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Surface Microhardness of Bulk-Fill Resin Composites Handled With Gloves

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Aim: It has been reported that resin composites may experience alterations in their mechanical properties when they come into contact with glove powder. Therefore, the present study aimed to compare the surface microhardness of 3 bulk-fill resin composites handled with latex and nitrile gloves prior to light curing.

Methods: This in vitro experimental study consisted of 90 resin composite specimens with a 6-mm diameter and a 4-mm height divided equally and randomly into 9 groups. Prior to light curing, the resin composites were handled with latex gloves, nitrile gloves, or only a spatula (control). Subsequently, the surface microhardness was measured with an Electronic Vickers Hardness Tester. The Kruskal–Wallis nonparametric H test with Bonferroni correction was used for comparisons. A significance level of 5% ($P < .05$) was considered.

Results: When comparing surface microhardness of each resin composite according to type of handling received, significant differences were observed in Filtek One Bulk Fill ($P < .001$) and Opus Bulk Fill ($P < .001$). In addition, these resin composites presented significantly higher surface microhardness than Tetric N-Ceram Bulk Fill resin ($P < .05$) when handled with latex gloves, nitrile gloves, and only a spatula. Finally, Filtek Bulk Fill resin presented significantly higher surface microhardness compared to Opus Bulk Fill resin when handled with nitrile gloves ($P = .038$) and a spatula only ($P = .033$).

Conclusions: The surface microhardness of Filtek One Bulk Fill and Opus Bulk Fill resin composites decreased significantly when handled with latex or nitrile gloves, showing no variation in Tetric N-Ceram Bulk Fill resin composite. In addition, Filtek One Bulk Fill resin composite showed significantly higher surface microhardness than Opus Bulk Fill and Tetric N-Ceram Bulk Fill resin composites when handled with nitrile gloves. It is recommended that bulk-fill resin composites be handled with a spatula, because the use of latex or nitrile gloves could adversely affect their clinical performance.

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Introduction

Over time, resin composites have achieved a very important role compared to amalgams, becoming the most widely used restoration material in recent times due to their aesthetic characteristics[1-3] as well as their physical, chemical, and mechanical properties being similar to tooth structure.[3,4] In addition to having good resistance and quality for dental treatments, these resin composites are characterised by their colour in different shades. Therefore, they play an important role in the reconstruction of teeth, being aesthetically acceptable with good adhesion capacity through adhesive mechanisms.[5,6] However, in spite of the advances in composition of these resin composites, the issue of polymer shrinkage when monomers are joined together in the light-curing process is still a challenge.[1,3,6] Because of this, a new generation of resin composites was developed with single-block placement (bulk-fill) in increments of 4 or 5 mm and with minimal shrinkage characteristics during light curing, so it is recommended for use in large posterior restorations to achieve a shorter operative time.[7,8]

Surface microhardness is one of the fundamental properties of resin composites to ensure their longevity, as it allows them to resist any damage to their surface due to compressive forces, polishing wear, or abrasive effect applied to the material.[9] Therefore, it is important to favour the preservation of this mechanical property because this would avoid microfractures in resin composite surface that in the long run would allow an adequate resistance to masticatory forces and thus avoid the retention of pigments or even the formation of secondary caries.[5,8,9]

It has been reported that handling resin composites with gloves could alter the light-curing process. When the resin composites come into contact with the cornstarch powder of the latex glove and also come into contact with the sulfides released by latex and nitrile gloves, mechanical properties may be affected.[10-12] The literature indicates that sulfides alter the surface microhardness of resin composites, contributing to the failure of restoration techniques in a short period of time.[10] In order to avoid such possible alterations in the mechanical properties of the resin composites, gloves without cornstarch powder, such as nitrile gloves, began to be manufactured.[13-16] Nitriles are synthetic polymers formed by a combination of monomers such as acrylonitrile, butadiene, carboxylic acid, and aluminum sulfate (sulfur) as a chemical product, which is also used in the manufacture of latex gloves.[17,18] Each monomer contributes a unique and important property. Acrylonitrile provides stiffness and resistance to penetration by solvents and chemicals such as oils and greases. Butadiene provides softness and flexibility and contributes to the elasticity of the glove. Finally, carboxylic acid contributes to the glove's tensile strength and tear resistance.[17-19]

To date, there is little evidence of studies comparing the surface microhardness properties of bulk fill–type resin composites when contaminated with different types of latex and nitrile gloves vs a control group with a spatula. The vast majority of studies assess adhesive strength using only latex gloves with or without powder or other substances as contaminants without contrasting these results with other glove types.[10,11,13,14,18]

Therefore, the present study aimed to compare the surface microhardness of 3 bulk-fill resin composites handled with latex and nitrile gloves prior to light curing. It was considered as a null hypothesis that there are no significant differences when comparing the surface microhardness of 3 block-fill resin composites handled with latex and nitrile gloves prior to light curing.

