Dental Preparation with Sonic vs High-speed Finishing: Analysis of Microleakage in Bonded Veneer Restorations

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Purpose: To compare marginal microleakage in porcelain veneer restorations following dental finishing using two types of instruments to test the hypothesis that microleakage will be less when teeth are prepared with sonic oscillating burs than when prepared with high-speed rotating burs.

Materials and Methods: Fifty-six extracted human maxillary central incisors were selected and divided randomly into two groups. Group 1 samples underwent dental finishing using high-speed rotating diamond burs, while group 2 used sonic oscillating diamond burs. Buccal chamfer preparation was carried out for both groups. Forty-eight of the samples (24 per group) were restored using IPS Empress ceramic veneers. 2% methylene blue was used to evaluate microleakage at the tooth/composite veneer interface. Teeth were sectioned lengthwise into three parts and microleakage was measured at two points – cervical and incisal – on each section. Before bonding, four teeth per group underwent SEM examination.

Results: Evaluation of microleakage at the cervical dentin margin showed a value of 10.5% in group 1 and 6.6% in group 2, which was statistically significantly different ($p < 0.05$). Incisal microleakage was 1.3% for group 1 and 1.2% for group 2, which was not significantly different. SEM revealed different patterns of surface texture in both areas according to the instrument used. Group 1 was exhibited parallel horizontal abrasion grooves with a milled effect and thick smear layers; group 2 showed abrasive erosion, discontinuous perpendicular depressions, and thin smear layers.

Conclusion: Tooth preparations finished with sonic burs produced significantly less microleakage in the cervical dentin area of bonded veneer restorations. No differences were found in the incisal enamel area.

Keywords: porcelain veneer, microleakage, dentin adhesion, enamel adhesion, oscillating burs.

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Porcelain veneers are used for correcting alterations of shape, position, and color of teeth; they offer the advantages of high levels of conservation and predictability.[18] The bond strength and durability of interfaces between porcelain, cement, and enamel/dentin are important for the success of ceramic veneers, particularly when dentin is to be covered using this method.[18,19] Dentin exposure in the gingival area resulting from dental preparation is common due to the thinness of the enamel layer.[10] Veneer failure rates have been associated with high degrees of dentin exposure,[7,8] which makes the gingival margin a challenging area for effective adhesion.[18,19] This also makes perfect marginal adjustment difficult and leads to biological (eg, caries and/or tooth sensitivity), mechanical (such as debonding), and esthetic alterations (for example, color alterations).[21,23]

Different authors have recommended different instrumentation to prepare teeth appropriately.[11,16] Preparation may be carried out using diamond burs attached to sonic devices or high-speed rotating instruments with diamond or tungsten carbide burs.[2,3,4,15] The action of conventional high-speed instruments used for dental preparation has been widely researched,[13,20,25] as well as the bond strengths and marginal microleakage it produces.[1] Some authors affirm that dental surface morphology of prepared teeth is influenced by the type of bur used for preparation.[9,22] When diamond rotating instruments are used, abrasive particles pass across the tooth surface and scratch troughs in the substrate surface. Tooth structure is ejected ahead of abrading particles and the surface is transformed into a series of ridges and troughs running parallel to the direction of the moving particles.[4] The re-

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Fig 1 High-speed diamond bur used for finishing.

Fig 2 Oscillating diamond bur used for finishing.

sultant axial wall roughness may influence the wettability and bonding quality of adhesive luting agents.[4,9,11,16]

Oscillating instruments make a three-dimensional elliptical movement with longitudinal and transversal components. There are certain advantages[16] to the use of sonic oscillating burs over conventional high-speed burs: minimal gum damage, less noise, and longer durability of the bur itself.[5,27] Dental preparation procedures by both oscillating and rotary burs produce similar intrapulpar temperature changes.[26]

Despite the apparent advantages of oscillating instruments, the present study addresses the lack of research carried out to date into microleakage of restorations on teeth finished with these instruments following preparation.

Reviewing the literature, it was noted that the roughened tooth surface texture produced by sonic oscillating instruments increases the total bonding surface area; this condiction favors wettability and increases restoration retention.[1] For this reason, less microleakage might be expected when teeth are finished with sonic oscillating instruments, due to the increased surface roughness produced. The aim of this study was to compare marginal microleakage in porcelain veneer restorations following dental preparation using these two types of instrumentation. The test hypothesis was that microleakage will be less when teeth are prepared with oscillating burs than with high-speed rotating burs.

