

Influence of Various Polishing Protocols on Polyether-Ether-Ketone Removable Partial Frameworks Fabricated By CAD / CAM (Scanning Electron Microscope Study)

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Abstract

Purpose: This in vitro scanning electron microscope study was performed to evaluate the influence of various polishing protocols on polyether-ether-ketone removable partial frameworks surface topography that fabricated by CAD / CAM.

Materials and Methods: an epoxy resin model represent maxillary class I Kennedy classification with remaining natural teeth extending from the first premolar on one side to the first premolar teeth on the other side were used in the study. First premolars and canines of epoxy resin model were prepared to receive full ceramo-metal crowns with mesial occlusal and cingulum rest seat, distal guiding planes, and first premolars mesio-buccal retentive undercuts of 0.50 mm depth. 3 specimens of themodified polyetheretherketoneRDP frameworks were fabricated by CAD/CAM techniques. According to polishing protocols the themodified polyetheretherketoneRDP frameworks were divided into three groups: Group I (control group): modified polyetheretherketoneRDP frameworks without polishing, Group II: modified polyetheretherketoneRDP frameworks was polished by using Abraso-Starglanz polishing system and Group III: modified polyetheretherketoneRDP frameworks was polished by using Acrypol polishing system. Surface changes between groups before and after polishing by different polishing protocols were evaluated by scanning electron micro-scope (SEM).

Results: It was noted that (group I) showed the highest surface roughness while the lowest surface roughness and highly smooth surface was showed in (group II). By using Student's t-test for comparing between groups, group II showed significance decrease in surface roughness compared to that in (group I) and group III where ($p < 0.001$).

Conclusions: Within the limitations of this study, it was concluded that: Polishing PEEK RPD framework with abrasto-starglaz paste was the most effective and promising polishing technique in production of highly smooth surface than acrypol polishing paste. For the laboratory-based protocols, both abrasto-starglaz and acrypol polishing pastes produce a significantly smoother PEEK surface than that of the non-polished PEEK.

Keywords: modified polyetheretherketone RDP frameworks, polishing techniques

Date of Submission: 13-02-2019

Date of acceptance: 28-02-2019

I. Introduction

Dental Health Survey found that partially dentate adult's proportion is increased as a result of elderly individual's number rise within the population, or a shift from total edentulism to partial edentulism. (1) Partially edentate patients demand restoration of their missing teeth, existing treatment modalities encompass fixed partial denture incorporate or unincorporated with dental implants. Oral health maintenance has progressed; thus people are suffer the loss of fewer teeth, leading to increase the necessity for treatment of partial denture (RPDs) preferably than complete denture, that are widely used in clinical practice and, has an advantages. (2,3)

The Conventional partial denture (RPDs) were usually fabricated from metal. such as cobalt-chromium or titanium, (4) The partial denture (RPDs) metal-based frameworks advantageous over partial denture (RPDs) acrylic resin are that provide stiffness and high strength, are less bulky and used in thin sections, allows designs

that minimize the gingival margins covering, conduct cold and heat for a more natural experience, allow for a stable denture base, and are resistant to corrosion.^(5,6)

The partial denture (RPDs) metal-based frameworks drawbacks comprise metal display causing esthetic issues, adverse tissue reactions, and biofilm production,⁽⁷⁾ that give the means of microorganism colonization in the surface area, allowing the development of a biofilm, which also act as a reservoir for respiratory pathogens.⁽⁸⁾ Due to the drawbacks of partial denture (RPDs) metal-based frameworks, the use of metal-free materials has been introduced.⁽¹⁾ Recently, an encouraging polymer-based partial denture (RPDs) framework consists of a modified polyetheretherketone polymer peek has a lot of benefits over those made of metal as improve esthetics because of their color and translucency, have higher elasticity, are lightweight, are more cost-effective, have low water sorption and solubility.⁽⁹⁻¹²⁾ The modified polyetheretherketone polymer peek RDP frameworks can be constructed by using computer-aided design and computer-aided manufacture (CAD/CAM) systems.⁽¹³⁾ A previous study⁽¹⁴⁾ concluded that, frameworks constructed from modified polyetheretherketone polymer recorded higher surface roughness than that of frameworks constructed from chromium cobalt alloy in regard to the surface roughness.

