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Effects of Sonic and Ultrasonic Scaling on the Surface Roughness of Tooth-colored Restorative Materials for Cervical Lesions

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Clinical Relevance

Both sonic and ultrasonic periodontal instrumentations may roughen the surface of tooth-colored restorative materials for Class V cavities. In general, glass ionomers are more prone to surface alterations than resin-based composites.

SUMMARY

This study investigated the effects of sonic and ultrasonic scaling on the surface roughness of five commonly used tooth-colored restorative materials for Class V cavities, including a flowable resin composite (Tetric Flow), a compomer (Compoglass F), a glass ionomer (Fuji II), a resin-modified glass ionomer (Fuji II LC Imp) and a resin composite (Z100). Twenty rectangular block specimens (16 x 6 x 1.5 mm) of each material were cured against matrix strips, then stored in artificial saliva for two months before performing the periodontal instrumentation. Each specimen was divided into two experimental zones, and both scaling treatments were performed on each sample. The surface roughness (Ra) of these materials was determined before and after the different instrumentations, and differences were evaluated with the use of a profilometer. Data were statistically analyzed using repeated measures of ANOVA with Tukey's multiple comparisons and paired *t*-tests at a significance level of 0.05. Significant increases in surface roughness of all test materials were recorded from both scaling treatments. With the exception of Tetric Flow, ultrasonic scaling had more adverse effects on the surface roughness of all test materials compared to sonic scaling. For the test materials Z100 and Tetric Flow, resin composites showed the least surface changes in both scaling treatments, while Fuji II glass ionomer demonstrated the greatest roughness after instrumentation. More importantly, the mean surface roughness values of several materials

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after instrumentation were above the critical threshold roughness of 0.2 µm.

INTRODUCTION

Sonic and ultrasonic scaling techniques are widely used in periodontal prophylaxis. The vibration of sonic scaler inserts ranges between 3,000 and 8,000 cycles per second, while the vibration of ultrasonic scaler inserts operate between 18,000 and 45,000 cycles per second. Studies have confirmed that both techniques appear to attain similar results as hand instruments for removing plaque, calculus and endotoxin.[1] The cleaning procedures, however, may increase surface roughness, which will influence bacterial colonization and increase the rate of plaque formation.[2-9]

Although the effects of periodontal instrumentation on tooth surfaces have been well investigated,[10-13] few studies have looked at their effects on restorative materials. Bjornson and others[14] demonstrated that all three types of periodontal instrumentation, the curette, the Cavitron scaler and the Titan-S scaler, altered the surface of resin composites but found that hand curettes yielded the most significant alterations. Prophylactic instruments may also cause surface deterioration of metal crown margins. It was reported that a high gold content was the least resistant to surface deterioration, and the ultrasonic scaler caused the greatest surface deterioration to all of the metals tested.[15] However, Lee and others[16] found that the use of ultrasonic scalers and hand scalers had no influence on the initially smooth porcelain surface.

The relationship between dental restorations and periodontal health has been thoroughly investigated for many years. Studies have focused on different aspects of periodontal-restorative interaction, such as surface roughness, the position of the restoration with aspect to the gingival margin, the presence of an overhang and the presence of marginal leakage. The surface roughness of restorative materials can influence staining, plaque accumulation, gingival irritation, recurrent caries and aesthetic appearance. Bollen and others[17] demonstrated that roughness beyond 0.2 µm results in a simultaneous increase in plaque deposits and increases the risk for caries and periodontal inflammation. Furthermore, Jones and others[18] claimed that a restoration surface should have a maximum roughness of less than 0.50 µm if it is not to be detected by the patient.

Several restorative materials are now available for Class V cavities. In addition to conventional resin composites and glass ionomer cements, more-recently developed tooth-colored filling materials, particularly resin-modified glass ionomer cements, polyacid-modified resin composites and flowable composites, have now broadened treatment options. The potential use of each of these five types of materials has its own advantages and disadvantages. As calculus and plaque deposits are often heaviest in the cervical area of teeth, restorations of Class V cavities are inadvertently exposed to these maintenance procedures. The effect of periodontal instrumentation on the surface roughness of these materials should be of interest. This study investigated the effects of sonic and ultrasonic scaling on the surface roughness of five different types of restorative materials commonly used in cervical lesions.

