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Influence of Implant Position on Occlusal Distribution in Implant-Assisted Distal Extension Removable Partial Dentures using T-Scan system

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Aim: To evaluate the effect of implant position on occlusal load distribution of implant retained partial over denture in mandibular bilateral distal extension cases using T-Scan system.

Materials and methods: Patients were selected according to certain inclusion and exclusion criteria. The selected patients were divided into three equal groups: Group (I): Patients in this group were rehabilitated with a conventional removable partial denture. Group (II): Patients in this group were rehabilitated with an implant assisted partial denture, with implant positioned at the first molar position. Group (III): Patients in this group were rehabilitated with an implant assisted partial denture with implant positioned at the second molar position**.** T- scan system was used for assessment and adjustment of occlusion.

Results: Comparing the three studied groups, a significant increase in the calculated occlusal load was detected in group I compared to group II and group III throughout the study period $P < 0.03$. However, insignificant difference was detected comparing group II and group III together $P > 0.03$. Although there was a significant difference between the conventional partial denture and implant supported partial over denture regarding time and force distribution, there was very little difference between group II and group III. Change in implant position had little effect on masticatory efficiency and can be regarded insignificant.

Conclusion: Partial denture retained by two Osseo integrated implants one on each side of the lower arch showed better effect on the distribution of occlusal load compared by conventional partial dentures. Changing implant position from first mandibular molar to second mandibular molar had no significant effect on the occlusal load analysis using T-Scan system.

Keywords: Partial denture, Implant, T-Scan.

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INTRODUCTION

Most of the problems in distal extension cases are attributed to disparity of support, and the difference in the viscoelastic response of supporting structures, the abutment teeth and the ridge, to loading. Consequently, when functional load is applied to the removable partial denture with distal extension base, this difference in support results in rotation of the denture and heavy torsion stresses on the abutment teeth and traumatization of the ridge. (1)

Implant assisted removable partial dentures (RPDs) provide considerable advantages over conventional RPDs. Implants are used to improve the removable partial denture support, enhance retention and stability, and preserve the residual ridge underneath the denture base and to reduce the stress applied on the abutment teeth. The use of a posterior implant underneath a removable partial denture can help establish stable occlusal support which might prevent bone remodelling in the TMJ, as well as the residual ridge resorption. (2)

However, dental implants may deteriorate under excursive overload and higher bite forces, eventually leading to bone loss and implant failure. Therefore, assessment of the occlusion is of utmost importance to relief these occlusal issues. (3)

Recently, computer-guided occlusal adjustments using T Scan occlusal analysis system is employed to alter a poorly contacting tooth sequence into multiple equal-intensity contacts occurring throughout the arches bilaterally. (4)

The T Scan III is an occlusal analysis system that records occlusal contact force distribution from the first tooth contact till maximum intercuspal position. It readily identifies the very first contact point that precedes numerous other contact points that occur during maxilla-mandibular functional movements. The T-Scan III determines the contact time-sequencing, and the percentage of relative occlusal force between various occlusal contacts, and then displays them all for dynamic analysis. (5)

Although many studies have been conducted to assess the implant retained over dentures as compared to conventional partial dentures, little studies have been carried out to determine the most favorable implant position in distal extension cases and its role in providing stable occlusion. (6)

MATERIALS AND METHODS

For all patients, full clinical examination of the remaining natural teeth and residual ridges was done to fulfill the prementioned criteria.

Pre-operative radiographic exploration for all patients was done, while wearing their diagnostic stents, using Cone beam computed tomography (CBCT) radiography to examine the condition of the edentulous ridges in the area of interest.

The bone height, width and quality were evaluated radiographically, and the mandibular canal was traced, to insure at least 6mm bone width and 11 mm bone height at proposed implant site. Also, to detect any pathological lesion, remaining roots or impacted teeth.

