©Operative Dentistry, 2017, **42-1,** 19-29

Clinical Effectiveness of Different Polishing Systems and Self-Etch Adhesives in Class V Composite Resin Restorations: Two-Year Randomized Controlled Clinical Trial

J-H Jang • H-Y Kim • S-M Shin • C-O Lee • DS Kim • K-K Choi • S-Y Kim

Clinical Relevance

A multi-step polishing system provides more desirable clinical results compared to simplified abrasive-impregnated rubber instruments. One-step and two-step self-etch adhesives show clinically equivalent performance.

SUMMARY

The aim of this randomized controlled clinical trial was to compare the clinical effectiveness of different polishing systems and self-etch adhesives in class V composite resin restorations. A total of 164 noncarious cervical lesions (NCCLs) from 35 patients were randomly allocated to one of four experimental groups, each of which used a combination of polishing systems and adhesives. The two polishing systems used were Sof-Lex XT (Sof), a multi-step abrasive disc, and Enhance/Pogo (EP), a simplified abrasive-impregnated rubber instrument. The adhesive systems were Clearfil

Ji-Hyun Jang, DDS, PhD, Department of Conservative Dentistry, Kyung Hee University Dental Hospital at Gang-dong, Seoul, Korea

Hae-Young Kim, DDS, PhD, Department of Public Health Sciences, Graduate School & Department of Health Policy and Management, College of Health Science, Korea University, Seoul, Korea

Su-Mi Shin, DDS, MSD, Department of Conservative Dentistry, Graduate School, Kyung Hee University, Seoul, Korea

Chung-Ok Lee, DDS, Department of Conservative Dentistry, Graduate School, Kyung Hee University, Seoul, Korea

Duck Su Kim, DDS, PhD, Department of Conservative Dentistry, School of Dentistry, Kyung Hee University, Seoul Korea

Kyoung-Kyu Choi, DDS, PhD, Department of Conservative Dentistry, School of Dentistry, Kyung Hee University, Seoul Korea

*Sun-Young Kim, DDS, PhD, Department of Conservative Dentistry, School of Dentistry, Kyung Hee University, Seoul Korea

*Corresponding author: Department of Conservative Dentistry, School of Dentistry, Kyung Hee University, 1 Hoegi-dong, Dongdaemun-gu, Seoul, Korea, 130-701; e-mail: kimsunyoung@khu.ac.kr

DOI: 10.2341/16-104-C

SE bond (CS), a two-step self-etch adhesive, and Xeno V (XE), a one-step self-etch adhesive. All NCCLs were restored with light-cured microhybrid resin composites (Z250). Restorations were evaluated at baseline and at 6, 12, 18, and 24 months by two blinded independent examiners using modified FDI criteria. The Fisher exact test and generalized estimating equation analysis considering repeated measurements were performed to compare the outcomes between the polishing systems and adhesives. Three restorations were dislodged: two in CS/Sof and one in CS/EP. None of the restorations required any repair or retreatment except those showing retention loss. Sof was superior to EP with regard to surface luster, staining, and marginal adaptation ($p<0.05$). CS and XE did not show differences in any criteria ($p>0.05$). Sof is clinically superior to EP for polishing performance in class V composite resin restoration. XE demonstrates clinically equivalent bonding performance to CS.

INTRODUCTION

Despite tremendous improvements in the material properties of adhesives and composite resin over the past several decades, the procedures of adhesive restorations are still technique sensitive and need to be meticulously performed to achieve an ideal restoration. Of the many procedures involved in adhesive restoration, finishing and polishing require special care and attention to achieve the desired anatomical contour and lustrous surface. Roughly polished restorations can cause a number of clinical problems, including plaque retention, chronic gingival inflammation, marginal discoloration, and secondary caries.[1] Furthermore, finishing and polishing can influence the long-term clinical performance of composite resin restorations, affecting marginal integrity, wear, and the durability of adhesive restorations.[1-3] Thus, appropriate polishing is a critical clinical procedure to enhance both esthetics and longevity of composite resin restorations.

The various types of tools commercially available for polishing composite resin restorations include abrasive polishing pastes, fluted carbide burs, diamond burs, stones, abrasive discs, and abrasive-impregnated rubber cups, points, and wheels.[4] Abrasive discs have traditionally been used for planar surfaces, such as anterior tooth restorations and cervical restorations with composite resins. Typically, polishing with abrasive discs is composed of a four-step progression from coarse to superfine, following the traditional polishing procedures.[5] Recently, abrasive-impregnated rubber instruments have emerged on the dental market. The abrasive-impregnated rubber instruments have a distinct advantage in areas where disc-type polishing instruments do not work properly, such as on the occlusal surface of posterior teeth and on the lingual surface of anterior teeth. These instruments are easy to use because of their availability in various forms and also because they require fewer steps. Thus, since abrasive-impregnated instruments simplify the polishing process, clinicians may prefer to use them even on planar surfaces.[6]

Many studies have reported *in vitro* comparisons of polishing outcomes, such as surface roughness, gloss, marginal irregularities, and staining susceptibility between traditional multistep abrasive discs and abrasive-impregnated rubber instruments.[7-14] A number of these studies have demonstrated no significant differences between the two polishing systems.[7,8] However, contradictory results (ie, better performance of one or the other method, depending on the experimental design) have also been reported in several other studies.[9-14] Even though the *in vitro* studies have discussed the importance of performing clinical studies to confirm the clinical efficacy of polishing instruments, to the best of our knowledge, there have been no clinical trials to compare the efficacy of polishing methods on composite resin restorations. Since a clinical trial is considered to provide the most reliable evidence of the effectiveness of clinical materials and methods,[15] a clinical evaluation of the effectiveness of different polishing methods through a randomized controlled trial would be of great worth.

