Libyan Journal of Science & Technology 11:2 (2020) 94–97

Faculty of Science - University of Benghazi

Libyan Journal of Science & Technology

journal home page: www.sc.uob.edu.ly/pages/page/77

Evaluation of the surface roughness of four different types of acrylic resin denture base materials: heat cure (HC), high impact heat cure (HIHC), heat cure clear (HCC), and clear chemical cure (CC). Part (1)

Salma A. Elnaili[a,*], and David G. Patrick[b]

[a] *Department of Prosthodontics, Faculty of Dentistry, University of Benghazi, Libya*

[b] *Department of Dental Material, School of Clinical Dentistry, University of Sheffield (UK)*

Highlights

- **This study showed that the surface roughness of denture base is affected by the type of acrylic resin.**
- **The study also showed that the chemical cure (CC) had higher surface irregularities than the conventional heat cure (HC).**
- **The study also find out that finishing and polishing the materials had a greater effect on the surface roughness rather than on their types.**
- **This study will open doors for future research in many related fields. For example, study the interaction of oral microorganism with acrylic resin denture base materials.**

ARTICLE INFO

Article history:

Received 01 March 2020
Revised 26 June 2020
Accepted 01 September 2020

Keywords:

Acrylic resin, surface roughness, profilometer, SEM

**Address of correspondence:*

E-mail address: salma82_2012@yahoo.com

S. A. Elnaili

ABSTRACT

Statement of problem: Resin-based poly (methylmetha acrylate) (PMMA) has been used instead of metallic materials for denture base construction, because of the following reasons: it is aesthetic superiority; ease of construction with very cheap equipment as well as it is ease of repair. However, despite the superiority of the acrylic resin as denture base material, it still has some limitations such as low surface roughness, which causes adhesion of oral microorganisms.

The aim: To assess and compare the surface roughness of four different types of acrylic resin denture base materials: heat cure (HC), high impact heat cure (HIHC), heat cure clear (HCC), and clear chemical cure (CC).

Material and methods: Twenty-five discs measuring 11 mm in diameter and 3 mm in thickness for each different type of acrylic resins were fabricated. All samples were polished to different roughness parameters, consisting of 600 and 1200 surface polishers. The average surface roughness (Ra) was measured using a profilometer, and the average mean was calculated. Furthermore, the surface characteristics were viewed by a scanning electron microscope (SEM).

Results: For statistical analysis, ANOVA single factor was used. The 600 surface polishers of all types (HC, HIHC, CC, and HCC) demonstrated higher average means of surface roughness than the 1200 surface polishers. The P-value of the average surface roughness between the 600 and 1200 surface polisher of each type of acrylic denture was significant in HIHC, CC and HCC ($P<0.018$, $P<0.006$, and $P<0.013$ respectively).

Conclusion: The surface texture differs according to the types of resin material; however, HIHC had by far the highest average surface roughness.

1. Introduction

Over the past few decades, improvements in dentistry including developments in the dental material field have greatly been realized owing to scientific research (Elshereksi *et al*., 2009; Mumcu *et al*., 2011; Morsy & Al-daous, 2013; Elshereksi *et al*., 2014). Furthermore, the patients' awareness of the dental treatment together with their knowledge has improved as a result of the increased media coverage which augmented the expectations of the patient (Anusavice, 2013). In addition, the age of the populations has increased owing to better life quality, life expectancy as well as better medical facilities, resulting in increased numbers of people who wear a denture (Anusavice, 2013). However, a denture is not only used by elderly individuals as a result of missing their teeth; rather, it is used to replace the missing teeth due to congenital causes or acquired causes such as trauma (Robert, 2005).