Polishing is the process that fulfilled after the finishing process to remove minute scratches from the surface of the prosthesis and obtain a smooth, light-reflective luster.⁽¹⁵⁾ Obtaining a polished surface is not only pivotal for esthetics, but it is a cornerstone in bacterial plaque accumulation which has a direct correlation between surface topography and formation of biofilm.⁽¹⁶⁻¹⁸⁾

Thus; this in vitro scanning electron microscope study was performed to evaluate the influence of various polishing protocols on polyether-ether-ketone removable partial frameworks surface topography that fabricated by CAD / CAM.

II. Material and Methods

This in vitro scanning electron microscope study was conducted on an experimental maxillary epoxy resin model. That represents class I Kennedy classification with remaining natural teeth extending from first premolar on one side to the first premolar on the other side. In order to evaluate the influence of 2 laboratory polishing techniques either by Abraso-Starglanz or Acrypol polishing system on the modified polyetheretherketone polymer peek RDP frameworks surface topography.

Maxillary class I Kennedy classification stone model was duplicated by silicon rubber base impression material (zeta plus, zhermack, Italy), pouring the silicon rubber base impression mold by epoxy resin material (bredent GmbH & CO.KG REF 520 00173). Both first premolars teeth and canines of the epoxy resin model were prepared to receive two units full Ceramo-metal crowns with mesial occlusal and cingulum rest seat, proximal guiding planes, and mesio-buccal retentive undercuts of 0.50 mm on first premolars.

The epoxy resin model was scanned by 3 Shape scanning machine dental system, by using desktop 3shape. The 3D model was exported as STL file format to be ready for wax design of RPD framework using CAD technology. The virtual cast was digitally surveyed at zero position, the undesirable undercut was blocked out, and the location of desired undercuts was completed. The outline of major and minor connectors were connected by dotted line, then anteroposterior palatal bar major connector was chosen. Retentive undercut depth was determined by using 3Shape scanning machine, undercut with orange color-coded equal to 0.5 mm depth, to receive RPI clasp. The clasp arm pattern originated from the proximal plate and curved 120 degrees around the buccal tooth surface in a single plane with clasp average width and thickness that was 1.5 mm. (fig.1, a) Furthermore, the design of external finish line right posterior was completed via connecting blue design digitally, that extended from posterior to anterior extension.

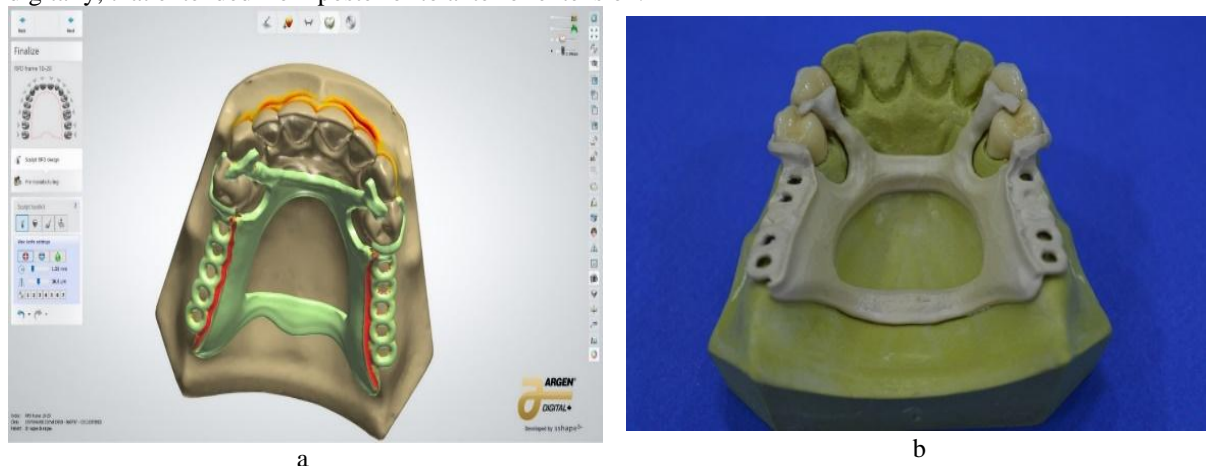


Fig.1: a- Final framework CAD design on virtual cast. b- Finished PEEK framework on epoxy-resin model.