Noncarious cervical lesions (NCCLs) are considered an ideal model for evaluation of the clinical performance of adhesive restorations since NCCLs offer good access for operative procedures and evaluation, operator variability is reduced since there are relatively minimal restorative procedures, and the lesions themselves are widely available in multiple teeth, facilitating patient selection and study design.[12,15] Many clinical trials have compared the clinical effectiveness of adhesives, composites, and operative procedures in composite resin restorations of NCCLs.[16-19] Both multistep abrasive discs and simplified abrasive-impregnated rubber instruments are used for polishing the convex surface in composite restorations of NCCLs. It would be of great interest and significance to compare the effectiveness of these two popular polishing systems

Table 1: *Materials Used in This Study*

Finishing/Polishing System	Type	Abrasive (Particle Size)
Sof-Lex XT (3M ESPE, St Paul, MN)	Dark orange (coarse)	Aluminum oxide (100 μm)
	Orange (medium)	Aluminum oxide (40 μm)
	Light orange (fine)	Aluminum oxide (24 μm)
	Yellow (superfine)	Aluminum oxide (8 μm)
Enhance/Pogo	Enhance	Aluminum oxide (40 μm)
(Dentsply Caulk, Milford, DE)	EP	Diamond micropolisher (10-15 μm)
Adhesives	**Chemical composition**	**Instruction for use**
Clearfil SE Bond Two-step self-etch (Kuraray, Osaka, Japan)	Primer: MDP, HEMA, photoinitiator, water hydrophilic dimethacrylate Bond: MDP, HEMA, Bis-GMA, hydrophobic dimethacrylate, colloidal silica, photoinitiators	1. Dry surface. 2. Apply primer for 20 s. 3. Gentle air stream. 4. Apply adhesive. 5. Light cure for 10 s.
Xeno V One-step self-etch (Dentsply Caulk)	Bifunctional acrylic amides, acrylamido alkylsulfonic acid, phosphoric acid ester, acrylic acid, water, tertiary butanol, butylated benzenediol, CQ, initiator, stabilizer	1. Apple adhesive. 2. Gently agitate 20 s. 3. Air blow at least 5 s. 4. Light cure for 20 s.
Composite resin	**Chemical composition**	**Classification filler wt%, filler size**
Filtek Z250 (3M ESPE)	Matrix: Bis-GMA,UDMA, Bis-EMA, TEGDMA Filler: Zirconia, silica	Microhybrid 78 wt%, 0.01-3.5 μm

Abbreviations: MDP, methacryloyloxydecyl dihydrogen phosphate; HEMA, hydroxyethyl methacrylate; Bis-GMA, bisphenol A diglycidylether methacrylate; CQ, camphorquinone; UDMA, urethane dimethacrylate; BisEMA, bisphenol A polyethylene glycol diether dimethacrylate; TEGDMA, triethylene glycol dimethacrylate.

in composite resin restorations of NCCLs. Therefore, the objective of this study was to compare the clinical effectiveness of abrasive disc–type and abrasive-impregnated rubber–type polishing systems in class V composite resin restorations. In addition, we have compared the clinical performance of a two-step self-etch adhesive and a one-step self-etch adhesive. Hence, composite resin restorations were placed in NCCLs using two different self-etch adhesives and then polished using either a multistep abrasive disc or a simplified abrasive-impregnated rubber instrument. The clinical performance of the restorations was then evaluated over 24 months using modified FDI criteria.

METHODS AND MATERIALS

Recruitment of Patients and Inclusion/Exclusion Criteria

This study was a single-center prospective randomized controlled clinical trial. Thirty-five patients with at least two NCCLs who visited K-H University Dental Hospital (KHUDH) from September 2011 to February 2012 participated in this study. Their mean age was 55 years (ranged from 30 to 73 years). The participants were apparently healthy patients with good oral hygiene. Patients who had severe chronic periodontitis, rampant caries, xerostomia, or orthodontic appliances or who were pregnant or nursing were excluded. Each patient was informed of the study and signed a consent form.

Operating Procedure

Four experimental groups combining two polishing systems and two adhesives were compared. The polishing systems used in this study were Sof-Lex XT (Sof; 3M ESPE, St Paul, MN) for the multistep abrasive disc and Enhance/Pogo (EP; Dentsply Caulk, Milford, DE) for the simplified abrasive-impregnated rubber instrument. The adhesives used were Clearfil SE bond (CS; Kuraray, Osaka, Japan) for the two-step self-etch adhesive and Xeno V (XE; Dentsply, DeTrey, Germany) for the one-step self-etch adhesive (Table 1). All NCCLs were restored with light-cured microhybrid resin composites (Z250, 3M ESPE). A total of 164 NCCLs from 35 patients were randomly allocated to one of four experimental groups using a randomization table. Approximately 40 restorations per group were placed in NCCLs of incisors, canines, premolars, and first molars. To minimize patient-related effects that may bias the results, no more than three restorations for one group were allowed in a patient.

Tooth shade was evaluated prior to the operative procedures by using Vita shade guide (Vita Zahnfabrik, Bad Säckingen, Germany). The lesion was cleaned with plain pumice slurry in a rubber cup and then washed and dried. No surface grinding or enamel beveling were performed for the lesion. The lesion was isolated with a cotton roll and gingival retraction cord (Ultrapak, Ultradent, South Jordan, UT) during the procedure.

Adhesive, either CS or XE, was applied to the lesion according to the manufacturer's instructions listed in Table 1. Composite resin was then built up and light cured with an LED light-curing unit (Bluephase, Ivoclar Vivadent, Schaan, Liechtenstein). The intensity of light was measured by a portable LED radiometer (Bluephase Meter II, Ivoclar Vivadent) prior to each restoration procedure to check for any drop in intensity. For large lesions, two or three increments of resin composite were separately applied. Great care was taken to avoid significant overhanging in the gingival margin during the composite resin buildup. The light curing was performed using a pulse delay cure technique with an initial cure for 2 seconds and final cure for 20 seconds following a waiting period of 3 minutes.[20]

Excess composite resin on the gingival margin of all restorations was trimmed with a #12 blade during the waiting period for the pulse delay cure. Gross reduction and finishing were performed with a fine diamond point (Mani, Tochigi, Japan) after a final light curing. Further finishing and polishing were then performed using either the Sof system or the EP system. In Sof groups, polishing was performed in a sequence of grit from coarse to superfine with 3/8-inch discs and a mandrel. Each disc step was performed in a dry field for 15 to 20 seconds with a low-speed hand piece. Rinsing and drying were performed before proceeding to the next grit sequence. In EP groups, polishing was sequentially performed with the point shape of Enhance and Pogo using a buffing motion with moderate to light intermittent pressure. Each step was carried out without water for 15 to 20 seconds with a low-speed hand piece. A rinse-and-dry procedure was performed between the use of Enhance and Pogo. One experienced operator performed all the procedures for all the restorations.

