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A randomised controlled study on the use of finishing and polishing systems on different resin composites using 3D contact optical profilometry and scanning electron microscopy

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ABSTRACT

Objectives: The aim of this study was to evaluate theeffects of different finishing and polishing techniques on the surface roughness of microhybrid and nanofilled resin composites.
Methods: The resin composites included were Filtek Z250 (a universal microhybrid resin composite) and Filtek Supreme XTE (a universal nanofill resin composite). Ninety cylindrical-shaped specimens were prepared for each composite resin material. The polishing methods used included tungsten carbide bur (TC); diamond bur (Db); Sof-Lex discs (S); Enhance PoGo discs (PG); TC + S; Db + S; TC + PG; Db + PG. Polymerisation against a Mylar strip without finishing and polishing acted as the control group. Surface roughness was measured using a 3D contact optical profilometer and surface morphology was examined by scanning electron microscope examination.
Results: The results showed that the Mylar-formed surfaces were smoothest for both composites. Finishing with the 20 μm diamond finishing bur caused significantly greater surface irregularity ($P < 0.0001$) and damage than finishing with the tungsten carbide finishing bur. The Enhance PoGo polishing system produced smoother surfaces than the Sof-Lex disc polishing system; this difference was statistically highly significant ($P < 0.0001$).
Conclusion: For both composites, the Mylar-formed surfaces were smoothest. Where indicated clinically, finishing is better conducted using a tungsten carbide bur- rather than a diamond finishing bur. The Enhance PoGo system was found to produce a smoother surface finish than the Sof-Lex system.
Clinical significance: If finishing and polishing is required the use a tungsten carbide finishing bur followed by Enhance PoGo polishing may be found to result in the smoothest surface finish.

1. Introduction

Advances in nanotechnology have led to the introduction of several new resin composite restorative materials (composites) with various claims of superior aesthetics. These materials are placed, however, using established techniques, with the inevitability that at least sections of the margins, if not the surfaces of restorations of these materials, need to be finished and polished, even when a careful matrix technique is applied.

Finishing refers to the contouring of the restoration to obtain the desired anatomy and complete any necessary occlusal adjustments, whereas polishing refers to the reduction of surface irregularities created by the finishing instruments.

One of the keys to achieving an aesthetic restoration is good surface finish [1]. Surface polish is important to the appearance and longevity of a tooth-coloured restoration [1]. The surface roughness of a composite restoration affects susceptibility to plaque accumulation [2–4], recurrent caries [1], suboptimal aesthetics of the restored tooth and potential for abrasion and wears kinetics. Surface roughness also influences resistance to staining [5] and the optical properties, including the reflectance of composite restorations.

Various instruments and methods have been advocated for the finishing and polishing of composite restorations. It has been shown that one-step polishing systems can be superior, or at least comparable to multi-step techniques, subject to the finishing regimen used prior to polishing [5,6].

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Table 1
Details of materials and instruments investigated.

Material	Manufacturer	Filler composition	Filler loading	Filler particle size	Resin type
Filtek Supreme XTE	3 M ESPE, St Paul, MN, USA	Silica/Zirconia cluster fillers	63.3% by volume	4–20 nm (average 11 nm)	Bis-GMA, UDMA, TEGDMA Bis-EMA
Filtek Z250	3 M ESPE, St Paul, MN, USA	Silica/Zirconia, cluster fillers	59.5% by volume	0.01–3.5 μm (average 0.6 μm)	TEDGMA, UDMA, Bis-EMA
Enhance PoGo discs	Dentsply Caulk, Milford, DE, USA	Cured composite of urethane dimethacrylate, fine diamond powder, silicon dioxide 7 μm, Al2O3			
Sof-Lex discs	3 M ESPE, Dental products, St Paul, MN, USA	Al2O3 flexible discs, 100 *μ*m (C), 29 *μ*m (M), 14 *μ*m (F), 5 *μ*m (SF)			

Table 2
Surface treatments allocated to the nine paired groups of composite specimens.

