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Original research

The effects of various scaling instruments on the surface roughness of monolithic zirconia and lithium disilicate

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Purpose

This *in vitro* study aims to evaluate the effects of plastic piezoelectric maintenance tips on the surface roughness of monolithic lithium disilicate and zirconia.

Materials and Methods

Fifty-four lithium disilicate and 54 zirconia disks were prepared with CAD/CAM. On each material, scaling with a stainless-steel curette or with a piezoelectric device using either a steel or plastic tip was conducted. The surface roughness of the materials before and after the instrumentation was measured with a profilometer. The changes in roughness of the materials according to the scaling methods were analyzed with generalized linear models. Mann-Whitney U with Bonferroni correction was used for between-group comparisons.

Results

The instruments caused surface alterations on both materials (p=0.001), while the roughness change of lithium disilicate and zirconia specimens did not demonstrate any statistically significant difference with each other (p=0.274). However, the curette was found to cause significantly more (p=0.019) roughness change (0.259 ±0.405) on the specimens than the piezoelectric plastic tip (0.060 ±0.238).

Conclusion

Piezoelectric scalers with plastic tips cause less deterioration on monolithic zirconia and lithium disilicate surfaces when compared to stainless-steel hand curettes.

Keywords: *Instrumentation, curette, plastic, ultrasonic, piezoelectric*

Introduction

The goals of initial periodontal treatment are to eliminate the primary etiological factor, oral biofilm, and implement a relatively smooth surface to prevent re-colonization (1). Given that favorable outcomes can be achieved both with hand instruments and ultrasonic devices, the surface structure following instrumentation is of significance, particularly regarding prevention of recurrence (2). Rough hard surfaces promote oral biofilm adherence by procuring an increased surface area in favor of initial bacterial attachment and resistance to mechanical plaque control (3). Hence, the characteristics of the restorative material and the scaling instrument are important factors in maintaining long-term success. In recent years, curettes and ultrasonic scaling tips produced of materials such as carbon, plastic or titanium have been developed, which are thought to cause less surface damage, especially on implant components. Concurrently, however, also new materials are being introduced to the market for prosthetic rehabilitation, which show various surface characteristics and possibly get affected to different extents by these new instruments.

In the last decade, the use of computer-aided design and manufacturing (CAD/CAM) technology in dentistry has significantly surged (4). Increasingly more clinicians prefer point-of-care digital dentistry rather

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than sending analog impressions to dental laboratories (5). This gained wide acceptance thanks to inexpensive CAD/CAM equipment and development of new restorative materials, particularly those that can fulfill esthetic requirements (6). Monolithic restorations, such as zirconia and lithium disilicate, provide acceptable results in this regard, also comply with biomechanical needs, do not require additional veneering or glazing, can be used longer when compared to metal-ceramic restorations and display a reduced risk of cohesive fracture when compared to conventional veneers (4,7-9). However, the surface characteristics of these materials following periodontal treatment, particularly with plastic scaling tips, are not fully revealed.

This *in vitro* study was planned to evaluate the deterioration of monolithic zirconia and lithium disilicate surfaces when they are exposed to various scaling instruments: hand instrumentation with a stainless-steel curette, piezoelectric scaling with conventional stainless-steel tips and piezoelectric scaling with plastic maintenance tips. The null hypotheses was that scaling with a hand curette, piezoelectric scaling with steel tips or piezoelectric scaling with plastic tips would create no change in the surface roughness of monolithic zirconia and lithium disilicate, and thus the surface roughness change of the materials would not differ between used instruments.

Materials and Methods

Sample size

The sample size was calculated with G-Power 3: 95% confidence (1-α), 95% test power (1-β) and an effect size of f=6.7 (large). The minimum required size of n=2 for each instrumentation method by material was calculated. Nonetheless, based on prior research, 18 disks were included in each group (10).

Material production and instrumentation

Fifty-four zirconia and 54 lithium disilicate disks (8 × 2 mm) were prepared with CAD/CAM. Zirconia disks were produced from Straumann Zolid SHT (Amann Girrbach Ceramill, Koblach, Austria) using the inLab MC X5 (Dentsply Sirona, York, PA) device. Lithium disilicate was scraped from Amber Mill blocks (HASS, Gangwon, Korea) with inLab MC XL (Dentsply Sirona, York, PA, USA). The materials were mechanically glazed, and assigned to three groups based on the scaling method: hand instrument, piezoelectric stainless-steel tip, and piezoelectric plastic maintenance tip. Scaling was conducted by a single periodontist (MY). The procedure with the hand instrument consisted of fifteen strokes with mild to moderate force at marked zones with a 7/8 Gracey curette (EverEdge, Hu-Friedy, Chicago, IL, USA) keeping the terminal shank parallel to the surface and using the modified pen grip. The instrument was sharpened every time before being applied to a new disk. Stainless-steel tips (G1-S; NSK, Tokyo, Japan) and plastic maintenance tips (V10-S; NSK, Tokyo, Japan) were separately used for ultrasonic scaling with a piezoelectric device (Variosurg, Model NE214; NSK, Tokyo, Japan) in "periodontology" mode at medium power (50%) under saline irrigation. The tips were positioned with an angle of approximately 10-15° on the disks and horizontally moved in the marked zones for 20 seconds with no lateral pressure, and were discarded and replaced with new ones following the procedure on every nine disks.

