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The Effect of Ultrasonic Instrumentation on Finish Line Integrity

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Abstract

Purpose: Ultrasonic scaler is frequently used for temporary cement remnants removal from abutment teeth. A major concern is the alteration of the structural integrity of the abutment finishing line by the ultrasonic scaler. The current study evaluates the influence of ultrasonic scaling on the integrity of the finish line. The effect of finish line design (chamfer or feather edge), and its location (dentin or enamel) was also evaluated.

Methods: Intact 22 human extracted molars were divided into 2 groups: finish line was prepared on enamel (n=11) and dentin (n=11), and further subdivided to finish line configuration groups (chamfer or knife-edge). Preparation of finish line was preformed following a standard repetitive procedure. 3D scans of the same tooth before and after ultrasonic instrumentation were performed. Pre and post scaling images were superimposed. The finish line alterations were evaluated and measured. The significance of the differences was evaluated using Students' t-test.

Results: The average alteration at the finish line area following ultrasonic scaling was 71.5 ± 24.6 µm. Higher alterations were found for enamel and for chamfer finish lines compared to dentin and knife edge, 134.4 ± 61.4 µm and 30.3 ±11.7 µm respectively. The highest change (228.6µm) was found for chamfer finish line located on enamel. The differences between groups were statistically significant ($p<0.05$).

Conclusion: Ultrasonic scaling alters the topography of the finish line area of abutment teeth and thus may compromise marginal fit and integrity of the final restoration.

Keywords: Ultrasonic; Temporary cement; Finish line

Introduction

The use of ultrasonic scalers can be found in almost all dental fields including prosthodontics [1]. It was initially introduced by Zinner at 1955, as an instrument to remove deposits from the tooth surface [2], followed by Richman [3] suggesting the instrument for endodontic use in 1957.

Vibrational energy originating from the oscillation generator is transferred to the scaler tip, causing micro vibrations that remove deposits from the dental surface, such as bacterial biofilm, calculus and endotoxins. It was proved to reduce scaling time, remove bacterial biofilm, and improve calculus removal [4]. When used for endodontic treatment it is advantageous for shaping and irrigating root canals [3]. In addition, to its use for the removal of intraradicular posts [5].

In prosthodontics, the process of indirect restoration requires the cementation of a provisional restoration to the abutment tooth by a temporary cement. All remnants of temporary cement must be removed prior to conventional impression or scan and the cementation of the definitive restoration.

The ultrasonic scaler can be used for this purpose successfully. It was suggested to be easier than hand excavation and even may improve the bond strength and resin infiltration to dentin [6].

On the other hand, it has been claimed that ultrasonic scaling can damage tooth structure [7].

It was reported that instrumentation with ultrasonic scaler can lead up to substance loss when applying a large amount of force, moreover, it can worsen enamel cracks and even endanger resin restorations [7].

Although it has been argued that 40-120 µm restorations' marginal gap at the finish line is clinically acceptable [8-10], the possible damage that can be produced by the use of ultrasonic cement cleaning is alarming.

With that being said, it may be speculated that ultrasonic scaling can alter the structure of the finish line after impressions were taken and thus may compromise the treatment outcome.

The objective of the present study was to evaluate the influence of ultrasonic scaling on the integrity of the finish line. Chamfer or feather edge finish lines on dentin or enamel were assessed following ultrasonic scaling. Our working hypothesis was that ultrasonic instrumentation alters the finish line, and that the amount of damage depends on the type of finish line and its anatomic location.

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Materials and Methods

The present study protocol was approved by the institutional review board and ethics committee of Hadassah Medical Centre in compliance with the Helsinki Declaration (approval # 0451-17-HMO).

Specimen preparation

Intact 22 human extracted molars were selected and stored in physiologic saline solution at room temperature immediately after extraction. Teeth were washed in water and carefully cleaned, and then embedded in dental stone. The Cement-Enamel Junction (CEJ) distance from the stone was ≥4mm (Figure 1 and 2).

The teeth were then divided randomly into 2 groups (n=11 for each group).

Enamel group finish line preparation

Finish line was placed 1-2 mm above the CEJ. Chamfer finish line on enamel was prepared using F2R coarse bur (ISO No. 199-018, Strauss&co, Ra'anana, Israel). Buccal reduction was performed to the depth of the bur, creating chamfer finish line (n=11) marked as CE (Figure 1). Knife-edge finish line on enamel was prepared using E5 coarse bur (ISO No. 249-014, Strauss&co). Buccal reduction was performed to the depth of the bur, creating knife-edge finish line (n=11) marked as KE (Figure 1).

