AL-AZHAR
Journal of Dentistry

The Official Publication
of The Faculty of Dental
Medicine For Girls,
Al-Azhar University
Cairo, Egypt.

Print ISSN 2974-4156 • Online ISSN 2974-4164

AZJD, Vol. 10, No. 2, April (2023) — PP. 335:342

The Effect of Zirconia and Titanium as Abutment Materials on Peri-Implant Soft and Hard Tissues in Mandibular Implant Supported Over-denture.

Reham M. Elshiekh[1*], Shereen M. Kabeel [2], Hala M. Gamal El-Din[3]

Codex : 1-07/23.04

azhardentj@azhar.edu.eg

http://adjg.journals.ekb.eg

DOI: 10.21608/adjg.2023.126015.1477

Restorative Dentistry
(Removable Prosthodontics, Fixed Prosthodontics, Endodontics, Dental Biomaterials, Operative Dentistry)

ABSTRACT

Purpose: To evaluate the effect of zirconia and titanium as abutment materials on peri-implant bone height changes and pocket depth in mandibular implant supported over-denture. **Subjects and methods**: Ten completely edentulous patients were selected from the Outpatient Clinic of the Faculty of Dental Medicine for Girls, Al-Azhar University. Two implants were implanted in the inter-foraminal area of mandibular ridge. Two different abutments were screwed over implants. Right abutment was constructed of zirconia and left one was constructed of titanium. Construction of maxillary complete denture and mandibular implant supported over-denture for all patients was performed. Radiographic and clinical evaluation of implants has been performed at denture insertion, 6 months, 9 months and 12 months. **Results**: The previous study illustrated that titanium abutments had significantly higher values of bone height changes and pocket depth measurements than zirconia abutments during follow up period. **Conclusion**: Zirconia abutments had great superiority over titanium abutments in preservation of peri-implant hard and soft tissues in mandibular implant-supported over-denture within the follow up period of this study.

KEYWORDS

Implant over-denture,
Zirconia abutment,
Titanium abutment.

INTRODUCTION

New research recommended the use of removable prosthesis with different abutments attached to dental implants or / and natural teeth. It has been presented as a widely approved and scientifically well-defined approach within dental field and predates the institution of oral implantology [(1)].

The use of implant supported over-denture with its stability, retention and support can be considered as an excellent treatment

1. Assistant Lecturer at Prosthodontic Department, Faculty of Dental Medicine for Girls, Al-Azhar University, Cairo, Egypt.
2. Assistant Professor at Prosthodontic Department, Faculty of Dental Medicine for Girls, Al-Azhar University, Cairo, Egypt.
3. Professor at Prosthodontic Department, Faculty of Dental Medicine for Girls, Al-Azhar University, Cairo, Egypt.

* Corresponding author email: drrehamelshiekh88@yahoo.com

modality and one of the most beneficial treatments offered to the completely edentulous patient [2].

Although the advantages of implant- retained over-denture, there is also some disadvantages such as; its great cost and multiple sessions. It requires surgical intervention which may restrict this treatment modality for some compromised patients [3].

The introduction of new materials in dental field introduces the great demand of esthetic among population. New developments in milling technology recommend two materials to be chosen for construction of different abutments. Titanium and zirconium are materials that have been used in the fabrication of abutments which meet the biological, mechanical and aesthetic considerations [4].

In implant supported over-dentures, zirconia abutments are used as supportive factors for removable dentures. Their advantages are great support of the denture, adequate holding, their supporting function combined with superior esthetics, simple handling and cost effective extensibility. Moreover, they might develop function as a result of reduced retention force changeability and they are of interest to patients who desire an attachment with tooth like color when the denture is taken away [5].

The application of computer aided design and computer aided manufacturing (CAD/CAM) technology system introduces the construction of zirconia abutment with a natural emergence form and adequate spatial outline at the cervical edge. Moreover, CAD/CAM technology optimally monitors the geometry of the abutment including the position of the abutment in accordance with the neighboring natural teeth and the soft tissues, therefore reducing the risk of cement remnants being deep in the sulcus [6].

Radiographic follow up examinations can supply evidence of alterations in bone height around implants over follow up period. The Reliable comparison of subsequent radiographs is only possible when the technique of measuring and analysis is reproducible, thus allowing linear and volumetric changes in bone height to be monitored [7].

Probing of the peri-implant soft tissues either in the absence or presence of bleeding on probing is a substantial measurement to differentiate a tissue status of peri-implant disease or health [8].

