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Two-year Randomized, Controlled Clinical Trial of a Flowable and Conventional Composite in Class I Restorations

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Clinical Relevance

Flowable composites may be an acceptable restorative material for small load-bearing posterior restorations.

SUMMARY

Objectives: This study evaluated the two-year clinical performance and volumetric wear of a flowable resin composite compared to a conventional highly filled composite resin in Class I restorations.

Methods and Materials: In this single-center, single-blinded, comparator-controlled clinical study (Institutional Review Board approved), 120 carious teeth distributed in 60 patients were randomly assigned to four calibrated practitioners who placed occlusal restorations (n=60 flowable and n=60 conventional composite). Direct and indirect assessment at baseline, six months, one year, and two years occurred during which the modified Cvar and Ryge criteria were evaluated. Volumetric wear was determined by superimposition of profilometer scans of baseline and two-year casts.

Results: At two years, there was no significant difference in anatomic form (p=0.80), color match (p=0.08), marginal adaptation (p=0.89), marginal discoloration (p=0.79), surface integrity (p=0.18), secondary caries (p=0.66), cold sensitivity (p=0.522), occlusal sensitivity (p=0.818), or volumetric wear (p=0.661) between materials. Both materials showed a decrease in all criteria except secondary caries (p=0.95) over time. Two-year mean volumetric wear was 3.16 ± 2.38 mm^3 for the flowable

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composite and 3.43 ± 2.50 mm^3 for the conventional composite.

Conclusions: The flowable and conventional composites used in this study have similar clinical efficacy after two years of service when placed as Class I occlusal restorations having isthmus widths less than one-half the intercuspal distance.

INTRODUCTION

Flowable composites were first introduced in the 1990s.[1] The handling characteristics and syringe delivery system of flowable composites remove some of the challenges encountered with placing composite resin in small to medium-sized preparations. Even though these materials are widely used by practicing dentists, their clinical applications have been limited by the mechanical limitations measured in early-generation flowable composites.[1,2] Early-generation flowable composites were filled at concentrations ranging from 50wt% to 70.5wt% (most studies only report wt% filler; however, vol% filler gives a better representation of composite microstructure).[1] Laboratory studies have shown that the increased filler content in current-generation flowable composites has improved several of the mechanical properties of these materials.

Filler content has been shown to influence the polymerization shrinkage of resin composites. Unlike resin, filler particles do not contract upon polymerization and, therefore, help decrease the polymerization shrinkage of composite resins. In studies[3,4] of experimental composites filled with varying concentrations of filler particles, filler concentration was inversely correlated to shrinkage and shrinkage stress. Labella and others[4] reported that the volumetric shrinkage of early-generation flowable composites (filler concentration 53wt%-68wt%) was higher (4%-6%) than that of conventional composites (approximately 2%). A study by Baroudi and others[5] concluded that flowable composites with a higher filler concentration (ranging from 55wt% to 71wt%) produced less shrinkage strain. The clinical repercussion of polymerization shrinkage is tooth-composite marginal opening, possibly leading to leakage around and ultimately under a restoration. An *in vitro* study by Bonilla and others[6] reported increased leakage under flowable composite occlusal restorations compared to restorations with a conventional composite.

Another criticism of flowable composite is that removing reinforcing particles from a composite decreases its strength. An *in vitro* evaluation of an experimental composite by Hosseinalipour and others[7] demonstrated that increasing hybrid filler content up to 65.2vol% (approximately 80wt%) increased flexural strength; and a study of 72 commercially available composites by Ilie and Hickel[8] showed that materials with filler content of ~78wt% had maximum flexural strength. Early-generation flowable composites (filler concentration 50wt%-70.5wt%) demonstrated lower flexural strength than did comparable conventional composites (75wt%-80wt%).[1] Studies by Irie and others[9] and Sumino and others[10] of current-generation flowable composites (65wt%-70wt% and 61%-71%), however, reported higher flexural strength than was associated with their conventional counterparts (56wt%-77wt% and 58wt%-69wt%). Similarly, early-generation flowable composites had lower fracture toughness than conventional composites,[1] while more highly filled flowable composites demonstrated similar fracture strength compared with conventional composites.[11]

