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The Effect of Two Different Bar Materials Constructed with CAD/CAM Technology on Implant Retained Mandibular Overdentures: Radiographic Evaluation

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Abstract

Background: Implant supported overdentures are a widely-accepted treatment approach with long-term effectiveness for restoring function and aesthetics, as well as improving masticatory efficiency and individual satisfaction. Recently, Computer aided design- Computer aided manufacturing (CAD/CAM) fabricated bars are increasingly used providing high stability levels, a stress-free fit, and high precision level.

Objective: to evaluate the crestal bone height surrounding the implants in implant-supported mandibular overdentures retained with CAD/CAM milled Co-Cr and PEEK bar attachments using CBCT.

Materials and Methods: Twenty completely edentulous patients were selected from the outpatient clinic, Prosthodontic Department, Faculty of Dentistry, Ain Shams University. They were classified into two groups: Group I: Ten patients received CAD/CAM milled Co-Cr bar supporting implant mandibular overdenture. Group II: Ten patients received CAD/CAM milled PEEK bar supporting implant mandibular overdenture. Radiographic evaluation using CBCT was carried out at insertion time, six months, and twelve months after loading to evaluate the marginal bone height changes around the implants in both groups.

Results: Statistical analysis of the data revealed significant increase in the amount of bone loss around the implants for group I (Co-Cr) compared to group II (PEEK) during the one year follow-up period.

Conclusion: The use of CAD/CAM milled Co-Cr and PEEK bar attachments to support implant mandibular overdenture meets the implant success criteria based on clinical and radiological findings after one year. However, CAD/CAM milled PEEK bar may be advantageous than CAD/CAM milled Co-Cr bar in terms of reduced bone loss.

Keywords: Implants Overdentures, Dental attachments, CAD/CAM, Bone loss

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Introduction

Oral rehabilitation with an overdenture on splinted or unsplinted implants is considered the standard of care in cases of mandibular edentulism. Numerous studies have shown that the mandibular implant overdenture is a simple and effective solution and leads to significant improvement of patient-based outcomes as compared to conventional dentures [1, 2]. The employment of a variety of attachment devices, including as studs, magnets, and bars, has shown clinically predictable and beneficial results. The attachments should be designed to provide equal implant-tissue support and optimal force distribution around the implants, allowing for physiologic bone loading. [3]. Implants splinted together with bars may reduce the risk of overloading each implant because of the increased surface area, load sharing between implants, and improved biomechanical distribution [4]. Implant-supported milled bars are manufactured by casting, electroerosion, or CAD-CAM and have precision attachments and rigid anchorage. The use of CAD/CAM technology to fabricate bars and frameworks has resulted in less distortion, better fit, and fewer fabrication stages [5]. A custom-fabricated bar could be precisely milled to create guide planes that allow the denture base to be correctly adapted to the milled bar, resulting in stability and resistance to rotational and lateral pressures. When a considerable ridge curvature is encountered, custom designed bars are more likely to follow the ridge curve without violating the tongue space [6] New polyetheretherketone (PEEK)-based materials have recently been launched to the market. PEEK has a good biocompatibility due to its inert nature, and it has a long clinical history in spinal implants, spanning more than a decade and a half. Furthermore, because PEEK has a modulus of elasticity that is approximately identical to that of bone, it can limit stress transmission to the abutment teeth. The removal of allergic reactions and metallic taste, as well as great polishing capabilities, minimal plaque affinity, and superior wear resistance, are all advantages of this polymer substance [7].

Materials and methods

Twenty completely edentulous patients were selected from the outpatient clinic, Prosthodontic Department, Faculty of Dentistry, Ain Shams University. Patients with metabolic diseases that may affect osseointegration such as diabetes mellitus and osteoporosis were excluded. In addition, patients with any contraindications to implant surgery such as bleeding disorders, radiation therapy to head and neck region and immunosuppressive therapy were also excluded. All patients had pre-operative cone beam computed tomography to evaluate the bone quality and quantity in the area anterior to the mental foramina. A tentative centric jaw relation was created to ensure the presence of sufficient restorative space to accommodate the milled bar prosthesis. All patients received upper and lower complete dentures constructed following the conventional procedures.

Virtual implant planning and stereolithographic surgical guide fabrication:

A. **Dual scan protocol:** Virtual planning began with dual scan protocol by modifying patient's lower complete denture into radiographic guide by placing multiple spherical radiographic composite markers on the labial and buccal flanges of the denture. Using the Cone Beam Computed Tomography (CBCT), the first scan was carried out for the lower denture on the cast and the second scan was performed with the patient wearing the lower denture and biting in centric occlusion.