The use of a complete denture for treating edentulous patients dates back to 700BC (Alla, 2013). Since then, different material types have been used to construct dentures in order to restore the physiological functions and esthetics of the oral tissues of the patients. These materials included vulcanized rubbers, ivory, wood, and bone (Morsy & Al-daous, 2013). Furthermore, materials such as cellulose plastics, bakelite modifications, vinyl acetate, and poly vinyl chloride were utilized in the early 1900's. Then, Walter Wright introduced the Poly (methyl methacrylate) (PMMA) in 1937. Although many new materials were introduced like light-activated urethane dimethacrylate and polystyrene rubber, PMMA is still the material of choice for the denture base constructions (Sakaguchi & Powers, 2012; Darbar *et al*., 1994; McCabe & Walls, 2008; Mohamed et al., 2008; Mohamed *et al*., 2010; Ladha & Shah, 2011).

Therefore, studying the surface properties of the acrylic resin denture base materials is absolutely crucial (Nevzatoğlu *et al*., 2007). According to Charman *et al*., (2009), the surface properties have an impact on service ability, hygienic of the denture and microorganism accumulation, as there is a relationship between

2020 University of Benghazi. All rights reserved. ISSN 2663-1407; National Library of Libya, Legal number: 390/2018

roughness and bacterial on the one hand and fungal growth as a risk for denture stomatitis on the other hand.

The aim of this study was to assess and compare the surface roughness of different types of acrylic resin denture base materials, which are heat cure, high impact heat cure, clear heat cure, and clear chemical cure in order to find out which type has the highest surface roughness. In addition, surface texture and morphology of denture base materials were viewed by a scanning electron microscope (SEM).

2. Experimental

Four types of denture base materials are currently used for fabrication of denture base. These materials include heat cure (Poly methylmeth acrylate-HC), high impact heat cure (ENIGMA-high base impact resistance-HIHC), heat cure clear (Aesthetic base material-HCC), and clear chemical cure (Aesthetic autopolmerisate-CC). These materials were used as received and manipulated according to their manufacturer's recommendations.

2.1 Materials

Twenty-five samples measuring 11 mm in diameter and 3mm in thickness for each different type of acrylic resins were prepared using modeling wax. In order to prepare modeling wax, silicon mold containing discs voids with the above dimensions was fabricated, and then wax was placed into these circles to produce modeling wax. After that, modeling wax was invested by dental stone in dental flasks to form a mold and finally processed as in conventional procedures as recommended by the manufactures. These flasks were placed in a curing bath for 6 hours at 95°C with the exception of auto-polymerized type, which was placed in hydroflask (Kulzer) containing hot water under pressure for 50 minutes at 55°C. After cooling down the flasks were opened and acrylic samples removed. The samples were trimmed by a low-speed handpiece to remove any excess and to be ready for polishing. Subsequently, all samples were polished by a grinder polisher (Buehler Metserve) using two sizes of silicon carbide paper (p600 and p1200 grit-silicon). First, all samples were polished by p600. Then, half of each type was polished again by grinding paper p1200. In order to test the surface roughness, all samples were washed with acetone, dried, and then tested by utilizing a contact profilometer (Stylus profilometer, Mitutoyo SurTest-SJ-301-Japan). Three readings for each sample were made and the mean value was calculated. The average surface roughness (Ra) in microns was used to express the surface roughness via movement of the diamond stylus instruments under constant pressure across the surface of the sample. The expression of surface roughness was calculated as follow:

$$Ra = \frac{1}{nS(X_i - X)}$$

Ra: average surface roughness
X: the mean height
Xi: an individual pixel height

To visualize the surface roughness of the samples, a scanning electron microscope (Philips XL-20) was utilized. Samples were fixed on aluminum stubs by using double-sided magnetic tape. The samples were then coated with gold in a sputter coater (Edwards S150b) for 1 minute 30 seconds at a pressure under 4 mbar. Lastly, pictures of various magnifications were taken.

