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COMPARING THE EFFECT OF CANINE GUIDED VERSUS GROUP FUNCTION OCCLUSION ON THE VERTICAL BONE LOSS AROUND IMPLANTS RETAINING MANDIBULAR HYBRID PROSTHESES

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ABSTRACT

Aim: The aim of this study was to evaluate the amount of marginal bone loss around mandibular fixed hybrid prostheses with different occlusal schemes among mandibular completely edentulous patients opposed by dentate maxilla.

Materials and methods: This study was conducted on 18 patients. The patients were distributed in two groups. All patients were with mandibular completely edentulous arch and were rehabilitated with five intra-foraminal implants which were restored by implant supported fixed hybrid prosthesis. For the first group: (C) canine guided occlusal scheme was used. As for the second group: (G) group function occlusal scheme was used. The amount of marginal bone loss in each group was measured by CBCT at 0, 6 and 12 months after delivery.

Results: Within both intervals, for left implant (1) and right implant (2), distal bone loss values measured in group function group were significantly higher than those in canine guided group ($p<0.05$). While for other implants the difference was not statistically significant ($p>0.05$) at the end of the study. There was no significant difference between total bone loss values measured in both groups ($p>0.05$) at the end of the study.

Conclusion: Both canine guided and group function occlusion are accepted occlusal schemes for fixed implant prosthetics, but canine guided occlusion tends to distribute the forces more evenly leading to more even bone loss than group function which concentrates stresses on the distal implants threatening the longevity of the distal implant.

KEYWORDS: Canine guidance, group function, occlusion, implants

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INTRODUCTION

The situation, where a patient has become completely edentulous in one arch while either some or all of his natural dentition is retained in the opposing arch, is not uncommon. It is often very hard to achieve a successful complete denture for such a patient [1]. There are two main causes for this difficulty. The first is related to the rigidity and firmness of the retained natural teeth in the bone as well as the magnitude of force they can deliver or resist without causing patient discomfort or displacement of the complete denture. The force falling on a single molar tooth has been estimated to be as high as 198lb. This sharply contrasts with the force that a complete denture, which simply rests on the delicate mucosa covering the ridge, can deliver or resist. The amount of force delivered by a complete denture has been well established to be a maximum static load of 26lb. The second cause of difficulty is mainly associated to the occlusal form of the remaining natural teeth, which directly affects the occlusal form of the constructed denture. This may be in the form of over-eruption or tilting of the remaining natural teeth that leads to sharp and high cusps. Consequently, occlusion as well as articulation of the teeth will commonly involve contact of inclined planes of the cusps in a manner that leads to the continuous thrusting or dragging of the denture horizontally on the ridge [2].

The high success rate and predictability of implant-supported fixed dental prostheses have made it a preferable treatment option for the replacement of missing dentition in completely edentulous patients. Their goal has been to restore form, esthetics, and function. Occlusion plays an important role in the biological and functional aspects of the implant supported prostheses. The proper control and maintenance of occlusion could significantly lead to the reduction of biological and mechanical complications, leading to a significant increase in the longevity of the final prosthesis[3].

While occlusal concepts of implant-supported fixed dental prostheses are derived from natural dentition and complete dentures, there are modifications due to the different biomechanical and biological characteristics of dental implants compared to natural dentition. When compared to natural dentition, dental implants lack a periodontal ligament. Thus, they are more susceptible to the effect of bending loads. Multiple risk factors have been linked to occlusal overloading of Implant-supported fixed dental prostheses, such as non-axial loading, occlusal morphology and scheme, prostheses with cantilever extensions, occlusal materials, an unfavorable crown-to-implant ratio as well as the patient's parafunctional activity. These factors usually lead to more technical, mechanical, or biological complications associated with implant-supported fixed dental prostheses and may result in undesirable dental implant loading. Thus, to increase the rate of clinical success, their occlusion should be carefully planned and controlled [4].

