The Effect of Different Fiber Concentrations on the Surface Roughness of Provisional Crown and Fixed Partial Denture Resin

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ABSTRACT

Objectives: The aim of this study was to investigate surface roughness in provisional crown acrylics, after polishing, reinforced with different concentrations of glass fibers.

Methods: A total of 48 disk-shaped specimens were prepared using autopolymerizing acrylic resin. These specimens were divided into four groups according to the level of glass fiber added: Group A (no fiber), Group B (0.5%), Group C (1%) and Group D (2%). After polishing the specimens, an average surface roughness (Ra) value was calculated using a profilometer from four randomly selected points on the surface.

Results: A significant difference was determined among the surface roughness values of provisional crown resins to which different concentrations of fiber had been added (P<.001).Tukey's test was then used to perform paired comparisons of the data between the different groups, and a significant difference was found between Group A (no fiber) and the other groups, between Group B (0.5%) and Group D (2%) and between Group C (1%) and Group D. On the other hand, there was no significant difference between Group B and Group C.

Conclusions: The reinforcement of provisional crown and fixed partial denture resin with glass fibers increases surface roughness. (Eur J Dent 2008;2:185-190)

Key words: Provisional restorations; Fiber; Roughness; Resin.

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INTRODUCTION

Provisional crown and fixed partial prosthesis today represent an important element of fixed prosthetic treatment.[1,2] These prosthesis are made with the aim of supporting the teeth for which preparation is being made, observing prognosis, and giving the patient function, phonation, aesthetic appearance and tissue compatibility until permanent restoration can be administered.[3-5]

In order for provisional restorations to be

successful, they have to be resistant to forces inside the mouth. Many fibers of various kinds have been tested in recent years in order to increase the fracture resistance of provisional crowns. While there have been many studies showing that these fibers increase the resistance of acrylics, there are none on their impact on surface roughness. The surface roughness of dental materials is the main influence on plaque formation, discoloration, abrasion and aesthetic appearance. Many bacteria are able to adhere to hard surfaces in the oral cavity.[6,7] The roughness of intra-oral hard surfaces and free energy have a significant effect on primary adhesion and oral micro-organism retention. A surface roughness of 0.3 mm can be felt by the tongue, thus having a negative impact on patient comfort.[8] In vitro studies regarding surface roughness for bacterial plaque retention have shown that an average surface roughness above 0.2 mm in fixed restorations increases the level of bacterial retention.[8-10]

The aim of this study was to investigate surface roughness in provisional crown resins, after polishing, reinforced with different concentrations of glass fibers.

MATERIALS AND METHODS

Generally used and commercially available autopolymerizing resin was used in this study for provisional crown and fixed partial restoration (Dentalon Plus, Heraeus, Kulzer GmbH, Wehrheim, Germany). The manufacturers recommended powder/liquid ratio was 2 grams of powder to 1 ml of liquid. Four different glass fiber groups in different concentrations were established, according to the powder to liquid mixture; Group A (no fiber), Group B (0.5%), Group C (1%) and Group D (2%), each group containing 12 disk specimens. A teflon mold was made in order to produce disk-shaped specimens (10 mm x 2 mm). The unprocessed glass fibers were then cut to a length of 3 mm and kept in a predetermined amount of monomer. The provisional crown acrylic was mixed in the light of the manufacturer's recommendations and added to the glass fiber mixture in predetermined quantities. The provisional resin paste added to glass fiber in desired concentrations was kneaded manually for 40 seconds and placed in the mold. This was then placed in a hydraulic press (Rucher PHI, Birmingham, UK) and pressure slowly applied in such a way as to permit excess resin to escape. Pressure of 20 psi (140 kPa) was applied for 5 minutes. Once polymerization had been completed, the specimens were removed from the mold and analyzed with regard to air bubbles and size. Defective specimens were excluded from the study, and 48 specimens were obtained.

All specimens were abraded for 10 seconds in a wet environment by means of a 300 rpm polishing device (Beuhler, Meta serv, Dusseldorf, Germany) using 600 grit sandpaper. All specimens were then polished for 15 seconds using a polishing machine with pumice mixed at a level of 2 g/2 ml. Finally, diamond polishing paste was applied using a polishing device at 15,000 rpm. All polishing was performed by a single operator.

