Clinical Wear Rate of Direct and Indirect Posterior Composite Resin Restorations

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The purpose of this randomized clinical trial was to determine the clinical wear behavior of three nanofilled composites (Filtek Supreme XT [FS], Tetric EvoCeram [TEC], and Aelite Aesthetic [AA]) with two indirect composites (Estenia [E] and Tescera ATL [TATL]) on permanent molar teeth. Fifty-four patients whose treatment plans included moderate Class I and/or II restorations on molar teeth were selected for inclusion in this study. Wear was measured by use of gypsum replicas at baseline and 6 and 12 months using three-dimensional scanning and rapid-form software to elucidate the wear mechanisms. For statistical analyses, one-way analysis of variance and the Scheffé test were used. Statistical results revealed that wear behavior of TATL was significantly different from that of AA ($P < .05$). No significant differences were detected between AA and E ($P > .05$) or between TEC, FS, and TATL composite resins ($P > .05$). The results showed similar clinical performance between the five composite resins evaluated. Therefore, composite resins may be indicated for the restoration of posterior teeth. However, the composition of the composite resin did affect the wear behavior of the composite material. (Int J Periodontics Restorative Dent 2012;32:e87–e94.)

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Because of improved biomechanical properties, resin-based direct posterior composite restorations are a routine and well-established treatment in dental practice today.[1,2] However, early attempts to place composite resins in posterior teeth as an alternative to amalgam had only limited success because of insufficient material properties, resulting in more clinical challenges and higher failure rates than amalgam restorations.[3] One of the most common causes of failure in posterior composite restorations is occlusal wear.[4] Since the early days of posterior composite resins, researchers have responded by developing new and modified versions of resin-based composites, techniques, and instruments for placing these restorations to improve wear resistance.[5]

Today, new nanofilled composite resins have been developed because of the increasing demand for a universal restorative material indicated for all types of direct restorations, including those on posterior teeth.[6,7] Nanofilled composite resins are distinguished from microfilled resins by the loading percentage and features of their filler particles. Microfilled composite resins present nearly 37% to 40% volume filler loading, while nanofilled resins have approximately 60% volume filler loading.[8] It may be hypothesized that filler morphology and filler loading influence the wear resistance of commercially available composite resins.[9] Indirect laboratory-processed composite resin systems also provide an esthetic alternative for intracoronal posterior restorations.[10] Additional clinical benefits include precise marginal integrity, wear resistance similar to enamel, wear compatibility with the opposing natural dentition, ideal proximal contacts, excellent anatomical morphology, and optimal esthetics.[11]

Several methods have been developed to evaluate intraoral wear of resin-based composites. The method developed by Leinfelder is the most widely used in clinical research and comprises 6 calibrated clinical casts exhibiting progressive wear in 100-μm increments.[12,13] The Moffa-Lugassy scale consists of 18 standard casts that differ by 25-μm increments in the early stages of wear.[5,14] The Vivadent scale is a combination of the Leinfelder and Moffa-Lugassy scales and exhibits greater sensitivity and precision in identifying wear.[15] Regardless of the type of device, however, all seem to have a few insufficiencies in common: They result in high standard deviations as a result of inaccurate replicas and they present repositioning problems and measuring-device restrictions.[16] Currently, digital mapping of tooth surfaces seems to be the most precise mechanical method for indirectly analyzing restoration wear.[17]

The aim of this study was to compare the clinical wear performance of three conventionally placed nanofilled composite restorations and two indirect composite inlays at 12 months by using a three-dimensional (3D) optical scanning method.

Method and materials

Following a positive review by the Dental Faculty Ethics Committee of Selcuk University, Konya, Turkey, young adult patients were selected among routine patients of the polyclinic. All patients signed a written informed consent form at the start of the project. This report presents data derived from resin-based composite and composite inlay Class I and II restorations placed over a period of 1 year (2005 to 2006). Extremely large restorations (ie, faciolingual occlusal isthmus more than two-thirds of the distance between the facial and lingual cusp tips) were avoided. All included restorations had all-enamel margins, were in occlusion at baseline, and had no pulp exposure at placement. A total of 100 Class I and II restorations were placed in 54 patients (22 men, 32 women; mean age, 23 years; age range, 20 to 28 years). All teeth were in occlusion and had at least one proximal contact with an adjacent tooth.

