Effects of ultrasonic and sonic scaling on surfaces of tooth-colored restorative materials: An in vitro study

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Abstract

Objective: The effects of sonic and ultrasonic scalings (USSs) on the surface roughness of nanohybrid, flowable, and polyacid-modified resin composites and conventional glass ionomer cement were examined, and the effectiveness of repolishing on the scaled material surfaces was determined.

Materials and Methods: The surface roughness of each sample was measured three times before and after each scaling and after repolishing, and the data were analyzed using repeated measures analysis of variance, Tukey’s multiple comparisons, and paired t-tests by a statistical program.

Results: Although sonic and USS both significantly increased the surface roughness of all the tooth-colored materials, USS roughened the surfaces of all the test materials more than SS did. Hence, USS may detrimentally affect tooth-colored restorative materials, especially conventional glass ionomers and compomers. Repolishing decreased the surface roughness of all the materials to near their baseline levels.

Conclusions: On the basis of these results, the repolishing of restoration surfaces is strongly recommended after dental scalings.

Key words: Repolishing, sonic scaling, tooth-colored dental materials, ultrasonic scaling

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Introduction

In the last decade, there has been great progress in the use of dental adhesives and resin composites and compomers, giving satisfactory results when used as tooth-colored restorative materials and combined with appropriate adhesive systems and properly implemented procedures. The use of esthetic restorative materials has increased substantially owing to the increased esthetic demands of patients, developments in the adhesive dentistry, improvements in material formulation, and facilitation of adhesive procedures; and the use of amalgams has also somewhat declined owing to the controversy of mercury toxicity. In some countries, patients and professionals widely prefer tooth-colored adhesive materials in molar regions. Resin composites seem to be the most commonly used dental restorative materials for permanent molars, which survive the longest among adolescents. In addition, various adhesive systems also show antibacterial properties. The esthetic appearance and longevity of tooth-colored restorations depend closely on the quality of the finished surface integrity, and a smooth surface texture is of great importance for restorations.

The surface roughness of restorative materials can promote biofilm formation, and a positive correlation was observed between surface roughness and vital Streptococcus mutans adhesion. Smooth resin composite surfaces exhibit less bacterial adhesion and accumulation than rougher ones do, and the smoothness of composite surfaces plays an important role in retarding biofilm adhesion and growth. Thus, increased surface roughness facilitates the adhesion of bacterial populations, which promotes periodontal diseases, secondary caries, surface...
staining, and discomfort due to the retention of bacterial plaque.\textsuperscript{12,23} Therefore, it is of great importance to be able to clean properly and treat tooth and restoration surfaces without traumatizing or damaging them.\textsuperscript{24}

Ultrasonic scaling (USS) devices have recently become universally used in addition to conventional periodontal handheld instruments, and they effectively disrupt biofilms with minimal trauma to tooth structures.\textsuperscript{12,23-26} Sonic and ultrasonic scalers have become the most widely used cleaning instruments among dental practitioners, because they make scaling more efficient and are easier to use than conventional handheld instruments. The effects of sonic and ultrasonic devices and laser treatments on hard and soft dental tissues have been investigated and well-documented in various studies.\textsuperscript{27-35} Laser treatments, however, have shown similar or less effectiveness than piezoelectric-driven scalers in removing calculus and treating periodontal tissues.\textsuperscript{28,30,33,34}

Nevertheless, limited information is available about the effects of sonic and USS on dental restorative materials, and a number of studies has shown that sonic and USS increased the surface roughness of tooth-colored restorations.\textsuperscript{36-38} It was also concluded that polishing scaled surfaces might overcome the change in surface roughness.\textsuperscript{16} Besides the type of adhesive system, margin locations also play an important role in the adaptation and integrity of composite restorations.\textsuperscript{17} Considering that the proximal or gingival margins of restorations are located near the periodontal tissues, we can suppose that sonic and ultrasonic devices may damage the marginal integrity of cervical restorations, thus leading to the development of tooth sensitivity and adversely affecting the longevity and esthetic appearance of the restorations.