Following the polishing process all specimens were washed in distilled water and left in an ultrasonic bath for 10 minutes. An average surface roughness value (Ra) from 4 randomly selected points on the surface was calculated using a profilometer (Mitutoyo Surf test 201, Japan). A 7.5 mm field was scanned at every measurement using the profilometer with a study gap of 250 µm. Forty-eight pieces of data (12 x 4) were obtained from each group, giving a total of 192 (Table 1). In addition to profilometric analysis, photographic images, 2 from each group, were obtained using a scanning electron microscope (SEM) at an original magnification of x400 in order to analyze post-polishing surface roughness.

The groups were compared using ANOVA for statistical analysis. Post-hoc analysis of the parameters obtained was performed using Turkey's test. $P < .001$ was regarded as significant. All analyses were performed using the statistical package for scientists (SIGMASTAT) Windows version 3.10b.

RESULTS

The averages and standard deviation values obtained as a result of the surface roughness test are shown in Table 1. The data obtained were first analyzed using ANOVA. A significant difference was determined among the surface roughness values of provisional crown resins to which different concentrations of fiber had been added ($P<.001$) (Table 1).

Tukey's test was then used to perform paired comparisons of the data between the different

groups, and a significant difference was found between Group A (no fiber) (Figure 1) and the other groups, between Group B (0.5%) and Group D (2%) and between Group C (1%) and Group D. On the other hand, there was no significant difference between Group B and Group C. In other words, no statistically significant difference was determined between the surface roughness of provisional crown resins reinforced with glass fibers at concentrations of 0.5% or 1%. In addition, compared with other groups, provisional crown resins reinforced with a 2% glass fiber concentration had a significantly greater surface roughness (Figure 2).

The SEM images obtained clearly show the glass fiber particles in the Group B, C and D provisional crown resins (Figures 3, 4 and 5). The surface roughness in Group A, with an average Ra value of 0.309, was statistically significantly different to that of the other groups. SEM images showed that provisional crown resins with no additional fiber had the lowest surface roughness, while provisional crown resins with a 2% concentration had a very different level of fiber coverage. The absence of any significant difference between Groups B and C, with 0.5% and 1% concentrations, respectively, according to measurements performed using Tukey's test, was confirmed by the SEM images.

DISCUSSION

Surface quality is an important factor affecting the state of dental restorations in the oral cavity in a number of regards. Rough surfaces collect more plaque and plaque content than smooth surfaces. Studies have shown that decreased roughness on intraoral surfaces reduces plaque formation.[9,11,12]

Various fibers have been used to strengthen the polymethylmetacrylate (PMMA) resins used in dentistry.[8,13,14] Although carbon fibers increase the abrasion, tensile and transverse strength, bending and elasticity modulus of PMMA resins, they are unpleasant in color. This makes them unpopular.[15-17] Polyethylene fibers increase PMMA resins' tensile and flexural strength and Young's modulus. In addition, they are not dark in color in the way carbon fibers are, but it may not be practical to roughen them in the dental surgery. However, glass fibers are invisible in PMMA resin. Glass fibers also have good biocompatibility, possess an appropriate capacity for bonding to the tooth structure and other resins, and are easily manipulated in the clinic or laboratory.[18,19] They have thus become very popular in recent years.

Although the effect of glass fibers on provisional crown resistance is known, the same cannot be said for their effect on surface roughness. Our study evaluated the effect of glass fibers added in different concentrations to provisional crown resins on surface roughness using polymetric analysis and SEM.

Fiber is installed in the resin in three different ways in dentistry: chopped, longitudinal and woven form.[14] Vallittu et al[20] reported that fibers installed longitudinally in the resin changed place with the pressure applied when the mold was placed in a hydraulic press and that their parallelism was impaired. Since the woven form resembles cloth, its contact with the acrylic is problematic and problems with bonding to the acrylic arise.[14,21] Since the negative features observed in the other forms are not seen in the chopped form, this was employed in our study.

