EGYPTIAN DENTAL JOURNAL
www.eda-egypt.org
VOL. 69, 2909:2915, OCTOBER, 2023
PRINT ISSN 0070-9484 • ONLINE ISSN 2090-2360
FIXED PROSTHODONTICS AND DENTAL MATERIALS
Submit Date : 19-07-2023 • Accept Date : 22-08-2023 • Available online: 15-10-2023 • DOI : 10.21608/EDJ.2023.223281.2639

SURFACE ROUGHNESS OF IMPLANT RETAINED ACRYLIC MANDIBULAR OVERDENTURE TREATED WITH TITANIUM DIOXIDE NANOPARTICLES: AN IN VITRO COMPARATIVE STUDY

Aml. A Shafik[*], Reham T. K. El Beheiry[**], Moataz H. Al-hosainy[**] *and* Amr M. I. Badr [***]

ABSTRACT

Statement of problem: to enhance the mechanical and biological qualities of heat-cured denture base resins, titanium dioxide nanoparticles (TiO2 NP) are utilized as fillers. Denture base resins' surface roughness is a crucial physical characteristic because roughened denture surfaces are prone to collect bacteria, which can cause oral candidiasis. The aim of this study was to evaluate the surface roughness of implant retained mandibular overdentures after adding Titanium Dioxide Nanoparticles**.**

Materials& Methods: Two implants were placed in the canine region of an Epoxy model that simulated an edentulous jaw. After being fastened to the implants bilaterally, the ball and socket abutments were covered by the appropriate metal housing. The acrylic resin denture (PMMA) was used to create Group A (the control group), and an acrylic resin treated with salinized titanium dioxide nanoparticles (Tio2 Nps), as the manufacturer's instructions, was used to create Group B. To measure the surface roughness of each denture, use a contact stylus profilometer surface roughness tester. to compare the two groups, the Student's t-test was performed. In all tests, P values under 0.05 are regarded as statistically significant.

Results: The dentures constructed from acrylic resin modified by Salinized Titanium Dioxide (Group B) showed statistically a significant difference than control group (Group A) regarding the surface roughness

Conclusion: Dentures constructed from acrylic resin modified with Salinized Tio2 Nps had a higher surface roughness than the dentures constructed from acrylic resin only.

KEYWORDS: PMMA/ Tio2 Nps/ stylus

* Demonstrator of Prosthetic Dentistry, Faculty of Dentistry, Minia University.
** Lecturer of Prosthetic Dentistry, Faculty of Dentistry, Minia University.
*** Professor and Head of Prosthetic Dentistry Department, Faculty of Dentistry, Minia University

INTRODUCTION

In the mandibular overdenture, there is a small residual ridge, that lacks sufficient retention and stability. Insertion of implants creates a more favorable environment for the prosthesis in edentulous patients. So implant-retained overdentures are considered the restoration of choice due to the reduced number of implants, improved phonetics, and sufficient stability and retention. [1]

The use of implants has dramatically improved treatment choices for most edentulous patients, but it may not be suitable for all patients, particularly in less prosperous countries or for patients who are unable to afford the costs associated with this treatment option. [2]

For the edentulous mandible, placement of implants is usually performed in the interforaminal area, particularly in the region of canine and first premolar teeth, due to the presence of good bone volume and density and the absence of vital structures.[3] A two-implant overdenture has been considered the first choice for the treatment of edentulous patients. [4]

The most common unsplinted attachment used to keep a mandibular overdenture is a ball and socket attachment because it is straightforward, less expensive, and affects patient satisfaction. [5]

Although Polymethyl Methacrylate (PMMA) offers numerous benefits, such as superior aesthetics, biocompatibility, and simplicity of laboratory processing for clinical usage. [6]

One of the many biomechanical parameters with clinical significance is surface roughness. It is preferable to have a smooth, well-polished surface to prevent the accumulation of bacteria and plaque. Roughened acrylic surfaces can collect plaque and bacterial adherence.

Plaque accumulation and stains are encouraged by the surface roughness and imperfections of a PMMA denture foundation, which over time has a negative impact on the appearance and biological characteristics of acrylic dentures. [7]

There is controversy concerning adding titanium dioxide nanoparticles to the implant-retained acrylic mandibular overdenture regarding surface roughness.

MATERIALS AND METHODS

A ready -made Epoxy model of mandibular completely edentulous ridge was used in that study. (Fig. 1).