Paired groups	Surface treatment
1	Polymerised against Mylar strip-no finishing or polishing
2	Water-cooled, multifluted, fine-needle, tungsten carbide bur only (9904, 30 Blade Needle, Jet Burs, Sybron Ltd, Canada) applied with light operating pressure for 20s
3	Water-cooled, tapered, fine (20 μm grit), finishing diamond bur only (UnoDent, Israel) applied with light pressure for 20s
4	Sof-Lex (3 M ESPE St. Paul MN, USA) polishing only, using single-use reducing grit size discs: 1982C (3000 rpm), 1982 M (3000 rpm), 1982 F (10,000 rpm) and 1982, SF (30,000 rpm) only, with each grit size disc being applied dry under constant pressure for 30 s, and the specimens being washed and air-dried between successive discs, according to manufacturer directions
5	One-step PoGo (Dentsply Sirona, USA, Batch No 081023) polishing only −initial 20 s 10,000 rpm, followed by 20 s at 2000 rpm under constant pressure and without water cooling, according to manufacturer directions
6	Tungsten carbide bur finishing followed by Sof-Lex polishing
7	Tungsten carbide bur finishing followed by PoGo polishing
8	Diamond finishing bur followed by Sof-Lex polishing
9	Diamond bur finishing followed by PoGo polishing

Table 3
Mean Ra values obtained for finishing and polishing regimens investigated when applied to the two selected composites.

	Mylar Strip Ra (μm)	Db Ra (μm)	Db + S Ra(μm)	Db + PG Ra(μm)	TC Ra (μm)	TC + PG Ra(μm)	TC + S Ra(μm)
XTE	0.06	2.48	0.23	0.25	0.26	0.09	0.16
Z250	0.07	2.82	0.25	0.25	0.27	0.10	0.16

XT = Filtek Supreme XTE; Z250 = Filtek Z250; Db = Diamond finishing bur; S = Sof-Lex discs; PG = Enhance PoGo discs; TC = Tungsten carbide finishing bur.

Analysis of the surface roughness of resin composite restorations can be undertaken using a variety of methods, including profilometry for quantitative analysis and scanning electron microscopy (SEM) for qualitative assessments. Existing literature includes limited information on surface roughness analysis of microhybrid and nano-resin composites using optical three-dimensional (3D) profilometer [7,8].

The aim of the present study was to compare and contrast the surface roughness of specimens of a microhybrid and a nanofilled composite to determine the most effective regime for the finishing and polishing of these resin systems. Surface roughness was investigated using optical 3D profilometry and SEM.

The null hypotheses were that there are no differences in surface roughness values between the two composites and no differences in surface roughness values following the use of the different finishing techniques and polishing systems on the two composites.

2. Materials and method

2.1. Preparation of composite resin specimens

Two light-polymerised composites were selected for use in this study: Filtek Supreme XTE universal restorative nanocomposite (batch number 20081112, 3 M ESPE, St. Paul MN, USA) and Filtek Z250 universal microhybrid composite (batch number 20081110, 3 M ESPE). The compositions of the two composites are shown in Table 1.

Ninety cylindrical specimens of each of the two composites were prepared using a ready-made plastic Teflon mould (Curing Depth Tester, Dentsply, UK) with a cylindrical cavity of 4 mm in diameter and 4 mm in depth. The mould was lubricated using Vaseline (Pure Petroleum Jelly, London, UK). A microscope glass slide (Fisherbrand, Fisher Scientific, FB58620, UK) 1.0 mm thick was placed under the mould. A straight, transparent Mylar strip (Hawe Transparent Strip, KerrHawe, Switzerland) was interposed between the microscope glass slide and the mould. The composite material was placed in the mould using a smooth-surface, round ended condenser, care being taken to avoid any air inclusions or folds in the composite adapted to the Mylar strip. The composite was polymerised in layers < 2 mm thick using a cordless LED curing light (Dentsply, SmartliteTM PS). The output intensity was measured after every 10 specimens, using a Coltolux light meter (Coltene/Whaledent) to ensure that the output > 900 mW/cm2.

Once polymerised, each specimen was extruded from the mould and stored separately in a labelled micro-centrifuge tube in distilled water at 37° C for 24 h. The specimens were handled using dressing tweezers applied to the sides of the cylinder to protect the flat, Mylar-formed surface of the composite from any damage or contamination.

2.2. Finishing and polishing

The 90 specimens of each composite were divided at random into nine groups, each comprising 10 specimens. Each group of Filtek Supreme XT specimens was paired with a group of Filtek Z250 specimens. A summary of the surface treatments applied to the flat, Mylar-formed surfaces included in the 20 specimens in each of the nine paired groups are detailed in Table 2. The allocation of surface treatment to paired specimen groups was random, using random number tables. Specimen were grasped and held in mosquito forceps (3 M, ESPE, St. Paul MN, USA) during allocated surface treatment, having been marked on the side to ensure that all finishing and polishing took place in the same direction. Before being returned to its water-filled tube, each specimen was rinsed thoroughly under cold, running water. The Sof-Lex discs (3 M, St. Paul, MN, USA) and Enhance PoGo systems (Dentsply