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Research Article

AN IN VITRO STUDY TO EVALUATE THE INFLUENCE OF IMMEDIATE AND DELAYED FINISHING AND POLISHING PROCEDURES WITH TWO POLISHING SYSTEMS ON THE SURFACE ROUGHNESS AND MICROHARDNESS OF COMPOSITE RESINS

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A B S T R A C T

Aim: The aim of this article is to evaluate the influence of immediate and delayed finishing and polishing procedures with two different types of polishing systems on the surface roughness and microhardness of composite resin.
Materials and methods: A total of 60 samples of nanocomposite (Filtek Z350) were prepared and divided into three equal groups (n=20). The control group (Group A; n = 20) received no finishing and polishing treatment. Finishing and polishing of remaining samples were done immediately and after 24 hours by Astropol (Group B; n=20) and Super Snap (Group C; n=20) polishing system. After the polishing procedures, average surface roughness (Ra) was assessed with a surface profilometer. The microhardness was determined using a Vickers hardness test. The data were obtained and statistically analysed.
Results: The smoothest surfaces were noticed with the control group. The Super-Snap polishing system showed statistically significant less surface roughness compared with Astropol. The microhardness did not show any significant variations after immediate finishing and polishing with the two systems but delayed polishing showed significantly better results than immediate polishing, control groups have shown lowest surface roughness and microhardness values.
Conclusion: It can be concluded that the use of Super-Snap polishing system resulted in smoother surface with nanocomposite material studied compared with Astropol.
The delayed finishing and polishing procedure obtained better surface microhardness values.
Clinical significance: Immediate and delayed finishing procedure can affect the physical properties and performance of resin composites.

INTRODUCTION

With the increasing demand of aesthetic restorations, the final aesthetic appearance for any composite restoration depends on the artistic ability of the clinician, the contouring and shaping as well as the finishing and polishing of the restoration. The finishing and polishing procedures employed for the tooth-coloured dental restorative materials, creates the proper anatomy and occlusal morphology of the restoration, a tight tooth-composite interface, polishing eliminates scratches, reduces surface roughness, establishes optimal aesthetics, acceptable oral health of soft tissues and marginal integrity of the restorative periodontal interface [(1)], improves its longevity and aesthetic appearance of the material[(2)]. Composite restoration should be highly polished as poorly finished and polished restoration can initiate biofilm adherence on its surface and the adjoining areas of the oral cavity [(3,4)].

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Different polishing kits are commercially available like carbide and diamond burs, abrasive discs, abrasive strips, abrasive-impregnated rubber cups and points & finishing and polishing pastes. Chairside polishing of the composite restoration is important for an aesthetic appearance and a smooth well-polished surface with less biofilm formation. The time elapsed before finishing and polishing process is responsible for affecting the physical properties, and might increase the possibility of early failure when the restoration is polished before adequate polymerization is achieved[(5)]

Hence, this study is aimed to compare and evaluate the surface roughness and microhardness of composite resin after finishing and polishing them immediately and after 24 hours of curing.

The objective of the current research was:

- To evaluate whether there is any difference in the surface roughness on composite resin surface after polishing them immediately and after 24hours of curing.

- To evaluate whether there is any difference in the surface roughness on composite resin surface after polishing them with two different polishing systems.
- To evaluate whether there is any difference in the microhardness of composite resin surface after polishing them immediately and after 24hours of curing.

Null Hypothesis-of the current research was that surface roughness and micro hardness of nanocomposite will not be influenced by immediate or delayed finishing and polishing procedure.

MATERIALS

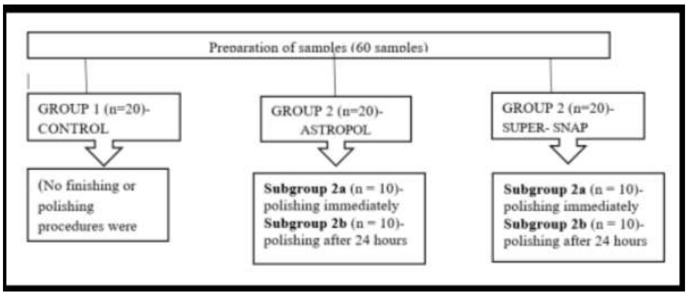
Product	Type	Composition
Filtek™ Z350 XT (3M ESPE, St. Paul, MN, USA)	Nanofilled composite	Matrix: Bis-GMA, UDMA, Bis-EMA, TEGDMA Filler: zirconia/silica Nanofillers of silicon (5–75 nm), Zircon/silicon nanoclusters (0.6–1.4 µm) nanofiller 78.5% wt, 59.5% vol
ASTROPOL(IVOCLAR VIVADENT)	Polishing system	Astropol HP (gray 45 µm), Astropol P (green 1 µm), and Astropol F (pink 0.3 µm) discs.
SUPER- SNAP(Shofu Inc., Kyoto, Japan)	Polishing system	Four sandpaper discs coarse: 80 µm; medium: 29 µm; fine: 14 µm; and superfine: 5 µm