Dentin group finish line preparation

Finish line was placed 1-2 mm below the CEJ. Chamfer finish line on dentin was prepared using F2R coarse bur (ISO No. 199-018, Strauss&co). Buccal reduction was performed to the depth of the bur, creating chamfer finish line (n=11) marked as CD (Figure 2). Knife-edge finish line on dentin was prepared using E5 coarse bur (ISO No. 249-014, Strauss&co). Buccal reduction was performed to the depth of the bur, creating knife-edge finish line (n=11) marked as KD (Figure 2).

All preparations were conducted by the same operator (I.S).

Experimental instrumentation

Sirosonic® TL, with Instrument 4L, Siroperio PE 1 (Sirona Dental Systems, Bensheim, Germany) was used for ultrasonic scaling, with 50% of maximum power level, suitable for daily use.

The teeth were instrumented according to manufacturers' instructions. The tip was applied parallel to the tooth axis and the working strokes run perpendicular to the tooth axis (Figure 3).

The strokes were conducted for 10secs for each finish line and control.

All procedures were conducted by the same operator.

Data collection

Each tooth was scanned using a desktop laboratory scanner (S900 ARTI Scanner, Zirkonzahn, Gais, Italy). Scanning was performed twice: (i) prior to instrumentation (Figure 4) and (ii) after instrumentation. The data was then imported into a CAD-based design application (Zirkonzahn Modellier, Zirkonzahn, Italy) and the 2 images for each tooth were superimposed (Figure 5). Measurements of the topographical change in μm at the finish line area were depicted along the finish line.

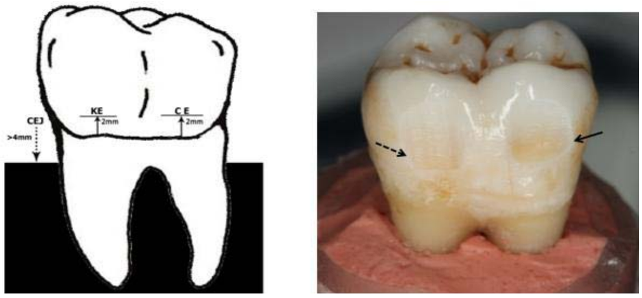

Figure 1: Scheme and photo of embedded tooth in stone showing enamel preparations.
Straight arrow for chamfer finish line, dashed arrow for knife-edge finish line. KE: Knife Edge Finish Line on Enamel; CE: Chamfer Finish Line on Enamel; CEJ: Cemento-Enamel Junction.

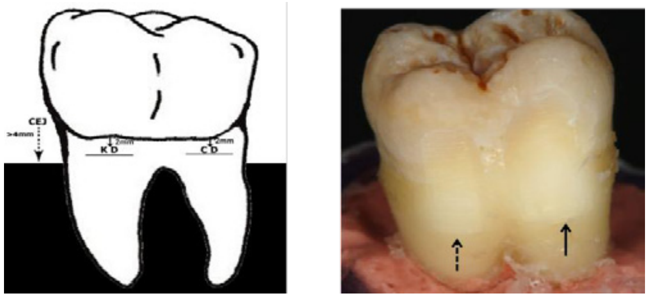

Figure 2: Scheme and Photo of embedded tooth in stone showing dentin preparations.
Straight arrow for chamfer finish line, dashed arrow for knife-edge finish line. KD: Knife Edge Finish Line on Dentin; CD: Chamfer Finish Line on Dentin; CEJ: Cemento-Enamel Junction.

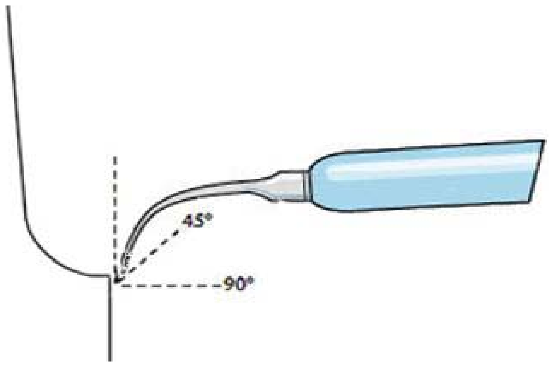

Figure 3: Scheme of experimental instrumentation with ultrasonic scaler on tooth surface.