B. Stereolithographic surgical guide fabrication: The mandibular CAD/CAM stereolithographic surgical guide was equipped with two metallic sleeves to guide implant placement in the virtually designed location with the precise depth, angulation, mesiodistal, and buccolingual positions as planned during computer simulation. In addition, three extra windows were constructed labially for fixation screws at a sufficient distance from the proposed implants' drilling locations.

Surgical protocol

- A silicon occlusal index (Zeta Plus, putty. C-silicone impression material-zhermack company-Italy) was used to support the surgical guide in the patient's mouth, and anchor pins were used to secure it to the mandibular bone. The osteotomy preparation was performed using the universal surgical kit supplied by the manufacture of the guide (In2Guide). The sequential drilling was done for each implant through the surgical guide. Sterile copious internal and external saline irrigation was used throughout the drilling procedure. Fig (1) Implants with diameter 4 mm and length 11mm, were inserted into the prepared osteotomy.

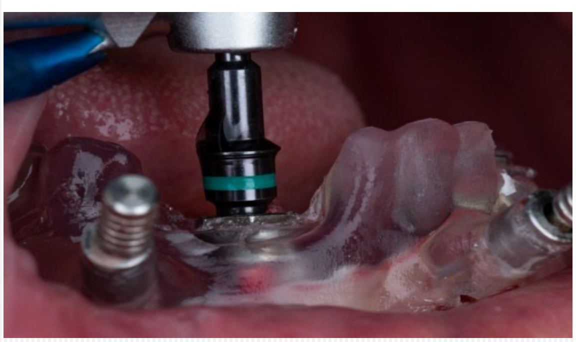

Figure 1: Sequential drilling for each implant through the surgical guide

Prosthetic procedures

After 3 months healing period, the patients were divided into two groups: Group I (Co-Cr) and Group II (PEEK).

a. **Second stage surgery:** The implants were exposed with a small crestal incision. The cover screws were unscrewed in anti-clockwise direction and replaced by healing abutments allowing the soft tissue to heal around it.

b. **Bar construction**

Impression procedure:

- After two weeks, closed tray impression technique was performed using viny polylsiloxane putty impression material (addition silicone) and a light body wash. The impression was poured to obtain a stone cast and a self-cured acrylic resin special tray was fabricated and modified by creating holes opposite to the implant sites. Healing abutments were removed and open tray impression technique was made using long retention screws connected to the implants, their seating was verified radiographically. Impression copings were splinted with duralay. Impression was made using vinyl polysiloxane regular body impression material.

Optical scanning and bar designing:

- Desktop extra-oral scanner was used to capture the 3-D orientation of the implants in the cast. A complete scan of the cast and its 3-D reconstruction was obtained for designing the bars using Exocad software. Fig (2) Non-engaging Ti-bases were connected to the implants in the stone casts, then a scan body was placed on the Ti-base and scanned using the desktop scanner. Using the software, the restoration type was selected as bar and design was selected as Rhein OT Bar-A with 5 mm height, 4 mm width and 1 to 2 mm space underneath the bar to facilitate oral hygiene. After the plan was completed, PMMA verification Jig was milled by the CAM and tried inside the patient's mouth to check passive fitting, extensions, and pressure areas. Fig (3)

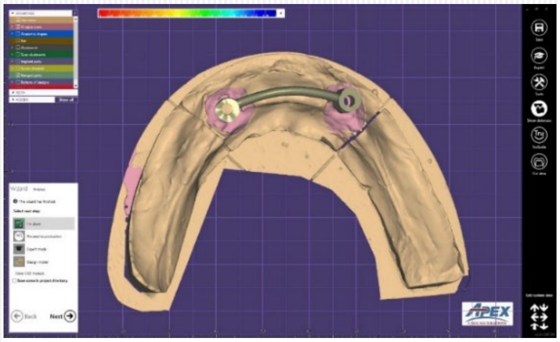

Figure 2: Bar design using Exocad software

Figure 3: Milled PMMA verification jig

The whole design was checked and STL file was exported to the milling machine. Milling of Co-Cr and PEEK bars were done. The bar was then checked for any roughness or residues. Titanium bases were painted with rouge. The bar was then seated over them and removed to detect any interferences that need to be removed. Easy seating of the bar over the titanium bases had to be verified.

Cementation of the bar:

- Sandblasting of the fitting surface of bar copings and titanium bases were carried out using 110 µm aluminum oxide particles (BEGO sandblaster, BEGO Bremer GMBH, Germany) at pressure of 2-3 bars. For PEEK bars a layer of PEEK primer (Visio Link, Bredent, Germany) was applied to the fitting surface of the bar copings and light cured for 90 seconds. Metal primer (MKZ-Primer, Bredent, Germany) was applied to the Ti-bases and the fitting surface of metallic bar copings for 30 seconds. The cement material was dispensed in the bar coping then the bar was seated in position under finger pressure for 2 minutes. Excess cement was removed and light curing for 20 seconds then followed. Cementation of the titanium bases took place by dual-cure adhesive resin cement (SuperCem, Self adhesive resin cement, South Korea) one by one individually to check seating of the bar in each time. Once cementation was completed, the bar was screwed in the patient's mouth and tightened using a torque wrench at 20NCm in the patient's mouth. Fig (4) Passive fit was checked visually by using a probe and by taking peri-apical radiographs to check for misfits. It was then confirmed by the one screw test which involved screwing the abutment on one side and checking the fit on the other terminal abutment.