METHODOLOGY

Sample preparation

A cylindrical shaped Teflon mould of dimensions 5mm×4mm was custom made for preparing the composite blocks. The mould was filled with the nanofilled composites (Filtek Z350 XT, 3M/ESPE, Salt Lake City, UT, USA) and cured by placing over a Mylar strip for 40 seconds in a curing unit device EliparTM Deep Cure-S LED curing light (3MTM ESPETM, St. Paul, MN, USA) with a light intensity of 900 mW/cm2 for 40 secs. Composite resin blocks (n=60) were then randomly divided into 3 groups according to the polishing systems used. For delayed polishing, samples were stored in artificial saliva for 24hours at temperature of 21 ± 2°C.

Polishing treatment



For Group 2 and Group 3, samples were polished in sequence for 30 seconds each in a single direction under constant cooling with a water jet. For both the polishing systems at each disc exchange, the composite surface was washed and air dried for 5 seconds. A new polishing disc was used after every fifth sample. The same specimens were used sequentially for measurements of surface roughness and microhardness

- **Surface roughness measurement**- A profilometer (Mitutoyo SJ-301 Surftest, Aurora, IL, USA) calibrated with a standard of known roughness .02 µm was used. The arithmetic mean of the absolute distance of the roughness profile (Ra, µm) was recorded within a measuring length of 4mm and with a cut off of 0.8mm. Four readings were taken for each specimen, one parallel, one perpendicular, and two diagonals in relation to the direction of the finishing/polishing instrument application. The mean of the four readings was obtained to represent each specimen.
- **Micro Hardness Testing**- Micro hardness of every specimen was determined using a micro-hardness tester (Micro-vickers hardness tester, Wolpert group, China) equipped with a diamond Vickers indenter. The indentation load was 0.1 N and the dwell time was 10s. Three indentations spaced equally over circle were made on the surface of each specimen.

Statistical Analysis

The obtained values for the surface roughness and microhardness were statistically analysed. The Ra values and the surface hardness were compared between the control and the two polishing systems using analysis of variance at a 95% confidence interval. Data were entered and analysed in statistical package of social sciences (SPSS) version 16.Descriptive measures were expressed in term of means and standard deviations for surface roughness and surface micro-hardness. Two-way ANOVA followed by Tukey test was run to test surface roughness and surface micro-hardness among different group.

RESULTS

Two-way ANOVA found a significant effect of finishing/polishing system on surface roughness ($p < 0.05$) no significant effect of the application time ($p = 0.2$). The control group produced significantly less surface roughness than the other types of polishing. Two-way ANOVA showed a significant effect of finishing/polishing system on microhardness ($p < 0.01$). There was significant effect of the application time ($p = 0.500$)

Table 1 Comparison of roughness (Ra, µm) means (± standard deviation) for the finishing and polishing systems studied according to application time

Immediate	Mean	Standard Deviation
CONTROL	0.036	0.004
ASTROPOL	0.261	0.05
SUPERSNAP	0.103	0.01

Delayed	Mean	Standard Deviation
CONTROL	0.02	0.003
ASTROPOL	0.042	0.005
SUPESNAP	0.029	0.001

Table 2 Comparison of microhardness means (± standard deviation) for the finishing and polishing systems studied according to application time.

	Immediate		Delayed	
	Mean	Standard Deviation	Mean	Standard Deviation
CONTROL	79.20	1.13	80.1	1.0
ASTROPOL	81.1	2.1	85.3	2.1
SUPESNAP	83.0	1.5	88.4	3.5

DISCUSSION

The finishing and polishing techniques employed for the tooth-coloured dental restorative materials improves its longevity and aesthetic appearance of the material[(2)]. Extrinsic factors are associated with the type of polishing system used, such as the flexibility of the material in which the abrasives are incorporated, the hardness of the abrasives, and the sequence they are used [6,7,8]. Surface roughness is one element that makes resin based composite materials susceptible to bacterial attachment and biofilm formation [9]. Previous studies have proposed that a surface roughness value of 200 nm is the upper limit for bacterial retention [10]

During the finishing and polishing procedure abrasion of resin matrix and filler particles can be accompanied:

1. by the softening of resin matrix due to the production of highly localized heat[11];
2. by the creation of residual defects and surface flaws caused by dislodgement or debonding of the glass fillers and [11,12]
3. by scratch lines left by abrasives of greater size[12].

These surface irregularities especially voids, cracks and pits are of critical clinical relevance as it has been reported to create protected sites for bacteria[13]. So, the smoothest surface finish is mandatory.