PEEK-Juvora™ disc with thickness 98x18mm ceramill peek at higher temperature 343 machined using ceramill motion 2 milling machine via subtractive technique (dry processing). Finally PEEK framework was removed, cleaned and smoothed to remove any sharp angles. (fig.1, b)According to polishing protocols the 3 PEEK RPD frameworks was divided into three groups:**Group I:** PEEK-Juvora™ RPD framework without polishing as a control group; **Group II:** PEEK-Juvora™ RPD framework was polished by using Abraso-Starglanz polishing system; **Group III:** PEEK-Juvora™ RPD framework was polished by using Acrypol polishing system. Polishing protocol sequence was used to group II and group III according to manufacturing instruction as revealed in **table 1**.

Table1: Polishing protocols, products, and manufacturers used.		
Polishing Protocol	Manufacture	Polishing method
ABR Abraso-starglanz	AbrasoStarglanz polishing paste (bredent GmbH & Co KG)	polishing motor (NSK ultimate 500); Polishing mop (high luster buffs) (bredent GmbH & Co.KG) Duration: 1 min,
Acrypol	Acrypol polishing paste (bredent GmbH)	Polishing motor (NSK ultimate 500) Polishing mops (fabric buffs) (bredent GmbH & Co.KG); Duration: 1min,

All the procedure of polishing were performed by the same operator to avoid operator variability. The influence of polishing protocols on surface topography of the retainer unit of the modified polyetheretherketone polymer peek RDP frameworks was evaluated by scanning electron microscope (SEM) (JOEL-JSM-6510LV (using 200 X magnification). this evaluation was done on 3 specimens that represent the three groups of the study. The SEM images were analyzed on Intel® Core I3® based computer using Video Test Morphology® software (Russia) with a specific built-in routine for pixel statistics.

Statistical Analysis

Data were tabulated, coded then analyzed using the computer program SPSS (Statistical package for social science) version 23.0 to obtain. Descriptive statistics were calculated in the form of Mean ± Standard deviation (SD). In the statistical comparison between the different groups, the significance of difference was tested using the following tests:- Student's *t*-test (Unpaired):-Used to compare between mean of two different groups of numerical (parametric) data. A *P* value <0.05 was considered statistically significant.

III. Result

PART 1. Scanning Electron Microscope Results for all groups

Figure 2: Scanning electron microscope images of group I that revealed the surface topography of the retainer unit of the modified polyetheretherketone peek RDP frameworks without polishing shows roughness of the surface with demarcation lines that represent the bur movements of the milling machine during the fabrication of the peek RDP frameworks.(fig. 2)

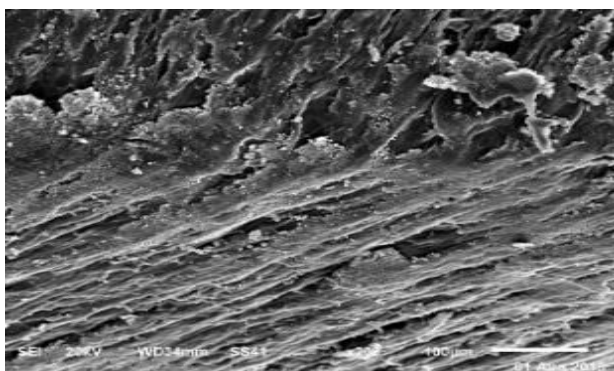


Fig. 2: SEM images under (200X) magnification for group I showed: exaggerated surface roughness and irregularities.

