5	0.4	0.3	0.4	0.4	0.4	0.5

*Indicates a statistically significant difference ($p < 0.05$)
Δ represents the dimensional change between baseline (M0) and post-removal measurements (M1 or M2). Occluso-pulpal regions (ΔDB: Dimensional change at the disto-buccal region, ΔDL: Disto-lingual, ΔCB: Central fossa buccal, ΔCL: Central fossa lingual, ΔMB: Mesio-buccal, ΔML: Mesio-lingual) and bucco-lingual regions (ΔD: Dimensional change at the distal region, ΔC: Central fossa, ΔM: Mesial) measurements are expressed as the difference between the baseline cavity dimensions (M0) and post-removal values (M1: with fiber-optic light, M2: without light).

DISCUSSION

Despite advancements in preventive measures and oral health education, managing dental caries through restorations remains a core aspect of dental practice. Over time, all restorations inevitably undergo degradation, requiring periodic intervention and management. Factors contributing to this include marginal defects, secondary caries, fractures of the restoration or adjacent tooth structure, and aesthetic concerns. Ultimately, it is clear that restorations are not permanent solutions and will require further intervention as they deteriorate.[14] The decision to intervene in an existing restoration often relies on the operator's subjective judgment, influenced by factors like the patient's age, the restoration's size and location, and particularly a change in dentist. When a new dentist takes over a case, they may apply different criteria or approaches, potentially leading to unnecessary interventions.[15]

Restoration removal often leads to excessive cavity enlargement or unnecessary removal of hard tissue. Repeated treatments on the same tooth progressively result in irreversible and unnecessary loss of tooth structure.[3] In modern dental practice, the increased use of tooth-colored restorations has contributed to over-prepared cavities during retreatments, largely due to the lack of integration of advanced technologies into clinical practice.[14] Compared to amalgam, the removal of resin-based restorations can result in up to twice the amount of structural tooth loss.[16]

This study evaluated the impact of high-speed handpieces with and without fiber-optic light on changes in tooth preparation dimensions during the removal of tooth-colored restorations. The results revealed that handpieces with fiber-optic light significantly preserved initial preparation dimensions, supporting minimally invasive dentistry principles. Consequently, the null hypothesis was rejected due to the observed differences between the two handpiece types.

Krejci et al.[17] evaluated volumetric cavity dimensions following the removal of different restorative materials and proposed the development of color indicators to enhance the visualization of the tooth-restoration interface. In line with this, a study comparing cavity dimensions during the removal of restorations made with different restorative materials, the use of a photochromic cavity liner was reported to create no significant difference.[5] On the other hand, a recent *in vitro* study, evaluated a white-opaque flowable composite as a depth marker and optical aid during restoration removal, assessing tooth structure loss in terms of weight and volume. The findings suggested that using a white-opaque flowable liner as a depth marker could provide practitioners with a visual aid during composite restoration replacement, effectively minimizing tooth structure loss.[18] However, the use of an additional material during restoration placement may not always be practical, feasible, or aesthetically acceptable. Thus, an aid that can be integrated during the removal process appears to be a more suitable option.

In a study comparing the fluorescence-aided identification of restorations (FAIR) method with fiber-optic illuminated handpieces for the selective removal of tooth-colored resin-based composite restorations, the FAIR method demonstrated superior outcomes, including more precise removal and preservation of sound tooth structure.[2] These findings align with our results, which also emphasized the advantages of fiber-optic light in minimizing cavity dimension changes. Moreover, composite resin and amalgam restorations were removed from occlusal cavities of primary molars using conventional high-speed burs and ultrasonic diamond tips, with findings indicating a comparable amount of tooth structure loss across both methods.[19] The use of the fiber-optic light in the handpieces for fluorescence excitation has been demonstrated to be an effective approach for implementing the fluorescence-aided identification technique (FIT), significantly enhancing the removal of tooth-colored restorations.[20] Similarly, Dettwiler et al.[21] compared the conventional composite removal technique with the FIT in terms of completeness, selectivity, and duration in an in vitro study using direct restored permanent posterior teeth. Their findings indicated that FIT facilitates the selective and efficient removal of tooth-colored composites. Additionally, Leontiev et al.[22] evaluated the accuracy of the conventional illumination method and the FIT in differentiating composite restorations from intact teeth. Their findings indicated that FIT is significantly more reliable than the conventional illumination method for detecting composite restorations. Despite the success of these advanced techniques, their high cost, relative time demands, and difficulty in clinical integration remain significant barriers. However, the present findings demonstrated that solely the inclusion of fiber-optic light in high-speed handpieces significantly reduced cavity dimension changes during restoration removal, thus supporting minimally invasive approaches. This underscores the importance of further research and highlights that even a simple modification, such as integrating light into conventional dental handpieces, can yield clinically meaningful improvements.

High-speed dental handpieces with fiber-optic light were introduced in the late 1980s and early 1990s.[23] This innovation provided direct illumination of the working area through integrated fiber-optic light sources in the handpiece head, enhancing visibility and precision for dental procedures. Given their ability to improve visibility, these handpieces can be considered a standard tool for both preclinical student training and routine clinical practice, ensuring consistency in dental education and patient care.

Restoration replacement has previously been evaluated using weight measurements, which assess the amount of material removed during the procedure by calculating the difference in weight before and after restoration removal.[16,17] Some studies have used superimposed photographs to investigate differences in the surfaces and contours of restorations and cavities.[1,7,9,24]

Other researchers have utilized intraoral scanners to collect three-dimensional data sets,[2,5] while Klein et al.[20] further employed these devices for comparative analyses. In the current study, a periodontal probe and a digital micrometer were used to analyze cavity preparations, as commonly utilized in preclinical student training and only linear dimensions were analyzed. Although more advanced techniques have been introduced, the use of a readily accessible periodontal probe by clinicians has also revealed statistically significant differences in the results. Further studies employing advanced measurement tools could potentially yield more precise or striking results, providing deeper insights into the cavity preparation outcomes.

Within the limitations of this study, several factors should be considered when interpreting the results. Firstly, this was an *in vitro* study, which may not fully replicate the complex clinical conditions encountered *in vivo,* such as the presence of saliva, blood, and patient movement. Secondly, the use of plastic teeth, rather than natural teeth, may have influenced the accuracy of the cavity preparation and material removal outcomes, particularly in mimicking the hardness and structural variability of dentin and enamel.[3] Additionally, only linear and surface dimensions were evaluated, as three-dimensional analysis tools were not utilized in this study. This could limit the comprehensive assessment of volume changes and microstructural alterations in the cavities. Lastly, the findings are based on a specific set of materials, handpieces, and operator experience, which may not be universally applicable. Future studies incorporating clinical conditions, natural teeth, and advanced three-dimensional measurement tools are recommended to validate and expand upon these findings, while also considering the broader implications of integrating fiber-optic technology into routine dental practice.

CONCLUSION

This *in vitro* study highlights the significant advantages of using high-speed handpieces with fiber-optic light for the removal of tooth-colored restorations. The findings demonstrate that fiber-optic light enhances precision during the restoration removal process, leading to significantly less unnecessary cavity dimension changes compared to handpieces without light. These results support the potential of fiber-optic light technology to improve restorative dentistry outcomes by preserving cavity integrity and promoting minimally invasive principles.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

ETHICS STATEMENT

Ethical approval was not required, as the research did not involve clinical studies or patient data.

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This research received no financial support.

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