In vitro studies have also suggested that flowable composites are less wear resistant than conventional composites. Filler particles protect the weaker resin matrix during abrasive wear.[12] In studies by Condon and Ferracane[13] and Lim and others[14], experimentally filled composites experienced less wear with increased filler content, and filler concentrations below 48vol% (approximately 60wt%-65wt%) showed considerably more wear than did more highly filled materials. *In vitro* wear studies by Schultz and others[15] and Clelland and others[16] of commercially available composites reported more wear on flowable composites than on highly filled materials. In these studies, the filler content of the flowable composites ranged from 59wt% to 68wt% and from 65wt% to 80wt%, while the conventional composites ranged from 77wt% to 80wt% and from 79wt% to 87wt%. An *in vitro* study by Sumino and others,[10] on the other hand, reported less wear with flowable composites; however, the flowable composites in their study had higher filler concentrations (61wt%-71wt%) than did the comparative conventional composites (58wt%-69wt%).[14]

As a result of their perceived mechanical limitations, flowable composites have traditionally been used clinically for restorations with minimal occlusal loading, such as liners, small Class I and II cavities, and Class V lesions. A clinical trial of small Class I restorations restored with two flowable composites demonstrated that marginal discoloration and marginal adaption worsened at three years after base-

Table 1: *Composition of Test Materials*

Material	Manufacturer	Filler Content	Filler Type
Filtek Supreme Ultra Flowable Restorative	3M ESPE	65wt% 46vol%	Silica nanoparticles Silica/zirconia nanoclusters
Filtek Supreme Ultra Universal Restorative	3M ESPE	72.5wt% 56vol%	Silica nanoparticles Silica/zirconia nanoclusters
Adper Single Bond Plus Adhesive	3M ESPE		Silica nanoparticles

line. The presence of secondary caries, anatomical form, retention, polishability, and color match of the restorations did not significantly change over the three-year period.[17,18] A two-year clinical trial compared conventional and flowable composites in Class II restorations and observed no difference between the materials.[19] One three-year and three two-year clinical trials compared conventional and flowable composites in cervical lesions for marginal discoloration, marginal adaptation, secondary caries, surface texture, color match, and anatomic form.[20-23] No difference was found between materials in any study except for one study[20] that reported that the conventional material had superior marginal adaptation.

The increased filler content of newer-generation flowable composites and corresponding improvements in properties warrant the further evaluation of these materials in load-bearing restorations. The purpose of this clinical trial was to evaluate the effectiveness of a new flowable resin composite (Filtek Supreme Ultra Flowable Restorative, 3M ESPE, St Paul, MN, USA; filler content: 65wt% and 46vol%) when used in Class I restorations compared to a conventional highly filled composite resin (Filtek Supreme Ultra, 3M ESPE; filler content: 72.5wt% and 55.6vol%) in Class I restorations. Our null hypothesis was that there would be no difference in any Cvar and Ryge criteria or clinical wear between the two composites. This was a single-center, single-blinded, comparator-controlled, randomized clinical trial of 24 months in duration.

METHODS AND MATERIALS

Prior to patient enrollment, an Institutional Review Board approved the clinical trial protocol. Inclusion criteria for patients in the study included the following: 1) 19 years or older, 2) good general health, 3) available for follow-up visits, and 4) have at least 28 teeth. The following exclusion criteria were used: 1) rampant uncontrolled caries, 2) advanced untreated periodontal disease, 3) >2 cigarette packs/d or equivalent chewing tobacco, 4) systemic or local disorders that contraindicate dental procedures included in this study, 5) evidence of xerostomia, 6) evidence of severe bruxing, clenching, or temporomandibular joint disorder, 7) pregnancy at the time of screening or tooth restoration, and 8) known sensitivity to acrylates or related materials. Inclusion criteria for restorations in the study included 1) at least one contact with an opposing natural or crowned tooth or a fixed partial denture, 2) a minimum of 1.5 mm in depth, 3) confined to occlusal pits and fissures, 4) initial restoration or an amalgam replacement, and 5) isthmus width from one-quarter to one-half the intercuspal distance. Exclusion criteria of the teeth were 1) periapical pathology or symptoms of pulpal pathology, 2) nonvital or previous root canal therapy, 3) previous pulp cap, 4) tooth hypersensitivity, 5) near exposures on preoperative radiographs, 6) severe periodontal disease, and 7) excessive biting forces. Sixty patients were enrolled in this study. The nature and purpose of the study, the clinical procedures, and the expected duration of participation were explained to each potential subject and informed consent was obtained.