This study aimed to evaluate the effect of titanium and zirconia as abutment materials on peri-implant bone height changes and pocket depth in the same patient in mandibular implant supported over-denture.

SUBJECTS AND METHODS

Patient Selection

Ten patients of age ranging from 55 to 65 years were chosen from outpatient clinic of Faculty of Dental Medicine for Girls, Al-Azhar University. Inclusion criteria for enrollment were; Patients had completely edentulous maxillary and mandibular ridges with adequate inter-arch space and normal ridge relationship. They were also medically free from any neurologic disturbance that might influence the neuro-muscular system or any systemic disease that might affect bone metabolism or delay post-operative healing.

The patients were instructed about all steps of this study. Only enthusiastic patients who showed co-operation collaborated in the study and an informed consent were assigned. Approval of REC (Research Ethic Committee) of the Faculty of dentistry for Girls, Al-Azhar University was obtained. (REC-PR-22-06)

Clinical examination:

Selected patients were examined intra-orally to evaluate the mucosa covering the edentulous ridge to verify the absence of signs of inflammation,

ulceration and infection. Digital examination: The width and the height of the residual ridge in the inter-foraminal region were roughly evaluated by palpating the ridge between the thumb and index fingers. Laboratory investigation pre-surgical blood analysis was carried out for all patients to avoid any complications during surgery such as: the pro-thrombin time, complete blood picture, glycated Hemoglobin.

Radiographic examination:

Cone beam radiograph (Cone Beam machine model Planmeca Paromax 3D manufacture in Finland) was taken with a radiographic stent. Availability of bone height and bucco-lingual width for implant placement was detected. Bone quality especially at the prospected implant sites was determined; the position of mental foramen and any bony pathological lesion and remaining root was also detected.

Surgical procedures:

Preliminary impression was taken for lower arch and cast was poured into stone cast. The prospective implant sites were marked on the cast at the canine regions of the lower arch. A metallic ball of 5 mm diameter was adapted to the marked sites using sticky wax. A wax template was then constructed on the lower ridge. The template was transferred into clear acrylic resin (Transparent cure acrylic resin manufacture Ivoclar Vivadent AG Schaan Lichtenstein) in the usual manner, finished, polished and checked in the patient's mouth.

The metal balls were removed from the radiographic stent and holes were drilled at the proposed implant sites to be used as a surgical stent. All patients received two root form, tapered screw endosteal implants (JD evolution system, Italy) with 11mm length and 3.2 mm diameter to be inserted bilaterally.

The pilot drill was the first drill used at the implant site followed by the sequential implant drills in order to increase diameter under copious normal saline irrigation. Color coded 3.2 mm diameter drills for 11.5 mm implant length was used to prepare the final depth and alignment of the implant site. Parallel pins were used to check the osteotomy path. Fixture driver was used to remove the fixture from its sterile package and to install the fixture in the osteotomy site then the implant was inserted into its site at first manually into the bone then by a ratchet in a clockwise direction until the implant platform became in level with bone. Finally, Hex driver was used to tighten the covering screws over the implants.

Preparation of the abutments:

For right side, titanium base (titanium base implant system, JD Evolution system, Italy) was reduced by a profile bur that is made of tungsten carbide to 2 mm length, 2.2 mm platform diameter and 0.5 chamfer finishing line. For left side, titanium abutment (Titanium base implant system, JD Evolution system, Italy) was reduced by 3 mm in length, 3.2 mm platform diameter and 0.5 chamfer finishing line. Cover screw of both implants was unscrewed in anti-clockwise direction. Left titanium abutment were screwed in place using screw driver (maximum 15 Ncm) and checked for proper fit in the implant (Fig.1.a) followed by screwing of right titanium base. Impression with rubber base material (Zetaplus / Oranwash L, Zhermack, Rovigo, Italy) was done for mandibular ridge then poured with dental stone (Dental stone manufacture hard stone, Spain).

The mandibular cast was scanned followed by scanning of Ti base separately (Sirona Dental Systems GmbH, D-6425 Bensheim, Germany). The collected data were displayed virtually on the screen. Zirconia abutment was designed with special software after ensuring a common path of insertion (Sirona Dental Systems GmbH, D-6425 Bensheim, Germany). The computer numeric control (CNC) data were transmitted to a milling

machine (Wieland dental, ivoclar vivodent, Zenotic select hybrid) and connected to the CAD system to mill zirconia abutment from semi-sintered zirconia blanks (Zenostar MO 2, Wieland dental, ivoclar vivodent). The fit of zirconia abutment to the Ti base was evaluated intraoral, when it was ensured to be accurate, cementation to Ti base was performed using glass ionomer cement (Type I, GC, Corporation, Tokyo, Japan) (Fig.1.b).