Surface roughness measurement

The surface roughness was evaluated by a single examiner (ED) with a profilometer (MarSurf PS1, Mahr GmbH, Germany) calibrated and set at a speed of 0.100 mm/s in a range of 600 µm on the marked zone. The average values of the measurements which were repeated five times, were used for statistical analysis. Disks were gold-coated with an ion-coating unit (Polaron SC Sputter Coater, Quorum Technologies, UK) and photographed with a scanning electron microscope (EVO L10, Carl Zeiss, Germany) for demonstrative reasons.

Statistical analysis

Data were analyzed with the Statistical Package for the Social Sciences (SPSS® V23, IBM®, Armonk, NY, USA). The normality of the distribution was examined with the Shapiro-Wilk test. Generalized linear models were used to examine the main effects and two- and three-way interactions in the analyses of the roughness and the roughness change values according to the material and the scaling method. Pairwise comparisons were performed using the Mann Whitney U test with Bonferroni correction. The results are presented as means and standard deviations. $p<0.05$ was considered statistically significant.

Results

The mean effect of scaling on the surface roughness (Ra) was found to be statistically significant (p=0.001), while the average Ra of the specimens before and after instrumentation were 0.708 ±0.354 and 0.867 ±0.428 respectively. Material (p=0.521), instrument (p=0.257), and material-instrument (p=0.395) interactions regarding Ra did not exhibit significant effects (Table 1). Based on the observation that all specimens showed surface alterations, the roughness changes (Rc) according to the material and the scaling instrument were evaluated in detail (Figures 1, Figure 2, Figure 3). No effect of the material and material-instrument interactions on Rc was observed (Table 2). However, significantly different surface alterations were observed according to the used instrument (Table 3). The hand curette group exhibited a larger Rc compared to the piezoelectric plastic maintenance tip (p=0.025). Rc of the piezoelectric stainless-steel tip did not exhibit any significant difference with the hand curette (p=0.500) or the plastic maintenance tip (p=0.595).

Discussion

The present study aimed to evaluate the surface deterioration caused by different oral prophylaxis instruments, particularly piezoelectric plastic tips, on two different monolithic materials, lithium disilicate and zirconia. The null hypothesis was partly rejected, revealing that instrumentation created a change in the surface roughness of both materials, and the instruments caused surface damage in different extents

Table 1. *Descriptive statistics of the initial and post-treatment surface roughness values according to the material and the instrument.*

		Lithium disilicate	Zirconia	Total
Hand curette	Initial	0.756 ±0.376	0.755 ±0.359	0.755 ±0.363
	Post-treatment	1.130 ±0.563	0.899 ±0.309	1,015 ±0.463
Piezoelectric stainless-steel tip	Initial	0.561 ±0.194	0.811 ±0.437	0.686 ±0.356
	Post-treatment	0.748 ±0.341	0.936 ±0.341	0.842 ±0.349
Piezoelectric plastic maintenance tip	Initial	0.555 ±0.230	0.811 ±0.405	0.683 ±0.350
	Post-treatment	0.565 ±0.255	0.921 ±0.497	0.743 ±0.429
Total	Initial	0.624 ±0.288	0.792 ±0.395	0.708 ±0.354*
	Post-treatment	0.814 ±0.465	0.919 ±0.384	±0.428*

* p=0.001

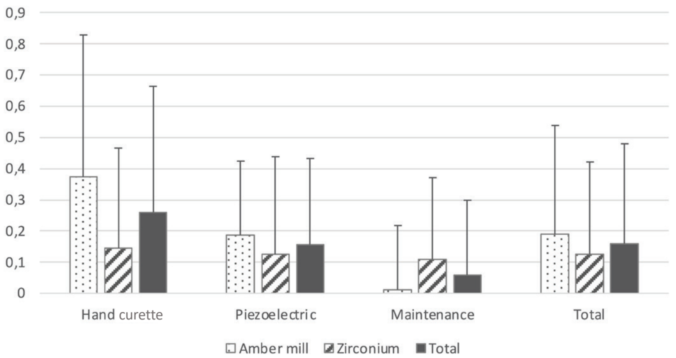

Figure 1. *The roughness changes according to the used instrument and the material.*