Prosthetic complications are more frequently observed in cases where full arch implant prostheses oppose natural or fixed restorations leading to issues like veneering porcelain chipping, acrylic tooth fracture, premature wear of acrylic teeth, screw loosening/fracture, and framework fracture. Multiple repair visits are required to fix such prosthetic complications incurring an increase in laboratory costs, treatment time and more crucially, dissatisfied patients[5].

To achieve ideal implant occlusion, stress around implant components must be controlled for a biologically and prosthetically acceptable bone-to-implant interface, ensuring long-term stability of the marginal bone [6].

The ideal occlusion for eccentric movements can be classified by three schemes according to the tooth contact condition; mutually protected canine guided articulation, group function, and balanced articulation. The balanced occlusion concept is applied to complete denture patients while mutually protected canine guided occlusion and group function are applied for natural dentition and fixed restorations[7].

In canine guided occlusion, the overlap of maxillary and mandibular canines results in disengagement of maxillary and mandibular posterior teeth during excursive movement of mandible whereas the group function is defined as multiple contact relations between the maxillary and mandibular teeth in lateral movements on the working side in which simultaneous contact of several teeth acts as a group to distribute occlusal forces[8].

Even though at maximum intercuspation they usually have comparable occlusal contacts, the contact of both schemes on lateral movement is significantly different. Canine guided occlusion is characterized by a prominent horizontal and vertical overlap of the canines which prevents the contact of posterior teeth in the lateral mandibular movement. Whereas group function occlusal scheme allows multiple tooth contacts between the mandibular and maxillary teeth on the working side only during lateral movement. Each lateral occlusion philosophy has its supporters but there is no clinical evidence to support the superiority of one philosophy against the other[9].

Careful evaluation and planning of occlusion is one of the crucial factors that should be considered in implant treatment. Overloading resulting from improper occlusion is one of the important reasons leading to unsuccessful implant treatment [10]. From the clinical point of view, occlusion in implant- supported fixed prosthesis, if poorly developed, could have an adverse effect on the implant supporting bone and associated prosthetic components[11].

Thus, the present study was initiated with the aim of evaluating the effect of canine guided versus group function occlusal schemes on marginal bone loss around mandibular fixed supported implant hybrid prothesis.

MATERIALS AND METHODS

A power analysis was designed to have adequate power to apply a two-sided statistical test of the null hypothesis that there is no difference between tested groups. By adopting an alpha level of (0.05) a beta of (0.2) i.e. power=80% and an effect size of (1.41) calculated based on the results of Block, Jonathan, et al.[12]; the predicted sample size (n) was a total of (18) cases. Sample size calculation was performed using G*Power version 3.1.9.7[13].

Eighteen patients with a completely edentulous mandible aged between 40 and 50 years were selected from the out-patient clinic of the Prosthodontic Department, Faculty of Dentistry, Ain Shams University. The study design was approved by the ethics committee of the faculty of dentistry, at Ain Shams University with approval number (FDASU-RecIM042103). All patients signed a written consent after being informed about the line of treatment and the need for frequent recall appointments throughout the total research period. Patients included in the study fulfilled the following criteria: completely edentulous mandible with dentulous maxilla.

Inclusion criteria included patients aged between 40-50 years with a lower jaw that is completely edentulous having a residual ridge with adequate quality and quantity of bone and covered by firm healthy mucosa. Exclusion criteria included patients with any complications that may prevent the surgery such as bone or mucosal diseases, metabolic diseases, or uncontrolled diabetes and any conditions that may complicate the treatment.

All patients had guided surgical installation of five implants.

Patient grouping:

The patients were randomly assigned in to two groups using random number generator and checker (www. psychicscience.org/random.aspx).

The same operator performed all the clinical steps; another operator who was blinded to the groups performed the measurements. The statistical analysist was also blinded to the groups to prevent any bias.

Group (C): Patients were rehabilitated with Porcelain Fused to metal (PFM), screw retained hybrid prosthesis following canine guided occlusal concept.

Group (G): Patients were rehabilitated with PFM screw retained hybrid prosthesis following group function occlusal concept.