Restorative materials

Three nanofilled composite restorative systems (Filtek Supreme XT [FS], 3M ESPE; Tetric EvoCeram [TEC], Ivoclar Vivadent; and Aelite Aesthetic [AA], Bisco) and two indirect inlay restorative systems (Estenia [E], Kuraray and Tescera ATL [TATL], Bisco) were used in this study. Their compositions are summarized in Table 1.

Clinical procedure

Composite inlay

All cavities were prepared according to common principles for adhesive inlays. To achieve estimated convergence angles between opposing walls of 10 to 12 degrees, cavities were prepared with 80-μm-grit and finished with 25-μm-grit diamond burs (KG Sorensen) under water cooling with a slight taper, and care was taken to minimize the increase in cavity extension. The cavities were prepared with rounded inner cavity angles to a depth that allowed at least 2 mm of resin material in the occlusal contact areas, and all undercuts were removed. Isolation of the tooth was provided by cotton rolls and a salivary aspirator before placement of the base. In most cases, a thin layer of calcium hydroxide base material (Life, Kerr) was placed on the pulpal and axial walls of deep cavities. Complete arch impressions were taken using a C-silicone impression material (Zetaplus, Zhermack). Provisional restorations were placed with eugenol-free

Table 1 Composition of direct composite resin and indirect inlay systems as provided by the manufacturer

Composite resin brand*	Organic matrix	Inorganic filler	% by weight	% by volume	Type of composite resin
FS	TEGDMA, bis-GMA, UDMA, bis-EMA	Zirconia silica: 0.6 to 1.4 µm, silica: 5 to 20 nm	78.5%	59.5%	Nanohybrid (direct)
TEC	bis-GMA, UDMA, DDDMA	Barium glass filler, ytterbium trifluoride, mixed oxide, and prepolymers: 40 to 550 nm	82.0%	61.0%	Nanohybrid (direct)
AA	Ebis-GMA, bis-GMA	Glass filler, amorphous silica	73.0%	54.0%	Reinforced nanofill (direct)
TATL	Ebis-GMA, UDMA	Glass filler, amorphous silica		20% to 60% 10% to 40%	Microhybrid (indirect)
E	UDMA, hydrophobic aromatic dimethacrylate, hydrophobic aliphatic dimethacrylate	Surface-treated alumina microfiller, silanated glass filler, silanated glass-ceramics	92.0%	82.0%	Hybrid ceramic (indirect)

TEGDMA = tetraethylene glycol dimethacrylate; bis-GMA = bisphenol A glycidyl dimethacrylate; UDMA = urethane dimethacrylate; bis-EMA = bisphenol A ethyleneglycol dimethacrylate; DDDMA = decandiol dimethacrylate; Ebis-GMA = ethoxylated bisphenol A glycidyl dimethacrylate.
*See text for description of acronyms.

light-curing temporary cement (Systemp inlay, Ivoclar Vivadent). One laboratory technician employed at the school of dentistry fabricated all inlays following the manufacturers' instructions.

The E inlays were built up in layers of 2.5 mm, and each layer was polymerized for 120 to 180 seconds from the occlusal direction with a curing unit (Hilux Expert, Benlioğlu Dental). The inlays were then removed from the cast, and composite inlays were postcured in a light oven for 180 seconds and then in a heat oven for 10 minutes at 114°C to improve the physical properties (CS-110 Light and Heat Curing System, Kuraray). The TATL inlay polymerization system (Tescera ATL Processing Unit, Bisco) had two specialized cups: one for pressure/light and one for water/pressure/light/heat. TATL inlays were built up in one increment and polymerized on the cast in the light-polymerization cup for 5 minutes. The inlays were then removed from the cast, and composite inlays were postcured in the heat cup submerged in water at a temperature of 120°C and a pressure of 6 bar.

The inlays were adjusted to the master cast and polished with silicone polisher, brushes, and a polishing paste. After clinical try-in, the inner surfaces of the inlays were etched with 37% phosphoric acid. All inlays were definitively inserted within 1 week after the impression was made. The E inlays were cemented with a dual-cure resin cement (Panavia F, Kuraray), and TATL inlays were also cemented with a dual-cure resin cement (Duo-Link, Bisco).