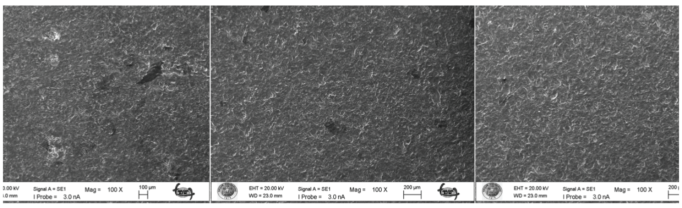

Figure 2. *Scanning electron microscopy images (×100) of lithium disilicate following treatment with hand curette, piezoelectric stainless-steel tip and piezoelectric plastic maintenance tip, respectively.*

when the materials were pooled. However, plastic or conventional steel tips did not exhibit a significant superiority to each other regarding surface damage. Thus, both can be reliable in the proximity of monolithic restorations. On the other hand, stainless-steel curettes caused more surface damage when compared to piezoelectric scaling with a plastic maintenance tip.

Monolithic zirconia restorations have significant advantages such as high flexural strength, minimal preparation

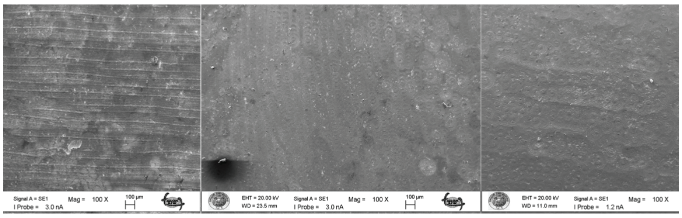

Figure 3. *Scanning electron microscopy images (×100) of zirconia following treatment with hand curette, piezoelectric stainless-steel tip and piezoelectric plastic maintenance tip, respectively.*

Table 2. *Evaluation of the roughness change according to the materials and the instruments.*

	Test statistics (Wald chi-square)	Degree of freedom	p
Material	1.196	1	0.274
Instrument	7.885	2	**0.019**
Material-instrument	5.383	2	0.068

Table 3. *Descriptive statistics of the roughness change.*

	Lithium disilicate	Zirconia	Total
Hand curette	0.374 ± 0.455	0.145 ± 0.322	0.259 ± 0.405^{a}
Piezoelectric stainless-steel tip	0.187 ± 0.238	0.126 ± 0.313	0.156 ± 0.276^{ab}
Piezoelectric plastic maintenance tip	0.010 ± 0.208	0.110 ± 0.262	0.060 ± 0.238^{b}
Total	0.190 ± 0.348	0.127 ± 0.295	0.159 ± 0.322

a-b: Values in the same column with different superscripts represent statistically significant differences

requirement, reduced wear on antagonists, less lab time and fewer dental sessions when compared with conventional materials (11). Until a few years ago, their main disadvantage was poor aesthetic performance due to insufficient translucency (12). However, recent changes in the composition, structure and manufacturing methods have led to monolithic zirconia with better translucency and, concurrently, a significant reduction in strength (13). Lithium disilicate obtained from Amber Mill, on the other hand, is relatively new to dental applications. It is generally used in the anterior zone for inlay and onlay restorations, partial and full crowns, and 3-unit fixed dental bridges (14). Both lithium disilicate and zirconia not only exhibit good biocompatibility and mechanical properties, but also exhibit good esthetic results (15). Thus, especially in periodontally compromised patients with the potential of frequently undergoing oral prophylaxis, exhibiting minimal surface roughness following the treatment can be the main criterion in material selection. According to our results, the materials do not have any significant advantages over each other, and both can be used in periodontitis patients with no reason for preference in regard to initial or post-treatment surface roughness. There are contradictory results in the literature about the extent of deterioration on lithium disilicate and zirconia surfaces following scaling with various instruments. No surface alterations were previously reported on these materials following treatment with stainless-steel curette, ultrasonic scaler or prophylaxis paste (16). Yet, our results are rather in accordance with other prior studies demonstrating an increase in roughness in both (10,17). Hence, effort should be given to decide upon the least harmful scaling instrument for zirconia and lithium disilicate restorations. Interestingly, in our study, the difference between the alterations caused by various instruments was negligible when the materials were evaluated separately. But when the materials were pooled, namely monolithic specimens were assessed in total, the plastic maintenance tip, which induced the lowest surface alteration, was found to be less harmful than the stainless-steel curette.