Materials and methods

Study design

The present study had an in vitro and cross-sectional experimental design. It was conducted at the School of Stomatology of the Universidad Privada San Juan Bautista and at the High Technology Laboratory Certificate (ISO/IEC Standard: 17025), Peru, in the months of February to April 2022. This study was exempted from review by an institutional ethics committee; however, it was issued approval letter No. 254-2022-CIEI-UPSJB. This study considered the CRIS Guidelines (Checklist for Reporting In-vitro Studies).[20]

Sample size and selection

Ninety bulk fill–type resin composite specimens were standardised and manufactured to be equally distributed in 3 groups (A, B, and C). Each group was subdivided into 3 subgroups and the resin composite specimens were randomly selected to receive different types of handling (**Figure**). The sample size for each subgroup was 10 resin composite specimens (n = 10) and was calculated based on analysis of variance with G*Power statistical software version 3.1.9.7 based on data obtained in a previous pilot study with 5 sample units for each type of resin composite, considering a significance level (α) of 0.05 and a statistical power (1-β) of 0.80, with an effect size equal to 1.018.

Sample characteristics and preparation

Specimens of 3 types of nanohybrid resin composites (A, B, and C) were made with standardised moulds of 6 mm diameter and 4 mm depth.[23] All resin composites used were A2 colour or equivalent.[21]

For the bulk-fill resin composite groups handled with gloves prior to light curing, the surfaces were lightly handled for 10 seconds with powdered (cornstarch) latex gloves (Cranberry Multisafe Sdn) or powder-free synthetic nitrile gloves (Kimberly-Clark Inc.). This was performed by a single operator with identical movements and in the same direction.[10,22,23] Each specimen preparation was performed with a new glove, placing the resin composite on the standardised mould and then pressing with a sterile spatula (Hu Friedy) and removing the excess.[12] The control group of each resin composite type was handled only with a sterile spatula (Hu Friedy).

To prevent the formation of the oxygen-inhibited layer, a layer of DeOx glycerin (Ultradent) with organic solvent purity of 99.1% was applied to the top surface of all bulk-fill resin composite specimens (A, B, and C).[12] The specimens were then light-cured from the top of the mould with a third-generation

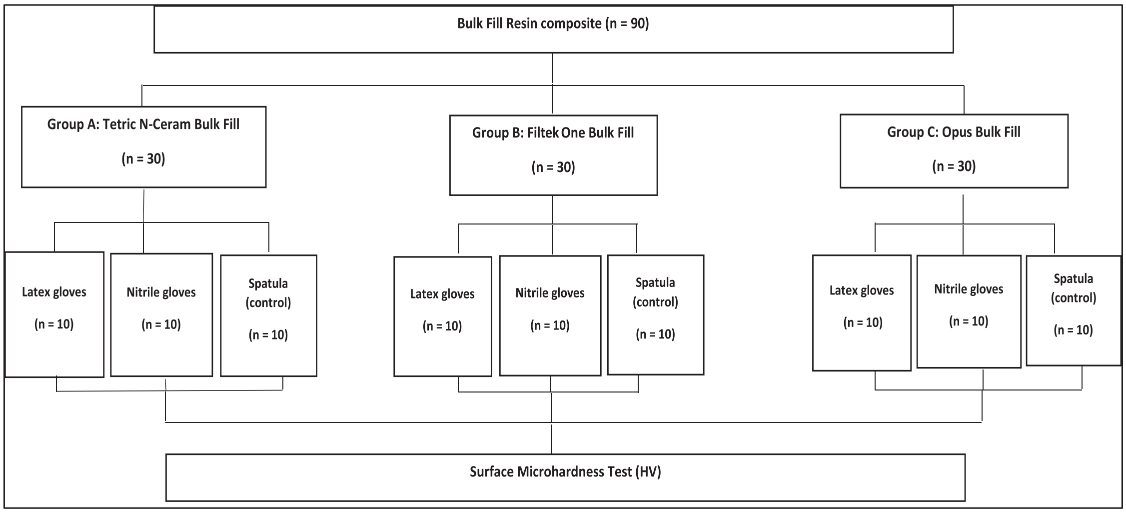

Figure – Random distribution of groups according to sample size.