3. Results

To investigate the surface roughness of the acrylic dentures, a profilometer was used. The surface roughness (Ra) was measured 3 times for each sample and the average mean was calculated. The results illustrated that 600-grit silicone surface polishers of all types (HC, HIHC, CC, and HCC) had higher average means of surface roughness than 1200 surface polishers. Therefore, the1200 surface polishers of all types were about 2/3 as high as the 600 polishers except in HIHC which was about half as common as the 600s (Table 1). The high impact heat cure (HIHC600) had by far the highest average means, which accounted for 1.9 µm. HIHC1200 was about half as much as HIHC600, which was made up of 0.9 µm, but it was still higher than the other three types of denture base materials. Heat cure (HC) and heat cure clear (HCC) had a quite similar average mean roughness in both 600 and 1200 whereas the chemical cure was slightly higher than HC and HCC. Furthermore, the P-value which is between the 600 and 1200 surface polishers of each type of acrylic denture was significant in HIHC, CC, and HCC which were 0.018, 0.006, and 0.013 respectively (Fig. 1).

Table 1

Mean and standard deviation for surface roughness (µm) of different types of denture base materials polished with 600 and 1200 surface polishers.

Materials	Grit-silicon polisher	Ra (µm) Mean±SD
Heat cure (HC)	600 1200	0.59±0.21 0.33±0.02
High impact heat cure (HIHC)	600 1200	1.87±0.20 0.87±0.30
Chemical cure (CC)	600 1200	0.71±0.08 0.40±0.03
Heat cure clear (HCC)	600 1200	0.56±0.05 0.30±0.09

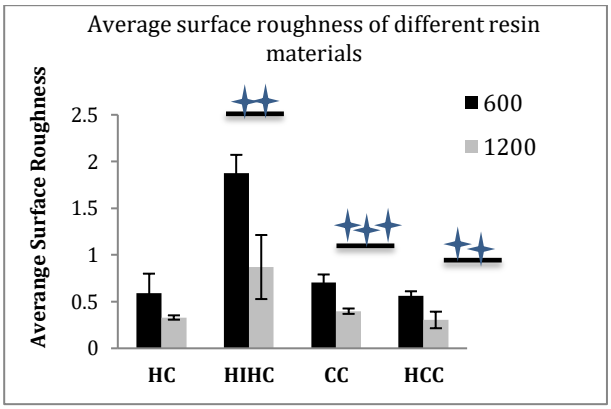

Fig. 1. The average of surface roughness at different surface polishers (600 and 1200).

4. Discussion

According to Anusavice (2013) the decrease in the surface roughness of the denture results in a decrease in the friction which in turn reduces the abrasion impact on the soft tissue of the patient. Moreover, other studies indicate that the high rough surface results in an increase in the stain as well as in the adhesion of the microorganisms in the surface (Boyd, 2001; Enas, 2017; Mai *et al*., 2018; Miranti *et al*., 2018). Therefore, clinicians and dentists should take the reduction in surface roughness into account when they choose the type of acrylic denture. Although in the current study only a small area of the samples was assessed by a profilometer, the statistical analysis showed that self-cure (CC) might be less suitable than the conventional heat cure as a denture base material. A previous study conducted by Kuharand and Funduk (2005) contrasted three different types of acrylic resins: heat cure (HC), injected heat cure (IHC), and auto-polymerized (CC). Therefore, 2 materials: CC and HC were similar to those in the present study. Additionally, they used the same testing machine which is the profilometer, and 6 various polishing techniques such as the polishing systems of 2 conventional laboratory lathes, the cream intended for the laboratory and the chair-side use, and polishing kits of 3 chair-side silicone. They found out that the surface roughness (Ra) was affected by the types of acrylic resins and by the method of finishing and polishing. For example, there was a significant difference in the average roughness between heat-polymerizing and auto-polymerizing resins. They demonstrated that chemical cure (CC) had greater surface roughness than a heat cure (HC) and injected heat cure

(IHC). This result was similar to that obtained in this study data in terms of HC and CC. In addition, Kuharand and Funduk (2005) observed that finishing and polishing the materials had a greater effect on the surface roughness rather than on their types.