METHODS AND MATERIALS

Five types of commonly used tooth-colored restorative materials for Class V cavities were tested (Table 1). These materials were slightly overfilled into the rectangular recesses (16 x 6 x 1.5 mm) of customized Teflon molds and covered with matrix strips. A glass slide was placed over the molds and pressure was applied, causing the excess material to extrude. These materials, except Fuji II, were then polymerized through the glass slide using a halogen light-curing unit (QHL75, Dentsply International, York, PA, USA) according to the respective manufacturers instructions. For the self-cured glass ionomer cement, specimens were left untouched for 10 minutes before being removed from the molds. Twenty specimens of each material were made. The specimens were stored in artificial saliva (Sali Lube Saliva Substitute, Sinphar Pharmaceutical Co, Taipei, Taiwan) at 37°C for two months prior to the scaling instrumentations.

Table 1: *Restorative Materials Used in This Study*

Group	Materials	Mean Particle Size (µm)	Batch #	Manufacturer
Flowable resin composite	Tetric Flow	0.7	G12407	Ivoclar Vivadent Schaan, Liechtenstein
Polyacid-modified resin	Compoglass F	1.0	F63825	Ivoclar Vivadent Schaan, Liechtenstein
Glass ionomer	Fuji II	4.5	0302121	GC Corporation Tokyo, Japan
Resin-modified glass ionomer	Fuji II LC Imp	4.5	0401121	GC Corporation Tokyo, Japan
Resin composite	Z 100	0.7	20040929	3M ESPE St Paul, MN, USA

For simulated scaling, a new sonic SONICflex scaler (Universal insert #5 with the SONICflex 2003 handle, KaVo, Biberach, Germany) and a new ultrasonic Cavitron scaler (P-10 insert with Bobcat ultrasonic scaler, Dentsply International) with a similar angulation and size were used. Each specimen was divided into two experimental zones. The left zone of each sample received sonic scaling, while the right zone was treated with ultrasonic scaling. The arithmetic mean roughness (Ra) values of both zones were recorded before and after the simulated periodontal scaling treatments with a profiliometer (Surtronic 3+, Taylor Hobson, Leicester, UK). The surface roughness of both zones was measured before instrumentation to serve as the baseline controls.

The directions of the sonic and ultrasonic scaling were approximately perpendicular to the axis of the restoration plate, and the scaling tip was angled approximately 15° to the restorative surface. To avoid inter-operator variation, all instrumentations were performed by one experienced periodontist. Twenty specimens of each material were subjected to both sonic and ultrasonic scaling treatment on both zones at a level 2 power setting, with copious water flow for 60 seconds. The specimens were rinsed in running tap water and further cleaned in an ultrasonic bath for 10 minutes and again analyzed using the surface profilometer. To examine the reliability of the measurement technique with the profilometer at the 95% confidence level, intervals were calculated for a series of 10 measurements at the same site for a randomly selected composite specimen.

SPSS 13.0 for Windows (SPSS Inc, Chicago, IL, USA) was used for the statistical analysis. Means and standard deviations for the Ra were calculated for each technique and material before and after instrumentation. For the statistical analysis, the results were evaluated using repeated-measures of ANOVA, Tukey's multiple comparisons and paired *t*-tests. Differences at $p<0.05$ were considered statistically significant.

Table 2: *Mean Surface Roughness (Ra) Observed with the Ultrasonic Scaling (US) and Sonic Scaling (SS) Instrumentations*

	Pre-US (μm)	Post-US (μm)	*t*-value	Pre-SS (μm)	Post-SS (μm)	*t*-value
Tetric Flow	0.062[a*] (0.011)	0.090[a] (0.025)	0.000	0.066[a] (0.019)	0.079[a] (0.017)	0.003
Compoglass F	0.131[b] (0.062)	0.335[ab] (0.159)	0.000	0.149[b] (0.083)	0.190[c] (0.093)	0.077
Fuji II	0.165[b] (0.117)	2.289[c] (0.625)	0.000	0.170[b] (0.088)	0.296[d] (0.112)	0.000
Fuji II LC Imp	0.091[a] (0.033)	0.686[b] (0.725)	0.002	0.101[a] (0.031)	0.165[bc] 0.087)	0.002
Z100	0.084[a] (0.034)	0.168[a] (0.175)	0.028	0.081[a] (0.036)	0.097[ab] (0.046)	0.095

