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Two Implants Retained Complete Mandibular Overdenture with Zirconia-PEEK Telescopic Attachment: Radiographic Evaluation of Peri-implant Bone Level Changes

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ABSTRACT

Aim: *Evaluation of peri-implant vertical and horizontal bone changes of two implants retained mandibular complete overdenture with Zirconia-PEEK telescopic attachment.*

Material and Method: *Six completely edentulous male patients with average age of 60 years were selected for this study. Each patient received two implants in the mandibular canine regions. Maxillary conventional complete dentures were constructed against implant retained mandibular overdentures for all patients. Zirconia- PEEK telescopic attachments were fabricated to retain the overdentures where primary telescopic crowns were constructed of zirconia and secondary ones were constructed of PEEK. Peri-implant vertical bone loss (VBL) and horizontal bone loss (HBL) were evaluated using standardized digital periapical radiographs at time of overdenture insertion (T0), after 6months (T6) and 12 months (T12) of overdenture use.*

Results: *Significant difference was observed between (T0 and T6), (T6 and T12) and (T0 and T12) for peri-implant vertical bone level in both mesial and distal implant surfaces. However, no significant difference was observed for horizontal bone level except between (T0 and T6) for both implant surfaces. Median values of peri-implant VBL ranged between 0.10mm and 0.35mm, while the comparison of VBL between different observation periods of the study revealed significant difference for both implant surfaces. Regarding HBL, insignificant difference was detected, except between (T6-T12) and (T0-T12) for the distal implant surface.*

Conclusion: *With respect to this study limitations, including the small sample size and the short term follow up, It could be concluded that:*
Although the siginificant change in peri-implant bone level associated with two implants retained mandibular overdenture with zirconia-PEEK telescopic attachment, the obtained bone loss was below the normal documented range for successful implants.

Keywords

Implants retained overdenture, Peri-implant bone changes, Zirconia-PEEK telescopic attachment.

Introduction

Edentulism is considered as a poor health consequence and may compromise the patient quality of life. The traditional treatment modality for edentulous patients is the conventional complete dentures. However, this treatment option has numerous problems, especially for lower dentures, as inadequate retention and stability. These limitations can be partially eliminated by using implants to retain the denture which is known as implant retained overdenture [1].

Implant-supported overdentures are comparatively simple, affordable and minimally invasive as well as effective treatment option for edentulous patients. However, an argument still present concerning the most successful overdenture design and the type of attachment system used [2,3].

It was reported that resilient telescopic attachment could be successfully applied to retain implant overdenture in case of resorped mandibular ridges [4]. Telescopic attachments offer superior retention force owing to the frictional fitting between primary and secondary crowns. The circumferential relation of telescopic crowns to the abutments permits well forces distribution, transfers the occlusal load in axial direction and thus reduces the rotational torque on the abutment [2].

A number of materials and materials combinations were used to fabricate telescopic attachments as precious and non-precious metal alloys, and recently, zirconia and PEEK [5]. Metal alloys are the frequently used materials for telescopic attachments construction; however, their clinical application is restricted to patients free from metal allergies. Moreover, some drawbacks and problems appeared when metal restorations were combined with other metals in the oral cavity as galvanic corrosion [6]. Esthetic problems also may arise, such as the show of metal crowns [5].

Main trend in dentistry in resent years is the replacement of conventional substances, especially metallic ones, by metal free. This trend is owing to the patients needs for optimum aesthetics as well as their concern about the biocompatibility of metallic alloys [7]. Zirconium dioxide (ZrO2), known as zirconia, with its excellent esthetics, biocompatibility, wear resistance, and superior mechanical properties has been verified as a suitable material for primary copings construction in telescopic attachments and has presented itself as a substitute to gold alloys [8]. Emera [9], concluded that all-zirconia double crown systems can be considered a biologically promising telescopic attachment.

Another favorable tooth-colored CAD-CAM material is polyether-ether-ketone (PEEK) which is a high-performance thermoplastic polymer. Its structure offers exceptional physical properties, biocompatibility and chemical resistance. Recently, it was reported that PEEK is an appropriate material for fabrication of telescopic attachments [10,11].

A novel concept is to combine these two biocompatible materials which are zirconia and PEEK so as to obtain metal free restorations such as telescopic attachments [12-17]. However, rare data is available about the peri-implant bone loss accompanied with telescopic attachments made of these two materials. Consequently, the aim of this study was to evaluate peri-implant vertical and horizontal bone level changes of two implants retained complete mandibular overdenture when using zirconia-PEEK telescopic attachments.

