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REVIEW ARTICLE

THE EFFECT OF VARIOUS COMPOSITE POLISHING SYSTEMS ON THE SURFACE ROUGHNESS AND MICRO HARDNESS OF NANOFILL AND NANOHYBRID COMPOSITE RESIN RESTORATIVES" AN IN VITRO STUDY

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ABSTRACT

Context: The key to esthetic and biologic integrity of restorations for a long term, lies in the finishing and polishing, which is the most often neglected procedure.Various finishing and polishing systems are available in the market, however, the polishing regimen for the newer nano-based composites have not been adequately investigated.

Aims: The purpose of this current study is to evaluate and compare the effect of two different polishing systems (Diamond Impregnated Compomaster and Aluminium oxide discs Super Snap Xtreme) on the surface roughness and micro hardness of a nanofill(Filtek Z 350 XT)and a nanohybrid composite resin(Filtek Z 250 XT).

Methods and Material: A total of 60 composite discs of which, 30 specimens of each restorative material , were fabricated (8 mm in diameter and 2 mm in thickness). The respective finishing and polishing procedures were carried out and all the specimens were subjected to Surface roughnesss measurement using a Profilometer and micro hardness measurement using a Vickers Micro hardness testing Machine.

Statistical analysis used: Means and Standard Deviation (Descriptive), one and two way ANOVA, Independent Sample t test, Pearson's correlation co efficient.

Results: The nanofill Z350 XT and Super Snap Xtreme aluminium oxide discs showed least roughness values and Nanohybrid composite specimens had a higher microhardness value.

Conclusions: Z350 XT showed least roughness values overall in comparison.For both nanohybrid and nanofill composites resins, the multistep polishing system-aluminium oxide discs (Supersnap Xtreme Shofu Inc.) provided significantly lower surface roughness .Nanohybrid composite specimens had a higher microhardness value when compared with nanofill specimens.

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INTRODUCTION

The last decade has seen an unprecendented shift in the concepts of adhesive dentistry that have led to the development of a wide variety of extensively researched dental composites. A major clinical disadvantage of traditional composites is the rough surface that develops during abrasive wear of the soft resin matrix also known as differential abrasion. Micro hardness is also an important property of the restorative material that dictates its clinical success (Ugur Erdemir, 2012). Numerous finishing and polishing systems are being marketed to achieve the best overall results. There is no general consensus in the dental literature on the best methods for finishing and polishing of different composite restoration materials (Mohammed, 2016).

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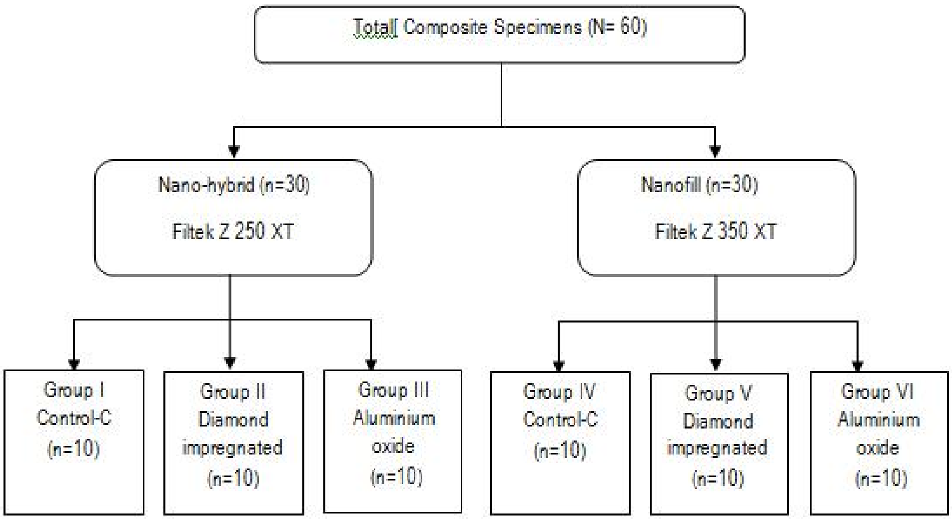
MATERIALS AND METHODS

The 60 specimens were prepared using a polytetrafluoro ethylene (PTFE) mould which was standardized to a dimension of (8mm in diameter X 2mm thick). The mould was placed on a Mylar strip supported by a glass slab and was overfilled with resin composite to obtain a flat surface without any defects and air entrapment, the filled mould was covered by another Mylar strip and a glass slab over it with a constant load application, to ensure excess resin-based composite material was extruded and to minimize polymerization reaction inhibition by oxygen. Both sides of the samples were polymerized for 40 seconds using a QTH light curing unit. The prepared specimens were removed from their moulds and stored in distilled water for 24 hours at 37^{o} C in an incubator in order to enable completion of the polymerization process. All the specimens were stabilized using a hand vice and subjected to a baseline finish using 1200 grit sandpaper for 30 seconds, under running water.



