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EVALUATION OF MARGINAL BONE HEIGHT CHANGES IN IMPLANT SUPPORTED MANDIBULAR OVERDENTURE RETAINED WITH TWO DIFFERENT MATERIALS OF BAR ATTACHMENTS

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ABSTRACT

Objective: To estimate crestal bone height changes and biting forces in three implant supported mandibular overdenture retained by Poly ether ketone (PEEK) bar and chromium cobalt (Co-Cr) bar attachment.

Materials and Methods : Twenty completely edentulous patients with age range above 60 years were participated in this study. Three implants were placed in the inter foraminal area; two implants were placed bilaterally in the right and left canine areas and one near the midline. In all patients, conventional maxillary full dentures were constructed against implant-supported mandibular overdentures.A random dividing was made for all patients to be two equal groups according to the bar attachments material. Polyether ether ketone (PEEK) bar attachments were fabricated to hold the overdenture for patients in group A, while custom-designed chromium cobalt (Co- Cr) bar attachments were constructed for patients in group B. Crestal bone loss around implants was assessed by CBCT after denture pick up (T0) base line ,after 3 months(T3), 6 months(T6) and after 12 months (T12) from the pickup of the overdentures. Bite force was evaluated using a load star sensor device at base line,1 month and 3 months from overdenture pick up.

Results: The obtained data revealed that bone loss in mesial, distal and average bone loss of PEEK group show higher significant value than the chrome cobalt bar group. For the buccal and lingual aspects, the difference was not statistically significant. Results of intergroup comparisons for biting force values presented that for peak and total biting force, PEEK group had significantly higher values. However, for low biting force there was no statistical significant difference between the two groups.

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Conclusion: This study concluded that there was no significant difference between PEEK milled bar attachment and (Co-Cr) bar regarding bone resorption however, PEEK bar attachment showed more biting forces than (Co-Cr) bar. Peek milled bar used to retain a three-implant supported overdenture improved patient masticatory efficiency

KEYWORDS: Implants retained overdenture, Polyether-ether Ketone, bar attachment, Chromium Cobalt, marginal bone loss, biting forces.

INTRODUCTION

Many problems related to complete dentures, involving reduced retention, stability of the denture, ache when chewing, and also less chewing efficiency.[1]

Many studies proved that implant-supported overdentures successfully solves these problems.[2] many studies were reported that three-implant mandibular overdentures have high implant success and survival rates, healthy peri-implant tissue, and appropriate peri-implant bone loss rates. It was suggested that placement of a midline implant in three-implant mandibular overdentures forbidden the rotation movement by preventing tissue intrusion into the denture midline area.[3, 4]

Various methods were utilized to evaluate the competence of the system of mastication, involving measurement of bite force and record the surface electromyograph (EMG) of the masticatory muscles.[5] One of the indexes of functional condition of muscle of mastication is the bite force resulting from the action of the elevator muscles adjusted by cranio-mandibular biomechanics. [6] Many researches have found a positive relationship between the efficiency of the system of mastication and maximum bite force (MBF). It has been shown that chewing efficiency changes by up to 50% even with the smallest changes in bite force. [7-9]

Various attachments systems have been used successfully in implant overdentures like ball and socket, locator, magnets, telescopic crowns and bars splinting implants in overdenture .[10]

The stable anchorage of mandibular overdentures has a major impact on the living standards of edentulous patients. Oral function can be enhanced with implant-supported overdentures; This enhancement mainly depends on the degree of prosthesis retention and stability and so on the fixation.[11] Individual attachments are less expensive and have less sensitive technology .But, bar attachments lead to more retention than individual attachments.[12]

Bar attachments, such as the Hader bar and Dolder bar, allow even stress distribution which exerted during chewing [13], moreover; implant supported overdenture with bar attachment provide successful results for the treatment of edentulous patients.[14]

Mechanical properties of Cobalt-chromium (Co-Cr) alloys are the reason of using it to make bars, such as its high modulus of elasticity, when comparing it with titanium and gold alloy it show more resistance to corrosion, Co-Cr alloys showed the advantage of retention load of using for a long time.[15]

Implant supported overdenture using bar attachments are traditionally made. using the lost-wax and conventional casting methods, which is time-consuming and some technical problems as porosity and poor fit which may occasionally associated fabrication of cast one-piece implant frameworks. Alternatively, the overdenture bar framework can also be manufactured using the CAD/CAM process.[16]

