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Clinical Impact of One-Step Polishing System to Different Composite Resin Restorations

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Abstract: To evaluate clinical performance of three different resin composites (microfilled, nanohybrid, nanofilled) polished with one-step polishing system in cervical restorations after 24 month. Thirty adult patients were selected from outpatient clinics with a total of 90 restorations (30 of each type of dental composite resin). All of the restorations were finished using fine grit finishing diamond under water-cooling to remove gross excess and polished with one-step polishing system. All restorations showed only minor changes and no differences were detected between their performance at any time period. Nanofill and nanohybrid composite resin showed a satisfactory clinical performance after 24 month as microfill composite resin.

Keywords: Clinical evaluation, Nanofill resin composite, Nanohybrid resin composite, Microfill resin composite, One-step polishing system.

INTRODUCTION

Proper finishing and polishing of dental restorations are important aspects in clinical restorative procedures, regardless of the type and location of the restoration, because they enhance both esthetics and longevity of restored teeth [1, 2]. Residual surface roughness, associated with improper finishing and polishing, can result in a number of clinical problems such as excessive plaque accumulation [3, 4], gingival irritation, increased surface staining, suboptimal esthetics of the restored teeth [5], marginal leakage and secondary caries [6, 7]. Therefore, maintaining the smooth surface of a restoration is of great important for its success.

Surface roughness influences resistance to staining [6, 7] and the natural gloss of the restoration [8, 9]. The most smooth and glossy surface is generally obtained under a Mylar strip without subsequent finishing or polishing, but unfortunately intra-oral finishing is always required [10]. The Mylar strip finished surface has higher resin content and will reduce the wear resistance of the restoration over time. Therefore, finishing and polishing of tooth-colored restoration after placement are inevitable procedures that will improve esthetics; early wear resistance, color stability and marginal integrity [11, 12]. Several investigations have shown that removal of the polymer-rich, outermost resin layer is essential to achieving a stain-resistant, more esthetically stable surface [13-15].

Clinicians have their choice among a wide range of finishing and polishing instruments. The search for the ideal polishing system for dental composites is ongoing [16]. With the ultimate goal of achieving a smooth surface of the composite restoration in fewer steps, current one-step systems appear to be as effective as multi-step systems for polishing dental composites [16]. The one-step polishing systems are appealing to the clinician [17]. So, this study was conducted to investigate two years clinical performance of three different resin composites (microfilled, nanohybrid, nanofilled) finished and polished with one-step polishing system in cervical restorations.

MATERIALS & METHODS

The composite restorative systems employed in this study were; microfill resin composite (Helimolar/Tetric N bond); nanohybrid composite (Tetric N Ceram / Tetric N bond) and nanofill resin composite (Filtek Z350XT / Single bond). The one-step polishing system used was (Astrobrush) Table-1.

The restorative materials were used in accordance with manufacturer's instructions and only one operator performed all the procedures of specimen's preparation and all restorative procedures. A light emitting diode (LED) visible-light curing unit (bluephaseC8, Ivoclar/VivadentAG Schaan, Liechtenstein) was used, and the power density of the light (800 mW/cm2) was checked every 10 specimens

with a digital readout dental radiometer (bluephase meter, IvoclarVivadent AG, Schaan, Liechtenstein).

Table-1: materials used in the study

Brand names	Specificatioin	Manufacture	Composition
Filtek™ Z350 XT	*Nano filled composite*	*3M ESPE St Paul, MN, USA*	*Matrix: Bis-GMA, UDMA, Bis-EMA,TEGDMA Filler: silica nanofiller (5−75 nm), zirconia/silica nanocluster (0.6−1.4 μm)*
Single Bond	*Two- step etch-and-rinse*	*3M ESPE*	*bis-GMA,HEMA, DMA, poly alkenoic acid copolymer intiator, water, ethanol*
			Scotchbond etchant :36% phosphoric acid with colloidal silica
Tetric N ceram	*Nano hybrid composite*	*IvoclarVivadent*	*Matrix: bisGMA,UDMA,TEGDMA,EthoxylatedBis-EMA. Filler:Barium glass, ytterbium trifluoride,mixed oxide, silicon dioxideprepolymers*
Teric N bond	*Two- step etch-and-rinse*	*IvoclarVivadent*	*BisGMA,UDMA, HEMA phosphoric acid acrylate,Nano-fillers (SiO2),Ethanol*
			Tetric N etch:37%wt.phsphoric acid in water, thickners, pigments.
Helimolar	*Microfilled composite*	*IvoclarVivadent*	*Matrix: Bis-GMA, UDMA, Decandioldimethacrylate, Filler:silicon dioxide, Prepolymer, Ytterbium trifluoride*
Astrobrush	*One step polishing system*	*IvoclarVivadent*	*Silicon carbide-impregnated polyamide bristle brush*