MATERIALS AND METHODS

Fifty-six extracted maxillary central human incisors were selected after undergoing optical microscope examination(OPMI Pico Dental, Carl Zeiss; Jena, Germany) to ensure that they were free of any fractures, fissures, and coronal wear.

The teeth were ramdomly divided into two groups and set in blocks of plaster up to the cementoenamel junction (roots were covered by a layer of wax in order to facilitate their later extraction) before performing preparation procedures. One clinician prepared the teeth prior to placing veneers, which were fabricated by a single laboratory technician.

Tooth Preparation Prior to Porcelain Veneer Placement

A single preparation technique was used, ie, window preparation, otherwise known as simple conventional preparation.[12] The vestibular face was reduced by 0.3 to 0.5 mm with chamfer terminations at the gingival margin level without incisal overlap.[29] The preparation area stretched from mesial to distal contact points.

Group 1. High-speed diamond rotary bur

Twenty-eight teeth were prepared using a KAVO Super Torque 660 turbine with a high-speed rotary diamond bur (Komet, 151-µm body/45-µm tip; lot 521443). The preparation areas were then polished using a finer-grained (45 µm) bur (Komet, Lot 235079) (Fig 1).

Group 2. Sonic oscillating instrument

The remaining 28 specimen teeth were prepared using the same turbine and bur type as above, but finishing was performed using a Kavo Soniflex 2003L oscillator fitted with a diamond bur (Komet, 45 µm) (Fig 2).

SEM Evaluation

Prior to bonding veneers, 4 teeth from each group (8 in total) were prepared for SEM evaluation by sputter-coating them with gold. Each sample was fixed to a metal support and placed in the sputtering machine, where a fine layer of gold was deposited on the tooth surfaces by the evaporization process. Afterwards, the samples were painted with liquid gold and examined under SEM.

Two areas per tooth (cervical and incisal) were examined with the JEOL JSM 6300 electron microscope (JEOL; Tokyo, Japan).

Impression Taking

Impressions were taken using silicon vinyl polysiloxane of two densities in a single session. The same impression system and materials were used for both groups.

Porcelain restorations were made by a laboratory technician (Ceramotecnic, Valencia, Spain) in IPS Empress ceramic (Ivoclar Vivadent; Schaan, Liechtenstein). Until the veneers were placed, the prepared teeth were kept in distilled water at 37°C.

Bonding

Internal veneer surfaces were etched and silanized before veneer placement. For the etching procedure, 9% hydrofluoric acid (Ultradent; South Jordan, UT, USA) was used for 2 min. After rinsing with water, the veneers were immersed in an aqueous solution and submitted to ultrasonic vibration for 5 min to remove hexafluorosilicate detritus. Then the inner veneer surfaces were silanized (Ultradent) for 1 min, and a single layer of adhesive Prime & Bond NT (Dentsply; Konstanz, Germany) was applied without polymerization.

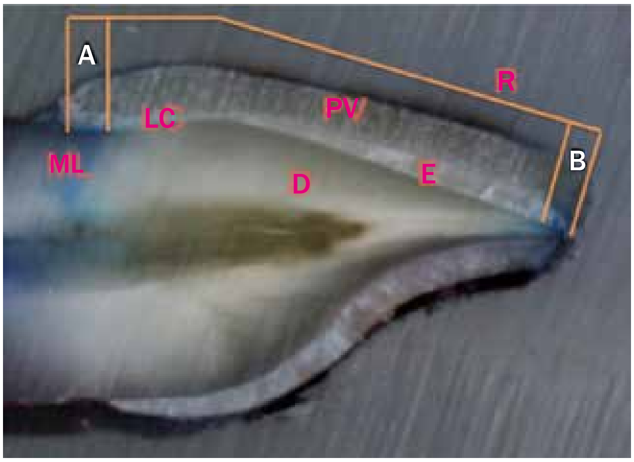

Fig 3 Lengthwise section of veneered tooth. PV: porcelain veneer; LC: luting cement; E: enamel; D: dentin; ML: microleakage (blue area); R: total length of veneered tooth. A: % microleakage in cervical area; B: % microleakage in incisal area.