Materials and Methods

Six healthy completely edentulous male patients with average age of 60 years were carefully chosen for this study. The inclusion criteria of the patients were satisfactory bone quantity and quality of mandibular residual alveolar ridge as confirmed by cone beam CT, sufficient restorative space to accommodate the telescopic attachment, and normal maxilla-mandibular relation (Angle's class I).

Exclusion criteria involved local inflammation and systemic diseases that restrict surgical procedures, bone metabolic disorders, history of parafunctional habits and radiotherapy to the head and neck region.

The research protocol was approved by the ethical committee of the faculty of dentistry, Mansoura university with code No. (04020418).

Pre-surgical procedures

Conventional complete dentures, with lingualized occlusion scheme, were constructed for each patient. Stereolithographic implant placement surgical guide was fabricated using dual-scan technique in the following steps:

- Extraoral scanning to the prepared mandibular denture with radiopaque markers (that used as reference points).
- Intraoral scanning while the patient was wearing the dentures and closing in centric relation.
- The two scans were combined for obtaining 3D software image. The bone thickness and height were measured for precise planning of implant placement. Universal surgical kit with consecutive drill diameter sleeves and horizontal indicators was provided with the surgical guide.

Surgical and prosthetic procedures

The surgical guide template was fixed intraoral and two implants (3.5mm diameter and 12 mm length) (Dentium Superline, Dentium, Co. Ltd., Korea) were inserted in the mandibular canine area bilaterally.

After the osseointegration period (3 months), cover screws were removed and replaced by healing abutments for more two weeks. Mandibular acrylic resin custom tray was constructed with two holes corresponding to each implant site to make the final impression as follows:

- Medium body rubber base impression was made for recording residual alveolar ridges.
- Two long transfer copings were screwed to the implants and splinted with light cured flowable composite.
- Light body rubber base material (Speedex, Coltene/ WhaledentInc, Cuyahoga Falls, OH, USA) was injected to record the peri-implant soft tissues.
- Implant analogues were fixed to the transfer copings prior to impression pouring. The implant abutments (Dentium

Superline, Dentium, Co. Ltd., Korea) were attached to implant analogues on the master cast (Figure 1).

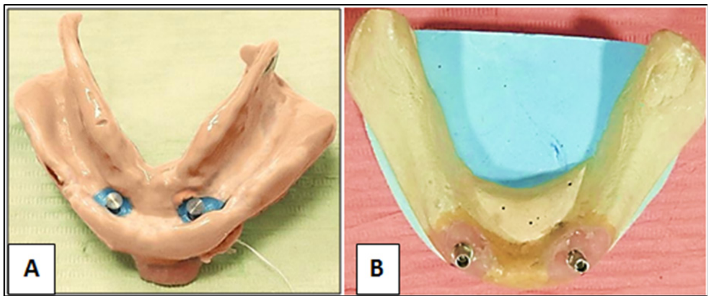

Figure 1: A- Final impression with the attached implant analogues.
B- Master cast with the screwed implant abutments.

Construction of CAD-CAM resilient telescopic attachment: (Figure 2)

A-Primary telescopic crown

The master model was scanned to obtain 3D virtual image. Software designing of the primary copings was done while the same parameters were maintained for all patients regarding 5mm height and 4˚ occlusal tapering. The software design was transmitted to the milling machine (Sheraeco_scan3 Germany) for milling of primary crowns from semi-sintered zirconia blocks (Zirconia Katan).

B-Secondary telescopic crown

Intraoral try in of primary copings was done followed by returning them back on the master cast to be scanned. Parameters of secondary copings software design were parallel walls, 0.5 mm as a minimal thickness and 0.3 mm occlusal space between primary and secondary copings. Proximal projections were applied to the design of secondary copings to improve their mechanical retention to the overdenture fitting surface as suggested by Emera [9]. Finally, data were transported to the CAM program to mill PEEK (ceramic filled Bio HPP) secondary crowns.

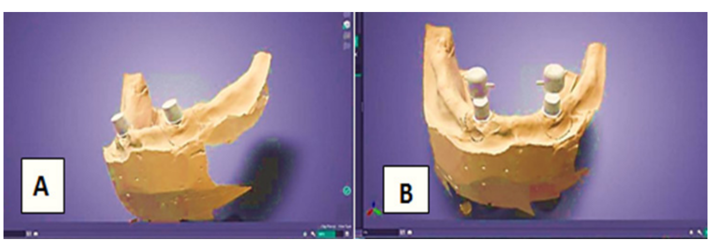

Figure 2: A- Final software design of primary telescopic crowns.
B- Final software design of secondary telescopic crowns.