The Ra values determined as a result of the surface roughness were: Group A (no fiber)

Table 1. Surface roughness results and standard deviations of the groups following polishing of provisional crown and fixed partial denture resin reinforced with different concentrations of glass fibers. ANOVA was used to compare the effect between the groups of different fiber concentrations on surface roughness; statistically significant (P < .05) differences in surface roughness are indicated by different letters. Power of performed test with alpha=0,050:1,000.

Groups	Fiber Level	n	Mean±SD	P
A	0%	48	0.309±0.141[a]	
B	0.5%	48	0.828±0.360[b]	<.001
C	1%	48	0.990±0.690[b]	
D	2%	48	1.734±0.900[c]	

0.309 Ra, Group B (0.5%) 0.2 Ra, Group C (1%) 0.990 Ra, and Group D (2%) 1.73 Ra. A significant difference was determined among the groups to which different concentrations of fiber were added (P<.001). No statistically significant difference was determined between the surface roughness values of provisional crown resins reinforced with different concentrations, 0.5% and 1%, of glass fiber in paired comparison tests.

The reinforcement of provisional crown acrylics with 1% glass fiber increases mechanical properties more than reinforcement with 0.5% glass fiber.[14,21] However, no significant difference in surface roughness in provisional crown acrylics reinforced with 0.5% and 1% concentrations of glass fiber was determined in our study. Therefore, in terms of surface roughness, we recommend the reinforcement of provisional crown acrylics with 0.5% and 1% concentrations of glass fiber.

In this study, Group A specimens to which no fiber was added exhibited smoother surfaces than specimens from Groups B, C and D to which fiber had been added, and the SEM images obtained strengthened this conclusion (Figures 6,7,8 and 9). According to an in vivo study by Quirynen et al,[22] clinically acceptable roughness values in the oral environment after hard surfaces have been polished should not exceed 0.2 µm. Wietnam and Eames[23] reported plaque accumulation on the surfaces of composite specimens with a surface roughness of 0.7-1.44 µm. This study shows that 2% glass fiber added to provisional crown resins leads to a level of surface roughness that will increase plaque accumulation (Ra=1.734). Glass fibers, which make a positive contribution to the physical characteristics of provisional crowns, have a negative effect on surface roughness and on plaque accumulation.

The SEM images obtained show glass fiber particles on the homogeneous structure of the

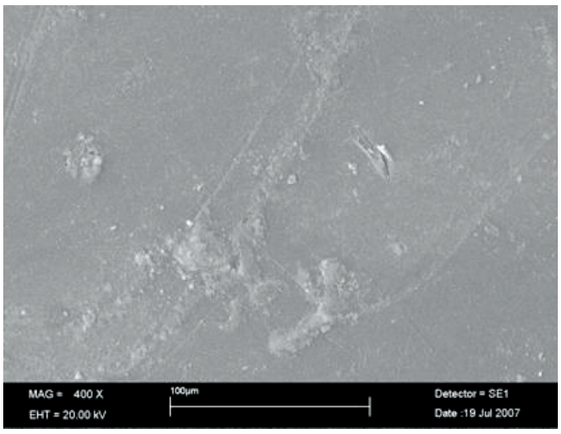

Figure 1. 0% glass fiber concentration.

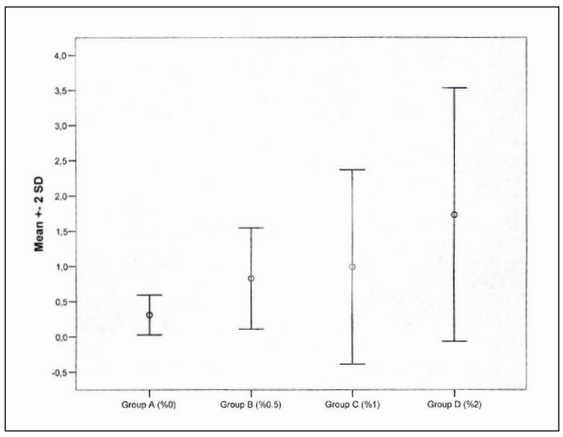

Figure 2. Mean surface roughness values for autopolymerizing resin after reinforced glass fiber with different concentrations.