Clinical Outcome Evaluation

The class V restorations were evaluated at baseline, 6, 12, 18, and 24 months by two blinded independent examiners. A flow diagram of clinical evaluation is shown in Figure 1. Modified FDI criteria were used to evaluate the clinical performance with respect to the esthetic, functional, and biological properties of the restorations (Table 2). We chose two of the original FDI criteria for each property to evaluate the class V restorations: surface luster and staining for esthetic properties, fracture and retention and marginal adaptation for functional properties, and postoperative sensitivity and recurrence of caries, erosion, and abfraction for biologic properties. Each criterion was evaluated with five scores: all scores ranged from 5 to 1 (with a score of 1 being the poorest). For interexaminer and intraexaminer calibration, the examiners were trained for each criteria using representative sample photographs obtained from previously published literature and from a Web-based tool called "e-calib" (www.e-calib.info).[21,22] If a discrepancy between examiners occurred during evaluation, it was resolved by consensus. All missing cases, including cases involving unannounced nonattendance of the subject at recall, were withdrawn from the study. A restoration with a fracture and a retention score of 1 was counted as missing in the other evaluation criteria. The interexaminer agreement rate ranged from 95% to 100% depending on the criteria.

Statistical Analysis

The frequencies and percentages of below-excellent outcomes (score of <5) at 24 months were displayed and tested according to groups (combinations of polishing methods and adhesives used) using the Fisher exact test. We also used the generalized estimating equations (GEE) approach with unstructured covariance to compare the possibility of outcomes under considering the repeated measures.[23] Models for marginal staining and marginal adaptation were estimated to compare the four groups (combinations of polishing methods and adhesives) and subsequently to compare multistep abrasive discs vs the simplified abrasive-impregnated rubber polishing instrument and two-step vs one-step adhesives. The interaction term was omitted as insignificant (in marginal staining, $p=0.615$, and in marginal adaptation, $p=0.157$). Models for surface luster, staining surface, fracture and retention, postoperative sensitivity, and recurrent caries could not be estimated because of the limited number of cases with below-excellent outcomes (score of <5). The same statistical process was also performed for the frequencies and percentages of below-good outcomes (score of <4). A level of 0.05 was adopted to determine the statistical significance of all differences. All statistical analyses were performed using SAS statistical software, version 9.1.3 (SAS Institute, Cary, NC), and models were calculated using the GENMOD procedure.[24]

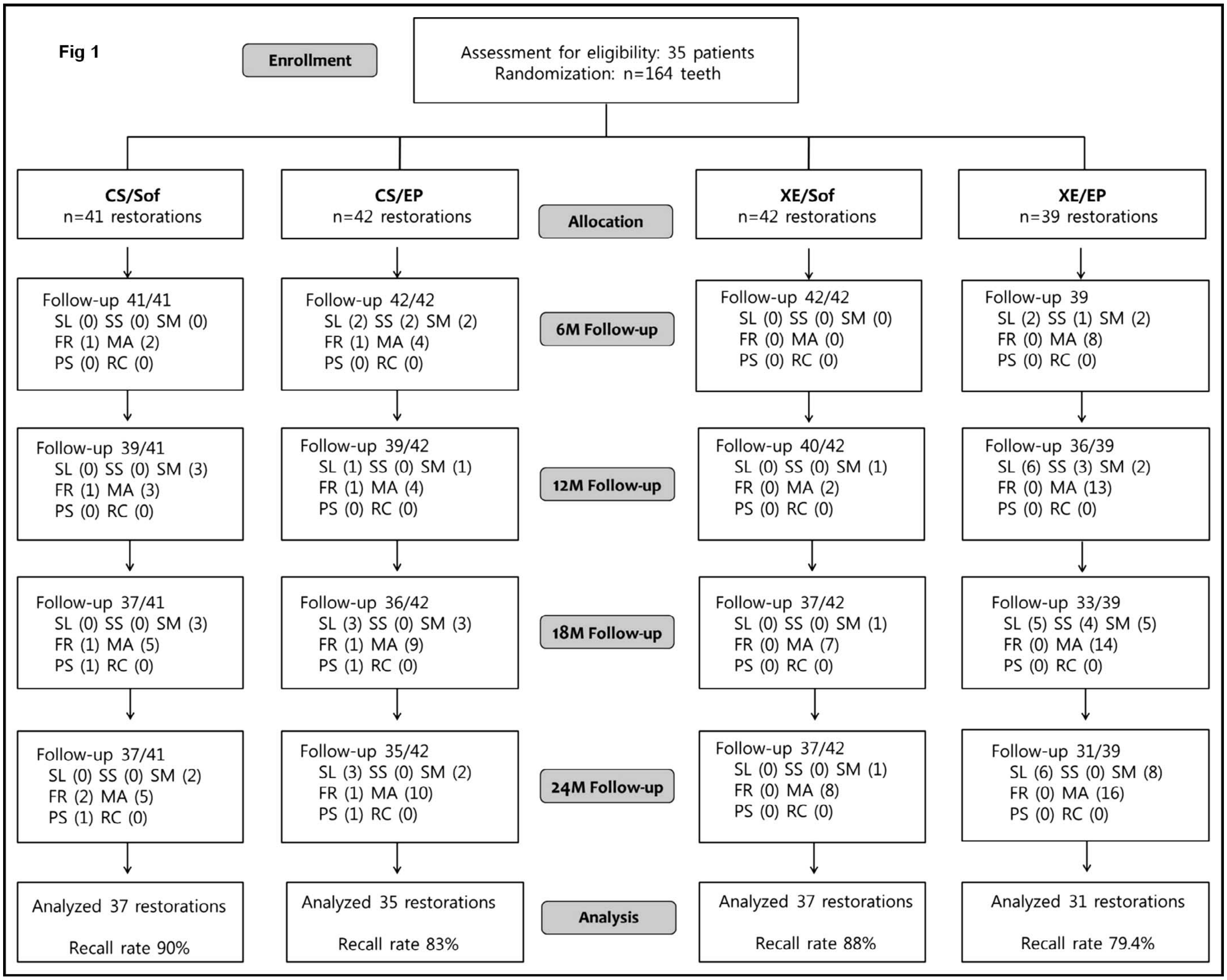

Figure 1. *Flow diagram for evaluation. Abbreviations: n, number of restorations; Sof, Sof-Lex; EP, Enhance/Pogo; CS, Clearfil SE bond; XE, Xeno V; SL, surface luster; SS, staining surface; SM, staining margin; FR, fracture and retention; MA, marginal adaptation; PS, postoperative sensitivity; RC, recurrent caries.*