Figure 4: Milled PEEK and Co-Cr bars in the patient mouth

- Construction of new complete lower denture was performed in the usual manner. Blocking out the undercuts beneath the bar using putty rubber base was essential before the pickup procedure. Plastic clip (Rhein83 Italy) attachments were secured over the bar on the delivery day. Pickup of the clip was made directly in the patient's mouth using autopolymerizing acrylic resin (Hard Denture Liner, Promedica GMBH, Germany). Patients were scheduled for follow-up appointments to assure the absence of complains and making CBCT radiographs to evaluate the implant marginal bone height changes.

Radiographic evaluation:

- The mesial, distal, buccal, and lingual marginal bone height changes around the implants were measured using CBCT at the time of implant loading, six, and twelve months postoperatively.

Results

Numerical data were explored for normality by inspecting the data distribution, calculating the mean using Kolmogorov-Smirnov and Shapiro-Wilk tests. Data revealed parametric distribution thus it was represented by mean and standard deviation (SD) values. Intra and intergroup comparisons were done utilizing paired t-test and independent t-test respectively to test peri-implant crestal bone level changes within the group during different recall appointments and between the two studied treatment modalities.

The significance level was set at $P \leq 0.05$ for all tests. Data were collected, tabulated, and statistically analyzed using Microsoft Excel ® 2016, Statistical Package for Social Science (SPSS)® Ver. 24. and Minitab ® statistical software Ver. 16. Data were revealed as mean (mm), mean difference (mm) and standard deviation. Table (1)

Patients expressed satisfaction as regards function retention and stability of their appliances. Clinically, no pain was elicited with palpation or percussion, no exudates was observed in relation to the implants.

The total change in marginal bone height for all surfaces from denture insertion to six months was 0.54 ±0.26 mm and 0.31 ±0.08 mm for group I and group II respectively. From six to twelve months, the total change in marginal bone height for all surfaces was 0.33 ±0.12 mm and 0.22 ±0.06 mm for group I and group II respectively. From insertion to twelve months' time interval, the total change in alveolar bone height for all surfaces was 0.87 ±0.26 mm and 0.53 ±0.12 mm for group I and group II respectively. Fig (5)

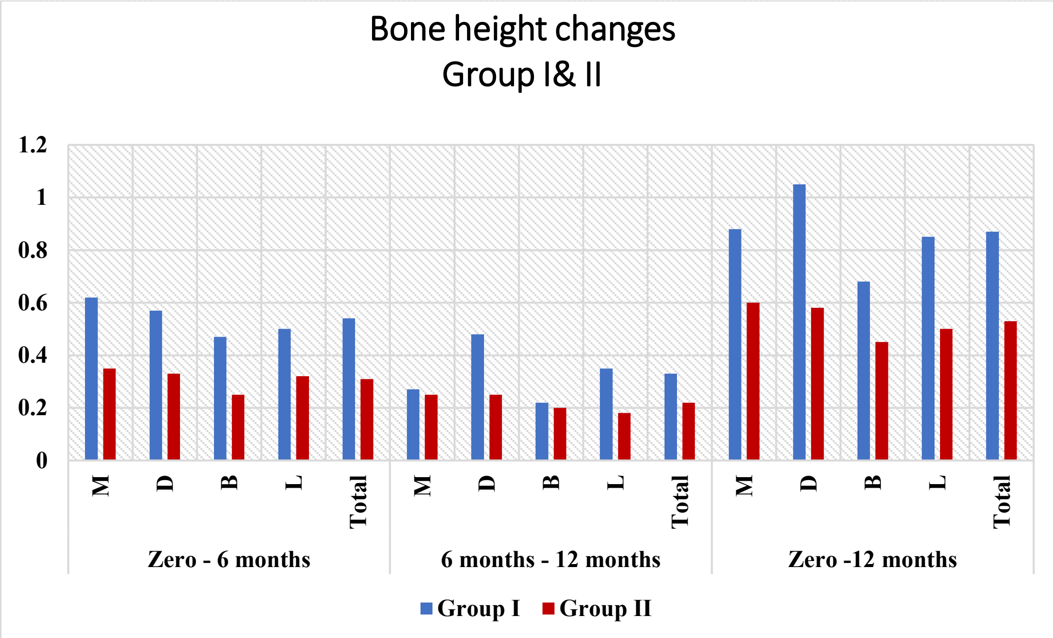

Figure 5: Comparison of mean differences and standard deviations of marginal bone height change for all surfaces of group I and group II among follow up period.