Fabrication of mandibular overdenture:

- Duplication of the master cast was done while the secondary telescopic crowns were attached to the primary ones.
- Polished and occlusal surfaces of the conventional mandibular denture were duplicated using a silicone index (Coltoflax; ColteneAG, Altstatten, Switzerland).
- Identical artificial teeth were placed in their corresponding rooms in the mold and the index was relocated over the duplicate master cast.
- Molten base plate wax was poured to fill the mold cavity then the conventional flasking procedures were performed.

Secondary crowns pick up procedures

Cementation of primary crowns to the implants abutments was done with respect to isolation measures against excess cement. Venting holes were opened through the lingual flanges of mandibular overdenture. Secondary crowns were located over primary ones with respect to the accurate path of insertion. Pick up of secondary crowns to the overdenture intaglio surface was completed, using an autopolymerized acrylic resin, under light biting force (Figures 3 and 4). Diamond bur was used to remove the excess acrylic resin material.

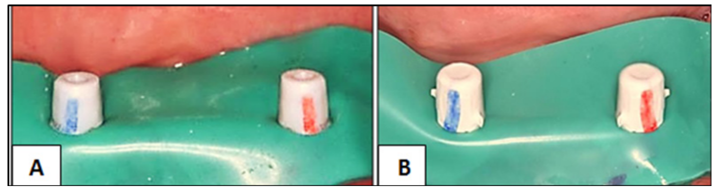

Figure 3: A-Cemented primary copings to the implant's abutments.
B- Secondary crowns in their correct position over the primary ones.

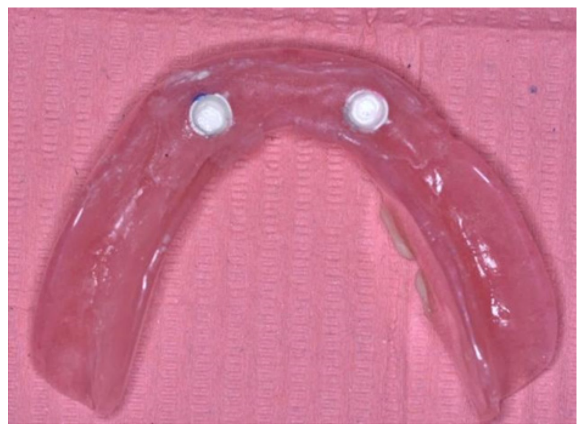

Figure 4: Picked up secondary crowns in the overdenture fitting surface.

Evaluation of peri-implant bone level changes

- Radiographic evaluation of peri-implant bone level changes was done using standardized digital periapical radiographs using modified film holder.
- vertical bone loss (VBL) and horizontal bone loss (HBL) were evaluated at the time of overdenture insertion (T0), after 6 months (T6), and 12 months (T12) of overdenture use.
- Ratio between actual implant dimensions and that on the radiograph was utilized to modify the obtained values of peri-implant bone levels.
- Vertical and horizontal peri-implant bone level changes were calculated according to Elsyad et al. [17] as the following: (Figure 5).

For measuring the vertical bone loss (VBL), distance from the implant shoulder (point A) to the first contact of bone to the implant (point B) was estimated in mm and denoted as the vertical bone level (AB line). To calculate VBL the AB line at T0 was subtracted from that at T6 and T12.

For measuring the horizontal alveolar bone loss (HBL), the distance from implant long axis (line which bisecting the implant) and (point C) {which is the intersecting point of the tangent to the crater-shaped defect (CB line) and the tangent to the horizontal bony crest (CD line)} was estimated and denoted as the horizontal bone level. To measure HBL the horizontal bone level at T0 was subtracted from that at T6 and T12.

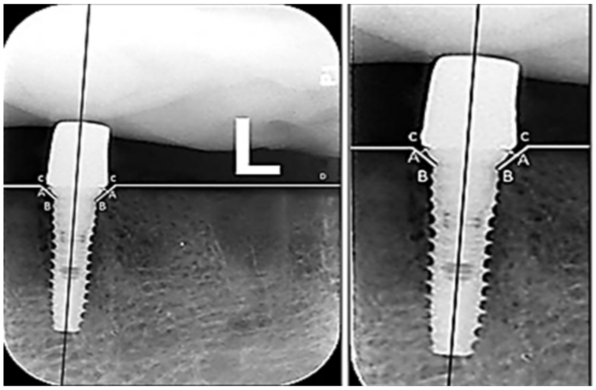

Figure 5: Traced periapical radiograph.