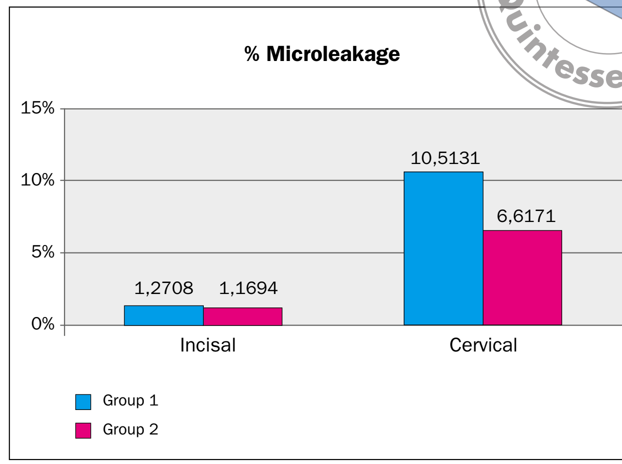

Fig 4 Bar graph comparomg incisal and cervical microleakage for the two groups. Cervical microleakage was 10.5% in group 1 and 6.6% in group 2. Incisal microleakage was 1.3% in group 1 and 1.2% in group 2. Values above bars are percent microleakage.

Teeth were prepared for bonding by the etch-and-rinse technique with phosphoric acid at 37% for 20 s and then bonded with Prime & Bond NT (Dentsply) applied in only one layer and polymerized for 20 s.

A photopolymerizable resin-based composite was used for luting (Variolink Veneer Color 3, lot K3779, Ivoclar Vivadent)[29] and polymerized using a Bluephase curing light (Ivoclar Vivadent) at 1200 mW/cm^2 light intensity for 40 s.

Microleakage Evaluation

Following veneer placement, the 48 veneered teeth were subjected to a thermocycling process for 1000 cycles in distilled water between 5°C and 55°C. Afterwards, the specimens' root sections were coated with two layers of red varnish to within 2 mm of the restoration edges. Tooth apices were covered with wax to avoid leakage in this area.

In order to evaluate the degree of leakage, specimens were submerged in a 2% methylene blue solution for 48 h at 37°C and then washed with water for 20 s. Subsequently, the specimens were embedded in epoxy resin (Epofix Kit, Electron Microscopy Sciences; Hatfield, PA, USA) and cut longitudinally into three sections using a 0.-mm-diameter precision diamond wire saw (Well Diamond Wiresaws; Mannheim, Germany) at low speed. Then the specimen surfaces were polished with disks of grain size 0.05 µm (Struers LaboPol-21; Ballerup, Denmark).

Microleakage was evaluated using an optical microscope (OPMI Pico dental microscope, Zeiss; Jena, Germany) and a millimeter ruler (Leone T3612-00; Firenze, Italy) to measuring the length of microleakage shown as a blue stain from the 2% methylene blue solution. Leakage was classified as follows:[13] cervical: reaching from the cervical edge towards the center of the veneer, expressed as a percentage of the total cervical-incisal veneer length; incisal: reaching from the incisal edge of the veneer towards its center, expressed as a percentage of the total cervical-incisal veneer length (Fig 3).

Statistical Analysis

The total study sample comprised 48 teeth (8 samples having been reserved for SEM examination), 24 finished with oscillating diamond burs and 24 with high-speed rotary diamond burs. Microleakage was measured in two areas (cervical and incisal) on each tooth.

The relation between finishing instrumentation and microleakage was analyzed by means of bivariate analysis. Data obtained for the two groups (group 1: high-speed diamond rotary bur; group 2: diamond bur in sonic oscillating instrument) were analyzed applying the Kolmogorov-Smirnov test and the Mann-Whitney non-parametric test. The significance level established for bivariate analysis was 5% ($p < 0.05$).

RESULTS

Microleakage Analysis

Cervical microleakage was 10.5% in group 1 and 6.6% in group 2, which was statistically significant. The difference in incisal microleakage between groups groups was lower and not significant: 1.3% leakage in group 1 vs 1.2% in group 2 (Fig 4).

Cervical microleakage differed significantly between groups ($p = 0.006$, Mann-Whitney test), as did incisal microleakage ($p = 0.343$, Mann-Whitney test). Thus, with significance set at $p < 0.05$, cervical microleakage differed significantly depending on whether surface roughening was carried out by oscillating or rotating burs. The box-plot diagram shows differences in cervical microleakage between the two study groups: in group 1, 50% of the samples showed microleakage below 10%, while in group 2, 75% of samples exhibited microleakage below 10% (Fig 5).