Figure 3: Scanning electron microscope images of group II that revealed the surface topography of the retainer unit of the modified polyetheretherketone peek RDP frameworks polished by AbrasoStarglanz polishing paste, highly smoothed surface with few irregularities, and small crack line in limited area was noticeable.(fig. 3)

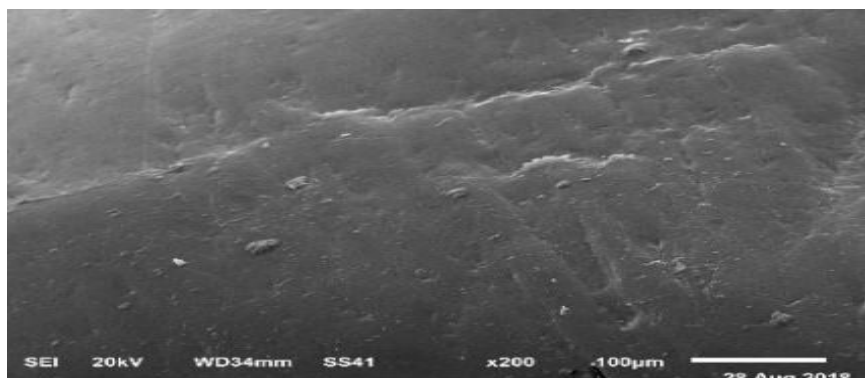


Fig. 3: SEM images under (200 X) magnification for group II: Showed highly smoothed surface with few irrregularites , and small crack line in limited area was noticeable.

Figure 4: Scanning electron microscope images of group III that revealed the surface topography of the retainer unit of themodified polyetheretherketone peek RDP frameworks polished by Acrypol polishing paste. Showed less smooth surface with irrregularities ,scratch line, small deprssion and elevation distrubuted throughout whole surface area.. (fig.4)

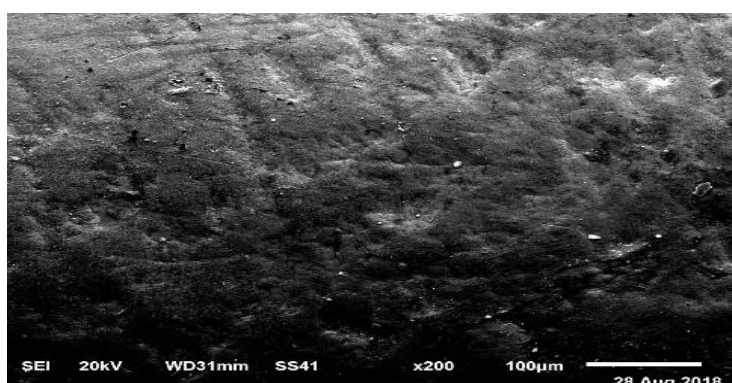


Fig. 4: SEM images under (200 X) magnification for group III: Showed less smooth surface with irrregularities ,scratch line, small deprssion and elevation distrubuted throughout whole surface area.

PART 2 Comparison of different groups to evaluate the effect of different polishing protocol on surface roughness of themodified polyetheretherketone peek RDP frameworks.

As shown in table 2By using Student’s t-test for comparing between groups, group II showed significance decrease in surface roughness throughout different parts of clasp arm compared to that in (group I) and group III where ($p < 0.001$). While group III showed significance decrease in surface roughness compared to that in groupI where ($p < 0.001$). However it was found that there was significant increase in surface roughness throughout all parts of clasp arm compared to that in group II where ($p < 0.001$).

It was noted, that (group I) showed the highest surface roughness throughout different parts of clasp arm while the lowest surface roughness and highly smooth surface throughout different parts of clasp arm was showed in (group II).