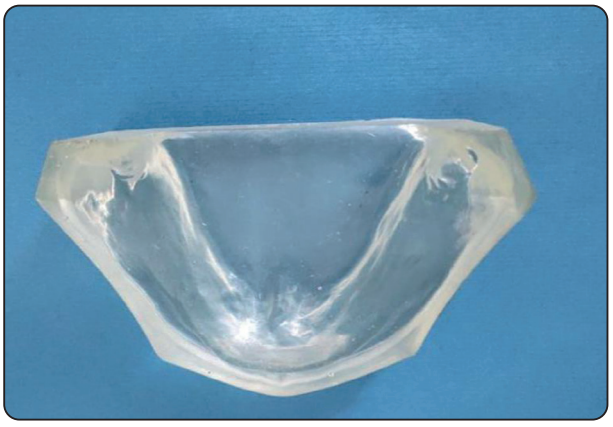

Fig. (1) A ready-made Epoxy model of completely edentulous ridge.

Implant installation procedure:

Two identical internal hex implants (3.5 mm diameter and 10 mm length, Neobiotic Co., Ltd., GURO 10F, E-space Bldg., 36, Digital-ro 27 gil, Guro-gu, Seoul, 08381, Republic of Korea) were inserted in the canine region perpendicular to the residual ridge area bilaterally (Fig. 2).

Fig. (2) The two implants were fixed at the mandibular canine region

The two implants received two identical ball and socket abutments (diameter 3.5 mm, Neobiotic Co., Ltd., MB35103Republic of Korea. Lot. P02022010028) bilaterally. Then the two abutments were covered with their corresponding metal housings (Fig. 3).

Salinization of Titanium dioxide nanoparticles (Tio2 Nps):

Tio2 NPS powder was mixed with Toluene in a container. Then the mixture was sonicated using an ultrasonic probe (cleaner). After that, 3-aminopropyl triethoxysilane (APTS) was added to that mixture. After 48 hours, that mixture was placed in the Evaporator (Dlab scientific Co., Ltd.RE100 -S, china) to remove the toluene. Then the Salinized Tio2 NPS was dried in a vacuum oven (Eco-type oven, Daihan Scientific, EON-50, Korea).

Fig. (3) The two ball and socket attachments

Measuring the powder of PMMA and Salinized Tio2 Nps:

Weighing 1% wt of Salinized Tio2 Nps (0.332gm by weight) and the powder of PMMA (33.2gm by weight) using Digital Balance (Electronic Balance ATY, Shimadzu Corporation) (Fig. 4).

Construction of the overdenture:

The Epoxy model with the implant installed was duplicated using the duplicating material to produce the casts used in the construction of the dentures. Two sheets of pink base plate wax were applied to the stone cast, and the setting up of teeth was done. In Group A, the dentures were made of PMMA only. In Group B, the dentures were made of PMMA modified by Salinized Tio2 Nps. For group B, the Salinized TiO2 NPS powder was added to the acrylic monomer and mixed. The acrylic powder was added to that mixture, and mixing continued until a consistent mixture was obtained. Flasking, packing, curing, finishing, and polishing were done for all dentures according to manufacturing instructions (Fig. 5).

Fig. (4) (Measuring the powder of PMMA and Salinized Tio2 Nps using Digital Balance)

Fig. (5) Finished and polished denture

Measuring the thickness of the dentures:

To confirm that all dentures had the same thickness a Calliper was used. All dentures were measured the same thickness especially at the canine regions.

Picking up procedure:

The nylon caps and steel housing were located over the ball abutments. Enough clearance was ensured at the fitting surface of the dentures. Petroleum jelly (Vaseline) was applied to the model. Small two holes were drilled at the lingual surface of the overdenture opposite each ball. The overdentures were seated over the model to pick up the two ball abutments using self-cure acrylic resin at the dough stage. Pressure was applied until the acrylic resin was completely cured. After the complete setting of the acrylic resin, the excess acrylic was removed and then finished (Fig. 6).

Fig. (6) Picking up the metal housing

Surface roughness (Ra) test

The surface roughness was measured using a Contact stylus Profilometer Surface Roughness Tester (Mitutoyo Surf Test SJ 210, Mituto Corp., Japan). The tester has a retractable drive unit type with a diamond contact stylus. Where the Stylus travels a distance of 4 mm at a speed of 0.5mm/sec with 4 mN of force. Then, this is converted to a digital signal, which is stored and displayed. The measurement was based on the average surface Roughness (Ra) value, which is the Mean of the profile movement above and below the mandibular dentures (Fig. 7,8).