Direct composite resin restorations

Before preparation, teeth were cleaned with pumice-water slurry in a rubber cup to remove salivary pellicle and any dental plaque; then the color of each tooth was determined using a color key. Enamel (or the existing restoration) was removed using a pear-shaped diamond bur (Jota) in a high-speed air turbine. Carious dentin was then mechanically removed using conventional round steel burs (ISO 012; ELA) in a slow, speed-reducing handpiece. Dentin hardness was checked using a dental explorer (Jensen). This was repeated until either a leathery hard texture was reached or a sharp scratching sound was heard on all teeth when checked with a dental explorer.[18] Cavities were designed according to the principles of minimally invasive dentistry.

Cotton rolls and salivary aspirator isolation were used for each patient. All Class II cavities were restored using a sectional metal matrix (Contact Matrix, Palodent) fixed with a ring and wooden wedges (Kerr) inserted with firm pressure. The adhesive procedures for direct composite resins were performed by applying freshly mixed self-etching primer (Clearfil SE Primer, Kuraray) to the cavity walls for 20 seconds, which were then gently air dried for 5 seconds. Bonding agent (Clearfil SE Bond, Kuraray) was applied using a microbrush and polymerized for 10 seconds. Then, the cavities were filled incrementally with facially and lingually inclined mesiodistal layers in increments of 2 mm. Between each increment, polymerization was performed with a halogen light-curing unit (Hilux Expert) for 20 (TEC, AA, FS) or 40 seconds (FS Dentin shade), and occlusion and articulation were checked and adjusted, followed by finishing with fine-grit diamond instruments (Jota). Then, restorations were polished using Sof-lex disks (3M ESPE) and rubber polishing instruments and a composite polishing kit (Enhance, Dentsply). All finishing procedures were performed under water cooling.

Wear evaluation

All patients received an oral hygiene briefing after restoration. Recalls were scheduled after 1 week (recorded as "baseline") and after 6 and 12 months. Clinicians' subjective evaluations of surface gloss (sleek, minor, or severe roughness) were documented. At baseline, low-viscosity polyether impressions (Impregum Penta DuoSoft, 3M ESPE) were taken. The impressions were disinfected with a commercial solution (Impresept, 3M ESPE), and super-hard stone-die replicas were prepared (Fujirock Pearl white1, GC). Patients were recalled after 6 and 12 months. At the recall appointments, the surfaces of the restorations were cleaned with a toothbrush and rinsed with water. Replicas were prepared as described for baseline documentation. Articulating paper (Double Check, Swedish Dental) was used to identify tooth contact points, and these were recorded by digital photography (Figs 1a to 1d).

3D scanning of the surfaces of the baseline and follow-up replica casts was performed using the 3D Optical Scan System (Breuckmann). The 3D point clouds were obtained, and shells were created using the surface analysis program optoCAD (Breuckmann). Standard computer algorithm software (RapidForm, 2005) was used to superimpose the images (Figs 2a to 2c) and calculate the amount of wear. Before the matching process, images of baseline and follow-up replicas were marked at nonessential sites to serve as reference points for superimposition of the tooth surfaces, then the software determined how closely the data points in follow-up images matched the data points in baseline images. Differences between baseline and follow-up images were then calculated. Maximum, minimum, and mean wear values were determined (Fig 2d). To determine the wear rate of the occlusal contact areas, the contact areas were deselected by aligning the contact points with the marked contact points of the intraoral photographs. Volume of the wear area was calculated as follows: mean vertical wear (mm) × contact area (mm^2) = volume (mm^3) (Fig 2e).[17]

Statistical analysis

Statistical analysis was performed using SPSS version 13.0 (SPSS) for descriptive statistics. The degree of wear was evaluated using one-way analysis of variance. The Scheffé multiple range test was used for post hoc analysis. Statistically significant differences were found in degree of wear between materials ($P < .05$).