Table (1): Mean differences and standard deviations of marginal bone height change for group I and group II during follow up period:

Intervals	Surface	Group I (Co-Cr)		Group II (PEEK)		P-value
		MD	SD	MD	SD	
Zero - 6 months	M	0.62	±0.34	0.35	±0.05	<0.001*
	D	0.57	±0.40	0.33	±0.12	0.01*
	B	0.47	±0.10	0.25	±0.05	<0.0001*
	L	0.50	±0.21	0.32	±0.08	0.001*
	Total	0.54	±0.26	0.31	±0.08	0.0005*
6 months - 12 months	M	0.27	±0.08	0.25	±0.05	0.34
	D	0.48	±0.17	0.25	±0.14	<0.0001*
	B	0.22	±0.08	0.20	±0.00	0.27
	L	0.35	±0.14	0.18	±0.04	<0.0001*
	Total	0.33	±0.12	0.22	±0.06	0.0007*
Zero -12 months	M	0.88	±0.35	0.60	±0.11	<0.0001*
	D	1.05	±0.29	0.58	±0.25	<0.0001*
	B	0.68	±0.13	0.45	±0.05	<0.0001*
	L	0.85	±0.27	0.50	±0.06	<0.0001*
	Total	0.87	±0.26	0.53	±0.12	<0.0001*

DISCUSSION

Guided implant placement using CAD/CAM technology was used in this study to allow the precise planning of implant positions on computed tomography scans and fabrication of accurate surgical guide that permits the surgeon to place implants precisely into the planned positions (8). Bar attachment was the one of choice in this study. It was stated that Bar-splinted dental implants allow better stress distribution and less prosthetic maintenance in comparison to non-splinted implants (9). Cone beam radiograph was used to assess alveolar bone height and its loss around implants. Cone beam was used as it provide accurate 3D image, with minimal dose of radiation compared to conventional CT system, inexpensive, and limited scan time (10). Success of dental implant treatment mainly depends on the sustainable long-term health of soft and hard peri implant tissues. Assessment of pain, infection, inflammation, and marginal alveolar bone loss are all considered as useful implant success criteria. Specific attention has been directed towards post-operative radiographic assessment of marginal alveolar bone loss around implants by serial radiographs. Vertical marginal bone

oral hygiene measures, proper implant insertion and angulation, and restricting the opposing occlusion to complete denture for reduction of lateral component of forces exerted during mastication and dissipating these forces. The results of this study at the end of 12 months follow-up period showed a statistically significant decrease in peri-implant bone height for the two studied groups. A total change of 0.87 mm and 0.53 mm was detected for Group I (Co-Cr) and Group II (PEEK) respectively.

This study revealed that the use of PEEK bar attachment showed less amount of peri-implant bone height loss throughout the one year follow up period compared to Co-Cr

loss at the peri-implant surfaces should not exceed 1–2mm during the first year of function and 0.2mm thereafter (11).

- Bone loss appeared to be within acceptable limits in both groups perhaps due to the prosthesis being constructed as passive as possible by CAD/CAM. Milling has proved to be more advantageous than casting as regards to passive fit and accuracy of margins (12, 13). Gianluca Paniz (14) and Jaafar Abdou (15) compared the accuracy of fit of full arch restorations constructed by milling and casting where milled restorations gave much more accurate margins and better passive fit. On the other hand, the effective splinting of the implants by the rigid milled bar may be responsible for reduced bone resorption values of milled bar. This was in line with Pozzi (16) at al. who evaluated bone resorption at 4 implant overdentures supported by CAD/CAM titanium milled bar. At the one year follow-up, they found a mean bone resorption of 0.29 ±0.16 mm.

The acceptable range of crestal bone height loss for the two groups may be also attributed to proper selection of cases, adequate implant length in proportion to the height of the residual alveolar ridge, proper bar attachment. PEEK material is characterized by excellent biocompatibility and exceptional physical and chemical properties regarding toughness, hardness, and elasticity. In term of load cushioning capacity of the prosthetic elements, PEEK has a comparable modulus of elasticity (4GPa) to that of bone (4.2GPa). Thus, the bone could allow bone stimulation favoring its remodeling without overloading (17).

CONCLUSION

Within the limitations of this study it could be concluded that: The use of CAD/CAM milled Co-Cr and PEEK bar attachments to support implant mandibular overdenture fulfils the criteria of implant success as indicated by clinical and radiographic outcomes after one year. However, CAD/CAM milled PEEK bar may be advantageous than CAD/CAM milled Co-Cr bar in terms of reduced bone loss.

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