However, when comparing this study with the other research studies, approximate results can be obtained. As the polishing techniques were affected by several factors, including the rotating polisher pressure and speed which are difficult to control, completely flat surfaces are not easy to obtain; besides, the operator experience (Kuharand and Funduk, 2005). According to Nevzatoğlu *et al.* (2007) who applied the non-contact technique, the profilometer, with the optical scanning probe instead of the diamond stylus (contact profilometer) in order to measure the surface roughness, the main disadvantage of the contact profilometer is that it inflicted damage on the surface during the measurements as a result of the stylus movement. Furthermore, to view the effect of polishing on the surface of the different acrylic resin, the scanning electron microscope (SEM) was used. The assessment of the different material types with SEM revealed various surface irregularity degrees (Figs. 2&3). Large porosity amounts were exhibited in the HIHC (Fig. 2A).

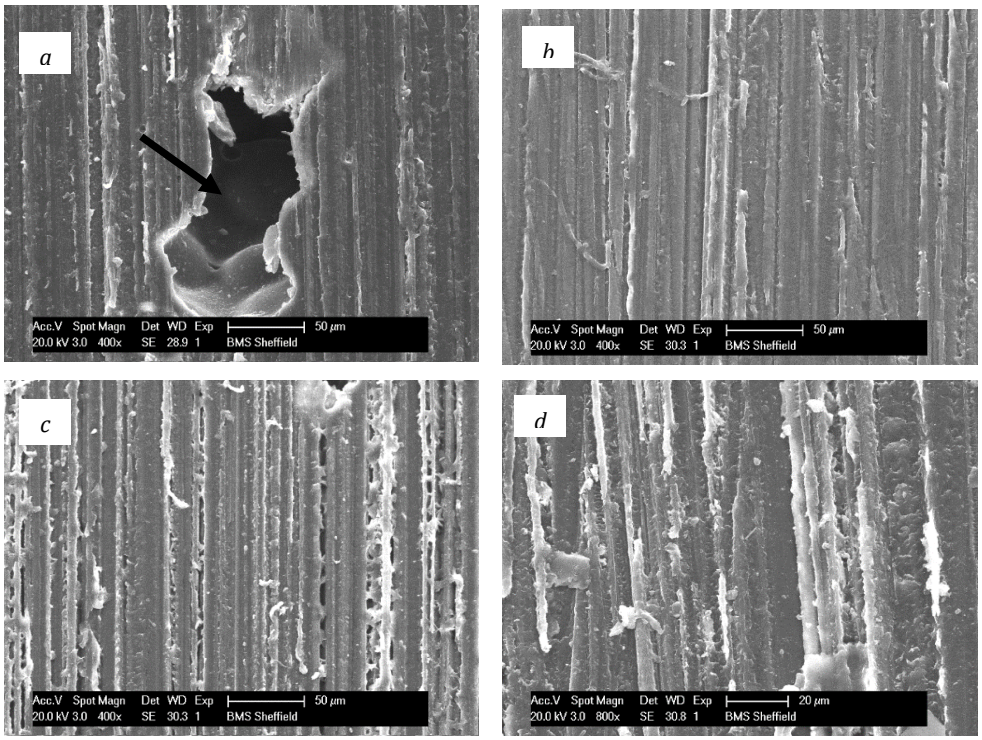

Fig. 2. SEM graphs of 600 polisher at magnifications 400x. (a-HIHC, b- HCC, c- HC and d- CC).