However, new metal-free materials such as zirconium and polyetheretherketone (PEEK) were introduced to overcome the problems associated with metallic bars as bad esthetic and allergic effect of base metals on some patients. [17]

Polyetheretherketone (PEEK) is a high-performance polymer used as a metal replacement for fixed and removable prosthesis. This material show many features like: good strength-to-weight ratio, resistance to corrosion, biocompatibility, radiolucency, low plaque affinity, and chemical stability[18,19]. As well, it has well mechanical behavior like low creep, wear resistance, low specific weight and shock absorption. [20] PEEK may be manufactured by CAD/CAM or injection molding. It has been proven that PEEK has a unique property; it has a low elastic modulus approaching that of the bone[20, 21] This study was proceeded to show the comparison between changes occur in bone height and masticatory forces experienced by three implant-supported overdentures fitted with two different materials of bar attachments Co-Cr bar attachment and a peek bar attachment.

MATERIALS AND METHODS

Twenty completely edentulous patients with age range between 61 and 75 were selected from the outpatient clinic of the prosthetics department Faculty of Dentistry Fayoum University with sufficient bone quantity and quality in the mandibular anterior area was identified with preoperative cone beam CT to accommodate implants with a length of 13 mm and a diameter of 3.75 mm*.By using a mean value articulator and by recording a tentative jaw relation the upper and lower diagnostic casts were mounted to evaluate inter-arch distance to ensure the presence of at least 12 mm allowing construction of the bar. Patients with parafunctional habits, metabolic bone disorders, or a history of head and neck radiation therapy were excluded. Patients were informed of all treatment steps and the need for recalls, and then signed a written consent. The suggestion of the study was accepted by the Ethics Committee of the Faculty of Dentistry of Fayoum University.

All the steps of construction of upper and lower complete denture were made which began from preliminary impression, final impression, jaw relation record ,try-in and delivery were supplied to the patients; one month After delivery of complete denture, a tissue-supported stereolithographic surgical guide for implant placement which provide precise location and angulation of dental implants was constructed using Dual scan protocol, then all the raw data were converted into 3D information using blue sky software** for designing of the surgical guide.

Broad spectrum antibiotic*** 24 hours before the surgery with non-steroidal anti-inflammatory ****analgesics twice per day after the surgery were given for all patients.

For both groups three implants were surgically placed as following, two bilaterally in the canine areas and one in the midline using a standardized 2-stage surgical protocol (Fig.1).

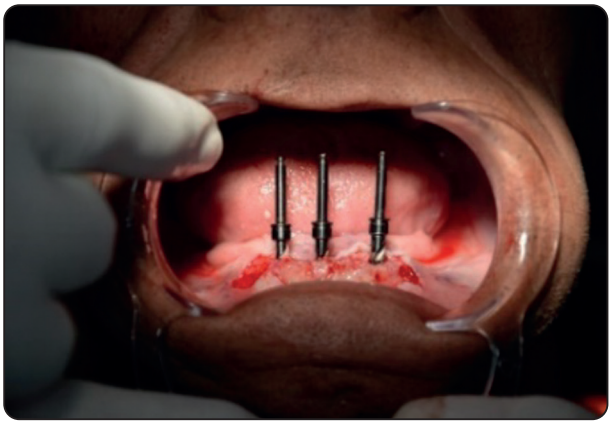

Fig. (1) Alignment of the three implants' position

After 3 months second stage surgery was done, the implants were exposed and unscrewing for cover screws was done then healing abutments of suitable length were screwed to allow the soft tissue healing around it within a week and the patient was instructed to rinse with warm saline, Open tray impression technique was done, first

* New Biotech Dental Implant, Guro-gu, Seoul,08381, Republic of Korea.

** Blue Sky Plan® V3, Blue Sky Bio, n® LLC, USA.

*** Augmentin 1g- Beecham MUP

**** Ibuprofen, Knoll, Ludwigshafen, Germany

:open tray impression analogs were screwed into implants ,second :all analogs were splinted together rigidly by using orthodontic power chain and Dura lay acrylic resin*, then an open tray impression was taken using medium-body polyether rubber base impression material**. The implant analogues were screwed to the impression copings then the impression was poured to obtain a master cast with splinted impression copings which screwed to implant analogue impeded in the cast, and then a verification jig was constructed to confirm the impression accuracy and examine it intraorally and by periapical radiograph

The patients were divided into two equal groups using randomly generated numbers prepared by a computer program***; The first group received a CAD/CAM-milled PEEK bar, and the second group received a cast Co-Cr metal bar.