RESULTS

Of the 164 restorations at baseline, 164 (100%), 154 (93.9%), 143 (87.2%), and 140 (85.3%) were observed at 6, 12, 18, and 24 months, respectively. Descriptive data expressed as percentages of outcomes for the four groups are shown in Table 3. A total of three restorations were dislodged over 24 months: two in the CS/Sof group and one in the CS/EP group. Except for those retention losses, none of the restorations required any repair or retreatment in all criteria over 24 months. The frequencies of below-excellent outcomes (score of <5) at 24 months are shown in Table 4. Significant differences in the proportions of below-excellent outcomes among the four groups were observed for surface luster, surface staining, marginal staining, and marginal adaptation ($p<0.05$). Polishing with multistep abrasive discs (Sof) was superior to that with simplified abrasive-impregnated rubbers (EP) with regard to surface luster, surface staining, marginal staining, and marginal adaptation ($p<0.05$). Two-step (CS) and one-step (XE) adhesives did not show any statistically significant differences in any criteria ($p>0.05$). Representative photographs for clinical evaluation with a score of <5 at 24 months are presented in Figure 2.

GEE analysis considering the five repeated measurements from baseline to 24 months is shown in Table 5. In the evaluation of marginal staining, there was no significant difference among the four groups,

Table 2: *Modified FDI Criteria Used in This Study*

Category	Rating	Description
A. Esthetic properties		
1. Surface luster	5	Luster comparable to enamel
	4	Slightly dull, not noticeable from speaking distance, some isolated pores
	3	Dull surface but acceptable if covered with film of saliva, multiple pores on more than one-third of the surface
	2	Rough surface, cannot be masked by saliva film, simple polishing not sufficient
	1	Very rough, unacceptable plaque-retentive surface
2.1 Staining (surface)	5	No staining
	4	Minor staining, easily removable by polishing
	3	Moderate surface staining that may also be present on other teeth, not esthetically unacceptable
	2	Unacceptable surface staining; major intervention necessary
	1	Severe surface and/or subsurface staining, not acceptable for intervention
2.2 Staining (margin)	5	No staining
	4	Minor staining, easily removable by polishing
	3	Moderate marginal staining, not esthetically unacceptable
	2	Pronounced marginal staining; major intervention necessary
	1	Deep marginal staining, not accessible for intervention
B. Functional properties		
3. Fractures and retention	5	Keep complete retention
	4	Small hairline crack
	3	Material chip fracture not affecting marginal integrity
	2	Material chip fracture that damages marginal quality, bulk fractures with partial loss (less than half of the restoration)
	1	Complete loss of restoration or multiple fractures
4. Marginal adaptation	5	Harmonious outline, no gaps
	4	Slight ditching, slight step/flashes, minor irregularities
	3	Major irregularities, ditching or flash, steps
	2	Severe ditching or marginal fractures, larger irregularities or steps (repair necessary)
	1	Generalized major gaps or irregularities
C. Biologic properties		
5. Postoperative sensitivity	5	No hypersensitivity
	4	Minor hypersensitivity for a limited period
	3	Moderate hypersensitivity (no treatment needed)
	2	Intense hypersensitivity with subjective symptoms
	1	Intense, acute pulpitis or nonvital tooth
6. Recurrence of caries, erosion, abfraction	5	No secondary or primary caries
	4	Small and localized erosion or abfraction
	3	Larger areas of erosion or abfraction, dentin not exposed
	2	Caries with cavitation and suspected undermining caries
		Erosion, abfraction in dentin
	1	Deep caries

Score designation: 5, clinically excellent/very good; 4, clinically good; 3, clinically sufficient/ satisfactory (minor shortcomings, no unacceptable effects but not adjustable without damage to the tooth); 2, clinically unsatisfactory (but reparable); 1, clinically poor (replacement necessary).

though the XE-EP group showed the highest percentage (6.5%) of worse outcomes. There was no significant difference both between the two polishing systems and between the two adhesives. In the evaluation of marginal adaptation, the XE-EP group showed a significant difference in the odds ratio (OR=4.07, p=0.001) compared to the CS-Sof group and also showed the highest percentage (24.6%) of worse outcome over 24 months. Use of the simplified abrasive-impregnated rubber polishing system re-

Table 3: *Descriptive Data (Percentage) of Clinical Outcomes Evaluated at Baseline and 6, 12, 18, and 24 Months According to the Modified FDI Criteria[a]*