Each enrolled patient possessed two teeth that met the inclusion criteria. Of these 120 teeth, 60 were allocated to the comparator group (Filtek Supreme Ultra) and 60 were allocated to the experimental group (Filtek Supreme Ultra Flowable). Manufacturer's information for all materials used in this study is presented in Table 1. The four participating clinicians were calibrated for placement and evaluation of the restorations prior to initiation of the study. During calibration, restorations were placed in typodont teeth exactly as described in the protocol to standardize all clinical procedures and familiarize the dentist with the materials. Patients were given local anesthesia as needed, and the teeth were isolated using nonlatex rubber dams. Shade selection was performed with the Vita shade guide. Conservative Class I cavity preparations were made with a high-speed handpiece, limiting tooth removal to no more than one-half the distance of the cusp tips on the occlusal surface of the prepared tooth. Any tooth with a pulpal exposure was excluded from the study. Any

Table 2: *Modified Cvar and Ryge Scoring Criteria for Clinical Assessment of Composite Restorations*

	Anatomic Form
A =	Restoration is continuous with existing anatomic form
B =	Restoration is discontinuous with existing anatomic form (undercontoured) but missing material is not sufficient to expose dentin or lining.
C =	Sufficient material is lost to expose dentin
Color Match	
A =	Restoration matches adjacent tooth structure in shade and/or translucency
B =	Mismatch in shade and/or translucency is within normal range of tooth shades
C =	Mismatch in shade and/or translucency is outside normal range of tooth shades
Marginal Adaptation	
A =	Explorer does not catch or slight catch with no visible crevice
B =	Explorer catches and crevice is visible but no exposure of dentin or base
C =	Explorer penetrates crevice and defect extended to enamel-dentin junction
D =	Restoration is fractured, mobile, or missing in part or *in toto*
Marginal Discoloration	
A =	No visual evidence of marginal discoloration
B =	Marginal discoloration present but has not penetrated in a pulpal direction
C =	Marginal discoloration has penetrated in a pulpal direction
Surface Integrity	
A =	Smooth surface with no irregularities
B =	Slightly rough or pitted—can be refinished
C =	Deeply pitted or grooved (not related to anatomy)—cannot be refinished
D =	Surface fracture or flaking
Secondary Caries	
A =	No caries present
D =	Caries present associated with the restoration

cavity preparation judged to be within 1 mm of pulpal tissue either clinically or radiographically was lined with Dycal (Dentsply Caulk, Milford, DE, USA), a calcium hydroxide containing liner or Vitrebond (3M ESPE), a resin-modified glass ionomer base. The preparations were etched with the 37% phosphoric acid applied initially to the enamel and then to dentin for 15 seconds, rinsed for 15 seconds, and dried using a cotton pellet or minisponge. Two or three consecutive coats (no curing between coats) of Single Bond Plus adhesive (3M ESPE) were applied to the enamel and dentin for 15 seconds, air-dried for five seconds, and light-cured for 10 seconds using the Elipar Freelight 2 LED curing light (3M ESPE, output=1000 mW/cm^2). Each resin composite was placed in 2-mm increments and cured for 20 seconds per increment. If dentin or A6B and B5B shades were used a 40-second cure was applied for each increment. Carbide finishing burs (7404, OS-1, OS-2, Brasseler, Savannah, GA, USA) were used to remove gross excess and to adjust the occlusion; this step was followed by finishing and polishing with Sof-Lex (3M ESPE) and Enhance/PoGo (Dentsply Caulk) points, cups, and discs.

The composite material used was determined by assigning the lowest numbered tooth to the material randomly assigned based on a computer-generated list with a block size of 2. The material used for either tooth was blinded to the patient; however, the difference in handling properties of the materials prevented blinding of the restoring dentist. Each patient was assigned a unique identification code, which was used to record the material used in each tooth.

