Original research article

# The effect of various polishing systems on the surface roughness of composite resins

**Didem Atabek,[1] Elif Sungurtekin Ekçi,[2]\***

**Mehmet Bani,[1] Nurhan Öztaş[1]**

[1]*Department of Pediatric Dentistry, Faculty of Dentistry, Gazi University, Ankara,* [2]*Department of Pediatric Dentistry, Faculty of Dentistry, Yeditepe University, İstanbul, Turkey*

## ABSTRACT

**OBJECTIVE:** **The aim of this *in vitro* study was to evaluate the effect of three finishing and polishing systems on the surface roughness of nano-manufactured composite resins.**

**MATERIALS AND METHOD:** **Nano-ceramic Ceram-X (Dentsply DeTrey, Konstanz, Germany), nano-filled Premise (Kerr Corporation, Orange, NJ, USA) and nano-filled Clearfil Majestic (Kuraray Medical Inc., Tokyo, Japan) composite resins were tested. Forty samples of each material were cured under matrix strips. The samples were then randomly assigned into four test groups: 1) unpolished; 2) polished with burs out of resin reinforced by zircon-rich glass fiber (Stainbuster, Abrasive Technology, Inc., Lewis Center, OH, USA); 3) polished with aluminum oxide impregnated polymer points (Enhance Finishing System, Dentsply Caulk, Milford, DE, USA) followed by diamond impregnated micro-polishing points (PoGo, Dentsply Caulk); and 4) polished with aluminum oxide disks (Sof-Lex, Dentsply Caulk). The sample surface roughness values (Ra) were determined using a profilometer, and the surfaces were observed under a scanning electron microscope. Data were analyzed using the Kruskal-Wallis test.**

**RESULTS:** **No statistically significant differences in surface roughness were detected among the finishing and polishing systems (p>0.05). However, all finishing and polishing techniques created statistically rougher surfaces than the control group (p<0.05). The mean Ra values of the finishing and polishing systems were ranked as follows: Mylar strip < Enhance Finishing System+PoGo < Stainbuster < Sof-Lex. These findings were confirmed by scanning electron microscope photomicrographs.**

**CONCLUSION:** **All polishing systems produced clinically acceptable surface roughness on the tested composite materials. The smoothest surfaces were achieved using the nano-ceramic composites with the Enhance Finishing System and PoGo.**

## INTRODUCTION

Rising esthetic requirements are forcing manufacturers and dental professionals to identify new approaches for improving restorative materials and handling techniques. Several changes have been made in the fabrication of dental resin composites to achieve better color stability, greater wear resistance and acceptable surface smoothness of restorations.[1] Nano-filled and nano-ceramic composite resin materials have been manufactured and are available as a result of recent developments in nanotechnology. Nanotechnology was first applied to dentistry in 1997 and has opened new opportunity for the design of restorative materials with improved characteristics.[2] Through the use of finer filler particles, nanotechnology can be used to increase the polishing capacity and clinical success of restorative materials.[3,4] Resin composites are typically composed of three major components (resin matrix, filler particles and coupling agent) and have been classified according to their various characteristics, such as filler type, filler distribution and average particle size of filler.[5] Nano-filled composite resin materials are formulated with nanomer and nanocluster filler particles combined with conventional resin matrixes.[1,3,5] Nanomers are discrete nanoagglomerated particles of 20–75 nm in size, while nanoclusters are loosely bound agglomerates of nano-sized particles.[3] With this technology, filler particles account for 80% of the resin matrix's total weight.[6] The manufacturers suggests that the combination of

nano-sized particles and nanocluster formulations reduces the interstitial spacing of the filler particles and, therefore, provides increased filler loading, better physical properties and improved polish retention.[1,3,6] In 2003, manufacturers combined nano-technology with methacrylate-modified polysiloxane to create nano-ceramic technology.[4] Nano-ceramic composite resins include glass fillers of 1.1–1.5 µm in size that account for 76% of total weight. According to the manufacturer, the use of nano-ceramic technology offers superior esthetics and handling properties. It is well-known that, as the size of filler particles is decreased and the percentage by weight is increased, the esthetic properties and polishing capacity of the material improves.[1,4-6] Because of composition diversity, various resin composites exhibit different levels of surface roughness after polishing.[5]