Presurgical stage:

Impressions were taken as well as diagnostic bite registration for mounting of the casts to check the occlusal plane for proper occlusal adjustment then lower single complete denture was constructed.

Surgical guide fabrication:

Prefabricated dentures were used as scan prosthesis and all participants underwent cone-beam computed tomography (CBCT, i-CAT Vision) using a dual scan technique. Finally, the resultant image was obtained as a DICOM file. The implants were then planned in 3D software fig (1), to achieve optimal position taking into consideration the alveolar process as well as the prosthetic demands (Blue Sky implant software). Then, a fully computer guided stent was printed.

Surgical stage:

Autoclaving of the surgical armamentarium was carried out then the surgical places and the circumoral tissues were wiped with antiseptic solution (Oral Betadine) for disinfection. Bilateral mandibular nerve block anesthesia was administered with a 4% Articaine anesthetic solution. Next, field block anesthesia was applied in order to minimize bleeding using ARTINIBSA 40 mg/ml + 0.01 mg/ml solution for injection. A fully computer-guided stent was accurately positioned on the mandible guided by the patient's occlusion and secured with three well-distributed fixation pins. After the removal of the soft tissue by the aid of a tissue punch, a series of drills were used to prepare the implant osteotomy sites until complete preparation was reached.

The anchorage pins were detached easily, to remove the computer-guided stent from the patient's mouth, to facilitate implant insertion. Unwrapping of the sterile implant box (VITRONEX) was done, and then the inner implant vial was opened. The sterile implant was introduced into its site, after washing the osteotomy thoroughly using sterile saline solution, by screwing it gently using moderate finger pressure [self-tapping]. Once resistance was felt, the ratchet wrench was adapted to the implant to continue the screwing process. The screwing process was stopped as soon as the implant became flushed with the crest of the bone at an insertion torque of 35N. Then the covering screws were placed over the five implants and the patients received post-surgical instructions. Finally, Panoramic and radiographs were obtained for all the implants to assure proper positioning.

Restorative procedures:

After three months, exposure of implants was performed, and healing abutments were placed (Fig 2). Two weeks later, transfer copings with long screws were fixed onto corresponding implants after the removal of the gingival formers to start preparation of a single step Open tray impression (Implant level impression). Transfer copings were splinted together by using dental floss and flowable composite (Coltene Brilliant Flow). After material setting, the tray was removed and the accuracy of the impression was verified after its cleaning and drying. The transfer mounts positions were accurately checked and screwing of the dummy implants to the transfers was done. The gingival formers were reattached to the implants, secured into place and then essential postoperative oral hygiene instructions were assigned to the patient.

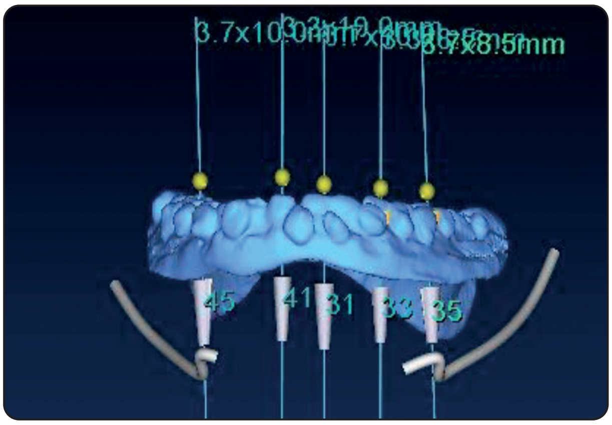

Fig. (1) Implant planning .


Fig. (2) Implants with healing abutments.

In the laboratory, a cast enclosing the implant dummy part with the attached abutment was obtained by pouring the impression utilizing extra-hard stone. This was followed by the fabrication of a custom tray; occlusion blocks in addition to a segmented implant verification jig (IVJ). The vertical dimension of occlusion was clinically evaluated in the patient's mouth, as well as the esthetics, centric relation, occlusion, midline and phonetics for a correct bite registration record using the occlusion blocks.