Abbreviations: bis-GMA, bisphenol-A glycidyl methacrylate; UDMA, urethane dimethacrylate; TEGDMA, triethyleneglycoldimethacrylate; DMA, dimethacrylate; Bis-EMA,Bisphenol A polyethylene glycol dietherdimethacrylate

Thirty patients within the age group of 20-40 years (with a mean age of 30 year), were enrolled from the Outpatient Clinic, at Faculty of Dentistry Mansoura University. They were attended for dental care. Each patient signed a written informed consent according to the regulations of our institution's ethics committee, following an explanation at the beginning of the study related to the nature and objectives of the clinical trial. Each patient received at least three restorations until the 90 restorations had been obtained.

The Inclusion Criteria were as follow [18]:

- Good general health and appropriate oral hygiene, Löe & Silness gingival index scored 0 [19].
- Presence of at least three comparable lesions either carious or non-carious in vital anterior teeth, premolars that required class V restoration of moderate size. A tooth was considered vital if it was clinically free from any signs or symptoms and normally responded to routine vitality testing.
- Normal functional occlusion.
- Patient must be able to return for periodic recall examination.

The Exclusion Criteria were as follow [18].

- Absence of antagonist teeth.
- Sever periodontal diseases and extremely poor oral hygiene.
- Symptoms of pulpitis, such as spontaneous pain or sensitivity to pressure.

The teeth were randomly restored with either restorative system; Helimolar (group A, n=30); Tetric N Ceram (group B, n=30) and Filtek Z350 XT (group C, n=30). The common characteristics of cavity preparations were comparable size of about 3–4 mm inciso-gingivally, 2–3 mm mesio-distally and 1 mm deep in dentin [1]. If the cavity extended for more than 1mm into dentin, a glass-ionomer cement lining (Vivaglass Liner, IvoclarVivadent) was applied at the pulpal floor. Control of the excavated cavity floor was mainly conducted by probing with a sharp explorer and by means of the color of the underlying dentin [20]. The incisal cavosurface margin was beveled [21], long enamel bevel of about 1mm to increase surface area for bonding and to enhance aesthetics, no retentive groove. The materials were manipulated and placed following the manufacturers' instructions, and then was finished and polished with one-step polishing system (Astrobrush) according to manufacturers' instruction.

Cavity preparation was made using a round carbide bur (Komet, 830L, Komet, Lemgo, Germany) with oil free high speed air turbine and constant water cooling (120.000rpm) and the incisal cavosurface margin was beveled with diamond point. The restorations were placed by using rubber dam isolation. Rubber dam was placed after opening the cavity and shade selection, appropriate enamel and dentin shades were selected using the Vita shade guide under ambient lighting condition. Local anesthesia was

administered for all patients to prevent patient discomfort during the restorative procedures.

Where microfill (Group A) composite was used, the cavity was etched with 37% phosphoric acid gel (Tetric N etch). The acid gel was first placed on enamel and dentin was conditioned during the last 15-s of the 30-s etching time. The cavity then thoroughly rinsed with water for 15s. Excess moisture was removed with dry applicator tip leaving the dentin surface with a slightly glossy wet appearance. The adhesive was applied with a microbrush. After 10 s, solvent was evaporated with gentle air stream followed by polymerization for 10 s. For nanohybrid (Group B) composite restorations, the prepared cavities were etched and the adhesive resin applied as in group A.

For nanofilled (Group C) composite restoration, the cavity was etched with 36% phosphoric acid (Scotchbond etchant) for 15-30 s followed by thorough rinsing with water for 10 s and gentle air drying. Two coats of Single bond adhesive were applied with 20 s waiting period in between the coats, followed by gentle air-drying for 10 s and finally light cured for 20 s.

Cavities for microfilled were restored in two increments with the same shade. While for nanohybrid and nanofilled; the first layer was dentin shade followed by second layer of enamel shade. The increment was adapted to the cavity margins using condenser**.** A cervical matrix band (kerrHawe SA, 6943 Biogio/Switzerland) was applied on superficial layer before curing. Each increment was cured for 20 s. Figs 1-4 showed restorative procedures for a case with class V carious lesion.