Fig 1a (left) *Maxillary left first molar with occlusal caries.*

Fig 1b (right) *Immediately postrestoration with Filtek Supreme XT.*

Fig 1c (left) *Tooth contact points recorded at baseline.*

Fig 1d (right) *Clinical view 12 months postrestoration.*

Figs 2a to 2c (left to right) *Wear results generated by the 3D scanner and produced from data collected from the super-hard stone-die replicas using the 3D Optical Scan system.*

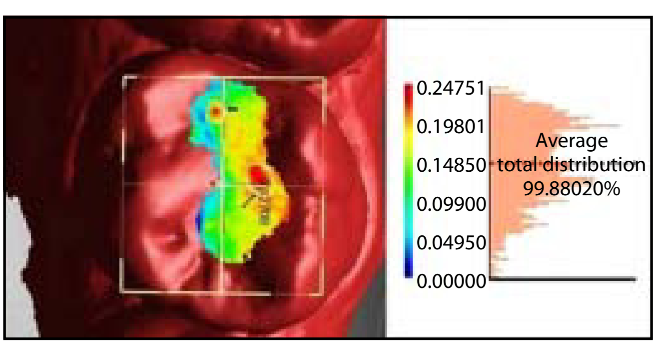

Fig 2d *Mean wear of the composite resin after adjustment to baseline.*

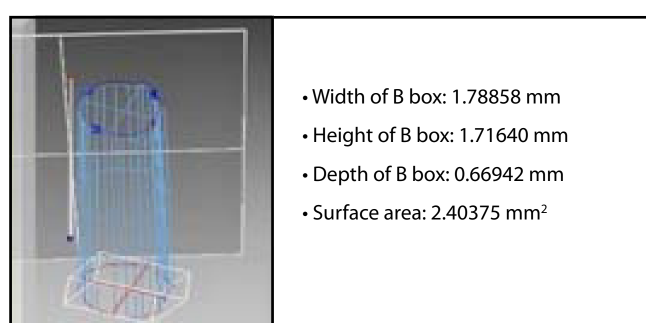

Fig 2e *Determination of the occlusal contact areas.*

Table 2 **Minimum, maximum, and mean volumetric wear values of the composite resins after 6 and 12 months (mm³)**

Composite resin	N	6 mo Minimum	6 mo Maximum	6 mo Mean ± SD*	12 mo Minimum	12 mo Maximum	12 mo Mean ± SD*
E	20	0.04	0.11	0.073 ± 0.02[a,b]	0.07	0.15	0.112 ± 0.02[a,b]
TATL	20	0.04	0.13	0.088 ± 0.02[b]	0.07	0.18	0.132 ± 0.03[b]
TEC	20	0.06	0.11	0.085 ± 0.01[b]	0.08	0.14	0.112 ± 0.02[a,b]
FS	20	0.05	0.12	0.087 ± 0.02[b]	0.06	0.16	0.112 ± 0.03[a,b]
AA	20	0.04	0.10	0.058 ± 0.01[a]	0.05	0.12	0.090 ± 0.02[a]

SD = standard deviation.
*Different letters indicate statistical significance (*P* < .05).

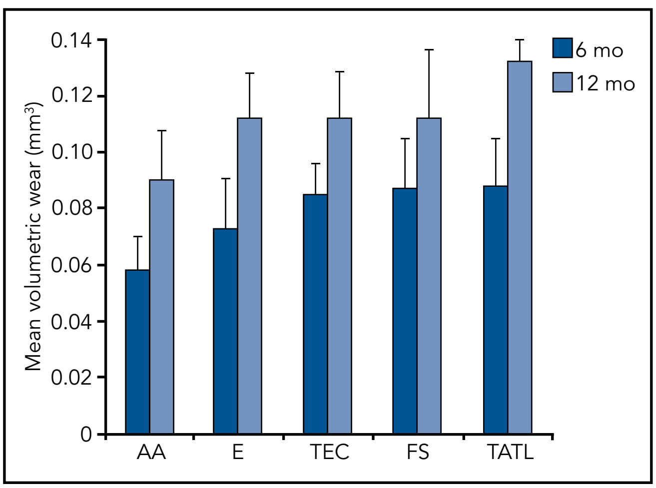

Fig 3 *Mean volumetric wear after 6 and 12 months for each experimental group. Vertical lines on top of the bars represent standard deviations.*

Results

After 12 months, all patients were available for evaluation. Thus, a total of 100 restorations (20 FS, 20 TEC, 20 AA, 20 E, and 20 TATL) were included in the statistical analysis. The mean total volumetric wear values after 6 and 12 months are summarized in Table 2. The highest mean wear rates were 0.088 ± 0.02 mm^3 and 0.132 ± 0.03 mm^3 for TATL indirect composite resin, and the lowest mean wear rates were 0.058 ± 0.01 mm^3 and 0.090 ± 0.02 mm^3 for AA nanofilled composite resin after 6 and 12 months, respectively. Statistical analysis revealed that wear behavior was significantly different between AA nanofilled composite resin and TATL microhybrid composite resin ($P < .05$) (Fig 3). No significant differences were detected between AA and E ($P > .05$) or between TEC, FS, and TATL ($P > .05$) (Fig 3).