The efficiency of finishing and polishing procedures on composite resin surfaces is an important factor affecting the long-term success of restorations. The esthetic properties and clinical stability of composite resins are increased by finishing and polishing procedures. Smooth, highly polished restorations have been shown to be more esthetic and more easily maintained than restorations with rougher surfaces.[1,5,7] The friction coefficient of unpolished and rough composite resin surfaces is increased, thereby reducing the wear resistance of the material. In addition, material surfaces are prone to discoloration and plaque accumulation, while teeth are susceptible to gingival irritation and secondary caries after inadequate polishing procedures.[1,7,8] Also, surface roughness may directly influence the wear behavior and marginal integrity of posterior composite resin restorations.[1,5,9] Therefore, maintaining the smooth surface of a restoration is of utmost importance for its success.[3,5,10]

After restoration, typically excess materials are removal and re-contouring and surface polishing are performed. Therefore, a wide variety of finishing and polishing devices, including diamond and carbide burs, abrasive impregnated rubber cups and points, aluminum oxide coated abrasive disks, abrasive strips and polishing pastes are available.[2,5,11] Although these systems have advantages and disadvantages, their efficiency with respect to producing smooth surfaces can vary.[11] These differences arise from the individual properties of these systems, as well as the formulations of composite resin materials. The type of inorganic filler, the size of the particles and the extent of the filler loading vary widely among these materials and these factors influence their polishability.[3] In addition, the resin matrixes and inorganic fillers differ in their hardness and, thus, do not abrade uniformly.[8]

Different finishing and polishing devices are available for the different categories of resin-based materials and types of restorations.[9] However, there is limited evidence indicating which finishing and polishing system would be most appropriate for nano-filled and nano-ceramic composite resin materials. Therefore, the aim of this *in vitro* study was to evaluate the effect of three finishing and polishing systems on the surface roughness of composite resins manufactured by nanotechnology.

## MATERIALS AND METHOD

The Ceram-X (Dentsply DeTrey, Konstanz, Germany), Premise (Kerr Corporation, Orange, NJ, USA) and Clearfil Majestic (Kuraray Medical Inc., Tokyo, Japan) composite resins were tested (Table 1).

Forty samples of each material were prepared using a plastic mold (10 mm in diameter and 2 mm in thickness). The mold was slightly over-filled with material, covered with a Mylar matrix strip (Yates and Bird/Motloid, Chicago, IL, USA) and pressed flat between two glass slides. The specimens were then polymerized with a light-curing unit for 40 sec (LED LCU, Elipar Freelight, 3M ESPE, St Paul, MN, USA). Following light curing, all specimens were stored in artificial saliva at 37 °C for 1 week. Each sample was then randomly assigned to 1 of 4 test groups (10 samples per test group). Group 1 was used as a no procedure control. In an attempt to mimic the clinical situation, all samples were contoured with carbide burs, except Group 1. Group 2 samples were treated with burs out of resin reinforced by zircon-rich glass fiber (Stainbuster, Abrasive Technology, Inc., Lewis Center, OH, USA). Group 3 was treated with aluminum oxide impregnated polymer points followed by diamond impregnated micro-polishing points (Enhance Finishing System [EFS] + PoGo, Dentsply Caulk, Milford, DE, USA). Group 4 was treated with aluminum oxide disks (Sof-Lex, 3M ESPE, St. Paul, MN, USA; Table 2). Specimen preparation, finishing and polishing procedures were carried out by the same operator in order to reduce variability. All specimens were finished and polished with a slow-speed handpiece with water spray and disks, burs and points were discarded after each use.