Each restoration was evaluated directly and indirectly at baseline (one week after restoration placement), six months, and one and two years post-restoration. The direct clinical evaluations were performed using the modified Cvar and Ryge criteria[24] presented in Table 2. These criteria include anatomic form, marginal adaptation, surface texture, color match, marginal discoloration, secondary caries, sensitivity to cold, and sensitivity to biting. Evaluators were calibrated for evaluation of each Cvar and Ryge criteria by examination of photographs and cast representative of various scores. Anatomic form, marginal adaptation, surface texture, and secondary caries were determined by visual and tactile examination. Digital images were taken at every recall to document color match and marginal discoloration of the composite restoration to the tooth (Figure 1). Sensitivity to cold was measured by applying a cotton pellet soaked with pulp vitality refrigerant spray (Endo Ice, Coltene/Whaledent, Cuyahoga Falls, OH, USA) to the tooth for three seconds. Sensitivity to biting was measured by having the patient bite on a cotton roll for five seconds. After each test, the subject was asked to place an "X" on a 10-mm line labeled "1" on the left and "10" on the right. Patients were told that a "10" represents the worst pain they can imagine (ie, childbirth, major surgery, or kidney stone) and that "1" represents no sensation at all. All clinical assessments were performed by two trained examiners other than the operating clinician, and a consensus agreement was established for all clinical assessments. Examiners were blinded to the material used for each restoration.

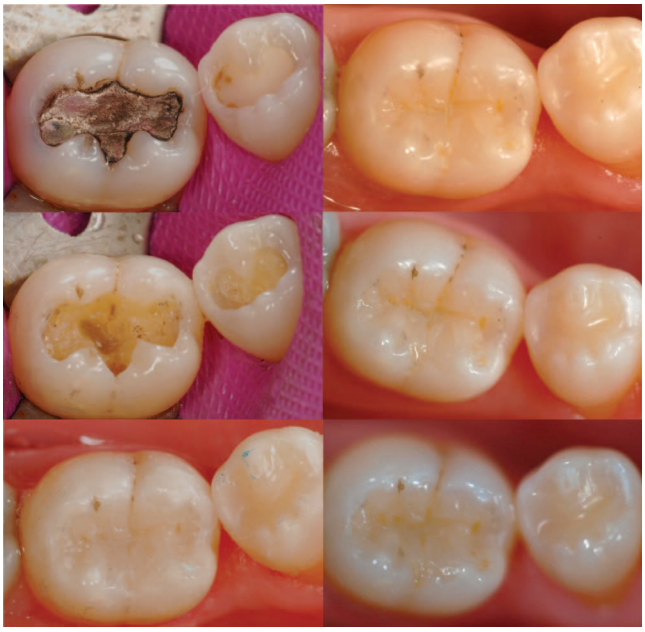

Figure 1. *Restoration of first mandibular molar with conventional composite and second mandibular premolar with flowable composite at (top left to bottom right) preoperative, preparation, baseline, six-month recall, 12-month recall, and 24-month recall.*

At the baseline and two-year evaluations, impressions were taken of the restored tooth with light-bodied polyvinylsiloxane (PVS) material around the tooth and heavy-body PVS in the tray (Imprint 3, 3M ESPE). The impressions were poured with vacuum-mixed gypsum stone (Silky-Rock, Whip Mix Corp, Louisville, KY, USA). The occlusal surfaces of the stone casts were scanned with a noncontact three-dimensional light profilometer (Proscan 2000, Scantron Industrial Products Ltd, Taunton, UK) with a resolution of 20 μm (mesial-distal) × 20 μm (buccal-lingual) × 75 nm (occlusal-gingival). The depth of focus was 2.5 mm for the profilometer. The baseline and two-year scans were superimposed, and the volumetric difference between scans was measured with Proform software. The two-year scans were modified to remove all data points aside from those approximately 0.5 mm outside of the margins of the restoration. This area was removed to eliminate any volumetric differences not present on the restoration (ie, errors on the cast, tooth wear). If the restoration could not be visualized on the cast, the clinical photograph of the preparation was used to determine restoration margins. All profilometry and superimposition were performed by the same trained investigator.

Each Cvar and Ryge outcome was compared between materials over time with a repeated measures analysis of variance (ANOVA) (α=0.05). Repeated-measures ANOVA was chosen instead of chi-square analysis in order to model these data as a repeated measure of correlated observations, which cannot be accomplished with 2 × 2 tables. Mean volumetric wear was compared between materials with a Mann-Whitney test (α=0.05).

RESULTS

At the two-year recall, 49 teeth remained in the flowable group (82% retention) and 49 teeth in the conventional group (82% retention). The majority of the missing data are due to noncompliance of the patient for recall evaluations. Within the flowable group, one restoration was replaced by the patient's local dentist and one restoration failed as a result of restoration chipping that extended slightly to the lingual surface that could not be smoothed and had to be replaced. In the conventional group, one restoration was replaced with a crown by the patient's local dentist. These three teeth were given failing scores (C or D) at each evaluation subsequent to failure. In the flowable group, 47 restorations were randomly placed in molars and 13 in premolars. In the conventional group, 51 restorations were randomly placed in molars and nine were placed in premolars.