Discussion

Resistance to occlusal wear is an important aspect of the clinical success of new restorative materials.[19] Enamel-like wear is necessary for composite resins since they should simulate the properties of enamel and dentin.[20] New types of direct and indirect composite resins were used in this study and were evaluated for clinical wear criteria with the methods of digital mapping, which have been defined by previous studies.[17,21] Because in vivo wear measurements are complicated and time-consuming, accelerated laboratory evaluation methods have been developed,[17,19] whereas the wear resistance of conventional composites differs from one study to another.[16] Heintze[22] provided an explanation for the phenomenon of poor reproducibility of wear results in vitro: Most wear simulators lack control and regulation of force development during dynamic loading of flat specimens. The 3D laser digitizing method is used in larger clinical studies.[23–25] With this method, a computer-driven laser scans a stone cast of the restoration being assessed and creates a 3D computerized surface model of the tooth.[26] The 3D optical-scanning method used in this study, in combination with the anatomical matching program, can detect wear with an accuracy of 10 µm and is more effective than a subjective evaluation for establishing wear rates of restorations. Because the process is quick and highly accurate, complex analyses of 3D wear can be conducted on a large number of samples.[17,26] The main disadvantage is that this method includes the need for replicas, a step during which errors are reported to occur.[27] An error of this magnitude would call into question the quantitative results for mean total vertical wear in this study. The objective of the study was to compare the rate of wear, so the error component described applied to all replica measurements in this study.

Clinical studies have revealed a tendency toward better clinical wear behavior for composite resin materials introduced in the last decade. In the study by Köhler et al,[28] wear measurement with the Leinfelder method realeved that wear values of composite resins were 167 and 158 µm. In a 2-year clinical study, Lund et al[29] evaluated the occlusal wear degree of composite resins using the Leinfelder method and recorded values between 29.8 and 40.6 µm. The mean rate of wear of enamel occlusal contact areas varies widely but has been reported to be approximately 29 µm per year in the molar region.[30] The mean rate of occlusal contact areas has been reported to be 0.02 to 3.16 mm^2 on enamel.[31] The rate of wear of posterior composite resin restorations in this study was comparable with that of enamel (approximately 0.13 ± 0.03 mm^3 in the occlusal contact areas after a 12-month observation period). This 1-year clinical study shows that composite resins and inlays were clinically successful,[32] and the clinical wear resistances of composite resins were found to be sufficient when compared to the rules of the ADA acceptance program.[33]

In this 1-year clinical study, there were statistically significant differences among the tested composite resin and inlay materials. At 6 months, the nanohybrid composite resin AA showed the lowest in vivo wear. At 12 months, the results were similar to those at 6 months. The difference between AA and TATL, both manufactured by the same company, could lie in the differences in their filler content. AA has smaller and a higher percentage of filler content, and the wear degree was the lowest. In general, material loss can decrease with reduced filler size, such as 100-nm spheric fillers.[34] According to Mitra et al,[7] the nanofilled composite could have similar mechanical properties to the hybrid composite since the nanocomposite system shows high translucency, high polish, and polish retention similar to those of microfills. Indirect laboratory-processed composite resin systems also provide an esthetic alternative for intracoronal posterior restorations.[15,16] The results of this study suggest that filler loading may be important in altering the wear performance of indirect composites. The effect of the composition of the composite resin material on wear has been confirmed by this study. The results of the present study showed similar clinical performance between the five composite resins evaluated and that composite resins may be indicated for restorations in posterior teeth. However, to be certain of the clinical determinations, long-term clinical studies are needed.

Conclusion

The composite resins used in this study had enough wear resistance for use in the restoration of posterior teeth, and the restorations were rated as clinically acceptable. It has been confirmed that the effect of the composition of the composite material on wear is important. These results should assist the clinician in the selection of restorative materials, based on knowledge of the different wear behaviors of restorative materials and of the individual needs of each patient.

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