Brand	Lot number	Manufacturer	Type	Composition	Shade
Filtek™ Z350 XT Universal Restorative	N734682	3M ESPE	Nano filled Composite	Matrix: Bis-GMA, UDMA, TEGDMA, and Bis-EMA, PEGDMA Filler particles: The fillers - 20 nm silica filler, 4 to 11 nm zirconia filler, and aggregated zirconia/silica cluster filler (comprised of 20 nm silica and 4 to 11 nm zirconia particles) ; average cluster particle size of 0.6 to 10 microns Inorganic filler loading is 78.5% by weight (63.3% by volume)	A1
Filtek™ Z250 XT Nano Hybrid Universal Restorative	N764893	3M ESPE	Nano hybrid Composite	•Matrix: Bis-GMA, UDMA, TEGDMA, and Bis-EMA, PEGDMA Filler particles: Surface-modified zirconia/silica with a median particle size of approximately 3 microns or less • Non-agglomerated/non-aggregated 20 nanometer surface-modified silica particles .0.01-3.5 um—avg0.6um filler loading is 82% by weight (68% by volume)	A1
Super Snap Xtreme	0914731	SHOFU		Aluminium oxide disks -400x 200μm 3D semispherical coating	
Compomaster	0309136	SHOFU		Diamond impregnated rubber abrasive-particle size 6 um--Silicone Base (25%), Diamond particles (75%)	

The control group specimens were finished with the 1200 grit silicon carbide paper and not subjected to any polishing procedure. Finishing of the specimens was done as per the manufacturers’ recommendation.

- For the Compomaster Polishing system-Firstly with Dura Green and Dura White stones (recommended speed range-5000 – 20,000 rpm and a contact pressure of 3-5 N); followed by Compomaster Coarse diamond polishers.
- For the Super Snap Xtreme system- Black (coarse), violet (medium) aluminium oxide discs

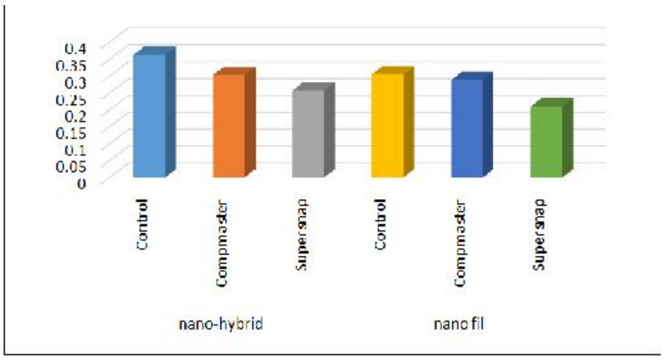
All of the specimens were polished on a flat surface by the same operator for 45 seconds and then rinsed for 10 seconds and air-dried for 5 seconds.

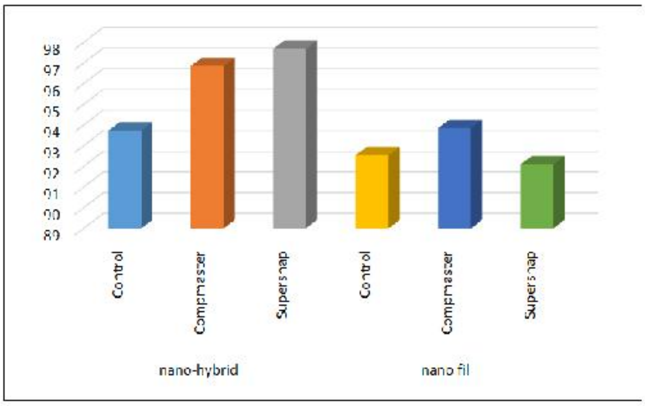
- Supersnap Xtreme polishing discs were used dry at a low speed of 10,000 rpm – 12,000 rpm with light intermittent strokes (0.3N-0.6N) as per manufacturers instruction.
- Compomaster polishing system was used dry at the recommended speed of 5000 rpm – 15,000 rpm and a pressure of 0.5 N as per manufacturers’ instruction.
- The handpiece was used with a constantly moving planar motion with repetitive stroking action to prevent heat build-up and formation of grooves. There was a conscious effort to standardize the stroke, downward force, and polishing time for all the instruments used.