Percent perfect Cvar and Ryge scores and visual analog pain scale recordings (mean±standard deviation [SD]) for the conventional and flowable composites are displayed in Table 3. Performance of materials for anatomic form, color match, marginal adaptation, marginal discoloration, surface integrity, and secondary caries was compared for each criterion by collapsing data into two groups (as a result of a limited number of non-alpha values). Each category was analyzed separately as a repeated measure over four time periods using a binomial distribution model with a logistic regression. Because values at the two-year follow-up were assumed to be less correlated to baseline measurements, a first-order autoregressive covariance matrix was selected for the repeated measures.

Pairwise comparisons of estimated marginal means using a sequential Bonferroni (α=0.05) was used to compare the performance of each material over time. Some degradation in performance occurred for each criterion over time, but no differences were noted in material performance at two years. Overall, no differences were noted between materials for anatomic form (p=0.80), color match (p=0.08), marginal adaptation (p=0.89), marginal discoloration (p=0.79), surface integrity (p=0.18), and secondary caries (p=0.66).

Table 3: *Percent Perfect Cvar and Ryge Scores and Visual Analog Pain Scale Recordings (Mean±Standard Deviation [SD]) for Conventional and Flowable Composites*

		Percent Alpha Score or Visual Analog Pain Scale Recording (Mean±SD)			
		Baseline	**6 Mo**	**12 Mo**	**24 Mo**
Anatomic form	Conventional	100.0%	98.3%	94.6%	86.0%
	Flowable	100.0%	100.0%	96.4%	89.8%
Color match	Conventional	88.3%	91.7%	83.9%	78.0%
	Flowable	96.6%	96.6%	92.7%	85.7%
Marginal adaptation	Conventional	98.3%	88.3%	78.6%	80.0%
	Flowable	96.6%	93.2%	81.8%	83.7%
Marginal discoloration	Conventional	98.3%	95.0%	91.1%	80.0%
	Flowable	98.3%	96.6%	90.9%	85.7%
Surface integrity	Conventional	96.7%	90.0%	78.6%	78.0%
	Flowable	98.3%	96.6%	92.7%	79.6%
Secondary caries	Conventional	98.3%	96.7%	94.6%	94.0%
	Flowable	100.0%	100.0%	94.5%	93.9%
Sensitivity to cold	Conventional	1.6 ± 2.0	1.8 ± 1.7	1.7 ± 1.7	1 ± 1.3
	Flowable	1.6 ± 1.6	1.5 ± 1.4	2.1 ± 2.2	1.5 ± 1.9
Sensitivity to biting	Conventional	0.7 ± 0.7	0.8 ± 0.8	0.3 ± 0.5	0.1 ± 0.3
	Flowable	0.5 ± 0.6	0.6 ± 0.7	0.3 ± 0.5	0.2 ± 0.5

Sensitivity was measured on a visual analog scale and was modeled as a normally distributed continuous variable. Pairwise comparisons of estimated marginal means were performed. Some changes in this value occurred over time but were not significant using the sequential Bonferroni post hoc *p*-value (α=0.05).

Biting values ranged from 0 to 5. These data were collapsed into three ordinal categories and modeled with the multinomial distribution with a cumulative logistic regression. The first-order autoregressive covariance matrix was employed for the repeated measures. No significant difference in materials was noted over the observation period, although bite levels of both materials changed significantly at each time period with respect to baseline measurements.

Two-year mean volumetric wear was 3.16 ± 2.38 mm^3 for the flowable composite and 3.43 ± 2.50 mm^3 for the conventional composite. Normality of the volumetric wear data was evaluated with a Shapiro-Wilk test and found to be nonparametric ($p<0.001$). A Mann-Whitney test determined that there was no significant difference between the volumetric wear of the flowable and conventional composites (p=0.661)

DISCUSSION

This study compared the clinical efficacy of a flowable (Filtek Supreme Ultra Flowable) and a conventional (Filtek Supreme Ultra Universal) composite. This prospective, single-blind, randomized, controlled clinical trial was conducted to determine the clinical performance of a flowable composite in a conservative Class I restoration. Regarding the clinical effectiveness of the flowable composite at two years, it had similar or superior properties to the conventional composite. There was no difference in anatomic form (p=0.80), color match (p=0.08), marginal adaptation (p=0.89), marginal discoloration (p=0.79), surface integrity (p=0.18), secondary caries (p=0.66), cold sensitivity (p=0.522), biting sensitivity (p=0.818), or volumetric wear (p=0.661) between materials. Both materials showed a decrease in perfect scores for all criteria except secondary caries (p=0.95) over time.