A sectional plane was set (Figure 6) perpendicular to the finish line at 5 arbitrary points. In each point, the distance between the two finish lines, before and after the instrumentation of the same tooth, was measured (Figure 6).

Statistical analysis

The significance of the differences between groups was analyzed using Students' *t*-test. First for the enamel and dentine groups (n=110 measurements for each group), and second for the chamfer and knife-edge groups (n=110 measurements for each group). The significance level was set to $p<0.05$.

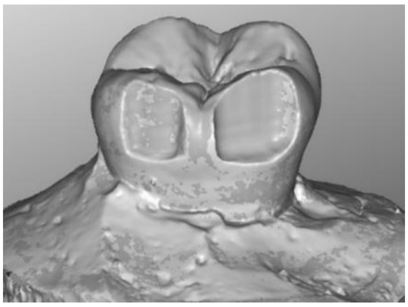

Figure 4: Scan of a tooth with finish lines on enamel, before instrumentation.

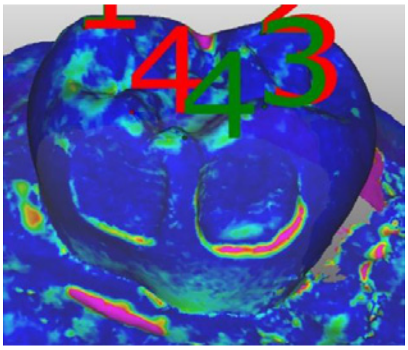

Figure 5: Superimposed figure comprised out of two scans of the same tooth, before and after ultrasonic instrumentation.
Warm color symbols larger mismatch during the superimposition procedure, resulted from the experimental instrumentation.

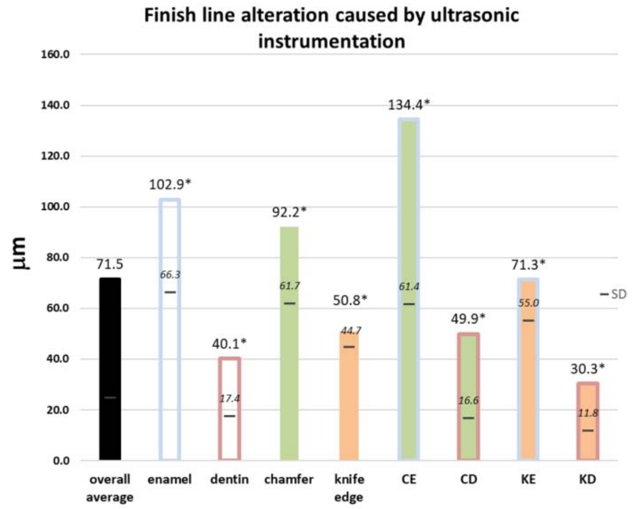

Figure 7: Ultrasonic instrumentation causes finish line alteration.
Overall average-black bar; Enamel-blue border; Dentin-red border; Chamfer finish line-green fill; Knife-edge finish line-orange fill.
CE: Chamfer Finish Line on Enamel; CD: Chamfer Finish Line on Dentin; KE: Knife Edge Finish Line on Enamel; KD: Knife Edge Finish Line on Dentin.
Values are presented in µm, asterisk represents statistical significance.

Results

Ultrasonic instrumentation caused finish line alteration ranging from 3.40µm to 228.6µm with an average of 71.5µm. The average values of change for each group are presented in Figure 7.

Ultrasonic instrumentation on finish lines positioned on enamel caused significantly higher alteration (102.86 ± 66.25 µm) compared to finish line positioned on dentin (40.12 ±17.4 µm) ($p<0.001$).

The finish line design also influenced the extent of change following ultrasonic instrumentation. While instrumentation on knife-edge finish lines resulted in an average 50.8µm (±44.7) change, chamfer finish lines demonstrated an average change values of 92.2µm (±61.7), the difference between the two was significant ($p<0.05$).

Analysis included all combinations of the different groups. Finish line with chamfer design that was placed on enamel showed the highest average change values -134.4µm (±61.4), while chamfer finish line located on dentin showed values of 49.9µm (±16.6). The difference between the two was significant ($p<0.001$).