All the data were measured, collected, tabulated and statistically examined.

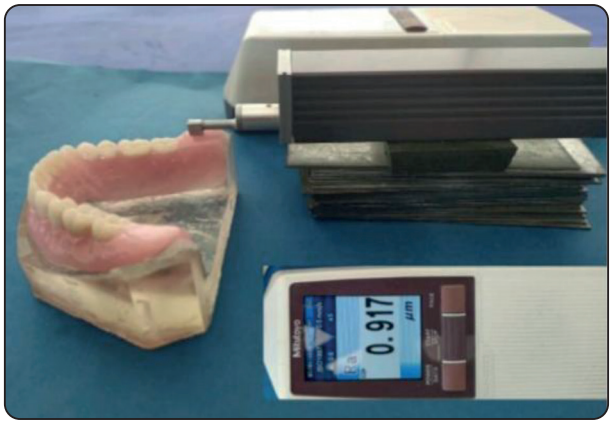

Fig. (7) Measuring the surface roughness for the acrylic dentures

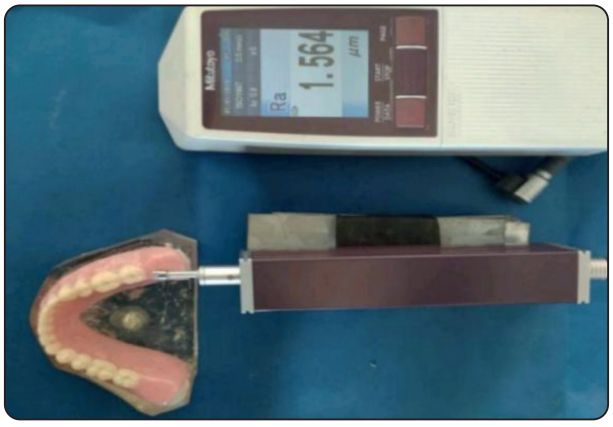

Fig. (8) Measuring the surface roughness for the acrylic dentures modified by Salinized Tio2 Nps)

RESULTS

By examining the data distribution and applying tests for normality (Kolmogorov-Smirnov and Shapiro-Wilk tests), numerical data were examined for normality. The distribution of all the data was normal (parametric). The mean and standard deviation (SD) values of the data were displayed. In order to compare the two groups, the Student's t-test was performed. The cutoff for significance was chosen at P 0.05. With IBM SPSS Statistics for Windows, Version 23.0, statistical analysis was carried out. IBM Corp., Armonk, New York.

I- Surface roughness (μm)

The dentures that were constructed from acrylic resin modified by Salinized Titanium Dioxide (Group B) showed statistically significantly higher mean surface roughness than control group (Group A).

TABLE (1) Descriptive statistics and results of Student's T-test for comparison between surface roughness (μm) of the two groups.

Salinized titanium dioxide (n=10)		PMMA (control group) (n=10)		P-value	Effect size
Mean	SD	**Mean**	SD		
1.391	0.0783	0.9113	0.0851	<0.001	8.869

Significant at P ≤ 0.05

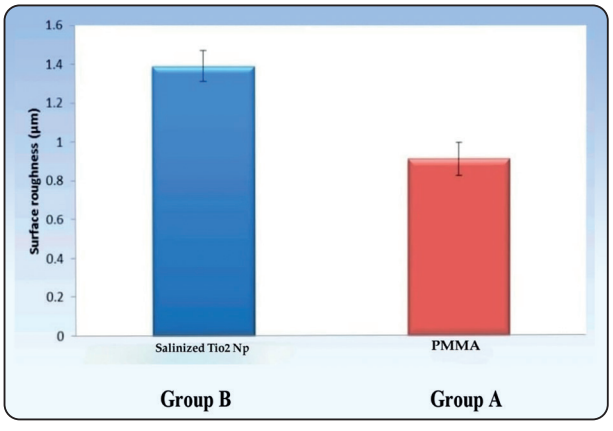

Fig. (9) Bar chart representing Mean and Standard deviation values for Surface roughness of the two groups (Group A and B)

DISCUSSION

The aim of the present study depends on a simplified approach to treatment planning decisions, attachment selection, and technique.