LED curing lamp (Valo, Ultradent) with an intensity of 1200 mW/cm^2 for 20 seconds at an angle of 90°.[6,12,24] The light intensity was verified with a radiometer (Litex 682, Dentamerica).

Surface microhardness test

Taking into consideration ISO 4049:2019,[25] surface microhardness (HV, Vickers hardness) measurements were performed on the top of the surface with an Electronic Vickers hardness tester (HVS-1000 Jinan Liangong Testing Technology Co.),[26-28] applying a 100 g-f load for 10 seconds on the surface at different equidistant points and maintaining a minimum distance of 1 mm adjacent to the margins of the sample. The length of the diagonal of each notch was measured directly using a graduated ocular lens at 40× magnification. Surface microhardness was determined using the following equation: $H = 1854.4\ (Pd^{-2})$, where H is the Vickers hardness (kg/mm^2), P is the load (g), and d is the average length of the notch diagonals (μm).

Statistical analysis

The collected data were analysed with SPSS statistical software, version 28.0 (IBM). For descriptive analysis, measures of central tendency such as mean and median and measures of dispersion such as standard deviation and interquartile range were used. Prior to testing the hypothesis, the surface microhardness values were assessed for normal distribution with the Shapiro–Wilk test and homogeneity of variances with the Levene test. Because they did not present homogeneous variances, the nonparametric Kruskal–Wallis H test with Dunnet post hoc and Bonferroni correction was used, considering a significance level of 5% ($P < .05$).

Results

When comparing surface microhardness of each resin composite according to type of handling received, significant differences were observed in B ($P < .001$) and C ($P < .001$). Thus, multiple comparisons showed that B and C handled only with a spatula showed significantly higher surface microhardness compared to the same ones handled with latex gloves ($P < .001$ and $P < .001$, respectively) and nitrile gloves ($P = .001$ and $P = 0.008$, respectively; Table 1).

When comparing surface microhardness of resin composites according to type of handling, significant differences were observed when handled with latex gloves ($P < .001$), nitrile gloves ($P < .001$), and only with a spatula ($P < .001$). Therefore, multiple comparisons showed that B and C presented significantly higher surface microhardness than A when handled with latex gloves ($P < .001$ and $P < .018$, respectively), nitrile gloves ($P < .001$ and $P < .031$, respectively) and only with a spatula ($P < .001$ and $P < .033$, respectively). Finally, B showed significantly higher surface microhardness compared to C when handled with nitrile gloves and a spatula only ($P = .038$ and $P = .033$, respectively; Table 2).

Discussion

The results showed that when Filtek One Bulk Fill and Opus Bulk Fill resin composites were handled with latex or nitrile gloves prior to light curing, the surface microhardness of both restorative materials was significantly reduced. In contrast, prior handling with latex or nitrile gloves did not significantly affect the surface microhardness of Tetric N-Ceram Bulk Fill resin composite. Therefore, the null hypothesis was not accepted for Filtek One Bulk Fill and Opus Bulk Fill composites, but it was accepted for Tetric N-Ceram Bulk Fill. These findings are relevant in highlighting the alteration of a surface mechanical property when handling Filtek Bulk Fill and Opus Bulk Fill resins with either latex powdered or nitrile gloves. It is important for dentists in training to be aware of this effect, as they could jeopardise the longevity of resin composite–based restorations by being tempted to manipulate them briefly in order to fit them into a difficult-to-access cavity, without ruling out the possibility that such

Table 1 – Descriptive values and comparison of surface microhardness of nanohybrid resin composites according to type of handling received.

Resin composite	Handling	No.	Mean	SD	Median	IQR	Min	Max	H	P*
A	Latex	10	50.95	4.26	51.00^x	4.90	42.50	58.60	0.748	.688
	Nitrile	10	49.46	4.92	50.90^x	8.50	41.70	56.10		
	Spatula	10	51.64	1.71	51.45^x	3.38	49.70	54.60		
B	Latex	10	68.84	4.34	69.80^x	4.90	60.10	74.20	19.374	<.001
	Nitrile	10	70.00	0.92	69.85^x	1.08	68.60	71.60		
	Spatula	10	81.73	2.16	81.60^y	2.18	77.90	85.50		
C	Latex	10	62.00	3.36	62.30^x	4.30	54.70	65.90	16.584	<.001
	Nitrile	10	63.49	4.43	64.65^x	7.65	56.50	69.10		
	Spatula	10	69.14	2.03	69.40^y	3.38	66.60	73.00		