After removal of cervical matrix, all restorations were finished with30 µm finishing diamond (gold 3168F, KG Sorensen, Barueri, Brazil) for 30 seconds using high speed hand piece under water cooling to remove gross excess and polished with one step silicon polisher for30 seconds using a planar motion under water spray. Astropol cups and Astrobrushes were used to polish the previously finished surfaces with light hand pressure in a low-speed hand piece which attached to electrical motor to fix the speed at1000 rpm. The finishing was done in conjunction with water spray to avoid the build-up of heat on the tooth as well as deterioration of finishing material [22].

Fig-1: A preoperative photograph of a patient with carious upper right lateral incisor

Fig-2: Class V cavity preparation of upper right lateral incisor.

Fig-3: Restoration placement and cured in presence of transparent cervical matrix

Fig-4: Postoperative photograph of restored tooth

Each restoration was clinically evaluated immediately following finishing and polishing (baseline), after 6, 12 and 24 month by two independent evaluators. Evaluators were not involved in the filling procedures. When disagreement occurred during evaluations, the restorations were re-evaluated by both evaluators and a consensus was obtained. Restoration was evaluated using United States Public Health Service (USPHS) [23] modified Ryge criteria for retention, marginal adaptation, polishability, secondary caries, soft tissue health, anatomic form, color match, surface stainin Table-2.

Restorations were given the score Alpha for the ideal clinical situation, Bravo for clinically acceptable, Charlie for clinically unacceptable and in need for replacement, or Delta representing fractured, mobile or missing restorations in need for immediate replacement. In addition, each restorative was assessed for postoperative sensitivity one week after placement and at each follow up examination. To detect secondary caries, the presence of softness, opacity, etching, or white spots are considered as evidence of undermining or demineralization in areas where the explorer catches or resist removal after insertion [24]. All evaluations were carried out under a dental operating light, using flat surfaced mirror and Sharp dental explorer. An evaluation sheet was used to record the patient scores at each follow up visit.

The collected data were down loaded to a computer using Microsoft Excel Version 7 and statistical analysis was performed using the SPSS statistical package (Statistical Package for the Social Science; SPSS Inc, Chicago, IL, USA). Pearson chi square test was conducted to compare between different materials at the same time with one-step polishing system and recall time periods for each material.

Table-2: Modified USPHS criteria for the direct clinical evaluation of the restorations

Category	Rating and characteristics
Anatomical form	A: Restoration's contour is continuous with existing anatomical form and margins. B: Restoration is slightly over contoured or under contoured. C: Marginal overhang or tooth structure (dentin or enamel) is exposed. D: Restoration is missing, traumatic occlusion or restoration causes pain in tooth or adjacent tissue
Secondary caries	A: No visible caries. C: Caries contiguous with the margin of the restoration.
Color match	A: No mismatch in color, shade or translucency between restoration and adjacent tooth structure. B: Mismatch between restoration and tooth structure within the normal range of tooth. C: Mismatch between restoration and tooth structure outside the normal range of tooth. D: Esthetically displeasing color, shade and translucency
Retention	A: Present B: Partial loss. C: Absent.
Marginal adaptation	A: Excellent continuity at resin–enamel interface; no ledge formation, no discoloration. B: Slight discoloration at resin–enamel interface; ledge at interface. C: Moderate discoloration at resin–enamel interface measuring 1 mm or greater. D: Recurrent decay at margin.
Polishability	A: Smooth and highly shiny, similar to enamel B: Smooth and satin, highly reflective C: Rough and shiny, satin, somewhat reflective D: Rough and dull or satin, not reflective
Surface roughness	A: restoration surface is as smooth as surrounding enamel B .The restoration surface is rougher than the surrounding enamel C.There is a crevice and fracture on the restoration
Soft tissue health	A: Excellent response—no inflammation. B: Slight inflammation of gingival tissue. C: Moderate to severe gingival inflammation.
Sensitivity	Post-operative sensitivity: yes or no.

A, Alpha; B, Bravo; C, Charlie; D, Delta.

RESULTS

After 24-month follow up examinations, 81 (96.7%) restorations of 90 were evaluated. Two patients (9 restorations) were unavailable at 6-month, 12-month, and 24-month recalls. Reasons for not attending each recall visit were checked. One patient was unavailable because he moved away; the other had trauma and had lost their teeth however, no negative appreciation for restorative procedures that were performed reported by this patient. All restorations showed only minor changes and no difference were detected between their performance at any time period Table-3.