The efficacies of the materials on biofilm removal and biofilm adherence following treatment were not evaluated in the present study, since there is sufficient information in the available literature (16,18-20). However, our study has the limitation that the applied force during the instrumentation was not measured. Clinically, this force can vary depending on the situation, the instrument and the operator's skills or preferences. Prior research pointed out a drastic force range from 1.01N to 10.35N, while up to 14N was used in studies evaluating surface alterations (21,22). In order to reduce the impact of this limitation on our results, instrumentation was conducted by an experienced periodontist with the modified pen grip and with mild to moderate force, copying the clinical setup and keeping the applied force as standard as possible. Moreover, the hand instruments were sharpened for every new disk to eliminate the effects of blunt instrumentation on the materials.

Both hand and power-driven instruments are effective in biofilm removal. Although similar clinical outcomes can be achieved particularly in single-rooted teeth, the hand instruments take more time and effort when compared to ultrasonic or sonic instruments (18). Therefore, there is a tendency to use power instruments, while the clinical relevance of various tip designs remains unknown (23). Due to the increase in dental implant applications and concurrent peri-implant diseases, developing more efficient and less harmful instruments for implant maintenance became a concern for the dental industry. The plastic tips are recommended particularly for this reason, since they have minimal impact on the titanium surfaces when compared to stainless-steel tips, although a sizable concession in efficiency has to be considered (24). To the best of the authors' knowledge, little is known about how these piezoelectric plastic tips affect monolithic materials. According to our results, if a choice between a stainless-steel curette and a piezoelectric plastic tip is to be made, the latter would be more advisable to reduce potential collateral damage to the material. It should also be considered that ultrasonic scaling with steel tips significantly impacts the optical properties of ceramic materials and may cause cracks and marks in esthetically challenging areas (25).

Conclusion

Within the limitations of our study, there are no drastic differences between stainless steel and plastic tips when conducting piezoelectric scaling in the proximity of monolithic zirconia or lithium disilicate restorations. However, piezoelectric scaling with plastic tips should be encouraged rather than stainless-steel hand curettes, since they create less surface deterioration on these materials.

Türkçe özet: *Çeşitli kazıma aletlerinin monolitik zirkonya ve lityum disilikatın yüzey pürüzlülüğüne etkisi. Amaç: Bu in vitro çalışma, plastik piezoelektrik kazıyıcı uçların monolitik lityum disilikat ve zirkonyanın yüzey pürüzlülüğü üzerindeki etkilerini değerlendirmeyi amaçlamaktadır. Gereç ve yöntem: CAD/CAM ile 54 adet lityum disilikat ve 54 adet zirkonyum disk hazırlandı. Her malzemede, bir paslanmaz çelik küret ile veya çelik veya plastik uç kullanan bir piezoelektrik cihazla kazıma yapıldı. Enstrümantasyondan önce ve sonra bir profilometre yardımıyla malzemelerin yüzey pürüzlülüğü ölçüldü. Kazıma yöntemlerine göre malzemelerin pürüzlülüklerindeki değişimler genelleştirilmiş lineer modeller ile analiz edildi. Gruplar arası karşılaştırmalarda Bonferroni düzeltmeli Mann-Whitney U kullanıldı. Bulgular: Aletler her iki malzemede de yüzey değişikliğine neden olurken (p=0,001), lityum disilikat ve zirkonya örneklerindeki pürüzlülük değişimleri birbirlerine göre istatistiksel anlamlı bir farklılık göstermedi (p=0,274). Ancak küretin (0,060 ±0,238) piezoelektrik plastik uca (0,259 ±0,405) göre malzemelerde anlamlı derecede daha fazla (p=0,019) pürüzlülük değişikliğine neden olduğu bulundu. Sonuç: Plastik uçlu piezoelektrik kazıyıcılar monolitik zirkonya ve lityum disilikat yüzeylerde paslanmaz çelik küretlere göre daha az bozulmaya neden olmaktadır. Anahtar Kelimeler: enstrümantasyon, küret, plastik, ultrasonik, piezoelektrik*

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Informed Consent: Not required.

Peer-review: Externally peer-reviewed.

Author contributions: MY, EOO participated in designing the study. MY, ED participated in generating the data for the study. MY, ED, EOO participated in gathering the data for the study. MY, ED participated in the analysis of the data. MY wrote the majority of the original draft of the paper. ED, EOO participated in writing the paper. MY, ED, EOO have had access to all of the raw data of the study. MY, ED, EOO have reviewed the pertinent raw data on which the results and conclusions of this study are based. MY, ED, EOO have approved the final version of this paper. MY guarantees that all individuals who meet the Journal's authorship criteria are included as authors of this paper.

Conflict of Interest: The authors declared that they have no conflict of interest.

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