*Table 1. Materials and polishing systems tested in the study*

| Materials and polishing systems | Type | Manufacturer |
|---|---|---|
| Ceram-X | Nano-ceramic composite resin | Dentsply DeTrey, Konstanz, Germany |
| Premise | Nano-filled composite resin | Kerr Corporation, Orange, NJ, USA |
| Clearfil Majesty Esthetic | Nano-filled composite resin | Kuraray Medical Inc., Tokyo, Japan |
| Matrix | Mylar strip | Yates and Bird/Motloid, Chicago, IL, USA |
| Stainbuster | Zircon-rich glass fiber | Abrasive Technology, Inc., Lewis Center, OH, USA |
| Enhance Finishing System + PoGo | Aluminum oxide impregnated polymer points + diamond impregnated micro-polishing points | Dentsply Caulk, Milford, DE, USA |
| Abrasive disc (Sof-Lex) | Aluminum oxide coated disk | Dentsply Caulk, Milford, DE, USA |

## Surface roughness test

The Ra values of the samples were obtained using an optical profilometer (Perthometer Unit, $L_T$ = 5.6 mm, $\lambda_c$ = 0.8 mm, Göttingen, Germany). Three tracings were recorded on each specimen perpendicular to the finishing and polishing scratch directions and the mean value used as the final Ra score for each specimen.

The statistical significance of the differences in mean Ra values between the groups was assessed with one-way analysis of variance (ANOVA) or Kruskal Wallis tests. Tukey tests were used where the ANOVA results were significant. The level of significance was set at p<0.05.

Representative samples having Ra scores closer to the mean values were selected from each group, coated with gold and examined under SEM (JSM-5600, JEOL, Tokyo, Japan). Photomicrographs were taken at ×1000 and ×2500 magnifications for comparing the surface topographies.

## RESULTS

The mean and standard deviations of the surface roughness values (Ra, μm) are shown in Table 2. The smoothest surfaces were obtained with the Mylar matrix group (control), independent of the type of composite resin (p<0.05). When the efficiencies of finishing and polishing systems were compared in terms of outer surface roughness of the tested materials, no significant differences were found among these techniques (p>0.05). However, all finishing and polishing techniques created statistically rougher surfaces than the control group (p<0.05; Figure 1). The mean Ra values of the finishing and polishing systems ranked as follows: Mylar strip < EFS+PoGo < Stainbuster < Sof-Lex.

For the nano-ceramic composite group (Ceram-X), the highest Ra values were found with Stainbuster (p<0.05), while the lowest mean values scores were detected with EFS+PoGo (p>0.05). The lowest Ra values were obtained with EFS+PoGo, whereas the highest values were found with the Stainbuster using

*Table 2.* Mean surface roughness values (Ra; mean ± SD, μm) of the composite resins and tested polishing systems

|  | **Ceram-X** | **Premise** | **Clearfil ME** |
|---|---|---|---|
| **Control** | 0.05±0.01[a,A] | 0.11±0.09[d,B] | 0.15±0.14[h,B] |
| **EFS+PoGo** | 0.65±0.17[b,C] | 0.64±0.26[e,C] | 0.56±0.19[i,D] |
| **Stainbuster** | 0.89±0.08[c,E] | 0.76±0.21[f,E] | 0.57±0.16[i,F] |
| **Sof-Lex** | 0.72±0.15[b,G] | 0.72±0.28[g,G] | 0.92±0.39[j,H] |

Different lowercase letters (for columns) and different capital letters (for rows) indicate a statistically significant difference (p<0.05).

the Premise nano-filled composite materials, however, these differences did not reach statistically significance. In the Clearfil ME group, the Ra values of Sof-Lex were statistically higher (p<0.05) than other groups, whereas the lowest values were obtained with EFS+PoGo, although this did not reach statistical significance.

When the surface roughness values were compared according to composite resin groups, the lowest values were found with Ceram-X in the control group (p<0.05). In the EFS+PoGo and Sof-Lex groups, the surface roughness values of the composite resins were found to be similar (p>0.05). Among these, the best results were obtained with Clearfil ME in the Stainbuster group (p<0.05).

SEM photomicrographs showed that the smoothest surfaces were obtained in the Ceram-X + matrix strip and Clearfil ME + EFS+PoGo treatments (Figure 2). The roughest surfaces were obtained in the Ceram-X + Stainbuster and Clearfil ME + Sof-Lex groups (Figure 2).