Table 2: Descriptive statistics before and after laboratory polishing and measurement and Comparison of different groups									
	Control group I		After polishing group II Abraso - Starglanz		After polishing group III Acrypol		P1	P2	P3
	Mean	±SD	Mean	±SD	Mean	±SD			
Body	7.278	1.456	1.25	0.25	3.13	0.63	<0.001*	<0.001*	<0.001*
Retentive	35.85	7.17	9.42	1.89	18.47	3.69	<0.001*	<0.001*	<0.001*
Shoulder	26.15	5.23	5.98	1.20	9.19	1.84	<0.001*	<0.001*	0.005*
Total	69.28	13.86	16.65	3.33	30.78	6.16	<0.001*	<0.001*	<0.001*

Data expressed as mean ±SD

SD: standard deviation M: mean P:Probability *:significance <0.05

Test used: Student’s t-test

P1: significance between Group I & Group II

P2: significance between Group I & Group III

P3: significance between Group II & Group III

IV. Discussion

The authors are unaware of data concerning polishing methods using PEEK restoration material, ⁽¹⁹⁾despite PEEK material's potential for restoration due to its outstanding mechanical, thermal, and chemical properties. These considerations justify this study's selection of PEEK for the evaluation of its surface properties and polishing ability. ⁽¹⁶⁾To counteract this development, it is essential to obtain a high luster, smooth restoration surface with low surface roughness values to prevent early settling bacteria from attaching. Even chemical surface properties show crucial impacts on plaque formation ^(18, 20)

The present study evaluated the effects of conventional laboratory polishing techniques with different polishing paste materials on the surface roughness of the modified polyetheretherketone PEEK RDP frameworks. The data demonstrated that the polishing techniques significantly decrease the surface roughness resulted from the action of cutting burs during the milling fabrication of the frameworks.

A significant difference was found in the surface roughness between unpolished modified polyetheretherketone RDP frameworks (group I) and polished modified polyetheretherketone RDP frameworks (group II, group III) which showed significant decrease in surface roughness to group I where ($P < .001$). This revealed that polishing is the key for successful restoration which was in agreement with **Taylor et al** ⁽²¹⁾ reported that rough surfaces have more plaque accumulation than smooth surfaces after studying the processing of plaque accumulation for 3 and 6 days on restorative and prosthetic materials with different surface free energy and surface roughness.

A significant difference was found in the surface roughness between polished PEEK framework (group II, group III) framework as group II showed significant decrease in surface roughness compared to that in group III where ($p < 0.001$) which may be explained by For group II: polishing modified polyetheretherketone RDP frameworks with abraso-star glaz polishing paste a perfect high smooth surface was produced quickly that may be attributed to its composition which was: aluminium oxide 20-40%, Distillates (petroleum), hydrotreated light 20-40%, Naphtha (petroleum), hydrotreated light 2.5-10, ammonia 25 % 0.1-5%. While polishing with Acrypol slightly abrasive materials virtually perfect high luster, less smooth PEEK surface was created that may be attributed to its composition which was a mixture of waxes, tensides, fatty acids, vegetable oils and various abrasives (SiO₂). Limitations of the present study were that it's in vitro nature, long-term influence of the surface roughness of the modified polyetheretherketone RDP frameworks, cannot be evaluated because of the in-vitro design of the study.

V. Conclusions

- 1- Within the limitations of the present study, the following conclusions were drawn:
- 2- Polishing PEEK RPD framework with abraso-starglaz polishing paste was the most effective and promising polishing technique in production of highly smooth PEEK surface than acrypol polishing paste
- 3- For the laboratory-based protocols, both abraso-starglaz and acrypol polishing pastes produce a significantly smoother PEEK surface than that of the non-polished PEEK