The reason for using the epoxy resin model is that it simulates the human mandibular bone in modulus of elasticity (20GpA). [8] Also, epoxy resin material has good mechanical properties that prevent mechanical failure of the model or implant detachment while applying forces to the assembly. [9]

An implant-retained overdenture system has been a common treatment for edentulous patients. It has improved overdenture retention, stability, support, and chewing ability. Moreover it preserve the surrounding bone, and enhanced patient satisfaction by utilizing different retentive attachment systems. [10]

Placement of the implant in the canine region, is necessary to limit forward rocking during function; if placed more posteriorly, greater hinging will be allowed, leading to greater leverage forces against the implants. [11]

Two equal implants (3.5 mm diameter /11mm in length) had been inserted in the canine areas bilaterally, a milling gadget had been used to ensure the implants were perpendicular to the residual ridge and parallel to each other. [12]

In the construction of the denture, the cast was produced by using an epoxy model that was duplicated using duplicating material to produce an accurate replica of the cast. The dentures had been made of an even thickness and shape by using the same sheets of base plate wax to standardize the thickness and using a micrometer (calliper) to confirm the same thickness of all dentures. [13]

In this study using Salinized TiO2 nanoparticles, the salinization process led to the creation of a layer of siloxane on the nanoparticle surface through the condensation process. So, these layers are formed as a result of the silane interaction with the hydroxyl group (OH–), which is present on the nanoparticle

surface, which will then induce the formation of the bonding between the inorganic filler and the organic polymer of PMMA. [14]

Ball attachments had been used due to their ease of handling, low cost, and possible application with both root- and implant-retained prostheses and for non splinted implants. [5]

TiO2 NP, when added to denture base resins, showed a significant increase in certain properties, like the mechanical properties of PMMA.[15], Hwever, on addition of these nanoparticles, the comparative effect on surface Roughness is not known.

The present study was undertaken to evaluate the effect on surface roughness of the addition of Tio2 NP in PMMA. Various studies were previously done with different Percentages of Tio2 NP (i.e., 1%, 2%, 3.5%, 4%, 5%, etc.), and it was shown that TiO2 NPs remains one of the preferred alternatives due to their ease of availability, low toxicity, chemical stability, good physical properties, antibacterial activity, and cost-effectiveness when added at very low concentrations[16,17,18].

Although, with the addition of TiO2 NP, improvements in certain mechanical properties were observed, the surface roughness also increased. [19]

While interpreting the results of this research, one should take the limitations of the study into consideration, as it was an in vitro study that does not simulate the oral cavity. [20] Thus, the direct implications of the results must be exercised with caution. However, in this study, the use of standardized experimental conditions was an advantage.

CONCLUSION

Within the limitations of the previous study we can conclude that: Dentures were constructed from acrylic resin modified with Salinized Tio2 Nps had higher surface roughness than the dentures that were constructed from acrylic resin only.

RECOMMENDATION

Addition of TiO2 NP improves certain mechanical properties, but also the surface roughness increases. Thus, additional methods to improve the surface roughness must be researched and recommended.

We should take the limitations of the study into consideration, where it was in vitro study. So, more clinical investigations and studies are recommended.

Author contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by [Aml Atef Shafik], [Reham Tharwat Kamal Mohamed], [Moataz Elhosainy Hassin], and (Amr Mohamed Ismail). The first draft of the manuscript was written by [Aml Atef shafik Nesim] and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Funding

The authors received no specific funding for this work

Acknowledgements

The corspondar would like to thank, Dr Reham Tharwat Kamal Mohamed and Mariam Raef Rafeek for their efforts in this study.

REFERENCES

1. Ortensi L, Martinolli M, Borromeo C, et al. Effectiveness of Ball Attachment Systems in Implant Retained- and Supported-Overdentures: A Three- to Five-Year Retrospective Examination. Dent J (Basel). 2019;7(3):84. Published 2019 Sep 1. Doi:10.3390/dj7030084.

2. Bernhart G, Koob A, Schmitter M, Gabbert O, Stober T and Rammelsberg P. Clinical success of implant-supported and tooth-implant-supported double crown-retained dentures. Clin Oral Investig. 2012;16(4):1031-1037. Doi:10.1007/s00784-011-0592.

3. Mona Abo Elezz: Effect of different implant numbers and locations on strains around implants retaining mandibular overdentures with locator attachments. An invitro strain gauge analysis. Egyptian Dental Journal. 2022, 2679-2690.

4. Srinivasan M, Makarov NA, Herrmann FR, and Müller F. Implant survival in 1- versus 2-implant mandibular overdentures: a systematic review and meta-analysis. Clin Oral Implants Res. 2016;27(1):63-72. Doi:10.1111/clr.12513.