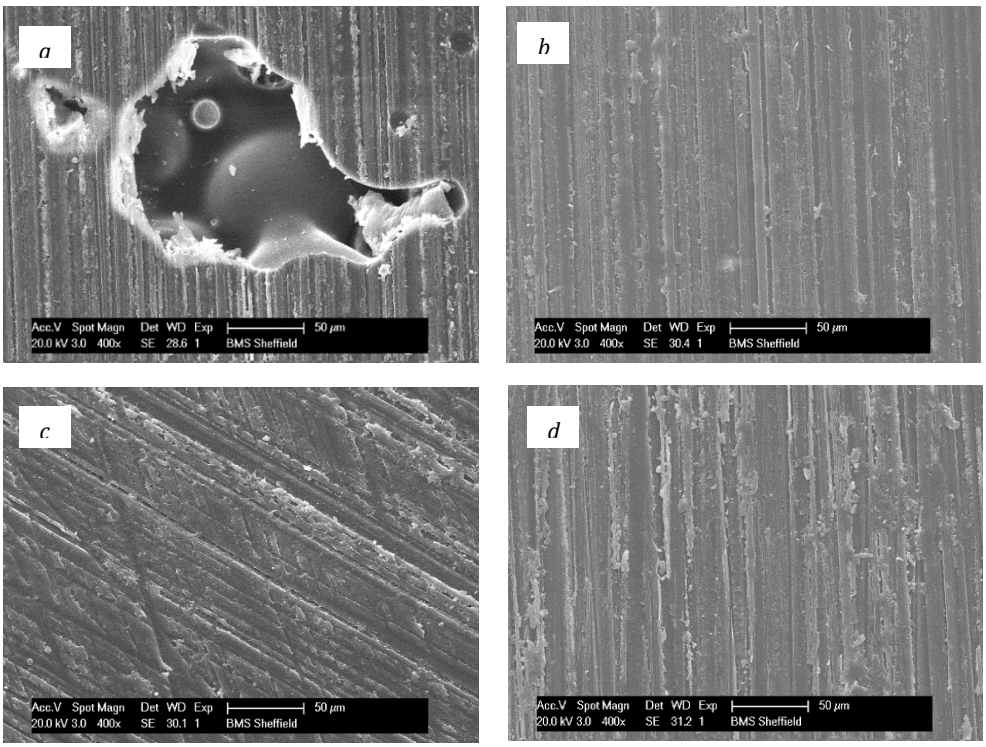

Fig. 3. SEM graphs of 1200 polisher grit-silicon at magnifications 400x. (a-HIHC, b- HCC, c- HC and d- CC).

HIHC displayed high surface porosities under SEM and the reason for that may contribute to the polishing effect on the materials rather than the material properties (Kuharand and Funduk, 2005). Regarding HCC and HC (600, 1200), HCC1200 had the least surface roughness, followed by HCC600 and HC1200, and lastly HC600, which had the highest surface irregularities. However, even though

three different types of heat cure (HIHC, HC and HCC) have shown a variable amount of surface porosity and irregularities, CC600 had much higher surface irregularities. Morgan and Wilson (2001) contributed the self-cure reins (CC) irregularities to the release of air bubbles during polymerization. Another study carried out by Kuhar and Funduk (2005) displayed a large porosity of chemical cure rein under SEM. Therefore, these results confirm observation previously reported which indicates that the chemical cure had higher surface irregularities than the conventional heat cure (HC).

5. Conclusion

Within the limitations of this study can be concluded that the surface roughness of 600-grit silicone surface polisher of all types (HC, HIHC, CC and HCC) had higher average means of surface roughness than the 1200 surface polisher. The surface of the denture base differs according to the polishing technique as well as types of materials. Thus, according to the finding of the current study, it should be recommended to use 1200 grit instead of 600 grit as the final step for surface polisher before utilizing polishing past.

Acknowledgments

The authors would like to thank the University of Sheffield for providing the facilities and lab equipment for doing the experimental testing.

References

Alla, R. K. (2013) 'Influence of Fiber Reinforcement on the properties of denture base resins', *J. Biomater and Nanobiotec*, 04(01), pp. 91–97.

Anusavice, K. J. (2013) Phillips' Science of Dental Materials 12th ed: Saunders, an imprint of Elsevier Inc pp. 9-14, 475-495.

Boyd, P. T. (2001) 'The relationship between substratum surface roughness and microbiological and organic soiling: *A review*', *Biofouling*, 17(1), pp. 59-71.