Group		CS/Sof					CS/EP					XE/Sof					XE/EP				
Criterion	**Time**	**5**	**4**	**3**	**2**	**1**	**5**	**4**	**3**	**2**	**1**	**5**	**4**	**3**	**2**	**1**	**5**	**4**	**3**	**2**	**1**
Esthetic properties																					
SL	0	100	0	0	0	0	100	0	0	0	0	100	0	0	0	0	100	0	0	0	0
	6 mo	100	0	0	0	0	95.1	4.9	0	0	0	100	0	0	0	0	94.8	2.6	2.6	0	0
	12 mo	100	0	0	0	0	97.4	2.6	0	0	0	100	0	0	0	0	83.3	13.9	2.8	0	0
	18 mo	100	0	0	0	0	91.4	8.6	0	0	0	100	0	0	0	0	84.8	12.1	3.1	0	0
	24 mo	100	0	0	0	0	91.2	8.8	0	0	0	100	0	0	0	0	80.6	16.2	3.2	0	0
SS	0	100	0	0	0	0	100	0	0	0	0	100	0	0	0	0	100	0	0	0	0
	6 mo	100	0	0	0	0	95.1	4.9	0	0	0	100	0	0	0	0	97.4	2.6	0	0	0
	12 mo	100	0	0	0	0	100	0	0	0	0	100	0	0	0	0	91.7	8.3	0	0	0
	18 mo	100	0	0	0	0	100	0	0	0	0	100	0	0	0	0	87.9	12.1	0	0	0
	24 mo	100	0	0	0	0	100	0	0	0	0	100	0	0	0	0	83.9	16.1	0	0	0
SM	0	100	0	0	0	0	100	0	0	0	0	100	0	0	0	0	100	0	0	0	0
	6 mo	100	0	0	0	0	95.1	4.9	0	0	0	100	0	0	0	0	94.9	5.1	0	0	0
	12 mo	92.1	7.9	0	0	0	97.4	2.6	0	0	0	97.5	2.5	0	0	0	94.4	5.6	0	0	0
	18 mo	91.7	8.3	0	0	0	91.4	8.6	0	0	0	97.3	2.7	0	0	0	84.8	15.2	0	0	0
	24 mo	94.3	5.7	0	0	0	94.1	5.9	0	0	0	97.3	2.7	0	0	0	74.2	25.8	0	0	0
Functional properties																					
FR	0	100	0	0	0	0	100	0	0	0	0	100	0	0	0	0	100	0	0	0	0
	6 mo	97.6	0	0	0	2.4	97.6	0	0	0	2.4	100	0	0	0	0	100	0	0	0	0
	12 mo	97.4	0	0	0	2.6	97.4	0	0	0	2.6	100	0	0	0	0	100	0	0	0	0
	18 mo	97.2	0	0	0	2.8	97.2	0	0	0	2.8	100	0	0	0	0	100	0	0	0	0
	24 mo	94.6	0	0	0	5.4	97.1	0	0	0	2.9	100	0	0	0	0	100	0	0	0	0
MA	0	100	0	0	0	0	100	0	0	0	0	100	0	0	0	0	100	0	0	0	0
	6 mo	95	5	0	0	0	90.5	9.5	0	0	0	100	0	0	0	0	79.5	20.5	0	0	0
	12 mo	92.1	7.9	0	0	0	89.5	10.5	0	0	0	95	5	0	0	0	63.9	33.3	2.8	0	0
	18 mo	86.1	13.9	0	0	0	74.3	25.7	0	0	0	81.1	18.9	0	0	0	57.6	36.4	6	0	0
	24 mo	85.7	14.3	0	0	0	70.6	29.4	0	0	0	78.4	18.9	2.7	0	0	48.4	41.9	9.7	0	0

Abbreviations: SL, surface luster; SS, staining surface; SM, staining margin; FR, fracture and retention; MA, marginal adaptation; PS, postoperative sensitivity; RC, recurrent caries; Sof, Sof-Lex; EP, Enhance/Pogo; CS, Clearfil SE bond; XE, Xeno V.

[a] The data of biologic properties including postoperative sensitivity (PS) and recurrent caries (RC) were omitted because those criteria showed the highest score (score of 5) in all experimental groups and evaluation time points, except one restoration of each CS/Sof (score of 3) and CS/EP (score of 4) for PS criteria in 18 months, respectively.

sulted in a significantly inferior performance compared to the multistep abrasive disc polishing system (OR=3.22, $p<0.001$).

In the analysis for the below-good outcomes (score of <4), frequencies at 24 months and GEE analysis considering the repeated measurements did not show any significant differences both between polishing systems and between adhesives.

DISCUSSION

To the best of our knowledge, this is the first study employing a randomized controlled clinical trial to clinically compare multistep abrasive discs with simplified abrasive-impregnated rubber instruments in terms of polishing effectiveness in class V composite resin restorations. The main finding of the present study is that Sof, a multistep abrasive disc system, showed better clinical performance than EP, a simplified abrasive-impregnated rubber system, in all the esthetic properties (surface luster, surface staining, and marginal staining) and one functional property (marginal adaptation) in composite resin restorations at 24 months. According to GEE analysis considering repeated observations over 24 months, polishing with multistep abrasive discs also presented a superior outcome in marginal adaptation compared to that with simplified abrasive-impregnated rubber instruments.

The polishing effectiveness of abrasive-coated discs and abrasive-impregnated rubber instruments has been previously compared in many *in vitro*

Table 4: *Frequencies (Percentage) of Below-Excellent Outcomes (Score of <5) for Each Criterion at 24 Months According to the Groups, Polishing System, and Adhesives*[a]

Criteria	Esthetic Properties			Functional Properties		Biologic Properties	
	SL	SS	SM	FR	MA	PS	RC
Group							
CS/Sof	0 (0.0) A	0 (0.0) A	2 (5.7) A	2 (5.4)	5 (14.3) A	1 (2.9)	0 (0.0)
CS/EP	3 (8.8) A	0 (0.0) A	2 (5.9) A	1 (2.9)	10 (29.4) B	1 (2.9)	0 (0.0)
XE/Sof	0 (0.0) A	0 (0.0) A	1 (2.7) A	0 (0.0)	8 (21.6) B	0 (0.0)	0 (0.0)
XE/EP	6 (19.4) B	5 (16.1) B	8 (25.8) B	0 (0.0)	16 (51.6) B	0 (0.0)	0 (0.0)
p-value[b]	0.001	0.001	0.011	0.509	0.008	0.726	—
Polishing system							
Sof	0 (0.0)	0 (0.0)	3 (4.2)	2 (2.7)	13 (18.1)	1 (1.4)	0 (0.0)
EP	9 (13.9)	5 (7.69)	10 (15.4)	1 (1.5)	26 (40.0)	1 (1.5)	0 (0.0)
p-value	<0.001	0.022	0.039	1.000	0.005	1.000	—
Dentin adhesive							
CS	3 (4.4)	0 (0.0)	4 (5.8)	3 (4.2)	15 (21.7)	2 (2.9)	0 (0.0)
XE	6 (8.8)	5 (7.4)	9 (13.2)	0 (0.0)	24 (35.3)	0 (0.0)	0 (0.0)
p-value	0.325	0.208	0.159	0.245	0.079	0.496	—