The alveolar ridges at the prospective implants sites were palpated to ensure the absence of any flabby tissues, bony undercuts, sharp bony edges and thin ridges or any abnormalities. Figure (1)

Intra oral examination of the remaining teeth was done. Carious teeth were restored and present restorations were evaluated.

Examination of the T.M.J was carried out to detect any disorders as clicking, dislocation or pain.

Radiographic examination of the abutment teeth and edentulous ridges was done to evaluate the crown/ root ratio, apical, periapical condition, periodontal membrane space and the condition of the alveolar bony support of the abutment teeth.

Thorough periodontal therapy of all the remaining teeth including supra-gingival and sub-gingival scaling and root planning was performed. All patients were motivated to follow proper oral hygiene measures.

Figure (1): U shaped ridge covered with firm mucosa

The selected patients were divided into three equal groups:

- Group (I): Patients in this group were rehabilitated with a conventional removable partial denture.
- Group (II): Patients in this group were rehabilitated with an implant assisted partial denture, with implant positioned at the first molar position.
- Group (III): Patients in this group were rehabilitated with an implant assisted partial over denture with implant positioned at the second molar position.

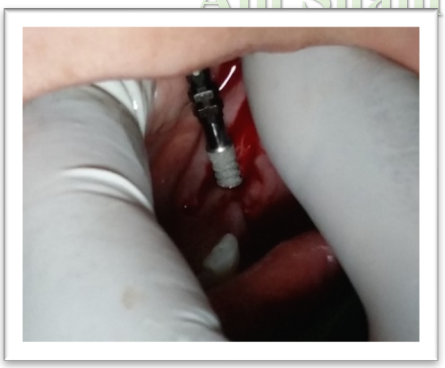

Figure (2): Surgical placement of the implant.

For group (II) and group (III), dental implants 4.2 mm in diameter and 8.5 mm in length were placed prior to partial denture construction at the site corresponding to the first molar in group II and second molar in group III.

The surgical stent was placed in the patient's mouth, to mark the exact fixture site. An insertion marking, for the determination of implant position, either at the first or second molar site depending on the group the patient belongs to. After finishing the drilling, clockwise rotations were used with fingers by the help of a finger key applying slight apical pressure until the implant threads grasp the bone, thus self-tapping was performed slowly. Fig (2) A cover screw was used to close the implant opening until healing period. After three months healing period partial dentures were constructed.

In group (II) and group (III), the removable partial denture frameworks were designed following the conventional design principles.

During wax up of the partial denture framework a hole on each side was made in the denture base area around the metal housing to ensure complete seating of all components in the patient's mouth without interference.

At the time denture insertion, the fitting surface of the acrylic resin of the denture base over the implant was slightly relieved, the metal housing was fitted in its position and evaluated the fit of the partial denture intraorally was performed.

Block-out shim was applied to the undercut portion of the neck of the ball head abutment to prevent the denture base from locking into it. Fig (3,4)

Figure (3): Block out shim was used to block undercuts below the abutment during pick up.

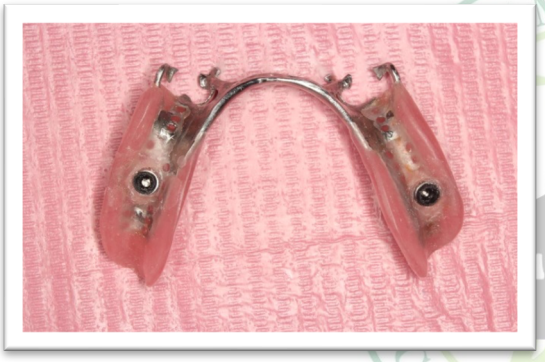

Figure (4): Pick up of metal housing using pink auto polymerized acrylic resin.