Complete denture construction:

According to conventional steps, construction of maxillary complete denture and mandibular implant supported over-denture for all patients (Fig.1.c). Finished denture was examined for retention, stability, extension, and articulation.

Evaluation of peri-implant hard tissues:

All patients were informed for follow up visits to evaluate marginal bone height changes of each implant using the linear measurement system of the software supplied by the cone beam computed tomography (CBCT). The mean of the peri-implant crestal bone loss was calculated by measuring bone height mesial, distal, buccal and lingual and divided by four to give the mean of bone height around each implant on both sides for each patient.

Evaluation of pocket depth

The measurement of pocket depth was evaluated from the deepest point of the sulcus, or pocket to the free gingival margin. Pocket depth was measured using metallic periodontal probe. The probe was inserted parallel to the vertical axis of the abutment and pocket depth was measured 6 points per the abutment on each side as follows, 3 points on buccal surface, (mesiobuccal, midbuccal and distobuccal) and 3 points on lingual surface, (mesiolingual, midlingual and distolingual). All measures were approximated to the nearest millimeter. The measures of the six areas were summed and divided by six to give pocket depth for each abutment on both sides.

Statistical analysis

Numerical data were introduced as mean and standard deviation (SD). Parametric data were analyzed using paired t-test for intergroup comparisons and measures ANOVA followed by Bonferroni post hoc test for intragroup comparisons. Non parametric data were statistically analyzed using Wilcoxon signed rank test for intergroup comparisons and Friedman's test followed by Wilcoxon signed rank tests with Bonferroni correction for intragroup comparisons. The significance level was set at $p \leq 0.05$. Statistical analysis was made with R l analysis software version 4.1.1 for Windows.

Figure (1): a) Titanium abutment b) Zirconia abutment c) Delivery of denture

RESULTS

Bone height changes:

At baseline, both groups had a value of (0.00±0.00). At 9, 12 months, zirconia abutment had a significantly lesser value than titanium abutment. (Table 1, Fig. 2)

Pocket depth:

At baseline, zirconia abutment had a lesser value than titanium abutment yet the difference was not statistically significant. At 6, 9 months, zirconia abutment had a significantly lesser value than titanium abutment. (Table 1, Fig. 2)

Table (1) *Mean, Standard deviation (SD) values of bone height change (mm) for both groups*

Parameter	Interval	(mean±SD)		p-value
		Zirconia abutment	Titanium abutment	
Bone height change (mm)	Baseline	0.00±0.00	0.00±0.00	NA*
	9 months	0.67±0.04	0.79±0.07	0.002**
	12 months	0.81±0.03	0.95±0.08	0.002**
Pocket depth (mm)	Baseline	0.14±0.38	0.43±0.53	0.172ns
	6 months	0.86±0.38	1.86±0.38	0.004**
	9 months	1.43±0.53	3.00±0.58	0.002**

**; NA not analyzed*

***; significant ($p \leq 0.05$) ns; non-significant ($p > 0.05$)*

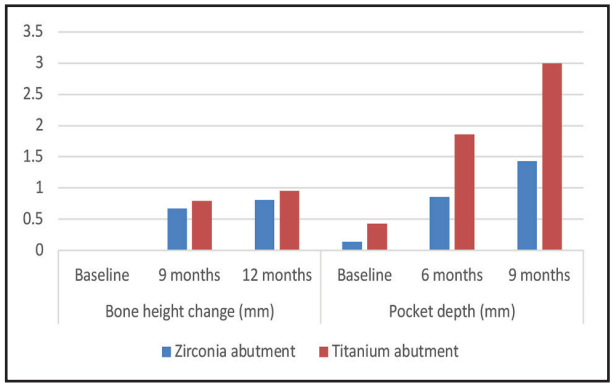

Figure (2) Bar chart showing average bone height changes and pocket depth

DISCUSSION

This study was designed to compare the influence of zirconia and titanium as abutment materials on bone height changes and pocket depth around implants in mandibular implant supported over-denture.

This study was also designed to compare between the impact of zirconia and titanium abutments in the same patient and under similar circumstances to keep the tested hypothesis accepted and on basic performance. Moreover, in systematic reviews and meta-analysis many researchers made a resolution to preclude studies in which both kinds of abutments were not compared in the same patient [9].