The dental composite resins are composed with both hard filler particles and softer resin matrix makes polishing procedure complicated due to the removal of softer resin rather than glass filler, thus increases the surface roughness[14]. For effective polishing a resin composite, an abrasive should remove the softer resin matrix as well as cut the relatively harder filler particles. Sen *et. al* stated, the polishing of methacrylate resin matrix produced the smoothest surface than the bisacryl resin matrix due to the presence of a homogenous composition[15]. Nanocomposites like Filtek Z350 XT have better handling properties, homogenous filler structure with increased filler load (82 wt%) with particle size (40-300nm).

Studies stated that curing composites against a Mylar polyester strip produced the smoothest surface and the surface had a high glossy finish[16,17]. This surface is rich in unpolymerized resin matrix alone and when exposed to oral environment may undergo degradation exposing the filler particles. This increases the rate of plaque accumulation and degradation of the restoration. Therefore, finishing and polishing of the surface of a resin composite restoration is critical in the clinical success. In many studies, a resin composite, polymerized against a Mylar strip, was used as a control [18]. Although Mylar strip provides the smoothest surface, in clinical settings, restorations routinely require final treatment for contouring, occlusal adjustment, and the removal of excess material. Due to its high resin content, the layer cured in contact with the strip is more susceptible to wear, and should be removed[18]. Stoddard and Johnson suggested that the material itself, filler size, content, type of abrasive used, number of strokes, amount of pressure applied, time spent on each abrasion, direction of the abrading surfaces, and geometry of the abrasive instruments impact the effectiveness of finishing and polishing systems[19].

Astropol is a silicon-based abrasive polisher point and Super Snap polishing system is composed of aluminium oxide particles, which abrade the resin matrix and filler particles simultaneously during polishing. Hence in the present study, surface roughness and microhardness on the composite dics after immediate and delayed polishing was assessed. In this study the results showed that the Group 3 (Super-Snap) produced smoother surface than the Group 2 (Astropol) with statistical significance ($p < 0.05$), similar to a study by Irie M, Suzuki K[20].

Increased smoothness of Super-Snap polished surface due to the fact that the abrasive particle size in ultrafine disc is of 8μm which is unable to displace filler particles in composites, thereby providing a homogenous abrasion of the fillers and resin matrix. Astropol HP contain diamond particles in its composition, diamond is harder than aluminum, causing deeper grooves on the surface of the composite, which results in more roughness [21]. Many studies reported that aluminium oxide discs gave smoother finish than diamond and silicon carbide polishing systems [22,23,24]. Moreover, delayed polishing showed lower surface roughness values because immediate polishing leads to removal of excess softer organic matrix leaving the harder filler particles on the surface before complete polymerisation could take place.

The hardness of the composite materials depends on the amount of filler, composition, resin type, and the depth of polymerization. The overall hardness of the material is influenced by the monomers that do not participate in the curing process, which lower the hardness. The increased amount of inorganic filler also contributes to the hardness of the composite[25,26].

In the present study, the control group (Mylar strip) showed lower microhardness values due the presence of excess organic matrix on the surface. Researchers concluded that micro hardness values for the composites finished with mylar strip were lower than those of properly polished surfaces [25,27,28]. In the present study, delayed finishing/polishing significantly increased the micro hardness of the composite irrespective of the polishing systems used. The results are also corroborated by another investigation where Yap *et al* concluded that polishing can give a more permanent deformation resistant surface but if polishing is performed without any delay after polymerization, due to partial maturation, composites are more prone to the effects of heat generation, in that way reducing their micro hardness[29]. Delayed polishing is also supported by Lopes et al where they suggested a delay of 24 hours after polymerization for the initiation of polishing of composite resulted in a surface of similar or even harder than that obtained with immediate finishing/polishing[30]. Venturini *et al* reported that immediate polishing did not produce a negative influence on the surface roughness, hardness and microleakage of a microfilled (Filtek A110) and a hybrid (Filtek Z250) resin composite compared to delayed polishing[31]. Polymerization of composite would not be complete prior to 24 hours and, water sorption would still be occurring, which could result in hygroscopic expansion of composites and reduction in surface properties. Excessive water absorption can decrease the life of a composite resin by plasticizing and expanding the resin component resulting in microcracks formation.

CONCLUSIONS

Within the limitations of this in vitro study:

- Surface roughness was least for control group-Mylar strip.
- The surface roughness owing to delayed finishing and polishing for both polishing systems had significant difference.

- Micro hardness of composite was lowest in Mylar matrix group. Immediate polishing procedure showed lower microhardness values as compared to polishing that was delayed for 24hours for both polishing groups.

Thus, delayed finishing and polishing should be done to increase the longevity of the composite restorations. Additional in vivo and in vitro studies are desirable to stimulate the clinical conditions and further substantiate the findings of this study.

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