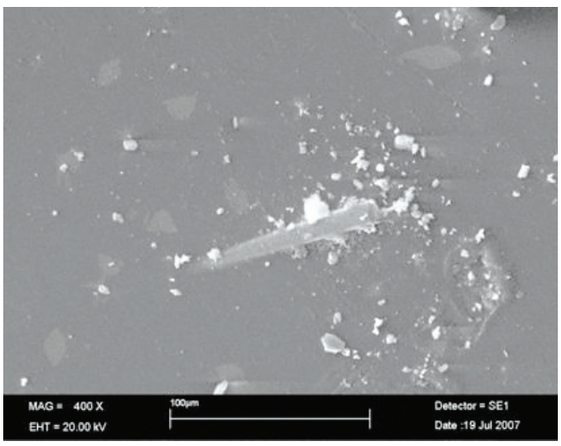

Figure 3. 0.5% glass fiber concentration.

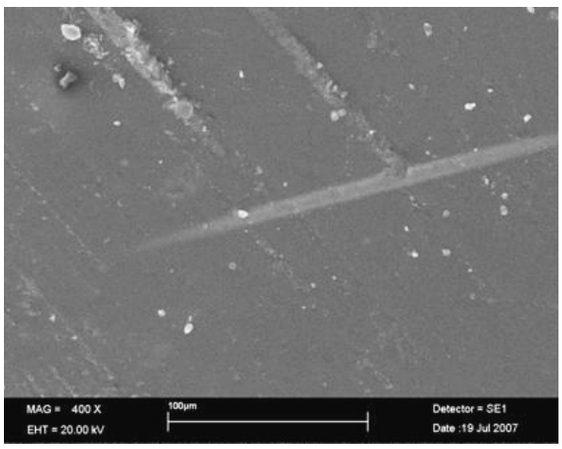

Figure 4. 1% glass fiber concentration.

provisional crown methacrylate resin acrylic material. The glass fiber concentration may affect distribution, acrylic arrangement or materials' natural chemistry surface roughness.

Borchers et al[24] reported that when long-term provisional crowns are employed the importance of preventing plaque accumulation rises and far more effective polishing systems are essential for provisional restorations.

It was determined within the parameters of this study that the reinforcement of methyl methacrylate with different concentrations of glass fiber increased surface roughness. The standardization of this study according to an in vitro protocol and its inability to ideally reflect clinical conditions are its main disadvantages. The polishing process in a clinical environment or in the laboratory is not as successful as the polishing process in this study. The first reason for this is that provisional crowns have concave and convex surfaces, for which reason polishing can never be performed on perfectly smooth surfaces as in this study. The second reason is that it is difficult to adjust the recommended speed and power of polishing materials in the surgery. In addition, effectiveness of polishing under clinical conditions is to a large extent dependent on the operator doing the polishing.

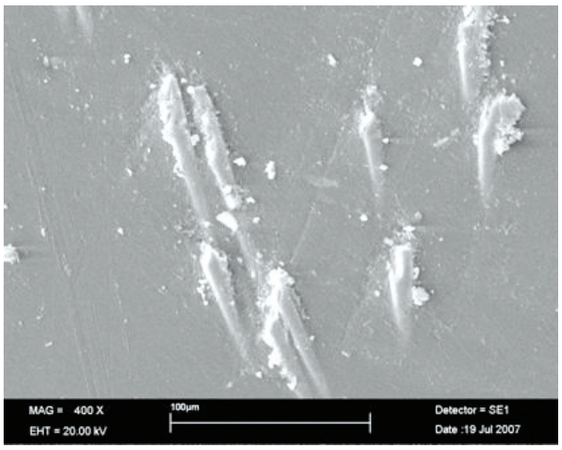

Figure 5. 2% glass fiber concentration.