Statistical analysis

Data were analyzed using the Statistical Package of Social Science (SPSS) program (Standard version 21). Normal distribution of data was verified by Shapiro test. Mean ± SD were used to describe parametric data (peri-implant vertical and horizontal bone levels) and Paired t-test was used for comparing them. While non-parametric data (peri-implant vertical and horizontal bone loss) were presented as median (min-max) and compared by Wilcoxon signed rank test. Level of significance was fixed at 5% (P value).

Results

Table 1: Showing mean values of peri-implant vertical and horizontal bone levels at different follow up periods of mesial and distal surfaces of both implants.

	Follow up periods			Paired t-test		
	T0 M ± SD	T6 M ± SD	T12 M ± SD	P1	P2	P3
VBM	1.85 ± 0.42	2.08 ± 0.47	2.18 ± 0.47	0.003*	0.001*	0.004*
VBD	1.83 ± 0.49	2.05 ± 0.51	2.22 ± 0.48	0.006*	0.001*	0.017*
HBM	1.88 ± 0.12	1.98 ± 0.11	2.18 ± 0.37	0.004*	0.122	0.270
HBD	1.93 ± 0.15	2.02 ± 0.17	1.93 ± 0.32	0.004*	1.00	0.383

T0: At the time of overdenture insertion. M: mean. **T6:** After 6 months of overdenture use. SD: standard deviation. **T12:** After 12 months of overdenture use P1: comparison between T0 and T6**. VBM:** Vertical bone level at mesial surface. P2: comparison between T6 and T12. **VBD:** Vertical bone level at distal surface. P3: comparison between T0 and T12. **HBM:** Horizontal bone level at mesial surface. **HBD:** Horizontal bone level at distal surface. **(*)** Statistical significance when $p<0.05$.

Comparison of mean values of vertical and horizontal bone levels at different follow up periods was done using paired sample T-test as shown in table1. Significant difference was found between (T0 and T6), (T6 and T12) and (T0 and T12) for vertical bone levels in both mesial and distal implant surfaces. However, no significant difference was observed for horizontal bone levels except between (T0 and T6) for both surfaces.

Table 2: Showing comparison of peri-implant vertical and horizontal bone loss between different follow-up periods for both implants.

	Follow up periods			Wilcoxon signed rank Test		
	T0-T6 M (Min-Max)	T6-T12 M (Min-Max)	T0-T12 M (Min-Max)	P1	P2	P3
VBL mesial	0.2 (0.1-0.5)	0.15 (0.0-0.2)	0.35 (0.2-0.7)	0.019*	0.024*	0.038*
VBL distal	0.2 (0.1-3.0)	0.10 (0.1-0.3)	0.30 (0.2-0.6)	0.012*	0.026*	0.024*
HBL mesial	0.1 (0.1-0.2)	0.05 (0.0-0.1)	0.10 (0.1-0.2)	0.102	0.060	0.317
HBL distal	0.1 (0.0-0.1)	0.0 (0.0-0.1)	0.1 (0.0-0.2)	0.157	0.046*	0.157

T0: At the time of overdenture insertion. VLB: Vertical bone loss. **T6:** After 6 months of overdenture use. HBL: Horizontal bone loss. **T12:** After 12 months of overdenture use. M: Median. Min: Minimum. **P1:** Comparsion between first and second six months Max: Maximum. **P2:** Comparsions between the second six months and the whole 12 months. **P3:** Comparsion between first six months and the whole 12 month. **(*)** statistical significance when $p <0.05$.

Comparison of vertical bone loss between different observation periods of the study revealed significant difference between first and second six months and between each of these periods and the whole 12 months of the follow up peroid. Regarding horizontal bone loss, insignificant difference was observed between different follow up periods, except between the second six months and the whole 12 months for the distal implant surface as shown in table 2.

Discussion

The introduction of zirconia and PEEK as biocompatible tooth-colored materials with superior physical properties had encouraged the fabrication of metal free CAD-CAM telescopic attachments [13-16]. However, further clinical researches were recommended to observe the prognosis of these materials when placed opposite to each other under function [5,18].

This clinical study was directed to evaluate the peri-implant bone level changes of two implants retained complete mandibular overdenture with zirconia-PEEK telescopic attachment. One of the most significant success criteria of dental implants, that should be evaluated, is the peri-implant bone level as a pathological reduction of the bone level may lead to loss of bone anchorage to the implant [19]. The maintenance of a stable marginal bone level is a challenge. Meanwhile, factors such as the choice of a well-documented implant design, good plaque control, and minimizing the so-called implant “overload” remain the strategic tools for success. Good planning and correct indication guarantee the latter [20].