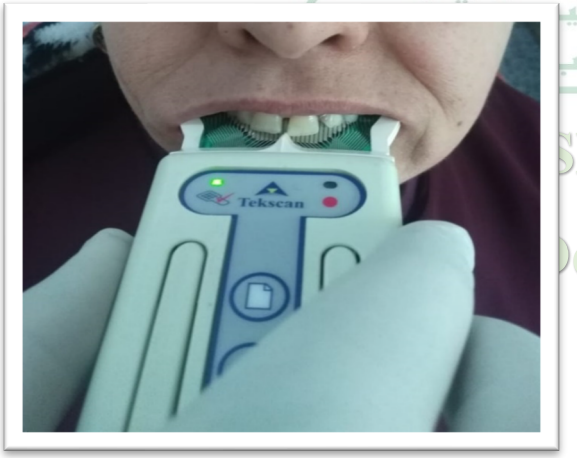

Figure (5): Patient clench during recording a scan via T-scan device.

T-Scan device used range of colours to differentiate the forces on the teeth, adjusting sensitivity ensure the entire colour spectrum is used to visualized the differences in these forces and the maximum forces are within the sensor force range, and this was done by: instructing the patient to bit and clench firmly. The patient was asked to clench and the tooth contact was observed on the screen. The ideal setting is maximum 3 pink contact. Figure (5)

With the sensor in patient mouth the "Red Recording button" was pressed and released, the sensor status indicator was changed from (Sensor OK) to (frame counter) in green recorded light on the handle was illuminated. The patient clenched and released.

The red scan button was clicked again to stop recording. Two records were taken for each patient by clicking the white button on the handle and a new window was opened.

As soon as recording was completed, the Real time window became a 2-D Movie window, which was divided into two equal-colored boxes (one green for the left side and one red for the right side) around the mid-sagittal plane showing the difference between the intensity of the biting forces on the both sides. The T-Scan III determines the contact time-sequencing, and the percentage of relative occlusal force between various occlusal contacts, and then displays them all for dynamic analysis.

Statistical Analysis

Statistical analysis was performed with Graph Pad Prism®2 and Microsoft Excel 20163 SPSS 20®. Data were presented as means and standard deviation (SD) values. Occlusal load analysis was recorded by using T-scan at fixed time intervals (immediately after loading, after six months and after 12 months). One way analysis of variance ANOVA test followed by Turkeys Post hoc test were performed to compare timing and percentage of occlusal force distribution within and between the three studied groups. The significance level was set at $P \leq 0.05$. Paired t test was used test was performed to compare between the right and left sides within each group through the follow up period.

RESULTS

The Mean value, standard deviation (SD) for the effect of timing on occlusal load distribution in the three studied groups during the twelve months follow up period and their level of significance are presented in table 1.

Table (1): Mean, standard deviation (SD) and ANOVA test for the effect of time on load distribution in the studied groups

Time	Group I		Group II		Group III	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
T0	1.75 A	0.32 A	1.26 B	0.4 B	1.21 B	0.24 B
T6	2.6 A	0.4 A	1.6 B	0.7 B	1.2 B	0.32 B
T12	6.1 C	0.52 C	1.8 B	0.3 B	1.5 B	0.21 B

Same superscript letters mean insignificant difference P>0.05
Different superscript letters mean significant difference P<0.05

Regarding Group I, the data obtained from table 1 revealed a minimal insignificant change in timing at 6 months p>0.05 follow up period however, this was followed by a significant change at the end of the 12 months follow up periods P<0.05.

For Group II the data obtained from table 1 revealed a minimal insignificant increase during the recall appointments P>0.05. For Group III the data obtained from table 1 revealed a minimal insignificant change during follow up periods P>0.05.

Comparing the three studied groups, table 1 revealed significant increase in the time needed from the initial occlusal contact to achieve maximum interception for group I P<0.05 compared to group II and group III, however a statistical non-significant difference was detected comparing group II and group III P ≥ 0.05.

The Mean value, standard deviation (SD) of the effect of percentage of occlusal load distribution in the three studied groups during the twelve months follow up period and their level of significance are presented in table 2.