Abbreviations: SL, surface luster; SS, staining surface; SM, staining margin; FR, fracture and retention; MA, marginal adaptation; PS, postoperative sensitivity; RC, recurrent caries; Sof, Sof-Lex; EP, Enhance/Pogo; CS, Clearfil SE bond; XE, Xeno V.
[a] *Different letters (A and B) represent significant differences among groups at an alpha level of 0.05.*
[b] p-*values by the Fisher exact test.*

studies. Among the various polishing systems, abrasive-coated discs have been reported to be the most effective polishing instruments available and are reported to produce the highest gloss and smoothest surface with composite resins.[9-11] On the other hand, in a number of recent studies, abrasive-impregnated rubber instruments showed comparable or even better performance in reducing the surface roughness when compared to abrasive discs.[12-14] These contradictory results from *in vitro* studies might be due to differences in the experimental conditions, such as initial roughness state, combinations of finishing and polishing protocols, and polishing time and pressure. Despite the use of a variety of *in vitro* experimental conditions, *in vitro* studies might not completely reflect the clinical

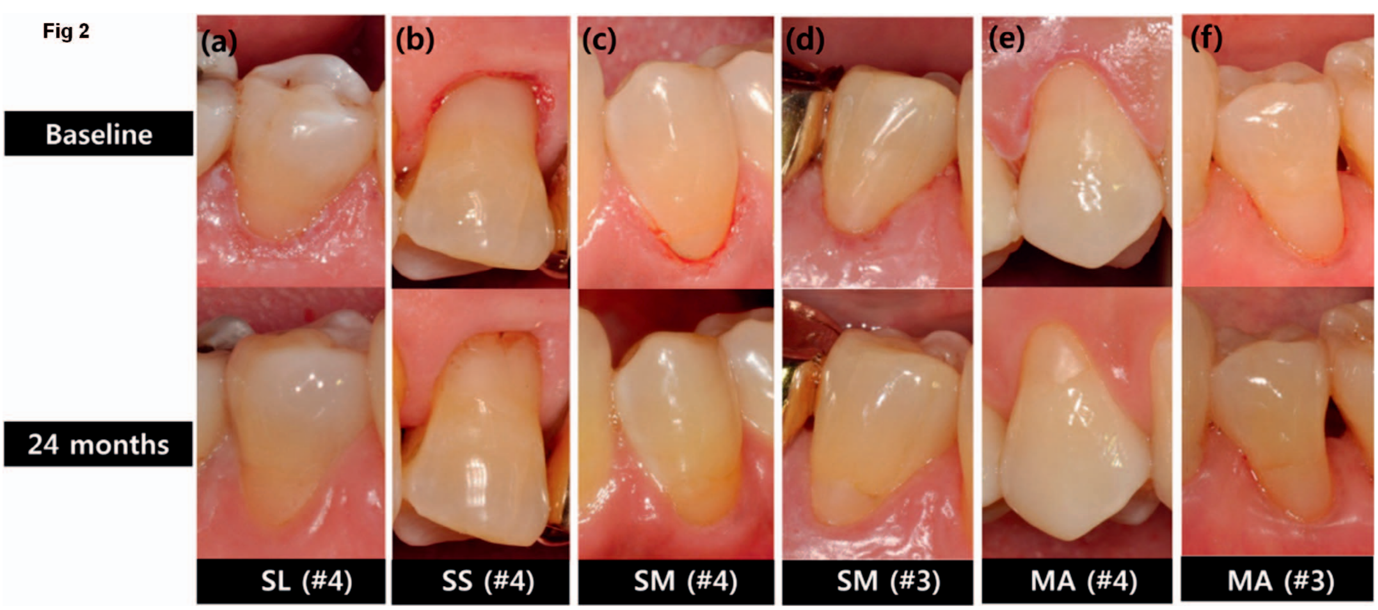

Figure 2. *Representative photographs for clinical evaluations with score <5 at 24 months. (a): Score 4 for surface luster. (b): Score 4 for surface staining. (c) and (d): Scores 4 and 3 for margin staining, respectively. (e) and (f): Scores 4 and 3 for marginal adaptation, respectively.*

Table 5: *Odds Ratio and Adjusted Proportion of Below-Excellent Outcomes (Score of <5) Under Consideration of Repeated Observation for 24 Months*[a]

Criteria	Group	Odds Ratio (95% Confidence Interval)	*p*-Value	Adjusted Log Odds	Adjusted Percentage
SM	CS/Sof	Reference	—	−3.89	2.0%
	CS/EP	1.22 (0.28-5.28)	0.786	−3.43	3.1%
	XE/Sof	0.45 (0.07-2.73)	0.382	−4.46	1.1%
	XE/EP	2.61 (0.68-9.99)	0.162	−2.67	6.5%
	EP[b]	2.60 (0.92-7.33)	0.072		
	XE[b]	1.21 (0.44-3.28)	0.714		
MA	CS/Sof	Reference	—	−2.79	5.8% A
	CS/EP	1.76 (0.71-4.34)	0.219	−2.06	11.3% A
	XE/Sof	1.04 (0.39-2.76)	0.936	−2.67	6.5% A
	XE/EP	4.07 (1.75-9.44)	0.001[c]	−1.12	24.6% B
	EP[b]	3.22 (1.63-6.35)	<0.001[c]		
	XE[b]	1.88 (0.97-3.66)	0.061		

Abbreviations: SM, staining margin; MA, marginal adaptation; Sof, Sof-Lex; EP, Enhance/Pogo; CS, Clearfil SE bond; XE, Xeno V.
[a] *Different letters (A and B) represent significant difference among groups at an alpha level of 0.05.*
[b] *Interaction term was omitted as insignificant in SM (p=0.615) and MA (p=0.157).*
[c] *p<0.05 by generalized estimating equation considering repeated observations for 24 months.*

efficacy of polishing instruments. Most *in vitro* studies evaluate the polishing performance on a flat and homogeneously finished composite specimen for experimental standardization, while, in clinical practice, the desired surface of composite restorations is rather convex or concave and the finishing state not as homogeneous as that observed in the experimental setting. Finishing with diamond point, the procedure implemented in the present study, delivers a comparatively good finish on curved surfaces and feather edges but has also been reported to leave a relatively irregular surface.[25,26] Finishing using abrasive disc instruments begins with a coarse disc before polishing proceeds with gradually finer-grained abrasive discs. Therefore, abrasive discs may have been less affected by the irregularity of the finished surface and hence may have produced a smoother final polishing surface than the abrasive-impregnated rubber instruments. This may explain the better clinical performance score in surface luster, surface staining, and marginal staining at 24 months.