Bar construction

Group A: CAD/CAM milled Peek bar:

Desktop extra-oral scanner was used to capture the 3-D orientation of the implant's location in each cast. The optical scanner light source reaches the object with fringes of light shot by a camera. By projecting many fringes and moving them along the whole surface to be scanned, a complete scan of the cast and its 3-D reconstruction was obtained for designing the bars using Exocad. (Fig. 2)

Scan bodies were screwed to the implant analogues on the cast and scanned using the desktop scanner. Alignment of the bar was made bucco-lingually, occluso-gingivally and mesio-distally. Smoothening and roundation of any roughness was made. 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). Finally, the position of the PEEK bar in the blank was determined. The whole design was checked and STL file was exported to the milling machine**** and milling of the PEEK bar was then done. The bar was then checked for any roughness or residues and then the bar was then checked over the implants Ti bases and removed to detect any interference. A layer of PEEK primer was applied to the fitting surface of the bar and left for 10 seconds then dryness was done and resin cement was applied and light cured for 20 second for each surface. Once cementation was completed, the bar was screwed in the patient's mouth and tightened using a torque wrench at 15NCm. (Fig. 4)

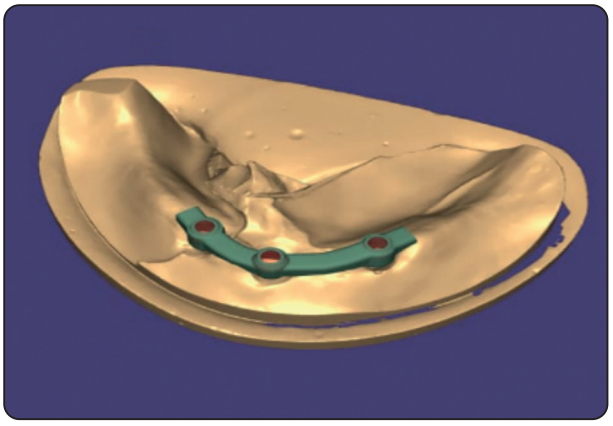

Fig. (2) Bar design using exocad

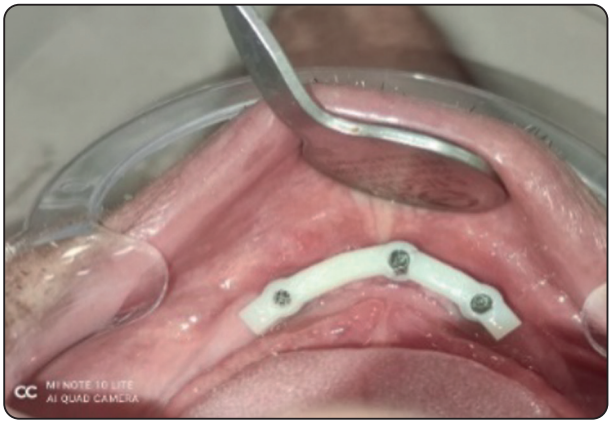

Fig. (3) Checking Milled PMMA verification jig intraorally

* inlay pattern resin - Reliance Dental Mfg.co.

** 3M ESPE ImpregumTM Soft, poly ether impression materials.

*** Excel spreadsheet

**** 5-axis planmeca planMill 50

Fig (4) The peek bar in the patient's mouth

Group B: Cast Co-Cr bar:

After the verfication jig was checked intraorally to insure accuracy of the impression and by periapical radiograph fig. (5). Three UCLA* abutments were screwed onto implant analogs on the poured cast and connected with a bar it's round surface in the top which are incorporated in to the wax pattern, in correct position on the ridge crest with 2mm clearance below the bar, After investing, the plastic bar and abutments were burned -out of the wax pattern and molten alloy (Co-Cr) was casted into the investment mold creating a framework pattern which provide cast interface that match directly with the implants, and then the bar was tried in the patient's mouth. Then (Co-Cr) bar was finally screwed intraorally to the implants.