This in vitro study investigated the effects of sonic and USS on the surface roughness of different types of tooth-colored restorative materials recommended for use at the cervical and approximal regions. We hypothesized that sonic and USSs would alter restoration surfaces to varying degrees, depending on which materials were used, and that repolishing the scaled surfaces would reduce their surface roughness to clinically acceptable values.\textsuperscript{39}

### Specimen preparation

The test materials were overfilled into 8-mm-diameter, 2-mm-high cylindrical stainless-steel molds; the surfaces of which were then covered with polyester strips and pressed flat using a glass microscope slide to remove excess material and prevent the formation of an oxygen-inhibited surface layer. The specimens were polymerized according to the manufacturers’ instructions by shining a curing light (Elipar, Freelight 2, 3M\textsuperscript{TM} ESPET\textsuperscript{TM}, Seefeld, Oberbay, Germany) through the glass and the polyester strip onto the top surfaces. After the first light-curing, the specimens were removed from the molds, and the opposite sides of the specimens were irradiated in the same manner. The intensity of the light was checked using a curing-light meter (Hilux\textsuperscript{TM} Curing-light Meter, Benlioglu Dental Inc., Ankara, Turkey) at the beginning of the experiment. Specimens were produced for each material group (n = 20), and once cured, were maintained at 100% relative humidity, at 37°C for 24 h. They were then successively polished with coarse then superfine abrasive discs (Sof-Lex\textsuperscript{TM}, 3M\textsuperscript{TM} ESPET\textsuperscript{TM}, St. Paul, MN, USA) for 10 s each under cool water,\textsuperscript{19} with the specimens rinsed under clean running water between each polishing step. The specimens were then ultrasonically cleaned (SOLTEC\textsuperscript{®}, SONICA\textsuperscript{®}, Milano, Italy) in distilled water for 10 min to remove polishing debris, and were then placed into 37°C distilled water for 24 h.

### Surface roughness measurements

The prepared specimens of each material group were randomly divided using a computer program (Research Randomizer Version 3.0, http://www.randomizer.org/) into two subgroups (n = 10) for the different scaling devices. The average surface roughness (Ra, in μm) of the specimens was determined with a precalibrated surface roughness tester (Surtronic 25, Taylor Hobson\textsuperscript{TM} Precision, England). Each specimen was measured at five indiscriminate areas, with the two outlier scores being excluded, and only the remaining three being included in the statistics. The average surface roughness of the specimens of each subgroup was measured and recorded to serve as the prescaling baseline controls.

A sonic scaler (SONICflex 2008, KaVo, Biberach, Germany) and an ultrasonic scaler (Cavitron\textsuperscript{®} SPS\textsuperscript{TM}, DENTSPLY\textsuperscript{®}, Konstanz, Germany) were used to simulate the scalings. These were similarly sized and oriented approximately perpendicular to the axis of the specimens, with their scaling tips angled at approximately 15° to the specimen surface. The specimens were scaled under copious amounts of flowing water and at a moderate power setting for 60 s, as previously described by Lai et al.\textsuperscript{,} All the specimens were scaled by the same operator to prevent operator variation. The scaled specimens were rinsed under running water and were cleaned in an ultrasonic bath for 10 min. The mean surface roughness (Ra)
values were then recorded. All the specimens were then repolished using the procedure described in the specimen preparation section and were ultrasonically cleaned. Finally, the surface roughness was measured for the third time and was recorded.

Statistical analysis
The means and standard deviations of the Ra values were determined. These data were then analyzed using repeated measures analysis of variance, Tukey’s multiple comparisons, and paired t-tests by a statistical program (IBM® SPSS® Statistics 20, SPSS® Inc., Chicago, IL, USA). Differences at the P < 0.05 level were considered statistically significant.

Results
The mean surface roughness (Ra, in μm) and standard deviation measured before and after scaling, and after repolishing of the specimens, are presented in Table 2. For the baseline measurements, the surfaces of the Tetric® Flow and Z550 were smoother than those of the Compoglass® F and Ketac® Molar. Statistical analysis showed that both types of scaling had significantly increased the surface roughness of all the test materials. The surfaces of the scaled Ketac® Molar were the roughest, and those of the Tetric® Flow were the smoothest after both types of scaling.

Ultrasonic scaling produced rougher surfaces than SS for all the material groups, especially for the Ketac® Molar and Compoglass® F; the statistical results revealed significant differences (P < 0.05) between the roughness values for the sonically and ultrasonically scaled Ketac® Molar and Compoglass® F subgroups [Table 3]. Repolishing the surfaces of all the sonically and ultrasonically scaled specimens decreased the roughness values to near their baseline levels [Figure 1].