The data obtained from table 2 showed that occlusal load analysis performed for group I, were 51.2, 63.6 and 79.3. at the time of denture insertion, 6 months and 12 months respectively. Statistical analysis of the data revealed that significant increase at the end of the follow up applied P < 0.5. Regarding group II, percentage of load distribution was found to be 40.2, 41.3 and 46.7 at the time of denture insertion, 6 months and 12 months respectively. Statistical analysis of the data revealed that insignificant increase during the one year follow up period. P > 0.5.

Regarding group III, load distribution was found to be 36.7, 32.3 and 38.6. at the time of denture insertion, 6 months and 12 months respectively. Statistical analysis of the data revealed that insignificant increase at all the recall appointments P > 0.5.

Comparing the three studied groups, significant increase in the calculated occlusal load was detected in group I compared to group II and group III throughout the study period P < 0.03. However, insignificant difference was detected comparing group II and group III together P > 0.03.

Table (2): Mean and standard deviation (SD) of the percentage of occlusal load distribution in the studied groups during follow up periods

Time	Group I mean ±SD	Group II mean ±SD	Group III mean ±SD
T0	51.2 % ± 2.7 A	40.2 % ± 5.3 B	36.7 % ± 2.7 B
T6	63.6 % ± 4.8 A	41.3 % ± 4.6 B	32.3 % ± 1.3 B
T12	79.3 % ± 2.7 C	46.7 % ± 6.2 B	38.6 % ± 2.3 B

Same superscript letters mean insignificant difference P>0.05
Different superscript letters mean significant difference P<0.05

DISCUSSION

The selected patients exhibited bilateral distal extension area, the opposing arch was either dentulous or partially edentulous that was restored by fixed restoration, to control the masticatory forces applied on the studied mandibular arch. (7)

The use of single dental implant can be used to resolve problems with mandibular bilateral distal extension removable partial dentures in a very cost-effective manner. (8)

In order to ensure implant success, it was necessary to select patients who were free from any local or systemic contraindications to this treatment modality. (9)

The development of harmonious occlusion is important to control the amount

of lateral stresses to the remaining teeth and dental implants. Partial loss of teeth is usually accompanied by tilting of adjacent teeth and irregularity of occlusal plane. [10]

Implant supported removable partial overdenture was constructed to replace the missing posterior teeth for distal extensions as an alternative approach to implant and tooth supported fixed prosthesis. It was agreed that rigid connection between implants and natural teeth is not recommended because the displacement under the occlusal force is quite different. Although an osseointegrated implant is not mobile under occlusal force, natural teeth have at least 30 μm physiologic mobility [10].

For partial overdenture, connection between the denture base and the implant, are more flexible than that of fixed prostheses because the only function of the distal implant is to resist the rotation potential that occurs at the distal end of the denture base during vertical loading. Thus, the overdenture would be quite safe. To compensate for the remarkable differences in displacement between implant and soft tissues, the denture base and healing abutment were fitted with autopolymerized acrylic resin under masticatory force using the overlay technique. Naturally, the maintenance of this connection has to continue to keep these displacement differences correct [11].

Two distally positioned implants in the area of the second molars would effectively transform the Kennedy Class I configuration to a more favorable Kennedy Class III. In this study, implant was placed distally in the first molar area in one group and second molar area in the second group. Theoretically, the implants should be located as distally as possible to provide maximum support. [12,13] The main objective of an implant located under the most posteriorly placed molar of the distal extension denture base is to stabilize the partial denture in a vertical direction and to minimize the amount of tipping forces transmitted to the abutments, due to the complex nature of the support encountered in distal extension case. [14]

Since the implant was positioned in the molar area in close proximity to the inferior alveolar canal, therefore, the selected implant length was 8.5 mm in length. To increase the implant surface area in contact with bone, the selected implant was 4.2 mm in diameter as allowed by the width of the ridge in this area and confirmed by cone beam tomographic radiograph. [15,16,17]