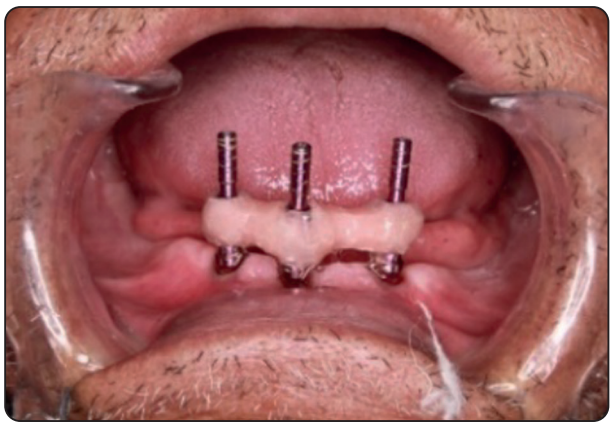

Fig. (5) Checking verification jig intraorally

A new complete lower denture was performed as usual by making final impression in acrylic resin special tray with silicon impression material, followed by jaw relation record, try-in, final denture insertion, and then Pick-up of the final denture was done after Blocking out the undercuts below the bar using elastomeric impression material and Plastic clip attachments were ensured over the bar, A sufficient relief was done in the fitting surface of the prostheses corresponding to the clip and A small bore was done at the lingual flange to permit escaping of extra material then the fitting surface at this area cured with acrylic monomer and auto polymerizing acrylic resin was mixed and applied in the recess.

Patient evaluation:

Bone height changes:

After post insertion adjustments; patients were frequently recalled for maintaining oral hygiene measures and the implant crestal bone height changes were evaluated using CBCT**. The mesial, distal, buccal, and lingual crestal bone height changes around the implants were measured at base line (at loading) (T0),3 months(T3),6 months(T6) and 12 months (T12) postoperatively. (fig 6)

The bone heights were measured by measuring the distance from the alveolar crest to the implant apex. Two horizontal lines at the alveolar bone crest and at the implant apex were drawn; the software then automatically gives the measurements in millimeters on the screen between the two lines. Values of linear measurements were recorded in the patient chart at every follow up visit and from these data mean value of bone height changes were calculated.

Biting force evaluation:

The sensor was placed in the working environment for 12 hours to reach a steady state and was

* University of California at Los Angeles Abutment

** Planmeca promax 3D classic, Planmeca, Finland.

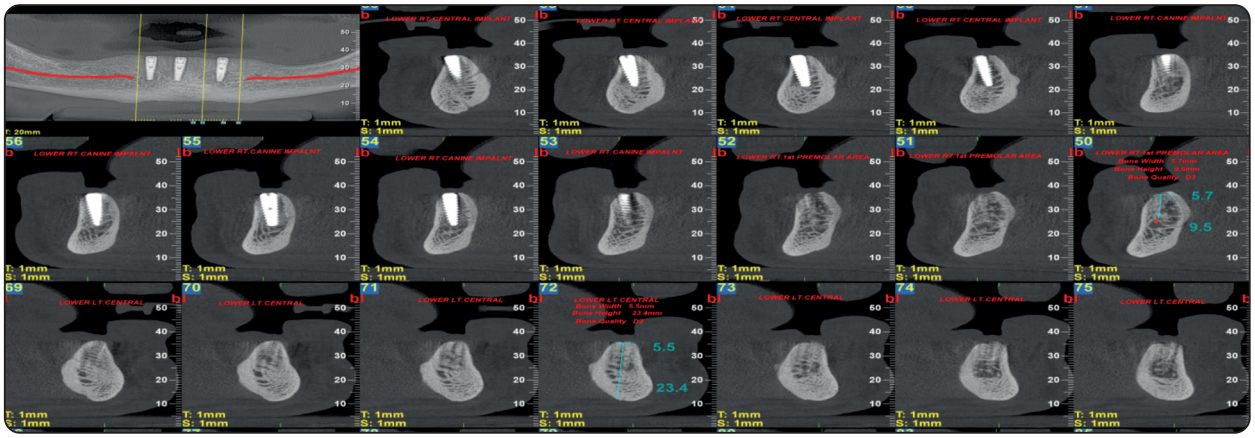

Fig. (6) Measurements of bone heights around the implants using CBCT

allowed to warm up by connecting it to power for 30 minutes to allow the signal conditioning electronics to stabilize and perform more accurately, however if the sensor was subjected to any significant changes in temperature may lead to thermal drift that may give error in reading obtained.