References

- [1]. Campbell SD, Cooper L, Craddock H, Hyde TP, Nattress B, Pavitt SH, Seymour DW. Removable partial dentures: The clinical need for innovation. *J Prosthet Dent.* 2017; 118:273-280.
- [2]. Levin L. Dealing with dental implant failures. *J Appl Oral Sci* 2008; 16:171-5.
- [3]. BOÇARI G, NedaH, Alesio B. The Advantages of Partial Dentures Made of Cast Framework Cr-Co toward those Made of Resin Based Dentures. *IntJ DentSciRes* 2014; 2.2: 32-35.
- [4]. Becker CM, Kaiser DA, Goldfogel MH. Evolution of removable partial denture design. *J Prosthodont* 1994; 3:158-66.
- [5]. Schneider R. Metals used to fabricate removable partial denture frameworks. *J Dent Technol.* 1996; 13:35-42.
- [6]. Khalifa AK, Elmekawy N. Bite Force and Bone Height Changes around Abutments Retaining Mandibular Removable Partial Denture with Wrought Wire and Polyamide Clasps: Split Mouth Study. *Egypt Dent J* 2019; 65:51-59.
- [7]. Schwitalla AD, Spintig T, Kallage I, Muller WD. Flexural behavior of PEEK materials for dental application. *Dent Mater* 2015; 31:1377-84.
- [8]. O'Donnell LE, Smith K, Williams C, Nile CJ, Lappin DF, Bradshaw D, et al. Dentures are a reservoir for respiratory pathogens. *J Prosthodont* 2016; 25: 99-104.
- [9]. Savitha PN, Lekha KP, Nadiger RK. Fatigue resistance and flexural behavior of acetal resin and chrome cobalt removable partial denture clasp: an in vitro study. *Eur J Prosthodont* 2015;3:71-6.
- [10]. Alla RK, Swamy R, Vyas R, Konakanchi A. Conventional and contemporary polymers for the fabrication of denture prosthesis: part I-overview, composition and properties. *Int J Appl Dent Sci* 2015;1:82-9.
- [11]. Najeeb S, Zafar MS, Khurshid Z, Siddiqui F. Applications of polyetheretherketone (PEEK) in oral implantology and prosthodontics. *J Prosthodont Res* 2016;60:12-9.
- [12]. Vojdani M, Giti R. Polyamide as a denture base material: a literature review. *J Dent (Shiraz)* 2015;16:1-9.
- [13]. Kurtz SM, Devine JN. PEEK biomaterials in trauma, orthopedic, and spinal implants. *Biomaterials* 2007;28:4845-69.

- [14]. El Mekawy N, Gad E. Retentive force and surface roughness of partial removable frameworks fabricated from conventional chrome-cobalt and cad / cam modified polyetheretherketone materials (within-subject evaluation). *Egypt Dent J* 2016; 62: 5055-5062.
- [15]. Jefferies SR. Abrasive finishing and polishing in restorative dentistry: a state-of-the-art review. *Dent Clin North Am.* 2007;51:379-97.
- [16]. Wang L, He S, Wu X, Liang S, Mu Z, Wei J, et al. Polyetheretherketone/nanofluorohydroxyapatite composite with antimicrobial activity and osseointegration properties. *Biomaterials* 2014; 35:6758-75.
- [17]. Wang L, Zhang H, Deng Y, Luo Z, Liu X, Wei S. Study of oral microbial adhesion and biofilm formation on the surface of nano-fluorohydroxyapatite/polyetheretherketone composite. *Zhonghua Kou Qiang Yi XueZaZhi* 2015; 50:378-82.
- [18]. Hahnel S, Wieser A, Lang R, Rosentritt M. Biofilm formation on the surface of modern implant abutment materials. *Clin Oral Impl Res* 2015; 26:1297-301.
- [19]. Liebermann A, Wimmer T, Schmidlin PR, Scherer H, Löffler P, Roos M, Stawarczyk B. Physicomechanical characterization of polyetheretherketone and current esthetic dental CAD/CAM polymers after aging in different storage media. *J Prosthet Dent.* 2016; 115:321-8.e2.
- [20]. Auschill TM, Arweiler NB, Brex M, Reich E, Sculean A, Netuschil L. The effect of dental restorative materials on dental biofilm. *Eur J Oral Sci.* 2002; 110:48-53.
- [21]. Taylor R, Maryan C, Verran J. Retention of oral microorganisms on cobalt-chromium alloy and dental acrylic resin with different surfacefinishes. *J Prosthet Dent* 1998;80: 592-7.

NohaElwaseefyBDS, MSc, Phd. " Influence of Various Polishing Protocols on Polyether-Ether-Ketone Removable Partial Frameworks Fabricated By CAD / CAM (Scanning Electron Microscope Study). " *IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)*, vol. 18, no. 2, 2019, pp 34-39.