Peri-implant bone loss can occur when the host tissues are unable to accommodate excessive forces applied to the implant supported prostheses. The stress is thus transmitted from the prostheses to the implant-bone interface at the crestal level, leading to loss of osseointegration and/or crestal bone loss [21]. As denture saddles of two implants retained overdentures, tend to function like a fulcrum, implants may receive a significant bending moment transmitted from the implant into the bone depending on the attachments system. The majority of researches have demonstrated that design of overdenture attachment can significantly affect stress/strain levels around implants. Thus, a detailed analysis to verify influence of the attachment systems is important [22,23].

Results of this study exhibited significant difference of peri-implant vertical bone level between different follow up periods in both mesial and distal implant surfaces. While, no significant difference was observed for horizontal bone level except between (T0 and T6) for both implant surfaces. This result is convenient with that of Awaad et al. [24] who evaluated the peri-implant bone height loss when using mandibular overdentures retained either by two or four implants with metallic telescopic attachments. They observed a significant peri-implant marginal bone loss when compared the bone level at the functional loading day with that after the interval of 12 months for both two and four implants groups.

The obtained vertical bone loss with telescopic attachment retained overdenrures may be explained by the prominent height of telescopic attachments, that may increase the vertical cantilever and the stresses transferred to the implant [4]. In agreement to this explanation, Heckmann et al. [25] concluded that telescopic attachment is exposed to horizontal forces because of the forward movement of the mandibular overdenture under occlusal load. Such forces could be exaggerated in cases with resorped residual ridges leading to greater moment loads on the implants.

Comparison between the study follow up periods regarding mean values of VBL and HBL revealed significant difference between the first and the second 6 months. Though, mean values of the observed bone loss in the second 6 months were less than that of the first ones. In line with this finding, Ericsson, et al, [26] reported that bone remodeling reaches a stable state after 6 months of implant loading. Similarly, Cochran et al. [27] stated that peri-implant bone remodeling is more emphasized in the first 6 months after implant placement.

The higher bone loss occurred in the first 6 months may possibly attributed to an organization of the peri-implant bone after implant placement. Trauma caused by surgical procedures may lead to necrosis of the surrounding bone that became substituted by woven bone. After numerous months, woven bone will be replaced by lamellar bone which is more mineralized and well organized. Therefore, the occlusal loading in the early period may lead to micro-damage in the peri-implant bone. Reduced bone loss in the second 6 months may be explained by the improved bone strength from the start of loading and up to one year later [28,29].

Median values of peri-implant vertical bone loss observed in the present study ranged between 0.10 mm and 0.35mm, which is less than the normal documented range for successful implants. During the first year, marginal bone loss of 1.5 mm has been accepted, while annual marginal bone loss of 0.2 mm is considered satisfactory for the subsequent years [30-32].

This result may be explained by that, one of the prosthetic objectives in combining the usage of PEEK to zirconia is the load cushioning capacity of PEEK [33]. It was confirmed that the application of wear resistant and hard material for primary coping against a less hard material for secondary coping could be beneficial. Minimal alterations will happen in the primary coping and the adaptation between both copings will be accomplished by the alterations in the secondary coping [18]. PEEK has a lower modulus of elasticity (4 GPa) in comparison to zirconia (210 GPa), so PEEK restorations absorb occlusal loads and wear as natural teeth. This observation is convenient to the result of a recent study that investigated wear of all-zirconia, all-PEEK and zirconia- PEEK telescopic attachments by evaluating surface changes of both copings using Scanning Electron Microscope. The greatest wear values were associated with zirconia-PEEK group, chiefly in secondary crowns [15].

This finding was also documented by previous study that evaluated stresses transmitted to two implants retaining mandibular complete overdenture with all-zirconia, all-PEEK and zirconia-PEEK telescopic attachments. The results of this study revealed that under both bilateral and unilateral loading the group of all-PEEK recorded the highest stress values followed by all-zirconia group. While the group of zirconia primary crowns and PEEK secondary crowns recorded the least stress values transmitted to the implants [14].

Regarding horizontal bone loss, insignificant difference was observed in the present study, except between (T6-T12) and (T0-T12) for the distal implant surface. This may be due to the concentration of compressive strain at distal side of the implant upon loading in contrast to the mesial side where maximum tensile strain was recorded [34].

Conclusion

With respect to this study limitations, including the small sample size and the short term follow up, It could be concluded that:
Although the siginificant change in peri-implant bone level associated with two implants retained mandibular overdenture with zirconia-PEEK telescopic attachment, the obtained bone loss was below the normal documented range for successful implants.

Recommendation

Further clinical studies with larger sample size and longer follow up period are recommended to evaluate the long-term serviceability of zirconia-PEEK telescopic attachments.

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