The verification jig was seated in place to ensure an accurate final impression. Checking for passive fit was done by x- ray and visible inspection around each cylinder to ensure complete seating.

Final impression and Jaw relation:

The customized impression tray underwent meticulous assessment to ensure an optimal fit, with careful attention to avoiding contact with the jig or transfers. A single step open-tray impression technique was done with putty and light bodied VPS material. Then, the impression was inspected for the required details. Last of all, the healing abutments were replaced. Face bow (Elite Facebow, Bio-Art, Brazil) record was taken and transferred to the semi adjustable articulator (Bio-Art articulator A7 plus, Bio-Art, Brazil) for mounting of upper cast.

Acrylic trial denture bases were fabricated each supported by two abutments on the fixtures which were made to record centric relation and eccentric relation. Eccentric relation records were made in wax and the condylar elements of the semi adjustable articulator were adjusted.

Framework try-in:

The final implant-supported prosthesis framework was fabricated using base metal alloy by lost wax technique (casting). On receiving the metal framework, the healing abutments were removed, and then the metal framework was checked for proper passive fit that is critical to ensure long-term success of the case. This was accomplished by using the single screw test on each implant (one screw was tightened to verify a passive fit i.e. no lifting of the framework at any side). Finally, the framework was removed, and the healing abutments were replaced. The case was returned to the laboratory for porcelain teeth build up as follows group (C) with canine guided occlusal scheme, and group (G) porcelain was built up with group function occlusal scheme. To develop the final occlusion maximum intercuspation in centric with no premature contact was confirmed. Then for canine guidance the canine would dis-occlude all posterior teeth during lateral mandibular movement, while for group function there was contact of teeth on working side, distributing the force between the teeth. Occlusion was made to direct forces on long access of the implant. Buccolingual width was kept to a minimum.

Final try in of framework with the porcelain teeth

For this step the healing abutments were removed and the metal framework with porcelain teeth was rechecked for passive fit. Then, the vertical dimension, centric relation, occlusion, shade, esthetics, tooth arrangement, midline and phonetics were verified. Articulating paper was employed to detect and rectify any high spots in centric then eccentric positions. For centric relation simultaneous bilateral contact with shim stock clearance (10μm) on cantilevers and anterior teeth with freedom in centric (1.0–1.5 mm) was verified. After accurate verification of occlusion, the healing abutments were replaced and the final try-in was returned to the laboratory for glazing and final adjustment.

Delivery of final screw-retained hybrid prosthesis:

The final implant prosthesis was seated on the implants after the removal of the healing abutments. The prosthetic screws were hand tightened in an alternating manner from one side to the other fig (3). The screws were tightened to the appropriate torque according to the manufacturer instructions. The occlusion was reconfirmed, and any needed adjustments were made to ensure contact of canine only during lateral movement in canine guided group Fig (4), and contact of canine and premolars during lateral movement in group function group Fig (5). Then, a small amount of sterile Teflon was placed in the screw access holes which were then filled with light cure composite (Coltene Brilliant Ever Glow) which prevents bacterial build-up. This was followed by final finishing and polishing of the light cured composite then CBCT was done to establish bone level base line.

Final adjustments & follow-up

Patients received detailed instructions for rigorous oral hygiene and recall appointments after 3, 6 and 12 months were scheduled for making the CBCT for bone level evaluation.

The implants were numbered from left to right as follows Left implant (1), Left implant (2), Midline implant, Right implant (1), Right implant (2) to facilitate communication.

Fig. (3) delivery of the final PFM hybrid prosthesis .

Fig. (4) canine guide occlusion.

Fig. (5) group function occlusion.

RESULTS

Numerical data are presented as mean and standard deviation values. They were checked for normality using Shapiro-Wilk's test. Data were found to be not normally distributed and were analyzed using Mann-Whitney U and signed rank tests for inter and intragroup comparisons respectively. The significance level was set at $p<0.05$ within all tests. Statistical analysis was performed with R statistical analysis software version 4.3.2 for Windows .