## DISCUSSION

The surface roughness of resin composites is recognized as an important clinical parameter, affecting wear resistance, plaque accumulation, gingival inflammation and material discoloration.[1,5,9] Here we aimed to
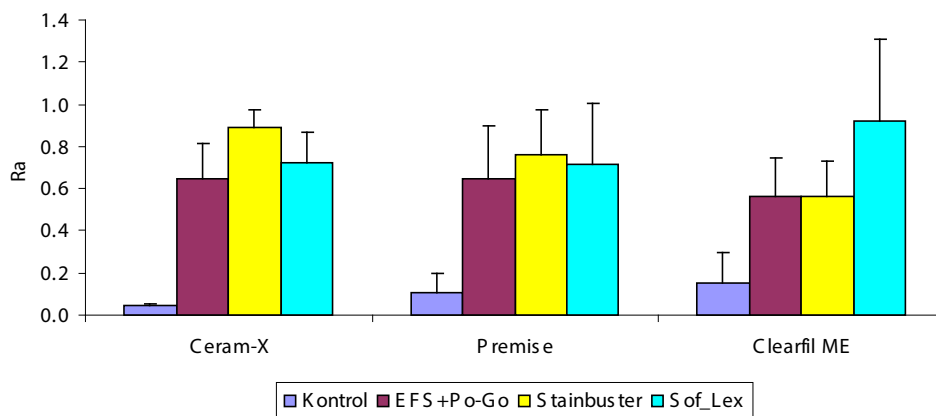


**Figure 1.** Mean Ra values (μm) of composite resins according to the tested polishing procedure.
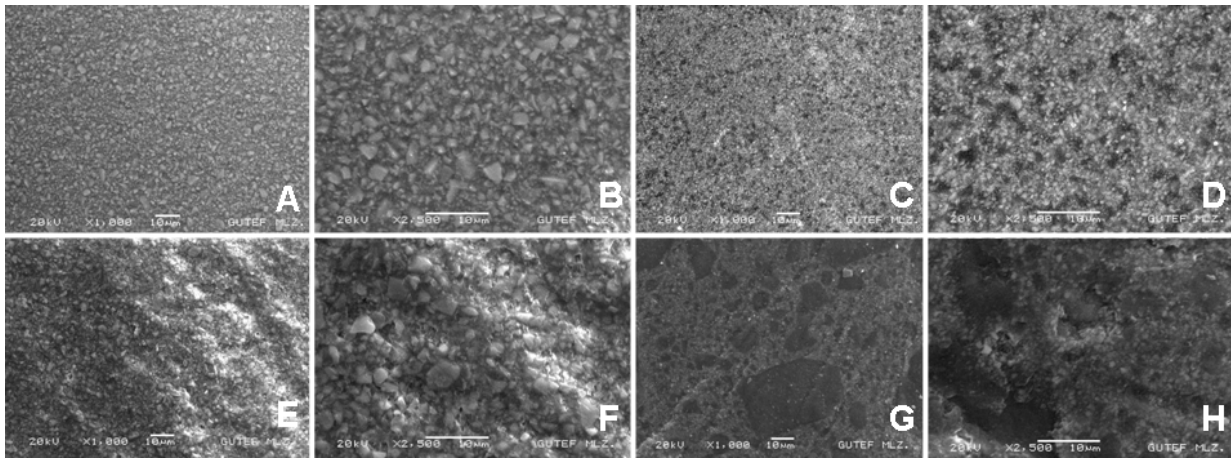
*Figure 2. SEM image of a sample from A: Ceram-X + matrix strip group (×1000); B: Ceram-X + matrix strip group (×2500); C: Clearfil ME + EFS+PoGo group (×1000); D: Clearfil ME + EFS+PoGo group (×2500); E: Ceram-X + Stainbuster group (×1000); F: Ceram-X + Stainbuster group (×2500); G: Clearfil ME + Sof-Lex group (×1000); H: Clearfil ME + Sof-Lex group (×2500).*

evaluate the efficiency of various polishing systems on nano-manufactured composite resins. Among available methods, matrix strips have been suggested to produce the smoothest surface on dental composites.[1,8-15] However, the resulting surface is polymer-rich and makes the restoration relatively unstable. Furthermore, this resin-rich surface should be removed since it can easily wear in the oral environment. In addition, the oral environment will be exposed to inorganic filler content if no polishing procedure is carried out.[9,11] Therefore, this layer is often clinically abolishing during removal of excess material or contouring of the restoration after placement, making the efficiency of finishing and polishing procedures an important factor in the clinical success of composite resin restorations.[5,9]