The height of the residual bone was evaluated prior to implant placement in order to assure proper implant positioning. A Cone beam tomographic radiograph was taken to all patients to evaluate alveolar bone height. Customized radiographic acrylic stent was constructed and the patients were scanned with the intra-oral stent containing radiopaque gutta percha, to evaluate the amount of available bone regarding width and the available bone height in relation to the inferior alveolar nerve. The gutta percha incorporated into the stent assisted in identifying the future implant site, length and diameter. [17,18,19]

Sufficient interocclusal space was necessary to accommodate the height of the ball anchor, the retentive matrix housing seated onto the anchor, and to allow a sufficient thickness of the combined denture base for the retention of the artificial teeth on the prosthesis. [20] To perform this, the selected attachments had the lowest 3 mm vertical height and minimal interocclusal distance was required.

Three months after implant insertion the top of the implant was exposed manually with a Tissue Punch forming a circular incision, in order to preserve as much tissue as possible at the implant connection to the healing caps. [21]

At the time of denture insertion for patients rehabilitated with implant supported

and retained RPD, relief was made in the fitting surface of the denture base in the implant area before incorporating the attachments. Sufficient resin was removed from the denture base to accommodate the O-ring housing on top of the implant. [22] Where the metal housing was incorporated in the combined denture base using the Pickup technique. [23]

To ensure proper Osseo integration three-month healing period was allowed before the second surgical technique for abutment placement and starting the denture construction steps. [24]

Patients were recalled for inspection, post insertion adjustments and T-scan was used to assess the occlusal forces distribution just immediately after loading, after three months and then after six months of implant loading for the patients of all groups. [25]

T-scan system was used for assessment of occlusal load distribution for the advantage of allowance adjustment of the occlusion, that's in return providing better functionally balanced teeth and positively influence muscular activity, and provide periodontal support, all with higher degree of precision other than old method used for occlusal analysis (articulating paper). [26]

Although there was significant difference between the conventional denture and implant supported partial over denture regarding time and force distribution, there was very little difference between group II and group III. Change in implant position had little effect on masticatory efficiency and can be regarded insignificant.

The results showed that implant-assisted RPDs provided significantly stable occlusion greater area of contact points than conventional RPDs.

Although non rigid connection between implants and natural teeth, was used in this study for group of patients rehabilitated with implant assisted RPD (group II and III), in conventional tooth-tissue supported distal extension bases (group I), even with functional basing; anterior placement of occlusal rest an inevitable movement of the distal end of the denture base, this effect is a result of a long effort arm induced during function. However, the presence of a distal implant probably enhanced DEB support by providing a posterior abutment comparable to a terminal natural abutment in bounded RPDs. Thus, causing theoretical transformation of Kennedy class I to Kennedy class III; resulting in better force distribution between abutments which can clarifies and justifies the results of this study

The results of this study revealed that implants should be located as distally as possible to provide maximal support and stable occlusal contacts. For group II and III; patients rehabilitated by implant assisted RPD, the improved support and retention of the RPD is most properly due to the use of the O ring attachment that decreased the denture movement in all directions. This may explain the undetected difference in the time needed from the initial occlusal contact to achieve maximum intercuspation and the percentage of occlusal load distribution between the two studied groups.

It was reported that using posteriorly placed implant to support distal extension dentures DEBs provides a stable occlusion and helps in re-establishing the stability of the remaining natural teeth, prevents torquing of the natural tooth abutment and reduces residual ridge resorption. Although alveolar ridge resorption was not evaluated in this study, it is well documented that distal extension removable partial denture is associated with ridge resorption and loss of occlusal contact and may account for the significant increase at the end of the follow up period for the recorded time needed from the initial occlusal contact to achieve maximum intercuspation and the percentage of occlusal load distribution for group I compared to group II and group III. [33]

CONCLUSION

Partial denture retained by two Osseo integrated implants one on each side of the lower arch showed better effect on the distribution of occlusal load compared by conventional partial dentures. Changing implant position from first mandibular molar to second mandibular molar had no significant effect on the occlusal load analysis using T-Scan system.

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