The patient was instructed to sit in upright position The maximum bite force (vertical inter-occlusal bite forces) was determined bilaterally using a Loadstar sensor* . The sensor is connected to the computer through a USB cable. The load sensor was horizontally positioned in the first molar area (right and left). For a few seconds, patients were encouraged to bite as hard as possible on the load sensor. Each second, a new record, the highest, was set. From the recording table, ten readings were chosen. This technique was done three times on each side with a two-minute interval, and the mean for both sides was recorded as MBF. The maximum bite force was determined in Newtons, this procedure was repeated at time of loading,1 month and 3 months after overdenture delivery (Fig. 7).

Statistical analysis:

Numerical data was represented as mean and standard deviation (SD) values. Shapiro-Wilk's test

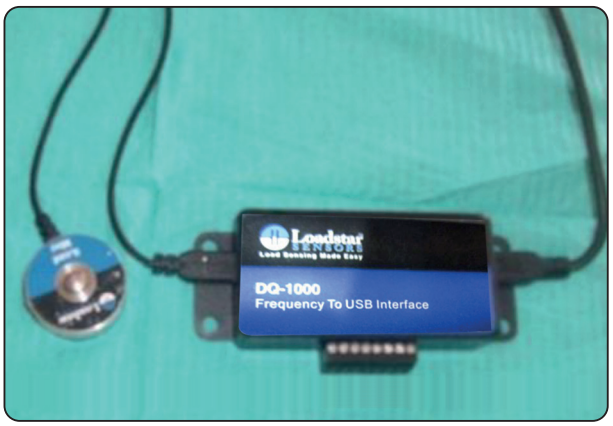

Fig. (7) Load star sensor device.

was used to test for normality. Data were normally distributed and were analyzed using two-way mixed model ANOVA followed by comparisons of estimated marginal means using multiple t-tests with p-value adjustment using false discovery rate method. The significance level was set at $p<0.05$ within all tests. Statistical analysis was performed with R statistical analysis software version 4.3.0 for Windows**.

* Load. star sensor, 453, Ravendal. Drive, Mountain View, CA .94043, USA

** R Core Team (2023). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

RESULTS

Mixed model ANOVA results were presented in tables (1) and (2) showed that for bone height and biting force respectively showed that there was a significant interaction between material and measurement time ($p<0.05$).

Comparisons of estimated marginal means for bone loss are presented in table (3). At baseline, there was no significant difference between both groups ($p=0.896$). At other intervals, bone loss measured in PEEK group was significantly higher than that measured in custom-made bar group ($p<0.05$). For both groups, there was a significant increase in bone loss staring from baseline until 12 months ($p<0.001$). Mean and standard deviation values for bone loss are presented in figures (8) and (9).

Comparisons of estimated marginal means for biting force are presented in table (4). At all intervals, biting force measured in PEEK group was significantly higher than that measured in custom-made bar group ($p<0.001$). For custom-made bar group, there was no significant difference between values measured at different intervals ($p>0.05$). For PEEK group, there was a significant increase of biting force after 1 and 3 months ($p<0.001$). Mean and standard deviation values for biting force are presented in figures (10) and (11).

TABLE (1) Mixed model ANOVA for bone height

Parameter	*DFn*	*DFd*	*SSn*	*SSd*	*f-value*	*p-value*
Material	1	6	0.76	0.61	7.48	**0.034***
Time	3	18	5.83	0.30	117.44	**<0.001***
Material * time	3	18	0.24	0.30	4.85	**0.012***

df= degree of freedom, SS= sum of squares, n= numerator, d= denominator, , *significant (p<0.05)

TABLE (2) Mixed model ANOVA for biting force

Parameter	*DFn*	*DFd*	*SSn*	*SSd*	*f-value*	*p-value*
Material	1	8	166.98	11.34	117.82	**<0.001***
Time	2	16	1.88	1.41	10.68	**0.001***
Material * time	2	16	2.50	1.41	14.22	**<0.001***

df= degree of freedom, SS= sum of squares, n= numerator, d= denominator, , *significant (p<0.05)

TABLE (3) Comparisons of estimated marginal means for bone loss (mm)