IQR, interquartile range.
A: Tetric N-Ceram Bulk Fill, B: Filtek Bulk Fill, C: Opus Bulk Fill, H: based on Kruskal–Wallis H.
x and y: Different letters in median column indicate significant differences ($P < .05$), based on Dunnet post hoc and its Bonferroni correction.
* $P < .05$ (significant difference).

manipulation could be inadvertent. Whatever the reason, it should be noted that for occupational safety reasons the manufacturers of all resin composites do not recommend handling them with or without gloves because for periods of more than 2.8 minutes the methacrylates present in the composition of these restorative materials could generate contact dermatitis.[22,29,30]

Karimzadeh et al[31] and Jager et al[32] mentioned that filler quantity in resin composites could be a factor that allows improving their surface microhardness.[2,33,34] In that sense, Rizzante et al,[33] in their study, observed that bulk fill–type nanohybrid resins achieved superior surface microhardness values compared to conventional resins with less filler.[11,12] As is known, Tetric N-Ceram Bulk Fill resin composite (76 wt%; 54 vol%) has lower inorganic filler and filler content than Filtek Bulk Fill (76.5 wt%; 58.4 vol%) and Opus Bulk Fill (76.5 wt%; 58.4 vol%) resins. This difference in filler may account for the fact that the Tetric N-Ceram resin composite had significantly lower surface microhardness values than the other 2 resin composites when all were handled with a spatula, powdered latex gloves, or nitrile gloves.[8,9,35,36] However, Corral et al[1] mentioned that other factors may be related to changes in surface microhardness of resin composites, stating that there is a close relationship between the filler proportion and polymerisation shrinkage, being that the resin composites with less filler are the ones that experience a higher degree of polymerisation shrinkage. On the other hand, the degree of conversion is another factor to consider,[37] since bulk fill–type resin composites present different monomers and/or modifications in their composition, according to Garrofé et al.[9]

Table 2 – Intergroup surface microhardness comparison of nanohybrid resin composites according to type of handling received.

Handling	Resin composite	n	Median	IQR	H	P
Latex	A	10	51.00^x	4.90	22.519	<.001
	B	10	69.80^y	4.90		
	C	10	62.30^y	4.30		
Nitrile	A	10	50.90^x	8.50	25.557	<.001
	B	10	69.85^y	1.08		
	C	10	64.65^z	7.65		
Spatula (control)	A	10	51.45^x	3.38	25.824	<.001
	B	10	81.60^y	2.18		
	C	10	69.40^z	3.38		

IQR, interquartile range.
A: Tetric N-Ceram Bulk Fill, B: Filtek Bulk Fill, C: Opus Bulk Fill; H: based on Kruskal–Wallis H.
x, y, and z: different letters in median column indicate significant differences ($P < .05$), based on Dunnet post hoc and its Bonferroni correction.
*$P < .05$ (significant differences).

One of the most frequent problems in restorative procedures is direct and unintentional contamination of resin composite surface in contact with glove cornstarch powder, saliva, blood, or other sources.[11,12,14,38,39] Martins et al[14] and Widiandini et al[16] reported that gloves jeopardise adhesion and mechanical properties of resin composites because they produce porosity on the surface of these restorative materials.[12,14,40] Ñaupari-Villasante et al[10] reported that the use of latex gloves influenced the physical properties of resin composites because it is known that sulfide present in latex can inhibit the polymerisation of other chemical compounds, such as impression silicones that contain chloroplatinic acid.[18,41] This argument is in agreement with Kimoto et al,[38] who reported that residual sulfide or sulfide chloride elements from latex gloves are transferred to other materials after a contact period of 5 seconds. This could explain the significant drop in the surface microhardness of Filtek One Bulk Fill and Opus Bulk Fill resin when handled with powdered latex gloves for 10 seconds. On the other hand, in the case of the Tetric N-Ceram Bulk Fill resin composite, no significant drop in surface microhardness could be evidenced when handled with the latex glove, possibly due to the influence of chemical components in this resin composite that are still largely unknown because they are trade secrets.[28] In addition, Sanders et al[13] reported that the polymerisation reaction of resin composites occurs by free radicals, as the photoinitiator dicetone-amine system (camphorquinone plus tertiary amines) and exposure to blue light initiate the reaction of a free radical with the organic matrix (bisphenol A-glycidyl methacrylate),[42,43] so both photochemical reactions could be sensitive to contamination by latex gloves.[11] However, more studies are still needed to determine whether there is any specific chemical reaction between latex gloves and resin composite.