The surface roughness of composite resins is influenced by filler size, hardness and amount, as well as the flexibility of the material used for polishing, hardness of the abrasive particles and grit size.[1,3] Nano-filled materials in dentistry are developed as a result of the combination of nano-sized particles with a conventional resin matrix. This technology not only improves the mechanical properties of conventional composite resins but also enhances esthetics by increasing polishing capacity and durability. The manufacturers claim that nano-filled composites have the strength of the hybrids and the polish of microfills.[1,6] Nano-particles are comprised of a polysiloxane backbone and may be best described as inorganic-organic hybrid particles. Methacrylic groups are attached to this backbone via Silicone-carbon-bonds. The inorganic Silicone component provides strength, while the organic part makes the particles compatible and polymerizable with the resin matrix.[4]

Here we tested the performance of various polishing procedures on three composite resin materials (a nano-ceramic composite, Ceram-X; and two nano-filled composites, Premise and Clearfil Majesty Esthetic). All composite surfaces created with Matrix strips

were found to be smoother than the other polishing systems, which is in line which literature findings.[9,12,14,15] Therefore, in order to mimic the clinical situation, we applied carbide burs prior to the polishing procedures. The mean Ra values found using the matrix strips were lower than the threshold Ra value of 0.2 μm suggested by Bollen *et al.*[16] and in accordance with the findings of other studies.[9,17]

The nano-filled composite resins demonstrated significantly greater roughness than the nano-ceramic composite resin under matrix strips. Since the filler loading of the nano-filled composites is higher than that of the nano-ceramic composites, the initially smooth surface of the nano-ceramic composite is likely related to the resin-rich surface of the material created after matrix strip placement.[15] Yap *et al.*[14] and Tjan *et al.*[18] suggested that materials with fillers of larger sizes generally show more surface roughness than those with fillers of smaller sizes. Therefore, the lower filler loading and higher resin ratio of nano-ceramic composite compared with nano-filled composites may be responsible for the significantly reduced surface roughness within control group.

For Ceram-X, significantly greater Ra values were found with Stainbuster. Similarly, Stainbuster performed best with Premise, although this did not reach statistical significance. Yap *et al.*[14] and Hoelscher *et al.*[19] obtained better surface finishing with aluminum oxide disks than with abrasive points plus polishing pastes for microfilled composite resins. The authors attribute their results to the shape of the abrasive point utilized; the application of cup-shaped points might cause filler displacement. Similarly, the Stainbuster results found here may be explained by the difference in the shape of the abrasive points, as well as the nature of the abrasive particles. However, in The Clearfil ME group, the Ra values for Sof-Lex were statistically higher than the other polishing systems employed. The differences in roughness after finishing and polishing among the techniques may also

be due to the distinct patterns of particle size and their arrangement within the resin matrix.[9] Aluminum oxide disks are of limited use because of their shape, which make them difficult to use efficiently, particularly in the posterior regions of the mouth.[11]

Barakah & Taher[20] evaluated the effect of polishing systems on the surface roughness of nanocomposite resin materials and obtained the smoothest surfaces with PoGo. Similarly, Can Say *et al.*[21] achieved significantly smoother surfaces with nano-hybrid composites using the Enhance Finishing System+PoGo. For a composite polishing system to be effective, the abrasive particles should be relatively harder than the filler particles. Otherwise, only the soft resin matrix will be removed, leaving the filler particles protruding from the surface, resulting in rougher surfaces.[9,15] Various materials and techniques are available to the clinicians for contouring, finishing and polishing procedures. However, there is no universally accepted method for composite finishing and polishing.[11] In the present study, the Enhance Finishing System+PoGo method produced the lowest surface roughness scores for all composite resins tested, although this result did not reach statistical significance. In addition, this finding was also confirmed by SEM photomicrographs. This result was attributed to the hardness of the aluminum oxide and diamond micro-particles that is greater than that of the inorganic filler particles of the composite resins used in this study.