Intergroup comparisons of distal bone loss:

Intergroup comparisons, mean and standard deviation values of distal bone loss (mm) are presented in table 1.

At all follow up periods, for left implant (1) and right implant (2), bone loss values measured in group function group were significantly higher than those in canine guided group ($p<0.05$). While for other implants the difference was not statistically significant ($p>0.05$).

Intergroup comparisons of mesial bone loss:

Intergroup comparisons, mean and standard deviation values of mesial bone loss (mm) are presented in table (2).

At the 0 to 6 time interval, for left implant (1), there was no significant difference between both groups ($p=0.127$). For right implant (2), bone loss value measured in group function group was significantly higher than that in canine guided group ($p=0.035$). For other implants, values measured in canine guided group were significantly higher ($p<0.001$). whereas for the 6 to 12 time interval, For both left implants and right implant (2), bone loss values measured in canine guided group were significantly higher than those in group function group ($p=0.002$). While for other implants the difference was not statistically significant ($p>0.05$).

Inter and intragroup comparisons of total bone loss

Inter and intragroup comparisons, mean and standard deviation values of total bone loss (mm) are presented in table (3).

TABLE (1) Intergroup comparisons, mean and standard deviation values of distal bone loss (mm).

Interval	Implant	Distal bone loss (mm) (Mean±SD)		p-value
		Canine guided	Group function	
0-6 months	Left implant (1)	0.10±0.05	0.50±0.10	**<0.001***
	Left implant (2)	0.27±0.03	0.21±0.10	**0.277ns**
	Midline implant	0.27±0.03	0.31±0.08	**0.489ns**
	Right implant (1)	0.27±0.03	0.21±0.10	**0.277ns**
	Right implant (2)	0.29±0.08	0.58±0.17	**0.001***
6-12 months	Left implant (1)	0.26±0.05	0.41±0.09	**0.003***
	Left implant (2)	0.10±0.05	0.21±0.10	**0.035***
	Midline implant	0.10±0.05	0.10±0.06	**1ns**
	Right implant (1)	0.10±0.05	0.10±0.06	**1ns**
	Right implant (2)	0.10±0.05	0.41±0.09	**<0.001***

; significant ($p<0.05$) ns; non-significant ($p>0.05$)

* 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/.

TABLE (2) Intergroup comparisons, mean and standard deviation values of mesial bone loss (mm).

Interval	Implant	Mesial bone loss (mm) (Mean±SD)		p-value
		Canine guided	Group function	
0-6 months	Left implant (1)	0.29±0.08	0.21±0.10	**0.127ns**
	Left implant (2)	0.27±0.03	0.10±0.06	**<0.001***
	Midline implant	0.27±0.03	0.10±0.06	**<0.001***
	Right implant (1)	0.27±0.03	0.10±0.06	**<0.001***
	Right implant (2)	0.10±0.05	0.21±0.10	**0.035***
6-12 months	Left implant (1)	0.26±0.05	0.10±0.06	**0.002***
	Left implant (2)	0.26±0.05	0.10±0.06	**0.002***
	Midline implant	0.10±0.05	0.10±0.06	**1ns**
	Right implant (1)	0.10±0.05	0.10±0.06	**1ns**
	Right implant (2)	0.26±0.05	0.10±0.06	**0.002***

; significant (p<0.05) ns; non-significant (p>0.05)

TABLE (3) Inter and intragroup comparisons, mean and standard deviation values of total bone loss (mm).

Interval	Total bone loss (mm) (Mean±SD)		p-value
	Canine guided	Group function	
0-6 months	0.20±0.10	0.19±0.16	**0.058ns**
6-12 months	0.16±0.09	0.18±0.13	**0.463ns**

; significant (p<0.05) ns; non-significant (p>0.05)

Within both intervals, there was no significant difference between bone loss values measured in both groups (p>0.05).