Table-3: Chi-square test for comparison of materials in each recall time period

Recall times	Material	Test values	Retention	Color Match	Surface staining	Anatomic form	Secondary caries	polishability	Marginal adaptation	Postoperative sensitivity	Soft tissue health
Baseline	Microfilled	chi squar	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		p value	1.000	1	1.000	1	1	1.000	1	1.000	1.000
	Nanohybrid	chi squar	0.000	0.000	0.000	0.000	0.000	0.000	0.000	.577	0.000
		p value	1.000	1	1.000	1	1	1.000	1.000	.749	1.000
	Nanofilled	chi squar	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		p value	1.000	1	1.000	1	1	1.000	1.000	1.000	1.000
6 month	Microfilled	chi squar	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.077	0.000
		p value	1.000	1	1.000	1	1	1.000	1.000	.354	1.000
	Nanohybrid	chi squar	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		p value	1.000	1	1.000	1	1	1.000	1.000	1.000	1.000
	Nanofilled	chi squar	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.077	0.000
		p value	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.354	1.000
12 month	Microfilled	chi squar	0.000	0.000	2.077	2. 077	0.000	0.000	2.077	0.000	1.080
		p value	1.000	1.000	.354	0.354	1.000	1.000	.354	1.000	.583
	Nanohybrid	chi squar	0.000	.000	1.080	2. 077	0.000	0.000	2.077	0.000	0.000
		p value	1.000	1.000	.583	0.354	1	1.000	. 354	1.000	1.000
	Nanofilled	chi squar	0.000	.000	0.000	0.000	0.000	1.080	0.000	0.000	1.080
		p value	1.000	1.000	1.000	1	1	.583	1.000	1.000	.583
24 month	Microfilled	chi squar	0.000	0.000	2.077	2. 077	0.000	0.000	2.077	0.000	1.080
		p value	1.000	1.000	.354	0.354	1	1.000	.354	1.000	.583
	Nanohybrid	chi squar	0.000	0.000	1.080	1.080	2.077	0.000	2.077	0.000	0.000
		p value	1.000	1.000	.583	.583	. 354	1.000	.354	1.000	1.000
	Nanofilled	chi squar	0.000	0.000	1.080	1.080	0.000	1.080	1.080	0.000	1.080
		P value	1.000	.362	.362	.362	1.000	1.000	1.000	1.000	.248

DISCUSSION

Nanotechnology has recently been used for development of composite resin. The new material represents an evolution on balance of aesthetics and mechanical properties, allowing them to be used in anterior and posterior restorations. Among the advantages of using this material, the following can be pointed out: lower polymerization shrinkage, improved

mechanical properties, favored optical behavior, greater brightness, surface smoothness, better color stability, and decreased wear. Improvements in resin-based composite technology have increased the acceptance of this class of materials among dental professionals, particularly for restoring anterior and posterior teeth [25, 26].

However, not only the material type and composition are responsible for maintaining the smoothness but also the finishing and polishing procedures. However, there are no consensuses in the literature concerning the effectiveness of different finishing and polishing procedures and systems used to finish and polish composite resins clinically [27]. In this study silicon polisher was selected because it presented with different geometry which is suitable for different area of the mouth.

Laboratory tests might provide useful information to the potential performance of a filling material and its' handling, but such tests cannot adequately evaluate the clinical performance of a material or clinical handling characteristics. Besides, in vitro studies cannot answer questions about in vivo longevity of these tooth colored restorations. The complexity of some masticatory system variables like temperature changes, and pH alterations makes reproduction of oral physiology difficult. Laboratory testing should not become an end in itself but allow a prognosis of the clinical performance of restorative materials and/or operative techniques. Therefore, only the clinical environment may be determinant in assessing dental materials or restorative techniques [28, 29].

The restorative systems were evaluated for 24-month which may be considered to provide timely information on the performance of restorations, particularly in terms of catastrophic failure and may be considered to be particularly appropriate for newly introduced materials such as that used in the present study [30]. In the current study, three restorations were placed in each patient to be subjected to the potential variables which vary from patient to patient, influencing the overall performance of a restoration [29]. Immediate finishing and polishing was recommended since this procedure reduces the number of clinical sessions and the wellness of the patients.