The age of the selected patients ranged between 55 and 65 years to avoid the effect of age changes on the condition of the oral soft tissues, residual ridge, tone of muscles and temporo-mandibular joint [10]. Patient general hygiene was properly evaluated to ensure that patients were free from systemic diseases that may reversely affect the bone or oral mucosa conditions [11].

An important regarding in construction of mandibular supported over-denture is to assure sufficient space for prosthetic part of the abutments where the minimum space requirement is 10-12 mm. So that, mounted diagnostic casts were fabricated for evaluation of arch relationship and the available inter-arch space for the mandibular denture to the antagonist [12].

Titanium was chosen as abutment material in this study as it was favorable material due to its toughness and higher resistance to deformation. In addition, it had shown better results promoting titanium abutments as highly credible. However, the major disadvantage is that their grayish color can shine through peri-implant soft tissues shown a dark appearance of the peri-implant oral mucosa[4].

The introduction of zirconia as a recent biocompatible material in restorative dental field, the light weight of the material, and the outstanding progression in CAD/CAM technology were the reasons that caused the fabrication of zirconia abutments to support mandibular over-denture in this study [13].

The hybrid construction Ti-base and zirconia abutment concept was chosen in this study as it has the following advantages including esthetic, reproduction of a tailored emergence profile, retrievability, better biomechanical performance and absence of ceramic remnants at the implant-abutment connection level [14].

CAD/CAM technology was used in this study for fabrication of zirconia abutment. CAD/CAM technology permits the construction of cost-effective abutment with improved material quality and high precision. New advancement in CAD/CAM technology has caused appreciably development in abutment manufacturing [15].

Cone Beam Computed Tomography (CBCT) was chosen as proprioceptive designing of oral implant system. It provides accurate measurements when compared with two dimensional (2D). Moreover, the use of CBCT for the assessment of vertical bone height around implants has been mentioned in several studies with improved precision compared with conventional imaging techniques [16].

The target of this study was also to compare the influence of zirconia and titanium abutments on peri-implant soft tissues. Biological measures like pocket depth were evaluated, as low plaque accumulation and presence of healthy supportive periodontal tissues is an important factor in survival of dental implants [17].

In comparison between peri-implant bone height changes in both abutments, zirconia abutments had distinction in term of protection of peri-implant bone height. This is in accordance with a previous evidence-based research, which was assessed the impact of both materials on the stability of peri-implant bone. It was stated that zirconia is a more preferred material to bone stability than titanium [16]. This is also in agreement with study explained that higher modulus for abutment material allowed for a more uniform stress distribution within the implant, thus providing a more effective and reliable load applied to the dental implant. This could clarify why zirconia could redistribute the stresses more widely to the fixture of dental implant when compared to other materials [18]. Moreover, this was in agreement with another study explained that the minimal reduction in bone height with zirconia abutment may be caused by the variation in surface energy of zirconia and titanium materials. Because zirconia has less surface energy, it appeared lower plaque collection compared with titanium [19].

In comparison between the influence of zirconia and titanium abutments on peri-implant pocket depth, zirconia had sublimity in improving soft tissue parameters. This is in agreement with the study that showed significantly lower pocket depth around zirconia abutments compared to titanium ones. This is due to highly polished and smooth zirconia surfaces which can supply better adhesion for epithelial cells to abutment surface and reduce accumulation of plaque leading to reduction in pocket depth parameters [20].

On the opposite side, this result was in conflict with the study stated that the effect of titanium and zirconia materials on soft tissue parameters was indifferent. It was stated that soft tissues were not influenced by the material of abutment. It appears that there are more substantial factors such as the absence/ presence of attached mucosa, 3D location of the implant and individual oral hygiene measures which mainly affect the risk for accumulation of microorganisms [21].

CONCLUSION

From this study, it could be concluded that zirconia abutments had great superiority over titanium abutments in keeping peri-implants soft and hard tissues healthy in mandibular implant supported over-denture within the follow up period.

RECOMMENDATIONS

The use of zirconia abutments to support mandibular implant over-denture have been established to be effective in order to fulfill main requirements of support and esthetics. More studies should be carried out and analyzed longitudinally concerning their biological response.

CONFLICTS OF INTEREST

The research team declare no conflicts of interest.

FUNDING

The research was self-funded.