Time	*Bone loss (mm) (Mean±SD)*		*t-value*	*p-value*
	Custom-made bar	*PEEK*		
Baseline	1.26 ± 0.06^{D}	1.27 ± 0.06^{D}	**-0.14**	**0.896**
3 months	1.54 ± 0.17^{C}	2.02 ± 0.30^{C}	**-3.50**	**0.013***
6 months	1.95 ± 0.04^{B}	2.31 ± 0.34^{B}	**-2.64**	**0.039***
12 months	2.22 ± 0.10^{A}	2.59 ± 0.25^{A}	**-2.68**	**0.036***

significant (p<0.05)

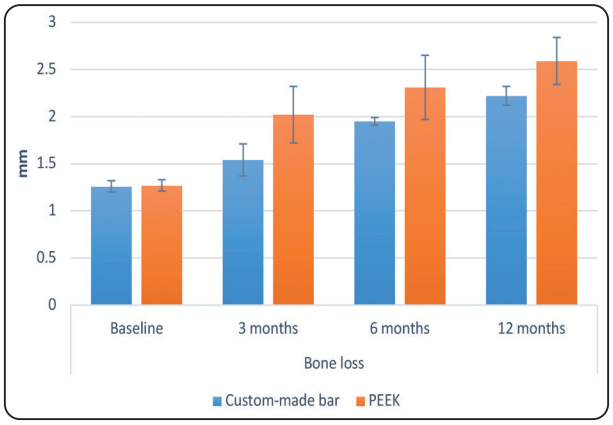

Fig. (8) Bar chart showing mean and standard deviation values of bone loss (mm).

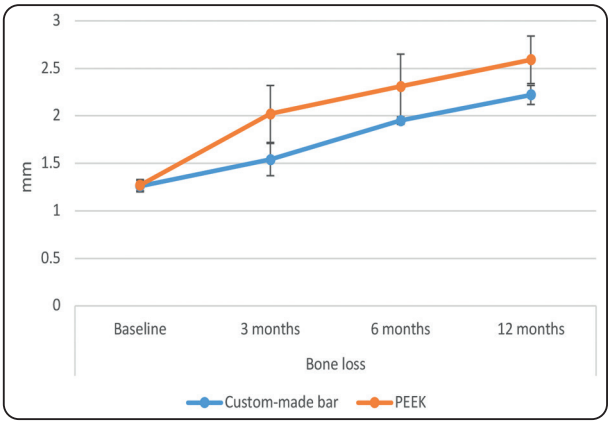

Fig. (9) Line chart showing mean and standard deviation values of bone loss (mm).

TABLE (4) Comparisons of estimated means for biting force (N)

Time	*Biting force (N) (Mean±SD)*		*t-value*	*p-value*
	Custom-made bar	*PEEK*		
Baseline	1.38±0.35^{A}	5.29±0.95^{B}	**-8.47**	**<0.001***
1 month	1.30±0.31^{A}	6.43±0.99^{A}	**-11.12**	**<0.001***
3 months	1.30±0.31^{A}	6.43±0.99^{A}	**-2.64**	**<0.001***

significant (p<0.05)

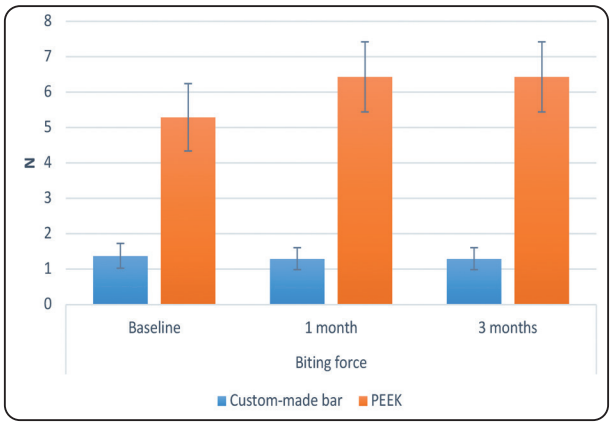

Fig. (10) Bar chart showing mean and standard deviation values of biting force (N).