In this study, evaluation of composites depicted minor changes compared to baseline. This fact is not surprising, since several studies have already shown a satisfactory performance of microfilled in anterior cavities because of their high translucency, high polish and polish retention [31-34]. In this study, the results of clinical evaluation of nanofilled and nanohybrid resin composites showed good performance in anterior teeth, which was similar to microfilled. This agrees with Quin *et al.*, [35] who found that nanocomposite exhibited acceptable clinical performance in class V for two years.

Retention

After 24 -month the studied restorative composite systems performed well in this regard. All the restorations were retained. This may be due to each restoration was used with its appropriate bonding agent according to its manufacture which is one-bottle etch-and-rinse adhesive.

Color stability

As regard to color matching ability of different materials, it was found that all restorative resin composites tested were in the range of alpha and bravo scores all over the recall periods in all the groups, there was no change in color matching ability of groups restored with nanofilled composite within the first year. At 24 month, few restoration recorded bravo score. This due to the nanofill resin composite which allows excellent polishability that diminish surface roughness and surface discoloration [25, 36]; filler loading of nanofilled resin composite is significantly increased in comparison with other two materials microfilled and nanohybrid. This increased filler loading is on the expense of resin matrix, which decreased the possibility of future discoloration due to degradation of uncured resin [9].

Anatomic form

The consistent alpha ratings for anatomic form reflect the relative resistance to wear of the tested materials. In the current study, few restorations were rated bravo after 12-24 month. This result was related to the good physical and mechanical properties of dental resin materials tested.

Polish ability

Polish ability is one of the desirable features of tooth colored dental restoratives. A unique drawback inherent to most composites is the difficulty in polishing due to its heterogeneity and they have problem in staying esthetic for long time.

The microscopic size of amorphous silica particles permits microfills to be highly polished since the particles are less than the wavelength of light; the eye sees them as smooth as diffuse reflection decrease in small filler particles and the surface looks glossy [37]. Improved translucency effects and polish ability were demonstrated as benefits of nanofiller additives in nanofilled dental resin composite [38].

Secondary caries

After the restorative material is placed in the mouth, it is immediately covered with a salivary pellicle, which spread rapidly into surface irregularities and more specifically into the micro-spaces between restoration and tooth structure. Oral bacteria are able to adhere to this pellicle and multiply invading this micro

spaces including further demineralization [39]. In the present study, all restorations behaved well in this regard except one case restored with nanohybrid composite detected with recurrent initial caries after 12-month. This fact points to a tight seal, which must be related to the excellent performance of the two- step etch & rinse adhesive system employed as already demonstrated in other clinical investigations, adequate restorative technique and good oral hygiene.

Surface texture

The size and composition of the filler particles of the resin composite primarily determine the surface texture of a restoration and the material's ability to be finished and polished [40]. In this study, despite the differences in filler percentage and the dimensions of the particles, the tested resin composite demonstrated good results after 24 month. Slightly rougher surface with moderate staining was observed in very few cases of all the three materials. This could be mainly due to the friction with food, tooth brush which increase surface roughness.

Marginal adaptation

Marginal adaptation of a composite resin restoration is dependent on several factors including: polymerization shrinkage, hygroscopic properties, bonding between restoration material and the cavity walls, coefficient of thermal expansion of the material, and the finishing methods.

As regard to marginal adaptation, there was change, in few cases, from alpha score to bravo score for all tested restoration over a period of 24 month .This could be attributed to the fact that marginal adaptation and discoloration in composite restorations was related to some factors such as type of adhesive system, restoration technique and accuracy in finishing restoration. The crevice probably was a direct result of a fracture of overlapping fine type marginal excess, which formed a ledge that caught the explorer during the follow-up examination.

Post-operative sensitivity

Postoperative sensitivity has been attributed to several factors, including; operative trauma, dentin etching, desiccation, leakage and bacterial penetration to the pulp. Obliteration of the exposed dentin tubules by a dental adhesive should eliminate possible thermal and mechanical oral stimuli [41]. The absence of postoperative sensitivity at 24- month in this study was related to excellent two -step etch and rinse adhesive systems, using sharp cutting bur under abundant irrigation with cold water spray, rubber dam isolation, insertion of a liner if necessary, careful drying of the cavity, incremental placement of dental composite resin.

CONCLUSION

Based on the findings of this study, nanofill and nanohybrid composite resin showed a satisfactory clinical performance after 24 month as microfill composite resin.

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