5. Anas El-Wegoud M, Fayyad A, Kaddah A, and Nabhan A. Bar versus ball attachments for implant-supported overdentures in complete edentulism: A systematic review. Clin Implant Dent Relat Res. 2018;20(2):243-250. Doi:10.1111/cid.12551.

6. Gad MM, Fouda SM, Al-Harbi FA, Näpänkangas R, and Raustia A. PMMA denture base material enhancement: a review of fiber, filler, and nanofiller addition. Int J Nanomedicine. 2017;12:3801-3812. Published 2017 May 17. Doi:10.2147/IJN.S130722.

7. Kurt A, Erkose-Genc G, Uzun M, Sarı T, and Isik-Ozkol G. The Effect of Cleaning Solutions on a Denture Base Material: Elimination of Candida albicans and Alteration of Physical Properties. J Prosthodont. 2018;27(6):577-583. Doi:10.1111/jopr.12539.

8. Lee CK, Karl M, and Kelly JR. Evaluation of test protocol variables for dental implant fatigue research. Dent Mater. 2009; 25(11):1419-1425. Doi:10.1016/j.dental.2009.07.003.

9. Stefos S, Kourtis S, Sarafianou A, and Zoidis P: The Influence Of Impression Material on the Accuracy of the Master Cast In Implant Restorations. The Open Dentistry Journal. 2018 Dec 31;12(1).

10. Singh S, Mishra SK, and Chowdhary R. Patient satisfaction and crestal bone changes with one-piece and two-piece single implant-retained mandibular overdenture: A randomized controlled clinical study. J Prosthodont Res. 2023;67(1):112-120. Doi:10.2186/jpr.JPR_D_20_00315.

11. Hong HR, Pae A, Kim Y, Paek J, Kim HS, and Kwon KR. Effect of implant position, angulation, and attachment height on peri-implant bone stress associated with mandibular two-implant overdentures: a finite element analysis. Int J Oral Maxillofac Implants. 2012;27(5): 69-76.

12. Tabatabaian F, Alaie F, and Seyedan K. Comparison of three attachments in implant-tissue supported overdentures: an in vitro study. J Dent (Tehran). 2010;7(3):113-118.

13. Sayed ME, Porwal A, Ehrenberg D, and Weiner S. Effect of Cast Modification on Denture Base Adaptation Following Maxillary Complete Denture Processing. J Prosthodont. 2019;28(1): 6-12. Doi:10.1111/jopr.12594.

14. Ali Sabri, B., Satgunam, M., Abreeza, N. M., and N. Abed, A. A review on enhancements of PMMA denture base material with different nano-fillers. Cogent Engineering. 2021, 8(1), 1875968.

15. Pai E, Nayak A, Hallikerimath RB, Ruttonji Z, Astagi P, and Pokale S. Comparison of titanium dioxide nanoparticles and silver nanoparticles for flexural strength once incorporated in heat-cure acrylic denture base resin: An in vitro Study. J Indian Prosthodont Soc. 2023;23(2):127-134. Doi:10.4103/jips.jips_354_22.

16. Frazer RQ, Byron RT, Osborne PB, and West KP. PMMA: an essential material in medicine and dentistry. J Long Term Eff Med Implants. 2005;15(6):629-639. Doi:10.1615/jlongtermeffmedimplants.v15.i6. 60.

17. Ghahremani L, Shirkavand S, Akbari F, and Sabzikari N. Tensile strength and impact strength of color modified acrylic resin reinforced with titanium dioxide nanoparticles. J Clin Exp Dent. 2017;9(5): 661-665. Published 2017 May 1. Doi:10.4317/jced.53620.

18. Gad MM, Rahoma A, Al-Thobity AM, and ArRejaie AS. Influence of incorporation of ZrO2 nanoparticles on the repair strength of polymethyl methacrylate denture bases. Int J Nanomedicine. 2016;11:5633-5643. Published 2016 Oct 27. Doi:10.2147/IJN.S120054.

19. Kaurani P, Hindocha AD, Jayasinghe RM, Pai UY, Batra K and Price C. Effect of addition of titanium dioxide nanoparticles on the antimicrobial properties, surface roughness and surface hardness of polymethyl methacrylate: A Systematic Review. F1000Res. 2023; 12:577. Published 2023 May 31.

20. Cristache CM and Totu EE. 3D Printing-Processed Polymers for Dental Applications. In Reactive and Functional Polymers. P 2020 Oct 24 (3): 141-164.