Ñaupari-Villasante et al[10] reported that the conversion degree of resin composites is affected when light does not directly hit them, and the presence of powder could be a contaminating factor that would interfere in the activation of photoinitiators. This could be explained by the fact that cornstarch powder present in latex gloves would form a physical barrier for the passage of light, even more so in massive fill resin composites such as Bulk Fill, because they need light to penetrate deeper and any foreign element on their surface would limit this penetration, causing defective photoactivation and reducing their physical properties. This is consistent with results obtained in the present study for Filtek Bulk Fill and Opus Bulk Fill because cornstarch powder particles, being larger (2.5 to 10 μm) than filler particles in these resin composites (4 to 20 nm),[39] may have interfered with the light-curing process and consequently affected the surface microhardness.[44] However, it should be noted that the Opus Bulk Fill resin composite was less affected than the Filtek One Bulk Fill resin composite when both were handled with powder gloves. This is probably due to the fact that the Opus Bulk Fill resin composite has a new advanced polymerisation system technology patented by FGM, which consists of a combination of different photoinitiators that interact with each other and amplify the polymerisation capacity, increasing the degree of conversion and depth of cure, which suggests that this could improve the surface mechanical properties of this restorative material.[45] On the other hand, it has been reported that powder particles from latex gloves cross-link with epichlorohydrin containing no more than 2% magnesium oxide as a dispersing agent. This epichlorohydrin, which makes the cornstarch powder absorbable, is also used as a solvent for natural and synthetic resins.[11,12] Therefore, the presence of residual epichlorohydrin in latex gloves could possibly explain the decrease in adequate polymerisation on the resin composite surface and thus affect the surface microhardness.[12]

Currently, there is little evidence to explain whether handling resin composites with nitrile gloves affects the surface microhardness property, so more research is needed to test this hypothesis. However, we can suppose that nitrile gloves, due to the similarity of some of their components with latex gloves components such as sulfur, could diminish and affect the polymerisation of some dental materials such as silicones or resin composites.[11,18,46] In addition, taking into consideration the findings obtained in the present study, it was observed that the Filtek Bulk Fill resin composite was significantly superior to the Opus Bulk Fill resin composite, and this in turn was significantly superior to the Tetric N-Ceram Bulk Fill resin composite when they were all handled with a spatula or nitrile gloves. It should also be noted that all the surface microhardness values decreased significantly in the case of Filtek Bulk Fill and Opus Bulk Fill resin composites, whilst in the case of Tetric N-Ceram Bulk Fill resin composite this decrease was not significant. This allows us to assume that handling with nitrile gloves would allow preserving the existing surface microhardness hierarchy between these resins under normal conditions.

The decision to include latex gloves with cornstarch powder, despite the fact that the US Food and Drug Administration does not recommend their use,[47,48] was due to the fact that this type of glove is still marketed in some countries such as Peru. Therefore, some authors have included the effects produced by the powder of these gloves when handling composite resins.[17,47,48]

The importance of the present study lies in the fact that the voluntary or involuntary manipulation of bulk fill–type resin composites with gloves can affect the microhardness property of this restorative material, putting at risk the longevity and success of the restoration. Therefore, it is important to gain greater expertise in the use of the spatula for the manipulation of resin composites and thus avoid detrimental effects on their longevity and resistance.

The data obtained should be taken with caution because, being an in vitro study, it is not possible to extrapolate them to the clinical field. Furthermore, according to previous reports,[10,11,14,22,49] manufacturers' instructions, and results of the present study, non–light-cured resin composites should not be touched with gloves but be handled with appropriate instruments in an isolated and dry environment. Another limitation is that a qualitative and quantitative analysis of possible contaminants that could have affected the mechanical properties of bulk-fill resin composites was not performed. Therefore, more studies are needed that focus specifically on assessing the effect of the mechanical properties of bulk-fill resin composites when handled with gloves of different types and brands, while considering possible confounding variables such as finishing and polishing; intensity of light curing; curing depth; handling and light-curing times; wavelength, direction, and distance of the light-curing unit; as well as colour and increment size of this restoration material.

Conclusions

The surface microhardness of Filtek Bulk Fill and Opus Bulk Fill resin composites decreased significantly when handled with latex or nitrile gloves, while for Tetric N-Ceram Bulk Fill resin composite this decrease was not significant. In addition, Filtek Bulk Fill resin composite showed significantly higher surface microhardness vs Opus Bulk Fill and Tetric N-Ceram Bulk Fill resin composites when all were handled with nitrile gloves. It is recommended that bulk fill resin composites be handled with a spatula because the use of latex or nitrile gloves could adversely affect their clinical performance.

Conflict of interest

None disclosed.

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