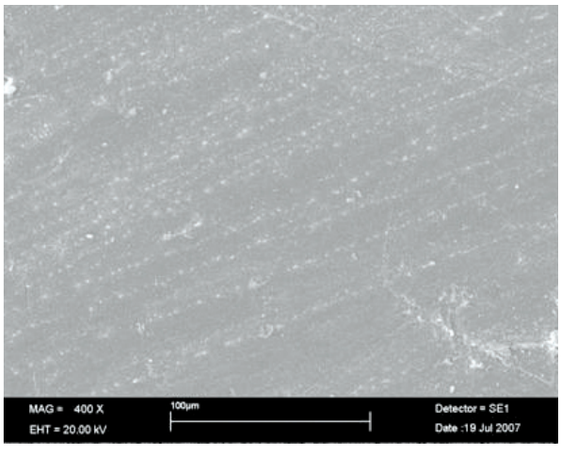

Figure 6. 0% glass fiber concentration.

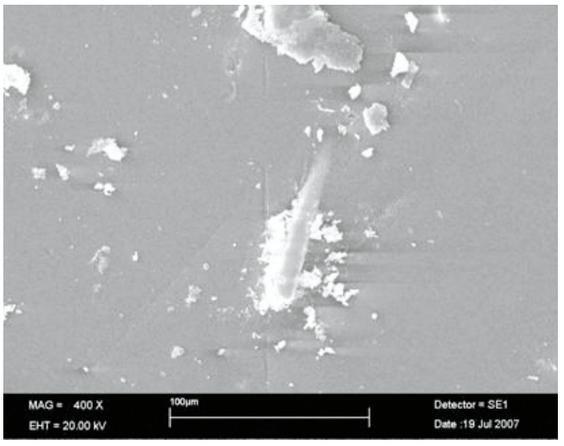

Figure 7. 0.5% glass fiber concentration.

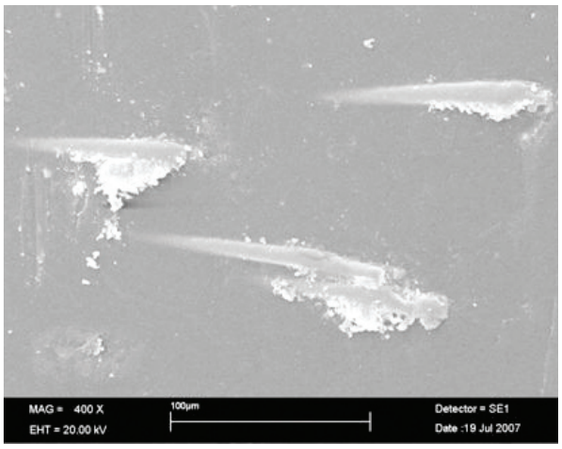

Figure 8. 1% glass fiber concentration.

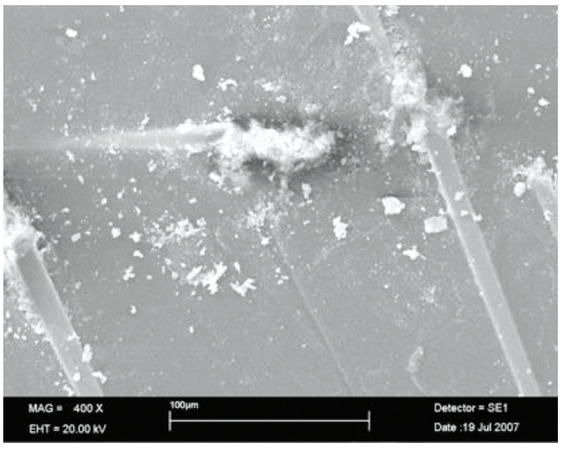

Figure 9. 2% glass fiber concentration.

CONCLUSIONS

The following conclusions emerged from within the parameters of this study:

1. The reinforcement of provisional crown and fixed partial denture resin with glass fibers increases surface roughness.

2. Paired comparisons between groups revealed no significant difference only between the average surface roughness values of provisional crown and fixed partial denture resin specimens reinforced with 0.5% and 1% concentrations of glass fiber.