Standard deviation in parentheses
**Mean values with the same superscript do not significantly differ form each other in each column (p<0.05).*

RESULTS

Table 2 shows the mean roughness values and their standard deviations, which were obtained both before and after the various instrumentations on the different test materials. No statistically significant difference in surface roughness of either zone was noted for each material before instrumentation. For the baseline measurements, Tetric Flow, Z100 and Fuji II LC Imp were significantly smoother than Compoglass F and Fuji II glass ionomer cement. After scaling treatment, both instrumentations significantly increased the surface roughness for all test materials except for Compoglass F and Z100, which were subjected to sonic scaling. Fuji II glass ionomer cement had the highest Ra values, while Tetric Flow and Z100 had the lowest Ra values in both instrumentations. The results of ANOVA also revealed a significant interaction ($p<0.001$) between the materials and scaling methods. With the exception of Tetric Flow, ultrasonic instrumentation generated more roughness than sonic scaling in all test materials, especially the Fuji II glass ionomer cement (Table 3).

Table 3: *Comparison of Mean Roughness (Ra) Between Different Instrumentations*

Materials	Difference
Tetric Flow	No significant difference
Compoglass F	US > SS
Fuji II (GI)	US > SS
Fuji II LC Imp	US > SS
Z100	US > SS

US, ultrasonic scaling; SS, sonic scaling
> denotes statistically significant difference at p<0.05.

Considering the 0.2 μm critical threshold surface roughness of bacterial adhesion, the mean Ra values recorded from Fuji II after both scaling treatments and Fuji II LC Imp and Compoglass F after ultrasonic scaling exceeded this threshold roughness (Figure 1).

DISCUSSION

The removal of plaque from tooth surfaces is an essential part of periodontal therapy. However, cleaning procedures may lead to a number of unintended side

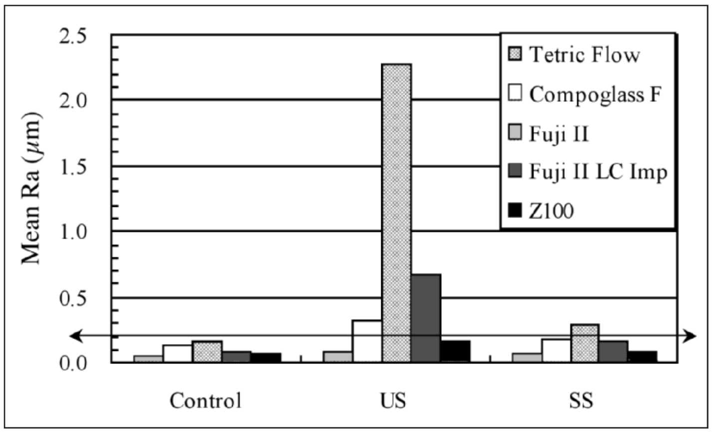

Figure 1: *Mean roughness of the test materials before instrumentation (control), after ultrasonic (US) or sonic scaling (SS), with reference to the critical threshold roughness of bacterial adhesion of 0.2 µm.*

effects. For example, increasing the surface roughness of dental hard tissues and restorative materials by scaling instrumentation has a considerable impact on promoting plaque formation, thereby increasing the risk for both caries and periodontal inflammation. This study showed that both sonic and ultrasonic instrumentation at a medium power setting significantly altered the surface roughness of the test materials. However, the effects of both scaling treatments on surface roughness were dependent on the material. Glass ionomers were dramatically roughened by both treatments, especially by ultrasonic scaling. Fuji II showed the highest roughness value of 2.289 µm after ultrasonic scaling, while Tetric Flow demonstrated the least surface roughness value of 0.079 µm after sonic treatment.