Ideally, the distribution of premolars and molars in each group should be kept even as a result of the clinical differences between their location and size. Premolar restorations would be expected to have lower occlusal forces than molars as a result of their distance from the fulcrum of the jaw. Premolars also have a smaller occlusal surface area, leading to more narrow preparations and higher c-factor. The incidence of premolar restorations was 22% in the flowable group and 15% in the conventional group. The allocation of premolars in each group is relatively even considering the random assignment of teeth to treatment groups.

The results of this study contradict the predictions that could be made for flowable composites based on *in vitro* data. Flowable materials have more poly-

merization shrinkage than conventional composites[4] and, therefore, should have pulled away from the walls of the restoration. This would have been observed in the present study as an increased prevalence of marginal discoloration, marginal discrepancies, and possibly secondary caries. These results were not seen in the present study. It is possible that the polymerization shrinkage that is observed in the laboratory is not sufficient to generate adequate stress to separate the bond between the composite and the tooth. The material tested in this study had lower polymerization shrinkage than did many comparable commercial flowable composites (mean vol% shrinkage: 3.3%±.4% for Filtek Supreme Ultra Flow and 3.9%-5.5% for other flowable composite materials tested).[25] Additionally, the lower modulus of elasticity of flowable materials has been theorized to reduce stresses generated at the adhesive interface.[19,22] It is also possible that marginal discrepancies were too small to be observed or felt and that they will grow with time. New research,[26] however, has shown that polymerization stresses may relax over time in a wet environment.

Another expected predicted result based on laboratory studies would have been increased wear of the flowable composite. Several clinical studies[27-31] have also quantitatively measured wear of composite resins using laser profilometry on casts. Some studies reported wear depths for posterior composite restorations that ranged from 22 to 91 μm/y,[27] 12 μm/y,[28] and 42-54 μm/y.[29] Other studies also reported volumetric wear as measuring 0.023 mm^3/y,[28] 0.09-0.132 mm^3/y,[30] and 1.14-1.51mm^3/5 y.[31] The wear values measured in this study (3.16±2.38 mm^3/2 y flowable; 3.43±2.50 mm^3/2 y conventional) are larger than values presented in previous studies. For example, one study[31] reported a wear rate of Filtek Supreme of 1.14 mm^3/5 y.[31] There is no current American Dental Association specification to recommend the maximum amount of volumetric composite wear; the most recent specification for vertical contact wear requires a maximum of 50 μm/y.[32]

The lower wear rate reported in previous studies may have been attributed to the protocol used for superimposition. In two of the studies, wear data at the cavo-surface margin was removed either by manually deleting the wear at beveled margins[31] or by discarding data attributed to marginal fractures.[28] In another study,[30] contact wear was measured by multiplying the contact areas by the mean vertical wear. In the present study, all wear was considered. As can be observed in Figure 2 (lower right frame), the greatest amount of wear was often observed at the cavo-surface margins. Other variation in the wear volumes reported between studies may be related to differences in the sizes of the composite restorations, impression and cast-making techniques, accuracy of scanning devices, and precision of the superimposition software. Variation could also be attributed to patient-related factors such as biting forces, the number of remaining teeth, and the positon of the restored tooth in the arch. Regardless of the magnitude of the wear, our study shows no difference in the wear of the flowable and conventional composites, which is in agreement with the qualitative wear measurement in a similar clinical study.[19]

A recent *in vitro* comparison of Filtek Supreme Ultra flowable and conventional reported similar flexural strength (133.3 MPa flowable and 116.1 MPa conventional) and fracture toughness (1.07 $MPa/m^{1/2}$ flowable and 1.03 $MPa/m^{1/2}$ conventional) and lower elastic modulus of the flowable (7.03 GPa) than the conventional (12.61 GPa) composite.[33] Only one restoration fracture was noted in the present study (although the two restorations replaced by other dentists may have been due to restoration fracture). These results indicate that the strength and toughness of the flowable material should be adequate for load-bearing restorations. It is important to note that the results can only be applied to the particular materials used in this study and restorations having isthmus widths of less than one-half the intercuspal distance.