Charman, K. M., Fernandez, P., Loewy, Z. & Middletona, A. (2009) ' Attachment of Streptococcus oralis on acrylic substrates of varying roughness', Letters in applied microbiology, 48(4), pp. 472–477.

Darbar, U. R., Huggett, R. & Harrison, A. (1994) 'Denture fracture-a survey', *Br. Dent.J*., 176, pp. 342-345.

Elshereksi, N. W., Mohamed, S. H., Arifin, A. & Ishak, Z. A. M. (2009) 'Effect of filler incorporation on the fracture toughness properties of denture base poly(methyl methacrylate)', *J. Phys. Sci*., 20(2), pp. 1–12.

Elshereksi, N. W., Mohamed, S. H., Arifin, A. & Ishak, Z. A. M. (2014) 'Thermal Characterisation of Poly(Methyl Methacrylate) Filled with Barium Titanate as Denture Base Material', *J. Phys Sci*., 25(2), pp. 15–27.

Enas, T. D. (2017) 'The Effect of Different Denture Base Materials on Microbial Flora Growth', Current Science International, 6(2), pp. 314-320.

Kuhar, M. & Funduk, N. (2005) 'Effects of polishing techniques on the surface roughness of acrylic denture base resins', *J. Prosthet Dent*., 93, pp. 76-85.

Ladha, K. & Shah, D. (2011) 'An in-vitro evaluation of the flexural strength of heat-polymerized poly (methyl methacrylate) denture resin reinforced with fibers', *J. Ind. Prosth. Soc*., 11, pp. 215–220.

Mai, S. D., Amr, M. B., Emad, M. A. & Gehan, F. M. (2018) 'Effect of two polishing techniques on surface roughness of three different denture base materials', *Alexandria Dental J*., 43(3), pp. 34-40.

McCabe, J. F. & Walls, A. W. G. (2008) '*Applied dental materials*' 9th ed. London: Blackwell.

Miranti, A., Ariadna, A. D. & Sri, A. (2018) 'SCandida Albicans Biofilm Profiles on Various Denture Base Materials', *J Int Dent Med Res*, 11(1), pp. 191-196.

Mohamed, S.H., Ajaal, T., & Al-Jadi, Alb. M. (2010) 'Evaluation of Impact Strength and Micro-Hardness of Denture Base Acrylic Resin (PMMA) Part II', *J. of Chemist and Chemic Eng*, 4(12), pp. 52-56.

Mohamed, S.H., Al-Jadi, Alb. M. & Ajaal, T. (2008) 'Using of HPLC analysis for evaluation of residual monomer content in denture base material and their effect on mechanical properties', *J. Phys. Sci*., 19(2), pp. 127-135.

Morgan, T.D. & Wilson, M. (2001) ' The effects of surface roughness and type of denture acrylic on biofilm formation by Streptococcus oralis in a constant depth film fermentor', *J App Microbiol*., 91, pp. 47–53.

Morsy, M.A. & Al-daous, M.A. (2013) 'Mechanical Properties, Evaluation of New. Au NP-PMMA Composite', *Inter. Rev. of Chem. Eng. J*. (I.RE.CH.E.), 1(5), pp. 66–70.

Mumcu, E., Clingir, A., Gencel, B. & Sulun, T., (2011) 'Flexural properties of a light-cure and a self-cure denture base materials compared to conventional alternatives', *J. advan. Prosth*., 3(3), pp. 136–9.

Nevzatoğlu, E. U., Ozcan, M., Kulak-Ozkan, Y. & Kadir, T. (2007) 'Adherence of Candida albicans to denture base acrylics and silicone-based resilient liner materials with different surface finishes', *Clin Oral Investig*, 11, pp. 231-236.

Robert, K. (2005) 'Personalized processed denture bases', Dentures. Dental La Product. 28.

Sakaguchi, R.L & Powers, J.M. (2012) Craig's Restorative Dental Materials. 13th ed. St. Louis: Mosby.ch.1, pp. 1-4.