Considering critical threshold roughness, previous studies proposed that surface roughness appears to cause significant *in vivo* effects only when the mean surface roughness exceeds 0.2 µm.[17,19] In the current study, all of the test materials presented acceptable surface roughness values before instrumentation, but Fuji II, Fuji II LC Imp and Compoglass F demonstrated roughness values above 0.2 µm after ultrasonic scaling. For specimens receiving sonic scaling, only Fuji II exceeded this criterion. Based on the results of this study, it seems appropriate to recommend the use of a sonic scaler in patients with multiple Class V restorations.

However, the effects of sonic and ultrasonic instruments on surface alterations are still inconclusive.[1] A previous study showed that a sonic instrument provides adequate calculus removal, while causing less root surface roughness than an ultrasonic instrument.[20] Nevertheless, Jotikasthira and others[11] found that sonic scalers removed calculus more fully, but they also left significantly more roughness, resulting in greater loss of tooth substance compared to ultrasonic instruments. Comparisons between studies of sonic and ultrasonic periodontal scalers are difficult, since there is little consistency among various designs and methodologies. Moreover, studies revealed that the design and angulation of the scaling tip, power setting, instrument pressure, tip to surface angle, sharpness of the working edge and instrumentation time all impact the degree of surface roughness.[11,14,20-23] Therefore, when considering all these variables, it is not possible to reach a conclusion regarding the method of instrumentation that causes the least amount of surface alterations, at this time.

With regard to the performance of different materials, it can be concluded that glass ionomers revealed the greatest increases in mean roughness of all test materials, while resin composites showed the smallest increases. The conventional glass ionomer (Fuji II) was significantly roughened by both scaling treatments. This might be attributable to its heterogeneous and biphasic nature. The weak polysalt matrix phases are preferentially removed, leaving the harder, unreacted glass particles protruding from the surface.[24-25] This accounts for the significant increase in Ra values observed after ultrasonic and sonic scaling. Compomer and resin-modified glass ionomers were not as affected. This could be attributable to their better wear resistance. Both materials contain photopolymerizable resin components, and this polysalt/resin matrix is obviously less susceptible to degradation by scaling instrumentation.[26-27] Consequently, the surface roughness of modified glass ionomers was less serious than that of conventional glass ionomers. The resin component not only accounts for the observed difference in surface roughening between conventional and modified glass ionomers but may also explain the disparity in compomer and resin-modified glass ionomers when subjected to different scaling treatments.

In terms of resin composites, both scaling treatments caused significant but similar changes in surface roughness, although the increase in roughness was subtle and might not be clinically significant. This finding is in agreement with that of a previous study. Bjornson and others[14] compared curette, ultrasonic scaling (with a Cavitron scaler) and sonic scaling (with a Titan-S scaler) to determine the degree of surface alterations of finished resin composites. All three types of manipulation significantly altered the resin composite surfaces. The ultrasonic scaler and the Titan-S sonic scaler produced similar weight and surface profile changes. On the basis of the results of the current study, flowable resin composites not only provided the smoothest initial surface, but they also demonstrated more-durable results when subjected to both scaling treatments. With respect to surface roughness, a flowable resin composite might be the material of choice for Class V tooth-colored restorations.

This study was an *in vitro* determination of the effects of periodontal scaling on the surface roughness of tooth-colored restorative materials commonly used for Class V cavities. As the surface of restorative materials is subjected to a variety of factors that may alter its quality, further studies are necessary to investigate the clinical relevance of these findings.

CONCLUSIONS

Simulated sonic and ultrasonic scaling roughens the tooth-colored restorative materials tested in this study. With the exception of Tetric Flow, ultrasonic scaling tended to have more dramatic effects than sonic scaling on the surface roughness of the test materials. Glass ionomers, resin-modified glass ionomers and compomers demonstrated a rougher surface than conventional or flowable resin composites after instrumentation. The surface roughness of some post-instrumented materials exceeded the critical threshold roughness of 0.2 µm. Based on these findings, routine periodontal scaling of Class V restorations should be carried out with caution, and subsequent polishing of roughened restorations after scaling might be indicated.

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