Care was taken to ensure that during each stage of finishing and polishing, the operator proceeded in one direction only. Then after the use of the next abrasive in the sequence, the polishing was continued in a direction perpendicular to the previous one. The process ensured that scratches became more visible and the effectiveness of the scratch removal could be assessed more rapidly (Anusavice, ?). The recommended abrasives were used in the proper sequence and intermediate steps were never skipped. All the specimens were subjected to Surface roughness measurement using a Surface Roughness Tester (Surfcom Flex, Germany) . The contact mode stylus pick-up system had a traversing distance (of the diamond stylus) of 4 mm. The radius of the 60 degree cone tracing diamond tip was 2 µm, the measuring force was 0.75mN and the drive speed was 1.5mm/sec. Further, the specimens were subjected to micro hardness measurement using a digital Vickers Micro hardness testing Machine(HWMMT – X7; Highwood) with a 100 g load and dwell time of 10 seconds.

RESULTS

The nanohybrid group had an overall higher average surface roughness value compared to the nano fill group .In both the groups the least surface roughness was exhibited by Super Snap Xtreme (0.2571 for nanohybrid and 0.2099 for the nanofill). The nanohybrid group had an overall higher average microhardness compared to the nano fill group. In the nanohybrid group, control showed the least average microhardness (93.73) and Super Snap Xtreme showed the highest average microhardness values(97.68). Whereas in the nanofill group highest microhardness was seen with the Compomaster polishing system(93.85).- The Super Snap Xtreme group showed statistically significant values with respect to both surface roughness and microhardness parameters. The Pearson's Correlation Coefficient test implies that for the nanohybrid group there is a negative relationship between surface roughness and microhardness and the difference was statistically significant.





DISCUSSION

In modern dentistry the most preferred nanomaterials are nanocomposites. Dental resin-based nanocomposites can be divided into two main groups: nanohybrids and nanofilled composites. Composites containing a high concentration of only nanosized fillers have also been introduced and are called "nanofills." These nanofill composites were developed to be used in all areas of the mouth with a high initial polish and superior polish retention (typical of microfills), as well as having excellent mechanical properties suitable for high stress-bearing restorations (typical of a hybrid). Annuls consist of particles of nearly uniform size, all in nanometric dimensions, with the ability to create nanoclusters as secondarily formed fillers. Nanohybrids consists of particles of various sizes including particles in the micrometric and nanometric ranges (Celik, 2009). Therefore, the finish and polish attainable on dental resin composites is to some extent a function of their composition, with some materials demonstrating a preference for certain polishing methods.

For a finishing and polishing system to be effective, the abrasive particles must be relatively harder than the fillers of the resin material. Otherwise, the polishing instrument will remove only the resin matrix and leave the filler particles protruding from the surface (Yazici, 2010). Finishing is the process that involves removing marginal irregularities, defining anatomic contours, and smoothing away surface roughness of a restoration. Margination is the specific step of the finishing process that involves the removal of excess restorative material at the junction of the tooth structure and the restorative material, and the application of various finishing techniques to establish a smooth, uniform, and well-adapted cavosurface margin. Polishing is the process of removing minute scratches from the surface of a restoration and obtain a smooth, light-reflective lustre. The polishing process is also intended to produce a homogeneous surface with minimal microscopic scratches and deflect (Jefferies, 2007).

The effectiveness of any finishing or polishing device, and the resultant surface roughness of the restoration, is determined by a number of factors

- Structure and mechanical properties of the substrate being finished and polished.
- Difference in the hardness between the abrasive device and the substrate
- Particle hardness, grit size, and shape of abrasive used in the device
- Physical properties of the backing or bonding material used to carry the abrasive material or substance (egg. rigidity, elasticity, flexibility, thickness, softness, porosity)
- Speed and pressure, application method at which the abrasive is applied to the substrate. Orientation of abrading surfaces and geometry (discs, cups, cones) of abrasive instruments.