DISCUSSION

Implant supported prosthesis are more affected by changes in occlusal schemes as they lack periodontal ligament with its proprioceptive and cushioning abilities. They are less forgiving to overload. Unfavorable occlusion will lead to crestal bone loss over time and ultimate loss of implants which would compromise the whole treatment plan(9). Pathological consequences can be precipitated by uncontrolled dynamic occlusion. When the mandible slides along the cuspal inclinations of teeth, the forces are transferred to the implants, supporting structures, temporomandibular joint and muscles of mastication. Many studies have proved that canine guided occlusion exhibits a protective role for posterior implants(7).

This study revealed that total bone loss for the group function group was slightly higher than the canine guided group but there was no significant difference between bone loss values measured in both groups at the end of the study.

Research on occlusion guidelines for implant-supported fixed restorations is limited. In the posterior region, implant-supported fixed prostheses typically favor anterior guidance as the initial contact with natural teeth to reduce lateral forces on the implants. Conversely, when anterior teeth cannot offer sufficient support and face periodic compromise, group function occlusion is recommended over canine guidance [14]. In a study by Ormianer and Palty, they found that patients with group functioning occlusion had 3 times more mechanical complications and more bone loss in comparison to patients with canine guided occlusion [15].

Anaraki MR et al., in their finite element analysis study comparing canine guidance to group function occlusion, observed significantly lower total maximum stress in the canine guidance occlusion[7]. Leja et al. reported lower incidence of cervical lesions in subjects with canine guidance compared to those with group function occlusion. Tokiwa et al. supported these results with their study, where they reported that less cervical lesions were observed in patients with canine guidance than patients with group function occlusion. The presence of canine guidance plays an important role in the reduction of the inter-arch forces, potentially decreasing normal tooth wear and parafunctional loads on implants [16].

The muscle force directly influences final force falling on the teeth. Lateral bite forces increase in the posterior regions in group function while two thirds of the masseter and temporalis muscle fibers remain relaxed in lateral movement of the mandible in canine guided occlusal schemes due to the absence of posterior contacts[7]. Belser and Hannam confirmed that canine guided occlusion caused a significant reduction of the masseter and temporalis EMG activity by 50 %. [17] Okano et al found less masseter and temporalis combined activity in canine guided occlusion on maximum clenching at edge-to-edge position[18].

This was contradicted by the study by Thornton LG, who evaluated 56 patients with different occlusal schemes for dental implants and concluded that group function occlusion was the preferred contact pattern, followed by canine guidance and balanced articulation. This finding may be attributed to the hypothesis that group function occlusion can be more functional and comfortable for the patient because it may assist in a wide distribution of the resultant occlusal forces on several teeth rather than on a single tooth and it leads to less force transmission and prevents teeth contact on non-working side from being subjected to the obliquely directed destructive forces[19].

Block et al. observed that the most desirable loading and resultant residual strain results were found in premolar loading guidance whereas canine loading presented the least desirable strain results, where the highest levels of horizontal strain was observed on loading with even higher levels of horizontal residual strain. A possible explanation for these findings as explained by the authors could be the fact that in canine guidance occlusion the loaded canine was only in contact distally, thus referring the forces in one direction, so the strain grew in a distal direction, in comparison to the premolar segment loading configuration where the loaded premolars were contact mesially and distally, referring the forces in two different directions[12].

For the distal implants in the group function group there was significant distal bone loss. This can be attributed to several factors like the implant distribution which led to a cantilever in the fixed prosthesis design. As Aglietta M and Wennström J concluded that a tendency to an increased marginal bone loss was observed around implant sites near to and distant from the cantilever extension. An overall mean change of 0.4 mm in marginal bone levels was observed between baseline and follow-up at implant sites adjacent to the cantilever extension[20][21].

According to this concept of occlusion, anterior teeth bear the load when posterior teeth are disoccluded in any excursive movement of mandible. The reason for redirecting the occlusal forces are that anterior teeth are located far away from TMJ and thereby have better leverage to offset.

CONCLUSION

Both canine guided and group function occlusion are accepted occlusal schemes for fixed implant prosthetics, but canine guided occlusion tends to distribute the forces more evenly leading to more even bone loss than group function which concentrates stresses on the distal implants threatening the longevity of the distal implant.

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