REFERENCES

1. Emera RM, Altonbary GY, Elbashir SA: Comparison between all zirconia, all PEEK, and zirconia-PEEK telescopic attachments for two implants retained-mandibular complete over-dentures: in vitro stress analysis study. Int J Implant Dent. 2019; 9: 24- 9.
2. Verma A: Prosthetic rehabilitation of an edentulous mandible by two implants retained-mandibular Over-denture: A case report. Int J App Dent Sci. 2020; 6: 757- 60.
3. Gray D, Patel J: Implant supported over-dentures: part 1. Br Dent J. 2021; 2: 94- 100.
4. Oyar P, Durkan R, Deste G: The effect of the design of a mandibular implant supported zirconia prosthesis on stress distribution. J Prosthet Dent. 2021; 3: 502- 11.
5. Scarano A, Stoppaccioli M, Casolino T: Zirconia crowns cemented on titanium bars Using CAD/CAM: A five-year follow-up prospective clinical study of 9 patients. BMC Oral Health. 2019; 19: 286- 95.
6. Ahmed KE: We Are Going Digital: The current state of CAD/CAM dentistry in prosthodontics. Prim Dent J. 2018; 7: 30- 5.
7. Frisch E, Vach K, Ratka-Krueger P: Impact of supportive implant therapy on peri-implant diseases: A retrospective 7-year study. J Clin Periodontol. 2020; 47: 101- 9.
8. Sennerby L, Coli P: Is peri-implant probing causing over-diagnosis and over treatment of dental implants? J Clin Med. 2019; 8: 1123- 36.
9. Yeung M, Abdulmajeed A, Bencharit S, Carrico CK, Deep GR: Accuracy and precision of 3D-printed implant surgical guides with different implant systems: An in vitro study. J Prosthet Dent. 2020; 6: 821- 28.
10. Park JC, SunBaek W, Cho KS, Jung UW, Choi SH: Long-term outcomes of dental implants placed in elderly patients: A retrospective clinical and radiographic analysis. Clin Oral Implants Res. 2017; 28: 186- 91.
11. Schimmel M, Srinivasan M, McKenna G, Muller F: Effect of advanced age and/or systemic conditions on dental implant survival: A systemic review and meta-analysis. Clin Oral Implants Res. 2018; 16: 311- 30.
12. Carpentieri J, Greenstein G, Cavallaro J: Hierarchy of restorative space required for different types of dental implant prostheses. J Am Dent Assoc. 2019; 8: 695- 706.
13. Lehmann F, Stober T, Schwindling FS: Electroplated telescopic retainers with zirconia primary crowns: 3 year results from a randomized clinical trial. Clin Oral Investigations. 2017; 21: 2653- 60.
14. Coelho P, Bonfnte E, Ikejiri L, Soares S: Retention of zirconia crowns to Ti-base abutments: Effect of luting protocol, abutment treatment and autoclave sterilization. J Prosthodont Res. 2021; 65: 537- 45.
15. Pissiotis AL, Papadiochou S: Marginal adaptation and CAD-CAM technology: A systematic review of restorative material and fabrication techniques. J Prosthet Dent. 2018; 4: 545- 51.
16. Jacobs R, Salmon B, Quirynen M, Vanderstuyft T, Vrancks M: CBCT vs other imaging modalities to assess peri-implant bone and diagnose complications: A systematic review. Eur J Oral Implantol. 2018; 11: 577- 92.
17. Asaad F, Larsson L, Dahlin C, Pazmino CG: Expression of microRNAs in periodontal and peri-implant diseases: A systematic review and meta- analysis. Int J Mol Sci. 2020; 11: 4147- 58.

18. Bharate V, Kumar Y, Koli D, Pruthi G, Jain V: Effect of different abutment materials (zirconia or titanium) on the crestal bone height in 1 year. J Oral Biol Craniofac Res. 2019; 10: 372- 74.

19. Pandoleon P, Bakopoulou A, Papadopoulou L, Koidis P: Evaluation of the biological behavior of various dental implant abutment materials on attachment and viability of human gingival fibroblasts. Dent Mater. 2019; 35: 1053- 63.

20. Basar EK, Buyukkaplan US, Ozarslan MM, Turker N: Effect of different surface treatments applied to short zirconia and titanium abutments. Int J Oral Maxillofac Implants. 2020; 5: 948- 54.

21. Sanz-Martin I, Sanz-Sanchez I, Carrillo de Albornoz A, Figuero E, Sanz M: Effect of modified abutment characteristics on peri-implant soft tissue health: A systematic review and meta-analysis. Clin Oral Implant Res. 2017; 29: 118- 29.

22. Furuhashi A, Ayukawa Y, Rakhmatia YD, Koyano K, Atsuta I: Soft tissue interface with various kinds of implant abutment materials. J Clin Med. 2021; 10: 2386- 95.