## CONCLUSION

Among the tested composite materials, all polishing systems produced clinically acceptable surface roughness results. The smoothest surfaces were achieved using nano-ceramic composites with the Enhance Finishing System and PoGo. Although this result did not reach statistical significance, we propose that the use of the Enhance Finishing System followed by PoGo application is likely to improve clinical success. Further studies are required on convex and concave tooth surfaces where there is limited access to better investigate how these resins and polishing systems will perform under clinical conditions.

**Conflict of interest disclosure:** The authors declare no conflict of interest related to this study.

## REFERENCES

**1.** Da Costa J, Ferracane J, Paravina RD, Mazur RF, Roeder L. The effect of different polishing systems on surface roughness and gloss of various resin composites. J Esthet Restor Dent 2007;19:214-24.

**2.** Yalçin F, Korkmaz Y, Başeren M. The effect of two different polishing techniques on microleakage of new composites in Class V restorations. J Contemp Dent Pract 2006;7:18-25.

**3.** Attar N. The Effect of Finishing and Polishing Procedures on the Surface Roughness of Composite Resin Materials. J Contemp Dent Pract 2007;8:27-35.

**4.** Schirrmeister JF, Huber K, Hellwig E, Hahn P. Two-year evaluation of a new nano-ceramic restorative material. Clin Oral Investig 2006;10:181-6.

**5.** Senawongse P, Pongprueksa P. Surface roughness of nanofill and nanohybrid resin composites after polishing and brushing. J Esthet Restor Dent 2007;19:265-73.

**6.** Mota EG, Oshima HM, Burnett LH Jr, Pires LA, Rosa RS. Evaluation of diametral tensile strength and Knoop microhardness of five nanofilled composites in dentin and enamel shades. Stomatologija 2006;8:67-9.

**7.** Ozgünaltay G, Yazici AR, Görücü J. Effect of finishing and polishing procedures on the surface roughness of new tooth-coloured restoratives. J Oral Rehabil 2003;30:218-24.

**8.** Gedik R, Hürmüzlü F, Coşkun A, Bektaş OO, Ozdemir AK. Surface roughness of new microhybrid resin-based composites. J Am Dent Assoc 2005;136:1106-12.

**9.** Barbosa SH, Zanata RL, Navarro MF de Lima, Nunes OB. Effect of different finishing and polishing techniques on the surface roughness of microfilled, hybrid and packeble composite resins. Braz Dent J 2005;16:39-44.

**10.** Yap AU, Yap SH, Teo CK, Ng JJ. Comparison of surface finish of new aesthetic restorative materials. Oper Dent 2004;29:100-4.

**11.** Uçtaşli MB, Arisu HD, Omürlü H, Eligüzeloğlu E, Ozcan S, Ergun G. The effect of different finishing and polishing systems on the surface roughness of different composite restorative materials. J Contemp Dent Pract 2007;8:89-96.

**12.** Hondrum SO, Fernández R Jr. Contouring, finishing, and polishing Class 5 restorative materials. Oper Dent 1997;22:30-6.

**13.** Radlanski RJ, Best T. New carbide finishing burs to reduce polishing efforts of light-cured restorations. Quintessence Int 2007;38:e555-63.

**14.** Yap AU, Lye KW, Sau CW. Surface characteristics of tooth-colored restoratives polished utilizing different polishing systems. Oper Dent 1997;22:260-5.

**15.** Uçtaşli MB, Bala O, Güllü A. Surface roughness of flowable and packable composite resin materials after finishing with abrasive discs. J Oral Rehabil 2004;31:1197-202.