In the present study, Sof also showed better marginal adaptation than EP at 24 months. An earlier *in vitro* study reported that the hardness of the aluminum oxide abrasive used in abrasive discs is higher than that of most filler particles in the composite resin formulation; thus, this abrasive cuts filler and resin matrix equally to produce a smooth surface.[27] Because of the hardness of the abrasive particle and the thin flexible backing, Sof appears to work better than EP in convex cervical composite restorations by blending smoothly with the contours of the tooth being restored. Moreover, EP also appears to be too bulky to reach the interproximal and cervical margin of class V composite restorations, regardless of their shape.

Although analysis of the percentages below score 5 (the clinically excellent outcome) indicated that the polishing performance of Sof is better in class V composite restorations, EP did not show any significant differences from Sof, in any criteria, in the analysis of the percentages below score 4 (the clinically good outcome). Accordingly, EP is also considered to be an effective instrument to obtain a clinically good polishing performance in class V composite restorations. The use of EP, which is an abrasive-impregnated rubber polishing system, is more advantageous when access to the anatomically contoured occlusal surface is required since the various forms of the instrument (cup, point, and wheel) offset the access limitations of the abrasive disc.[13,28] Additional significant advantages of abrasive-impregnated rubber instruments over multistep abrasive discs include the relative ease of handling and the significant time savings.

It is not clearly understood why the XE-EP group showed a significantly inferior outcome to the CS-Sof group with regard to marginal adaptation. The observed difference between the polishing systems presented a high odds ratio showing significance, while the observed difference between the adhesives did not (Table 5). Therefore, the polishing system is assumed to be a variable with significantly more effect than the adhesive system. In previous studies, one-step self-etch adhesives have been reported to show lower bond strength to enamel relative to two-step self-etch adhesives.[29-31] The lower bond strength of one-step self-etch adhesives is likely to be more evident for uncut enamel without additional acid etching, as in the present study.[32,33] The possibility of leaving a thin overhang of composite resin on the uncut enamel is greater when polishing with EP than when polishing with Sof, which shows superior finishing ability by starting the procedure with a 100-μm-grain-sized coarse disc. This thin overhang might be more easily fractured out from restorations bonded with XE due to the relatively weak bond strength in comparison to the bond strength with CS. As a consequence, fracturing of a thin overhang may be reflected as inferior performance in the marginal adaptation in the XE-EP group in comparison with the CS-Sof group.

The FDI criteria that were recently introduced for clinical evaluation of dental restorations were slightly modified in the present study. From the 16 categories of original FDI criteria for evaluation of class V restorations, we appropriately chose representative categories that we could easily assess. For the sake of convenience, each criterion was scored from a high of 5 (clinically excellent) to a low of 1. This was in contrast to the original FDI criteria, where 1 was best and 5 was worst.[15] In addition, in several criteria, the original subscores were integrated to present one score for simplification of the evaluation. The FDI criteria appear to be more sensitive and more precise in the evaluation of composite resin restorations in comparison with the US Public Health Service criteria system, which had been generally used in many clinical trials, because of the use of a detailed scoring system.

The present study does not address all clinical aspects of polishing systems utilized in composite resin restorations. A number of studies have reported that the polishing outcome depends on the filler size, shape, and loading of composite resin.[32,33] The present study used only one type of microhybrid composite resin. The dependence of clinical polishing effectiveness on the different filler types of composite resin would be an intriguing issue for future studies. Another limitation of this study is that the observation period of 24 months may be relatively short to confirm the clinical polishing performance over the whole service span of composite resin restorations. Further observations with longer follow-up are required.

CONCLUSIONS

In conclusion, multistep abrasive discs (Sof) were clinically superior in clinical polishing performance to simplified abrasive-impregnated rubber instruments (EP) with regard to criteria such as surface luster, surface staining, marginal staining, and marginal adaptation for class V composite resin restorations over a 24-month follow-up period. Although EP showed inferior performance to Sof, this instrument still presented clinically good outcomes. Considering the advantage of EP in ease of handling and time saving, abrasive-impregnated rubber instruments may also be recommended for the polishing of class V composite resin restorations. XE, one-step self-etch adhesives showed clinically equivalent performance to CS, two-step self-etch adhesives.

Acknowledgements

This study was supported by a grant of the Korea Health Technology R&D Project through the Korea Health Industry Development Institute (KHIDI), funded by the Ministry of Health & Welfare, Republic of Korea (HI14C1817).

Regulatory Statement

This study was conducted in accordance with all the provisions of the local human subjects oversight committee guidelines and policies of the Institutional Review Board of KHUDH. The approval code for this study is KHD-IRB 1603-5.

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.

(Accepted 30 June 2016)

REFERENCES

1. Yap A, Lye K, & Sau C (1997) Surface characteristics of tooth-colored restoratives polished utilizing different polishing systems *Operative Dentistry* **22(6)** 260-265.
2. Ferreira RS, Lopes GC, & Baratieri LN (2004) Direct posterior resin composite restorations: Considerations on finishing/polishing. Clinical procedures *Quintessence International* **35(5)** 359-366.
3. Hoelscher DC, Neme AM, Pink FE, & Hughes PJ (1997) The effect of three finishing systems on four esthetic restorative materials *Operative Dentistry* **23(1)** 36-42.
4. Jefferies SR (2007) Abrasive finishing and polishing in restorative dentistry: A state-of-the-art review *Dental Clinics of North America* **51(2)** 379-397.
5. Lutz F, Setcos JC, & Phillips RW (1983) New finishing instruments for composite resins *Journal of the American Dental Association* **107(4)** 575-580.
6. Scientific Documentation of Enhance-PoGo. (2014) Retrieved online Feb 2014 from: http://www.dentsply.com
7. Berger SB, Palialol AR, Cavalli V, & Giannini M (2011) Surface roughness and staining susceptibility of compos-

ite resins after finishing and polishing *Journal of Esthetic and Restorative Dentistry* **23(1)** 34-43.