REFERENCES

1. Haselton DR, Diaz-Arnold AM, Dawson DV. Effect of storage solution on surface roughness of provisional crown and fixed partial denture materials. *J Prosthodont* 2004;13:227-232.
2. Young HM, Smith, CT, Morton, D. Comparative in vitro evaluation of two provisional restorative materials. *J Prosthet Dent* 2001;85:129-132.
3. Sham AS, Chu FC, Chai J, Chow TW. Color stability of provisional prosthodontic materials. *J Prosthet Dent* 2004;91:447-452.
4. Rosenstiel S, Land MF, Fujimoto J. *Conprovisional Fixed Prosthodontics.* 3rd ed. St. Louis: MO Mosby; 2001. p. 381-416.
5. Shillingburg HT, Hobo S, Whitsett LD, Jacobi R, Brackett SE. *Fundamentals of Fixed Prosthodontics.* 3rd ed. Chichago: Quintessence Publishing; 1997. p. 225-256.
6. Sen D, Goller G, Issever H. The effect of two polishing pastes on the surface roughness of bis-acryl composite and methacrylate-based resins. *J Prosthet Dent* 2002;88:527-532.
7. Maalhagh FA, Wagner WC, Pink FE, Neme AM. Evaluation of surface finish and polish of eight provisional restorative materials using acrylic bur and abrasive disk with and without pumice. *Oper Dent* 2003;28:734–739.
8. Tacir IH, Kama JD, Zortuk M, Eskimez S. Flexural properties of glass fiber reinforced acrylic resin polymers. *Aust Dent J* 2006;51:52-56.
9. Heintze SD, Forjanic M, Rousson V. Surface roughness and gloss of dental materials as a function of force and polishing time in vitro. *Dent Mater* 2005;22:146-165.
10. Rosentritt M, Behr M, Lang R, Handel G. Flexural properties of prosthetic provisional polymers. *Eur J Prosthodont Restor Dent* 2004;12:75-79.
11. Auschill TM, Arweiler NB, Brecx M, Reich E, Sculean A, Netuschil L. The effect of dental restorative materials on dental biofilm. *Eur J Oral Sci* 2002;110:48-53.
12. Hannig M. Transmission electron microscopy of early plaque formation on dental materials in vivo. *Eur J Oral Sci* 1999;107:55-64.
13. Uzun G, Keyf F. The effect of fiber reinforcement type and water storage on strength properties of a provisional fixed partial denture resin. *J Biomater Appl* 2003;17:277-286.
14. Uzun G, Keyf F. The effect of woven, chopped and longitudinal glass fibers reinforcement on the transverse strength of a repair resin. *J Biomater Appl* 2001;15:351-358.
15. Kanie T, Fujii K, Arikawa H, Inoue K. Flexural properties and impact strength of denture base polymer reinforced with woven glass fibers. *Dent Mater* 2000;16:150-158.
16. Schreiber CK. Polymethylmethacrylate reinforced with carbon fibers. *Br Dent J* 1971;130:29–30.
17. Larson WR, Dixon DL, Aquilino SA, Clancy JM. The effect of carbon graphite fiber reinforcement on the strength of provisional crown and fixed partial denture resins. *J Prosthet Dent* 1991;66:816–820.
18. Vallittu PK. Ultra-high-modulus polyethylene ribbon as reinforcement for denture polymethyl methacrylate: a short communication. *Dent Mater* 1997:13:381–382.
19. Ramos V, Runyan DA, Christensen LC. The effect of plasma treated polyethylene fiber on the fracture strength of polymethyl methacrylate. *J Prosthet Dent* 1996;76:94–96.
20. Vallittu PK. Flexural properties of acrylic resin polymers reinforced with unidirectional and woven glass fibers. *J Prosthet Dent* 1999;81:318-326.
21. Kanie T, Arikawa H, Fujii K, Ban S. Mechanical properties of reinforced denture base resin: the effect of position and the number of woven glass fibers. *Dent Mater* 2002;21:261–269.
22. Quirynen M, Bollen CM, Papaioannou W, Van EJ, Van SD. The influence of titanium abutment surface roughness on plaque accumulation and gingivitis: short-term observations. *Int J Oral Maxillofac Implants* 1996;11:169-178.
23. Weitman RT, Eames, WB. Plaque accumulation on composite surfaces after various finishing procedures. *Oral Health* 1999;65:29-33.
24. Borchers L, Tavassol F, Tschernitschek H. Surface quality achieved by polishing and by varnishing of provisional crown and fixed partial denture resins. *J Prosthet Dent* 1999;82:550-556.