**16.** Bollen CM, Lambrechts P, Quirynen M. Comparison of surface roughness of oral hard materials to the threshold surface roughness for bacterial plaque retention: a review of the literature. Dent Mater 1997;13:258-69.

**17.** Quirynen M, Bollen CM, Papaioannou W, Van Eldere J, van Steenberghe D. The influence of titanium abutment surface roughness on plaque accumulation and gingivitis: short-term observations. Int J Oral Maxillofac Implants 1996;11:169-78.

**18.** Tjan AH, Chan CA. The polishability of posterior composites. J Prosthet Dent 1989;61:138-46.

**19.** Hoelscher DC, Neme AM, Pink FE, Hughes PJ. The effect of three finishing systems on four esthetic restorative materials. Oper Dent 1998;23:36-42.

**20.** Barakah HM, Taher NM. Effect of polishing systems on stain susceptibility and surface roughness of nanocomposite resin material. J Prosthet Dent 2014;112:625-31.

**21.** Can Say E, Yurdagüven H, Yaman BC, Özer F. Surface roughness and morphology of resin composites polished with two-step polishing systems. Dent Mater J 2014;33:332-42.

## Farklı polisaj sistemlerinin kompozit rezinlerin yüzey pürüzlülüğüne etkisi

### ÖZET

**AMAÇ: Bu *in vitro* çalışmanın amacı üç farklı bitirme ve cilalama sisteminin nano-teknoloji ile üretilmiş kompozit rezinlerin yüzey pürüzlülüğüne etkisini incelemektir.**

**GEREÇ VE YÖNTEM: Bu çalışmada nano-seramik Ceram-X (Dentsply DeTrey, Konstanz, Almanya), nano-dolduruculu Premise (Kerr Corporation, Orange, NJ, ABD) ve nano-**

dolduruculu Clearfil Majestic (Kuraray Medical Inc., Tokyo, Japonya) test edildi. Her bir materyalden 40 adet örnek şeffaf bantlar kullanılarak hazırlandı. Materyaller 10'ar örnekten oluşan 4 çalışma grubuna ayrıldı: 1) cilalanmamış, 2) zirkondan zengin cam fiber ile güçlendirilmiş rezin frezlerle cilalanmış (Stainbuster, Abrasive Technology, Inc., Lewis Center, OH, ABD), 3) alüminyum oksit ile kaplanmış polimer uçlar (Enhance Finishing System, Dentsply Caulk, Milford, DE, ABD) ardından elmas kaplı mikro-cilalama uçları (PoGo, Dentsply Caulk) ile cilalanmış ve 4) alüminyum oksit diskleri ile cilalanmış (Sof-Lex, Dentsply Caulk). Tüm örneklerin yüzey pürüzlülük değerleri (Ra) optik profilometre ile değerlendirildi, yüzeyler taramalı elektron mikroskopu (SEM) ile incelendi. Veriler Kruskal-Wallis testi kullanılarak istatistiksel olarak analiz edildi.

**BULGULAR: Bitirme ve cilalama sistemlerinin yüzey pürüzlülüğüne istatistiksel olarak anlamlı bir etkisinin** olmadığı belirlendi (p>0.05). Bununla beraber, tüm bitirme ve cilalama sistemlerinin kontrol grubuna göre istatistiksel olarak anlamlı derecede daha pürüzlü yüzeyler oluşturduğu görüldü (p<0.05). Bitirme ve cilalama sistemlerinin Ra değerlerine göre sıralaması: Mylar strip < Enhance Finishing System+PoGo < Stainbuster < Sof-Lex olarak bulgulandı. Sonuçlar SEM görüntüleri ile de doğrulandı.

**SONUÇ: Tüm cilalama sistemlerinin test edilen kompozit materyalleri üzerinde klinik olarak kabul edilebilir düzeyde yüzey pürüzlülüğü oluşturduğu görüldü. Diğer bitirme sistemlerine göre en düzgün yüzeyler Enhance Finishing System+PoGo ile nano-seramik kompozitler üzerinde elde edildi.**

**ANAHTAR KELIMELER: Dental estetik; diş parlatma; kompozit dental rezin**