Knife-edge design located on dentin yielded the lowest change values measured - 30.3µm (±11.7). While knife-edge design on enamel presented higher change 71.3µm (±54.9). The difference between the two was significant ($p<0.05$).

Discussion

Working with an ultrasonic scaler at the finish line area may lead to consequences that could be detrimental regarding finish line integrity and accuracy of the restoration.

Furthermore, parameters such as the type of finish line and its location on the tooth (e.g. enamel or dentin) might affect the extent of the finish line disintegrity as well.

In the present study, we found that the average amount of

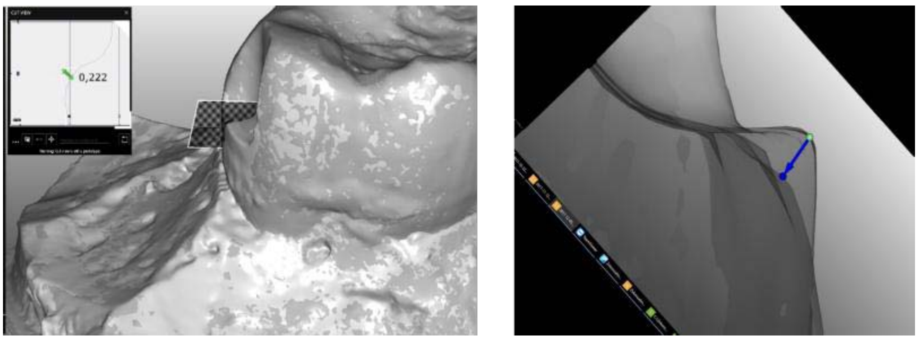

Figure 6: Distance measurement between the two scans.
A plane was set perpendicular to the finish line, and a value was measured as the shortest distance between the two scans.

alteration and topographical defects at the finish line, before and after ultrasonic scaling, resulted in an average 71.5µm. Such alterations are more extreme when the ultrasonic instrumentation is performed on enamel compared to preparations on dentin.

It is well recognized, that marginal fit is highly important to quality of the restoration, and an effort should be done to minimize the gap during the process of fabricating such a restoration.

It may be suggested, that careless ultrasonic instrumentation at the finish line area my hinder acceptable and accurate marginal fit of the temporary and final restorations, producing an unacceptable restoration margin. The wide gap may lead to plaque accumulation and thereby an increased risk for secondary caries. Specifically, this is of great concern in cases when multiple sessions of temporization are needed.

Both enamel and dentin are brittle anisotropic substances, thus their fracture toughness is changed according to the orientation of the force applied to the rods and tubules respectively. When the pattern of the forces is mixed, parallel and perpendicular fractures can occur, with substantial difference between enamel and dentin [11].

This difference was attributed to the macro and micro structure of the two substances and the different properties of enamel rods versus the tubules and collagen comprising the dentin.

The current study corresponds with these findings. We found that alterations at finish lines located on enamel were 2.5 times greater than on dentin (102.9 and 40.1 µm, respectively), regardless of the design of the preparation. These findings support the hypothesis that finish lines located on enamel and finish lines located on dentin will result in different values of alteration following ultrasonic instrumentation.

The unique microstructural properties of enamel may also provide explanation for the high change values of standard deviation found for enamel (102.86µm ±66.25). The reason may be related to the fact that hydroxyapatite crystals, which are tightly packed as a mass forming the enamel rod, do not themselves cleave during fracture. It is most likely that the crack will occur between the rods, where the crystals are less organized and less dense, resulting in deeper and wider gaps.

Nowadays, when prosthetic treatment involving All-Ceramic restorations is constantly increasing and becoming more popular, there is less need to place the restorations' margin sub gingivally [12]. Moreover, partial coverage restorations are very common nowadays, including veneers, onlays and inlays. For such restorations, enamel margins are clearly preferred, allowing better adhesion [13]. For this reason, in many cases the preferred design is finish line located on enamel. The results of our study may suggest that extra caution should be implied in those cases, due to potential structural damage that can occur when working with ultrasonic instrumentation around the margins.

Ultrasonic instrumentation on different finish lines produced different effects. The chamfer finish line was found to be more susceptible to alterations than the knife-edge finish line (92.2µm and 50.8µm, respectively). This could be a result of the steep outer angle created at the most horizontal component of the preparation. It seems that potentially greater force could be exerted on this point, resulting in focal distribution of force, which may lead to a fracture. In addition, a larger horizontal component, especially on enamel, may cut the enamel rods in a parallel orientation, making the parallel mode of fracture favorable upon the perpendicular one.