Discussion
Scaling is a basic procedure used in periodontal therapy, and piezoelectric-driven devices have become widely used to clean periodontal and cervical tooth areas.[27‑35] However, these treatments might cause rough areas such as scratches, nicks, and chips on tooth-colored restorative materials.[36‑38] Thus, sonic and ultrasonic scalers placed especially near cervical regions can easily damage restoration surfaces and margins, leading to dentinal sensitivity and subsequent dental and periodontal problems. Therefore, routine periodontal scaling procedures should be performed very carefully to ensure minimal damage to tooth and restoration surfaces. Proper
instruments such as scaler tips and conditions like power settings should be carefully chosen in order to perform ideal treatments without damaging tooth and restoration surfaces.\textsuperscript{[25,33]} Smooth resin composite surfaces exhibit less bacterial accumulation,\textsuperscript{[20]} and so material surface alteration is another factor in determining bacterial adhesion.\textsuperscript{[40]}

We intended to assess the surface alteration of tooth-colored restorative materials with different chemical properties when used with different scaling devices. The flowable and nanohybrid resin composite already showed smoother surfaces than the other materials at the beginning of the study, and all of the sonically and ultrasonically scaled materials showed statistically significant changes in surface roughness. The glass ionomer, Ketac\textsuperscript{®} Molar, exhibited the roughest surfaces, while the flowable resin composite, Tetric\textsuperscript{®} Flow, had the smoothest surfaces. These findings are consistent with those of Hossam \textit{et al}., Lai \textit{et al}., Mourouzis \textit{et al}., and Hossm \textit{et al}., who found ultrasonically scaled flowable composite material to have the smoothest surfaces among all of the nanofilled, Silorane\textsuperscript{TM}-based, and hybrid composites. Furthermore, fewer bacteria were found to grow on the flowable composite surface than on the other resin composite surfaces.\textsuperscript{[16]}

In the present study, both scaling types significantly roughened the surfaces of all the test materials; however, USS more adversely affected the surface texture of all the materials than SS, especially in the Ketac\textsuperscript{®} Molar and Compoglass\textsuperscript{®} groups. Our findings are also similar to those of Lai \textit{et al}., wherein different tooth-colored materials used for filling Class V cavities were investigated using both ultrasonic and SSS, and a significant increase in surface roughness was recorded for all the materials. Moreover, the flowable composite Tetric\textsuperscript{®} Flow showed the least significant surface changes, and USS roughened the surfaces of the test materials more than SS, except in the case of Tetric\textsuperscript{®} Flow. Mourouzis \textit{et al}., examined the effects of SS on the surface roughness of some tooth-colored materials, finding that all of the sonically scaled test groups to exhibit significantly rougher surfaces, which were subsequently smoothed upon repolishing. The results of the present study also indicate that repolishing decreases the roughness values of all the materials to near their baseline levels; and thus, repolishing may be important for smoothing the dental- and periodontal-scaling-induced roughened surfaces of tooth-colored restorations. It should also be noted here that the threshold surface roughness for bacterial retention is 0.2 μm, above which more plaque may accumulate.\textsuperscript{[41]} The findings of the current study indicate that sonic and USSs may increase surface roughness above the 0.2 μm threshold for the composites and glass ionomer materials tested, and that USS seems to more dramatically increase the surface roughness.

Polishing roughens the material surfaces the least, and so provides the least opportunity for plaque formation. It also seems to be very important to choose proper restorative materials for filling cavities in critical dental areas where traumatic periodontal treatments like scaling could be performed from time to time. Within the limitations of the current study, the flowable composite, Tetric\textsuperscript{®} Flow, appears to be the most suitable for such a purpose. This resin composite is a low-flowable material that exhibits a decreased filler loading (67% filler by weight, 43% by volume) and a high radiopacity, which have previously been recommended for many clinical uses.\textsuperscript{[42,43]}

\textbf{Conclusion}

All the sonically and ultrasonically scaled tooth-colored materials tested in this study were found to have significantly rougher surfaces; and the flowable composite, Tetric\textsuperscript{®} Flow, showed smoother surfaces than the Z550, Compoglass\textsuperscript{®} F, and Ketac\textsuperscript{®} Molar. USS produced rougher surfaces than SS and, therefore, much more adversely affected the surfaces of glass ionomer and polyacid-modified resin composites. Repolishing reduced the surface roughness of all the tooth-colored materials to near their baseline levels, and thus, repolishing scaled restorations is strongly recommended in order to reproduce clinically acceptable restoration surfaces. Within the limitations of the present study, the flowable composite seemed to be the most suitable restorative material for risky tooth areas, at least when used with proper finishing and polishing systems.

\textbf{References}

Erdilek, et al.: Effects of scaling on surfaces of restorative


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