Scanning Electron Microscopy Analysis

Scanning electron micrographs of the cervical region revealed sealed dentinal tubules, the dentinal smear

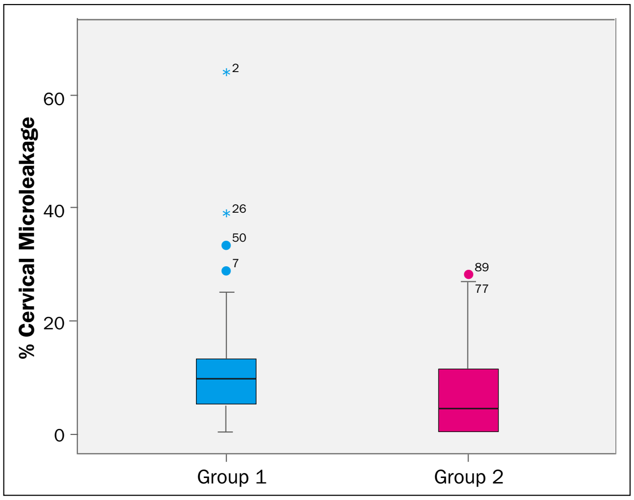

Fig 5 Box-plot diagram showing significant differences in cervical microleakage between the two study groups: group 1 values fall mainly between 5 and 15, while group 2 values are mostly between 0 and 10. In group 1, 50% of the samples exhibited less than 10% microleakage, while in group 2, 75% of samples showed microleakage of less than 10%.

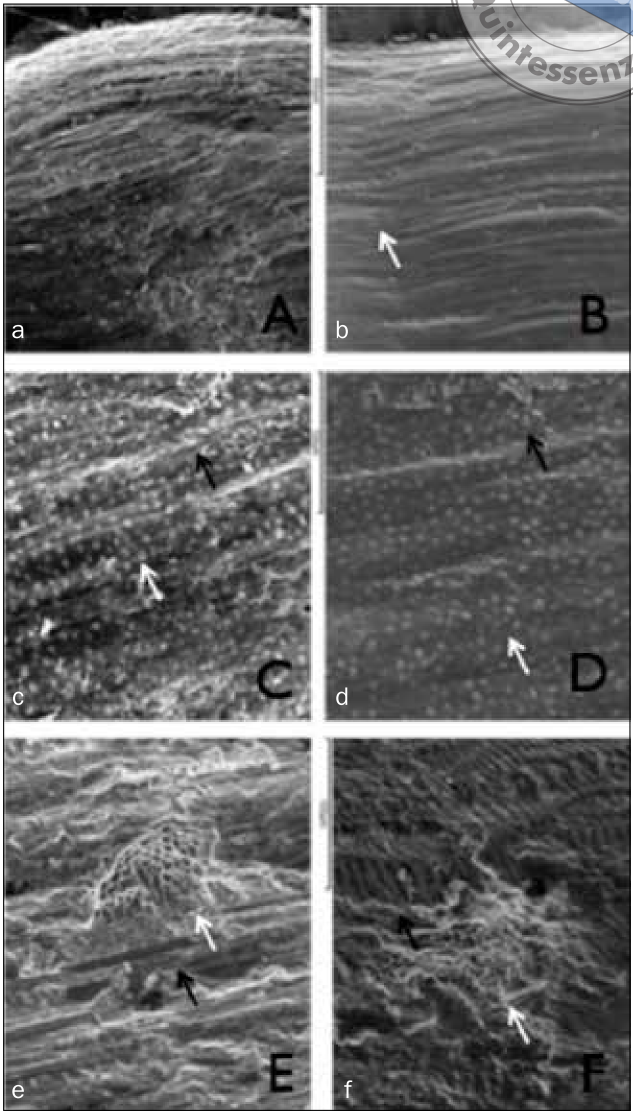

Fig 6 (right) SEM micrographs of prepared tooth surfaces. a) Group 1, cervical area (100X) shows irregular or roughened surface with a thick dentinal smear layer. b) Group 2, cervical area (100X) surface with deeper grooves of pockmarked appearance (arrow), smoother, and with less dentinal smear. c) Group 1, cervical area (500X) and d) group 2, cervical area (500X), showing sealed dentinal tubules (white arrow), absence of enamel prisms, abundant dentinal smear (black arrow), and grooves produced by the two types of instrument. e) Group 1, incisal area (500X), enamel prisms can be seen (white arrow) and parallel horizontal grooves (black arrow), characteristic of high-speed instruments. f) Group 2, incisal area (500X) enamel prisms (white arrow) and discontinuous perpendicular grooves (black arrow) characteristic of oscillating instruments.

layer, and an absence of enamel prisms; in contrast, enamel prisms were present in the incisal region (Fig 6). The two groups had different surface texture patterns. Group 1 had parallel troughs, scratched into the surface by abrading particles propelled by the high speed of the instrument used. Group 2 showed abrasive erosion, with deep, pockmarked grooves, discontinuous perpendicular troughs characteristic of oscillating instruments and thin smear layers.