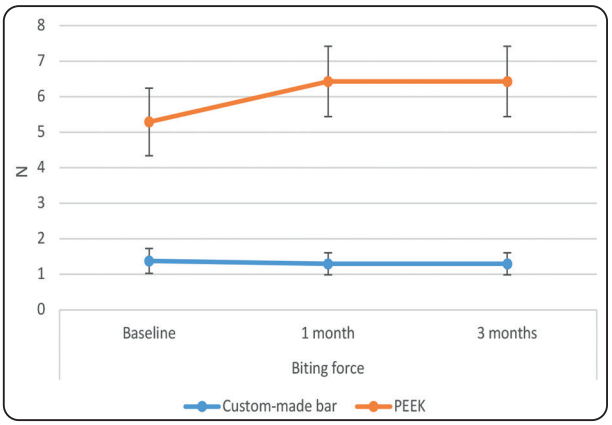

Fig. (11) Line chart showing mean and standard deviation values of biting force (N).

DISCUSSION

The present study was interested in use 2 different bar attachments supported by 3 dental implants in the anterior mandible to benefit from the advantages of implant supported overdentures over conventional complete.[22]

Patient with adequate bone volume in the inter foraminal region with minimum Width 6mm and minimum height 13 mm to allow proper placement of implants Which is determined by radiographic examination using cone beam computed tomography.[23]

The guided surgery is a very prices for implant placement. It decreases the operation chair time, the surgery become more precise and less painful , and the implants are placed in a restoratively driven manner through surgical guide fast and simple. So all information obtained from a virtual planning can be transferred for the surgical field through manufacturing of surgical guides .[24, 25]

Using dual scan technique, where the patient's existing lower denture was used for the two scans after being modified into a radiographic guide, ensure the proper planning of implants with consideration of the anatomy like the location of mandibular nerve. Also, this technique provides artifact free and high-resolution digitalization of radiographic guide. [26-28]

In this study the bar attachment is the only choice. Which allows less prosthetic maintenance and better stress distribution in comparison to anon-splinted implants. [6, 29]

The records of biting force were carried out after one month from denture pickup for confirmation of Patient's comfort as any pain affect biting force records. then after 3 months for neuromuscular coordination, adaptability of the patient and settling of the denture. [30, 31]

In this study the result revealed that the use of three implants supported mandibular overdenture retained with milled PEEK bars shows higher values of bone height changes around the implants and this result may be explained as the PEEK bar has a unique property; it has low elastic modulus similar to that of bone [32, 33]. This explains a significantly higher values of bone height changes in the mesial, distal and average aspects of PEEK than the custom-made bar. [34]

Elasticity of PEEK bar allowed more stresses to applied to implant supported overdenture. However, the rest of the aspects showed no significant difference. The crestal bone loss that occurred during the follow up period may be due to surgical trauma during drilling, the remodeling process post implant insertion and/or due to occlusal loading[35, 36]

The present study's results revealed that; there was a gradual increase in the maximum biting force in patients rehabilitated by implant overdentures in the two studied groups throughout study period. This finding may be due to many reasons; the gradual rise in the maximum bite force may be due to the neuromuscular co-ordination and adaptability of the patient to the prostheses upon time; however it was reported that implant supported prostheses may restore the oral function successfully, both subjective and objective indicators of chewing ability score better compared to conventional complete dentures; more over the refined stability and retention provided by the implants may have lowered patient's fear and promoted them to exert higher biting force.[37-40]

Longitudinal study compared the maximum biting forces and the level of activity of the muscles of mastication two months after mandibular implants placement for denture stabilization. This study reported marked rise in bite force value from 41% to 58% bilaterally in molar area after the implants supporting. This study also revealed rise in the amount of the effort exerted by the muscles from 24% to35% at the same two month period.[41-43]

The higher security of implant retained overdentures had provided the patients more confidence and improving their self-esteem leading

to higher maximum biting force values. Moreover, it is documented that the presence of sufficient number of dental contacts provide a stable reference for the contraction of supra-mandibular masticatory muscles, both static (biting, swallowing) and dynamic (chewing) activities have been reported to be more efficient. [44, 45]

However regarding the PEEK group shows high values for maximum biting forces, the more biting forces were due to patient more comfort and an improvement in masticatory efficiency rather than that in CO-CR bar.

CONCLUSION

We concluded that there was no significant difference between PEEK milled bar attachment and custom-made bar regarding bone resorption however, Peek bar attachment showed more biting forces than Co-Cr custom made bar. Peek milled bar used to retain a three-implant supported overdenture improved patient masticatory efficiency. Its a successful alternative to conventional CO CR bar retaining mandibular overdenture due to it's clinical prosthetic advantages.

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