As discussed above, fracture parallel to enamel rods occurs in lower energy than the perpendicular one, therefore exposing the chamfer finish line to greater alterations, especially on enamel. This can explain the high values (134.4µm) found for this group combining chamfer finish line on enamel. The same chamfer design, but on dentin, resulted in lesser alteration (49.9µm). The reasons could be related to the higher toughness of dentin compared to enamel and also, cutting through the tubules in a horizontal fashion may favor a fracture mode that is parallel to the tubule. In the case of dentin, it may yield higher values of resistance, therefore lower values of alteration after ultrasonic instrumentation.

At the era of all ceramic restorations, in which adhesion plays a major role, cleaning the cementation area from temporary cement remnants before definitive cementation is extremely important.

Studies conducted regarding the interaction between ultrasonic instrumentation and tooth tissues evaluated bond strength in relation to cleaned surfaces. Results showed that alteration in bond strength might occur due to the interaction with ultrasonic instrument [14]. These findings correspond with the findings of the present study in a manner that alterations in the surface structure can occur due to routine cleaning procedure.

In summary, within the limitations of the present in vitro study, it can be concluded that ultrasonic instrumentation can alter the finish line integrity by 71.5µm in average. Finish line located on enamel is more susceptible to damage compared to finish line on dentin. Chamfer finish line is more vulnerable compared to knife-edge finish line. Moreover, when the chamfer is located on dentin it is more prone to change following ultrasonic instrumentation.

Conclusion

The results suggest that ultrasonic instrumentation could negatively affect the clinical quality of the treatment, by compromising the restorations' marginal integrity. These findings call for alternative methods for remnants removal of temporary cement in the finish line proximity.

Acknowledgments

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References

1. Plotino G, Pameijer CH, Grande NM, Somma. Ultrasonics in endodontics: a review of the literature. J endod. 2007; 33: 81-95.
2. Zinner DD. Recent ultrasonic dental studies, including periodontia, without the use of an abrasive. J Dent Res. 1955; 34: 748-749.
3. Richman MJ. The use of ultrasonics in root canal therapy and root resection. J. Dent. Med. 1957; 12: 12-18.
4. Arabaci T, Cicek, Y, Canakci CF. Sonic and ultrasonic scalers in periodontal treatment: a review. Int J Dent Hyg. 2007; 5: 2-12.
5. Aguiar AC, Meireles DA, Marques AA, Sponchiado Júnior EC, Garrido AD, Garcia LD. Effect of ultrasonic tip designs on intraradicular post removal. Restor Dent Endod. 2014; 39: 265-269.
6. Niyomsujarit N, Senawongse P, Harnirattisai C. Bond strength of self-

etching adhesives to dentin surface after smear layer removal with ultrasonic brushing. Dent Mater J. 2019; 38: 287-294.

7. Kim SY, Kang MK, Kang SM, Kim HE. Effects of ultrasonic instrumentation on enamel surfaces with various defects. Int J Dent Hyg. 2018; 16: 219-224.

8. McLean JW, Von Fraunhofer JA. The estimation of cement film thickness by an in vivo technique. Br Dent J. 1971; 131: 107-111.

9. Fransson B, Øilo G, Gjeitanger R. The fit of metal-ceramic crowns, a clinical study. Dent Mater. 1985; 1: 197-199.

10. May KB, Russell MM, Razzoog ME, Lang BR. Precision of fit: the Procera AllCeram crown. J Prosthet Den. 1998; 80: 394-404.

11. Rasmussen ST, Patchin RE, Scott DB, Heuer AH. Fracture properties of human enamel and dentin. J Dent Res. 1976; 55: 154-164.

12. Spear F, Holloway J. Which all-ceramic system is optimal for anterior esthetics? J Am Dent Assoc. 2008; 139: 19-24.

13. Veneziani M. Posterior indirect adhesive restorations: updated indications and the Morphology Driven Preparation Technique. Int J Esthet Dent. 2017; 12: 204-230.

14. Angerame D, Sorrentino R, Cettolin D, Zarone F. The Effects of Scaling and Root Planning on the Marginal Gap and Microleakage of Indirect Composite Crowns Prepared With Different Finish Lines: An *In Vitro* Study. Oper Dent. 2012; 37: 650-659.