The Shofu polishing system, Compomaster, widely used in Japan, has 6-µm Diamond abrasive particles are dispersed and held in softer, elastomeric or rubberlike rotary devices. Super Snap Xtreme is an aluminium coated abrasive discs and strips are made by bonding abrasive particles onto a thin polymer or plastic backing. They are used in a sequence of grits, starting with a coarser grit disc and finishing with a superfine grit. Super Snap Extreme is a recent next generation enhancement to the original green and red Super-Snap disks of the Super Snap Rainbow kit. Since it is a relatively new product there are no studies that have evaluated its efficiency hence this polishing system was subjected to evaluation n the present study (Shofu Company Brochure). Manufacturers claim , that , the main feature of Super Snap Extreme is a 3D X-Tra coating(originally developed for the semiconductor industry) on red superfine disk – semi spherical shaped grits covering surface – allows space for ground debris discharge and reduce generated heat without any denaturing of the material. The New 3D coating maintains a smoother polishing surface, reduces clogging and secondary scratches (Shofu Company Brochure). Several studies have reported that the resin rich layer on top may have poor physical, mechanical, and biological properties(Hanadi, 2010 and Vipul Sapra, 2013). Hence, In this study All the specimens were subjected to a baseline finish using 1200 grit sandpaper for 30 seconds, under running water. Previous studies have also pre treated the resin surface in a similar manner in order to produce standard and stable surface without undulations. Overall, the nanohybrid group had a higher surface roughness value than the nano fill group It has been suggested that filler size and load have the potential to influence the surface characteristics of a resin composite. Filler particles should be situated as close as possible in order to protect the resin matrix from abrasives by decreasing the size and increasing the volume fraction of fillers. Harder filler particles are left protruding from the surface during polishing as the softer resin matrix is preferentially removed. Resin composites with larger filler particles, leaving the surface rough due to pluck out of filler particles after wearing out of resin matrix during polishing, are expected to have higher Ra values after polishing. Nanofill composites are a combination of nanosized particles and the nanocluster. During abrasion, the primary particles (nanomer sized), and not the clusters themselves, can be worn away, rather than be plucked out; thus, resulting in a smoother finish (Raja Rajeswari Kaminedi, 2014 and Fatma aytac, 2016). This result is in accordance with two other similar studies authored by Rai and Gupta *et al* and Kaminadi *et al* in which the nanofill when compared to the nanohybrid after polishing showed lesser surface roughness values. Most investigators agree that flexible aluminium oxide discs are the best instruments for providing low roughness on composite surfaces (Berastegui & others, 1992; Toledano, De La Torre & Osório, 1994; Lu, Roeder & Powers, 2003). Van Dijken and Ruyter (1987) showed that the capability of aluminium oxide discs to produce a smooth surface was related to their ability to cut the filler particle and matrix equally. The nanohybrid group had a higher microhardness than the nano fill group .This could be because the nanohybrid resin, has a higher filler loading of 82% by weight (68% by volume) as compared with the nanofill resin which has an Inorganic filler loading is 78.5% by weight (63.3% by volume).

When comparing the polishing systems as well; for the nanohybrid group – the control showed the least microhardness and Super Snap Extreme showed the highest microhardness values. The justification for this could be attributed to the fact that a negative correlation between the two parameters surface roughness and microhardness was obtained for the nanohybrid in this study. The Super Snap Extreme group showed statistically significant values with respect to both surface roughness and microhardness parameters. The Nano fill group polished with Super Snap Extreme showed the least surface roughness while the highest microhardness values were seen with the nanohybrid Super snap Extreme group. The aluminium oxide discs performed better because the fillers in composite are so small that their stiffness is reduced and so their malleability promotes a homogeneous abrasion of the fillers and the resin matrix. Some of the limitations of this study would include the use of a 3D laser profilometer, Atomic Force Microscope or Scanning Electron Microscope for the profilometric analysis. Thermocycling of the specimens could have been done to imitate the effects of long-term oral cavity exposure .Some studies have used a pressure device to standardize the pressure of polishing. Another recent study has shown that when comparing microhardness levels after first round of curing, finishing and then recurring the composite ; the Recurred dental composite group might lead to re-establishing a stronger layer of composite, which will remain since no further finishing is necessary (Ihab, 201).

Conclusion

Within the limitations of this in- vitro study, the following conclusions were drawn:

- Between the nanohybrid and nanofill composite resin— the nanofill Z350 XT showed least roughness values overall in comparison.
- For both nanohybrid and nanofill composites resins, the multistep polishing system-aluminium oxide discs (Supersnap Xtreme Shofu Inc.) provided significantly lower surface roughness.
- Nanohybrid composite specimens had a higher microhardness value when compared with nanofill specimens and in intragroup comparison the diamond impregnated polishing kit brought about higher microhardness values for the nanofill group whereas for the nanohybrid, supersnap xtreme produced a surface with higher microhardness.

Legends

- Composition of materials used
- Graph representing average surface roughness values obtained in Ra units
- Graph representing average microhardness values obtained in VHN units

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