8. Antonson SA, Yazici AR, Kilinc E, Antonson DE, & Hardigan P (2011) Comparison of different finishing/polishing systems on surface roughness and gloss of resin composites *Journal of Dentistry* **39(Supplement 1)** e9-e17.

9. Borges AB, Marsilio AL, Pagani C, & Rodrigues JR (2004) Surface roughness of packable composite resins polished with various systems *Journal of Esthetic and Restorative Dentistry* **16(1)** 42-47.

10. Çelik C, & Ozgünaltay G (2009) Effect of finishing and polishing procedures on surface roughness of tooth-colored materials *Quintessence International* **40(9)** 783-789.

11. Lu H, Roeder LB, & Powers JM (2003) Effect of polishing systems on the surface roughness of microhybrid composites *Journal of Esthetic and Restorative Dentistry* **15(5)** 297-303.

12. Korkmaz Y, Ozel E, Attar N, & Aksoy G (2008) The influence of one-step polishing systems on the surface roughness and microhardness of nanocomposites *Operative Dentistry* **33(1)** 44-50.

13. Jung M, Eichelberger K, & Klimek J (2007) Surface geometry of four nanofiller and one hybrid composite after one-step and multiple-step polishing *Operative Dentistry* **32(4)** 347-355.

14. Kim YM, Shin SJ, Song MJ, & Park JW (2011) The evaluation of surface roughness and polishing time between polishing systems *Restorative Dentistry and Endodontics* **36(2)** 119-124.

15. Hickel R, Roulet JF, Bayne S, Heintze SD, Mjör IA, Peters M, Rousson V, Randall R, Schmalz G, Tyas M, & Vanherle G (2007) Recommendations for conducting controlled clinical studies of dental restorative materials *Clinical Oral Investigations* **11(1)** 5-33.

16. Kim SY, Lee KW, Seong SR, Lee MA, Lee IB, Son HH, Kim HY, Oh MH, & Cho BH (2009) Two-year clinical effectiveness of adhesives and retention form on resin composite restorations of non-carious cervical lesions *Operative Dentistry* **39(5)** 507-515.

17. Häfer M, Jentsch H, Haak R, & Schneider H (2015) A three-year clinical evaluation of a one-step self-etch and a two-step etch-and-rinse adhesive in non-carious cervical lesions *Journal of Dentistry* **43(3)** 350-361.

18. Lawson NC, Robles A, Fu CC, Lin CP, Sawlani K, & Burgess JO (2015) Two-year clinical trial of a universal adhesive in total-etch and self-etch mode in non-carious cervical lesions *Journal of Dentistry* **43(10)** 1229-1234.

19. Lee KW, Choung SJ, Han YC, Son HH, Um CM, Oh MH, & Cho BH (2006) Prospective clinical evaluation of three different bonding systems in class V resin restorations with or without mechanical retention *Restorative Dentistry and Endodontics* **31(4)** 300-311.

20. Suh BI, Feng L, Wang Y, Cripe C, Cincione F, & de Rjik W (1999) The effect of the pulse-delay cure technique on residual strain in composites *Compendium of Continuing Education in Dentistry* **20(2)** 13-14.

21. Hickel R, Peschke A, Tyas M, Mjör I, Bayne S, Peters M, Hiller KA, Randall R, Vanherle G, & Heintze SD (2010) FDI World Dental Federation: Clinical criteria for the evaluation of direct and indirect restorations—Update and clinical examples *Clinical Oral Investigations* **14(4)** 349-366.

22. Hickel R, Peschke A, Tyas M, Mjör I, Bayne S, Peters M, Hiller KA, Randall R, Vanherle G, & Heintze SD (2010) FDI World Dental Federation—Clinical criteria for the evaluation of direct and indirect restorations: Update and clinical examples *Journal of Adhesive Dentistry* **12(4)** 259-272.

23. Kuss O (2002) How to use SAS for logistic regression with correlated data. *Proceedings of the 27th Annual SAS Users Group International Conference* 261.

24. Stokes ME, Davis CS, & Koch GG (2001) *Categorical Data Analysis Using SAS*. **2nd edition** SAS Institute/Wiley, Cary NC.

25. Reis AF, Giannini M, Lovadino JR, & Ambrosano GM (2003) Effects of various finishing systems on the surface roughness and staining susceptibility of packable composite resins *Dental Materials* **19(1)** 12-18.

26. Ferracane JL, Condon JR, & Mitchem JC (1992) Evaluation of subsurface defects created during the finishing of composites *Journal of Dental Research* **71(9)** 1628-1632.

27. van Dijken JW, & Ruyter IE (1987) Surface characteristics of posterior composites after polishing and toothbrushing *Acta Odontologica Scandinavica* **45(5)** 337-346.

28. Zimmerli B, Lussi A, & Flury S (2011) Operator variability using different polishing methods and surface geometry of a nanohybrid composite *Operative Dentistry* **36(1)** 52-59.

29. De Munck J, Van Meerbeek B, Satoshi I, Vargas M, Yoshida Y, Armstrong S, Lambrechts P, & Vanherle G (2003) Microtensile bond strengths of one- and two-step self-etch adhesives to bur-cut enamel and dentin *American Journal of Dentistry* **16(6)** 414-420.

30. Brackett WW, Ito S, Nishitani Y, Haisch LD, & Pashley DH (2006) The microtensile bond strength of self-etching adhesives to ground enamel *Operative Dentistry* **31(3)** 332-337.

31. Patil D, Singbal KP, & Kamat S (2011) Comparative evaluation of the enamel bond strength of "etch-and-rinse" and "all-in-one" bonding agents on cut and uncut enamel surfaces *Journal of Conservative Dentistry* **14(2)** 147-150.

32. Da Costa J, Ferracane J, Paravina RD, Mazur RF, & Roeder L (2007) The effect of different polishing systems on surface roughness and gloss of various resin composites *Journal of Esthetic and Restorative Dentistry* **19(4)** 214-224.

33. Ergücü Z, Türkün LS, & Aladag A (2008) Color stability of nanocomposites polished with one-step systems *Operative Dentistry* **33(4)** 413-420.