DISCUSSION

As stated in a study carried out by Vieira et al,[28] marginal adaptation of laminate veneers is influence by the following factors: tooth preparation, whether the boundaries of preparation areas are over enamel or dentin, conditioning technique used, adhesive, insertion technique, and the restorative material.

The present study was designed to reproduce standard clinical protocols used for veneer restorations, while also selecting techniques that appear to keep microleakage to a minimum. Thus, the commonly used window preparation method[12,28] has been shown to yield lower levels of microleakage compared to other preparation methods.[24] Following the recommendations of numerous authors, a standard bonding procedure was used in the study; the internal surfaces of the porcelain veneers were etched with hydrofluoric acid, silanized, and bonded to the teeth which had been prepared using an etch-and-rinse adhesive luting composite.[6,8,12,18] Some studies[1,20] have investigated the influence of the bur material used for tooth preparation and have shown that preparation using tungsten carbide burs produces greater microleakage than diamond burs, which some authors[20] claim is a result of the surface texture produced by tungsten carbide burs (galling pattern), which negatively influences adhesion. For this reason, the present study used diamond burs for both study groups.

Although some authors[15] have found no difference in surface roughness of the cervical dentin margins prepared by coarse, fine, or super-fine tipped diamond burs, Price and Sutow[20] and Wahle and Wendt[30] observed significant differences in the surface roughness of tooth preparations performed with different grit diamonds. The present study used the same bur grit in both groups, but different surface roughness resulted from the two different cutting technologies studied.

The null hypothesis that microleakage would be less when teeth were prepared with oscillating burs than with high-speed rotating burs was confirmed in cervical but not in incisal areas. In incisal areas, all restoration edges were on enamel, and incisal microleakage was seen to be minimal in both study groups; this minimal microleakage on enamel is corroborated by several clinical studies.[6,8] However, in cervical areas all restoration edges were over dentin. Ferrari et al[10] states that when vestibular surface reduction is 0.4 to 0.6 mm, dentin will be exposed in the cervical area; this was confirmed by the present SEM analysis. Microleakage is more frequent when the cervical preparation margin is on dentin[8] due to the differences in bond strengths for dentin and enamel.

The present study followed the same protocol for all specimens with the exception of the instrument used for dental finishing, from which we may deduce that the choice of instrument contributes to the significantly different degrees of cervical microleakage observed.[1] Greater cervical microleakage occurred following preparation with high-speed rotating than with oscillating instruments. This may be due to the different surface texture patterns produced.[15] Although some authors[27] state that use of sonic tips has no influence on the dentin bond strength when an etch-an-rinse adhesive is used, studies by Price and Sutow[20] and Siegel and Fraunhofer[22] affirm that the characteristic appearance of the dentinal surfaces is determined by the shape of the instrument used and this would appear to be supported by the present findings.

Group 1 samples were textured with shallow parallel grooves, made by abrasive particles passing across the tooth surface and scratching troughs into surface, propelled by the high speed of the instrument used for preparation;[4] an abundance of dentinal smear was also observed. Some authors have stated[19] that this smear layer is not completely removed after etch-and-rinse procedures and for this reason, bonding at the cervix will depend on intertubular hybridization rather than on intertubular resin tag formation.

Group 2 samples showed abrasive wear with a pockmarked appearance, ie, discontinuous perpendicular grooves where large particles had been torn away. The rough texture increases the bonding surface area, which Ayad et al[3] claims is a condition that favors wettability and so increases restoration retention.

CONCLUSIONS

1. Cervical microleakage (preparation margin in dentin) was significantly less when tooth finishing was carried out using diamond burs in a sonic oscillating instrument.
2. There were no statistically significant differences in microleakage between the two groups (high-speed diamond burs vs oscillating diamond burs) when the incisal edges of the prepared area were located in enamel.
3. Cervical microleakage was greater than incisal microleakage in both study groups.

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Clinical relevance: The use of oscillating diamond burs for dental finishing reduces microleakage in vitro in veneer restorations whenever the restoration edges are situated over dentin. For this reason, their use can be recommended for dental preparation prior to porcelain laminate veneer bonding, which will help reduce clinical problems resulting from microleakage.