Limitations of this study include the relatively small sample size and high patient drop-out rate. Wear measurement was hindered by the limited accuracy of the impression material, imperfections in the casts, and operator subjectivity in the manipulation of the superimposition software. The differences in the surface profilometry and superimposition protocols in this study and those of previous studies make direct comparison of wear data irrelevant. Future studies will explore digital impressioning for quantitative wear measurement and positioning matrices that can be worn by patients during scanning to aid in scan superimposition.

CONCLUSIONS

The flowable composite used in this study had clinical efficacy after two years of service that was similar to that of a conventional composite when placed as Class I occlusal restorations having

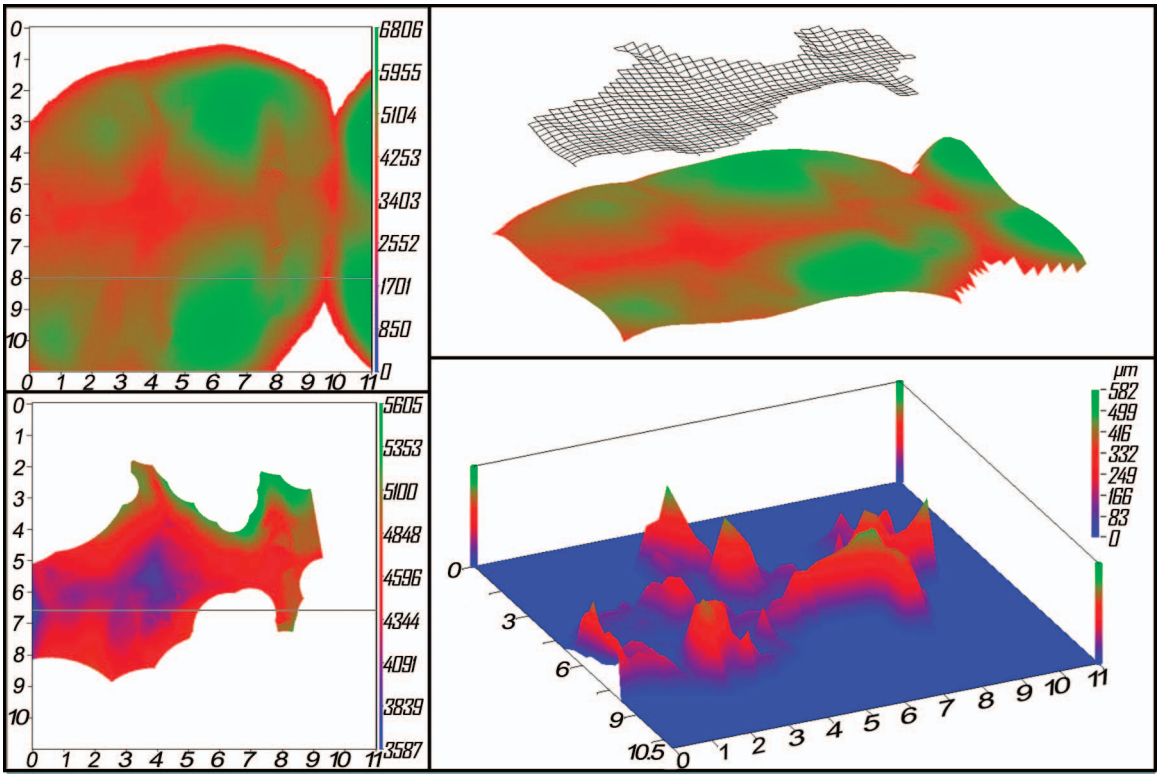

Figure 2. *Representative superimposition of baseline and two-year clinical scans. Baseline occlusal scan (top left frame), two-year occlusal scan trimmed to 0.5 mm from restoration margin (bottom left frame), superimposition of two-year mesh scan on baseline scan (top right frame), and difference between baseline scan and two-year scan (bottom right frame).*

isthmus widths of less than one-half the intercuspal distance.

Acknowledgment

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Regulatory Statement

This study was conducted in accordance with all the provisions of the local human subjects oversight committee guidelines and policies of WIRB. The approval code for this study is CR-10-013.

Conflict of Interest

The authors of this manuscript certify that they have no proprietary, financial or other personal interest of any nature or kind in any product, service and/or company that is presented in this article.

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