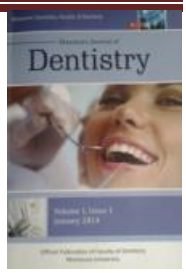
Abutment Tissue Health as Related to Clasp Design in Implant Assisted Mandibular Distal Extension Removable Partial Overdentures.



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Abstract:
Objectives: The purpose of this study was to clinically evaluate the effect of clasp design on tissue health around abutment teeth and implants assisting mandibular bilateral distal extension removable partial overdenture.
Methods: 10 partially edentulous patients with completely edentulous maxilla opposed by partially edentulous mandible with first premolars and six anterior teeth remaining were selected for this study. Single implants were placed bilaterally at the first molar area of the mandibular distal extension ridges as a vertical stop. The metallic framework was designed as two distal extension meshwork that covers the anterior two thirds of the ridge area; the two distal extensions connected together via lingual bar major connector. According to the clasp design the ten patients were randomly divided into two equal groups; Group I: Aker clasps were constructed on the first premolars.Group II: Reverse Aker clasps were constructed on the first premolars. Mandibular bilateral distal extension removable partial over denture was constructed and delivered to the patients. Clinical evaluation parameters that included; Plaque index, Bleeding index, Gingival index, Probing depth, and Mobility were performed immediately before insertion and three & six months after insertion of the definitive prosthesis.
Results: The abutment teeth in group (I) record significant higher (GI), (BI), (PTVs) than those in group (II) during all intervals of study. Also the implants in group (I) record significant higher (GI), (BI), (PTVs) than those in group (II) during all intervals of study.
Conclusions: In comparison to Aker clasps, the reverse Aker clasps are considered better in regard to the preservation of abutment teeth and oral tissue health around the implants located in the first molar area for assisting mandibular bilateral distal extended removable partial overdenture.

Keywords: *Clasp design, implant assisted mandibular distal extension, removable partial overdentures.*

Introduction

Patients lacking mandibular posterior teeth as (Kennedy's class I and II) are frequently present in the dental clinics and require more accurate prosthodontics rehabilitation for preserving the remaining teeth and residual ridge. One treatment option for these cases is the distal extension removable partial denture. The difference of resilience between the mucosa and the periodontal ligament present a considerable challenge, as support is needed from natural teeth, mucosa, and residual alveolar ridges.

Many investigators suggested different approaches to balance the loads distributed among the teeth and ridge mucosa such as making functional impressions, periodic rebasing of the prosthetic seat, use of stress releasing clasps and splinting of the distal support abutments [1]**.** None of the management options appear to provide an ideal solution to this situation. As a possible solution to this clinical challenge, single implants placed bilaterally at the distal extension of the denture base will minimize the resultant denture displacement and bone resorption [2].

Dental implants placed in posterior sites modify the Kennedy's classification of partially edentulous arches by converting Class I into Class III to overcome the numerous problems associated with removable partial dentures in addition to achieving a higher level of patient satisfaction [3,4]**.** The implant may be used for supported only by using healing caps or for retention by using attachment systems connected to the implant [5].

Osseointegrated implant (not mobile) and abutment tooth (at least 30 µm physiologic mobility) show different displacement under occlusal forces [6]. As the different retainers influenced the occlusal load distribution, the type of retainer is important for a long-term successful restoration. This study was aimed to clinically evaluate the effect of different clasp designs on the tissue health around the abutment teeth and distal implants supporting the mandibular bilateral distal extension removable partial overdenture.

Patients and methods

Patient selection

Ten healthy partially edentulous male patients (mean age 55 year) were consecutively selected for this study from the outpatient clinic of the Prosthodontic Department, Faculty of Dentistry, Mansoura University. All patients had complete maxillary edentulous arch and mandibular bilateral distal extension ridge, with remaining anterior teeth and first premolars. Mandibular bilateral distal extension residual alveolar ridges were covered with healthy firm mucosa. The distance between the mandibular alveolar crest and the inferior alveolar canal at the first molar region was at least 12 mm as verified by a panoramic radiograph. A minimum distance of 8 mm was to exist between the gingival margin of remaining natural teeth and functional depth of floor of the mouth. Also the patient had maintained good oral hygiene with periodontally healthy abutment teeth. Patient's exclusion criteria include systemic diseases related to bone resorption or contraindication for

surgical intervention and chronic para-functional habits (as smoking, bruxism or clinching).

Surgical & prosthetic procedues

For every patient, a temporary mandibular acrylic prosthesis and a clear acrylic resin surgical guide (template) were constructed according to El-Helw and Ismail **[**7**].** After trial they were flasked, finished, polished, occlusally adjusted and delivered. The later used for placement of osseointegrated implants at the first molar region.

The surgical procedures were done according to standardized one step surgical approach described by Cecchinato [8]. Two implants (Dyna® HELIX® ART, Holand) of suitable size (of 3.6 mm diameter and 10 mm length) were surgically inserted parallel to each other, guided by paralleling tools, in the 1st molar areas of mandibular distal extension ridges. Healing abutments (4 mm diameter and 2 mm height) will be screwed into the fixtures to act as definitive supporting element (Fig. 1). The mucoperiosteal flaps were carefully closed with multiple stitches**.** Postsurgical digital panoramic x-ray was made to verify position and orientation of fixtures on both sides (Fig. 2).

According to the early progressive loading protocol followed in this study the temporary prosthesis was worn but completely relieved around healing abutments for the two weeks after surgery. Then relieved areas were directly relined with soft liner. The metallic framework was designed as follows (Fig. 3), two distal extension meshwork covering the anterior two thirds of the ridge area connected together with lingual bar major connector. Bilateral openings in the meshworks were done to accommodate the healing abutments. According to the clasp design the ten patients were randomly divided into two equal groups as follows:

Group I: Aker clasps were constructed on the first premolars.

Group II: Reverse Aker clasps were constructed on the first premolars.

After jaw relation record and mounting on semi-adjustable articulator, Non anatomical acrylic resin teeth (Major, Dental Industry, Monocolieri, Italy) were arranged for balanced occlusal contacts. After try in, denture was processed, finished and polished.

The fitting surface of the prosthesis of both group I and II was fitted to the implant healing abutment according to Ohkubo et al 2 and Phoenix et al. [9] as follow:

• Any contact between the tissue surface of the removable partial overdenture base and the healing abutment was removed.

• The tissue surface was prepared so that a butt joint will be formed and a small hole was made in the approximate center of the area occupied by the abutment and exit on the lingual side of the replacement tooth.

• Auto-polymerizing acrylic resin (Acrostone, cold curing resin, Egypt) was mixed and a small amount was placed in the prepared concavity in the acrylic resin base. A small rubber dam ring was placed around the healing abutment before the pick-up procedure. A layer of separating medium was applied on the implant healing abutment. The prosthesis was seated in the mouth and the patient was asked to close on cotton roll while partial polymerization occurred.

• The prosthesis was removed and placed in warm water until polymerization was completed. Any flash that gone beyond the butt joint preparation was removed with a bur, resin was also removed in areas of contact with the free gingival margin. The resin that flowed through the hole in the base was finished flush with the polished surface. Finally the occlusion was verified and the final prosthesis was delivered (Fig. 4)

Clinical evaluation parameters of tissue changes

For every patient, clinical evaluations will be done immediately before and three &six months after insertion of definitive prosthesis using the following parameters:

1.Plaque index: Mombelli et al. [10].
2.Bleeding index: Mombelli et al. [10].
3.Gingival index: Loe and Silness [11].
4.Probing depth: Eickholz et al. [12].
5.Mobility: using Periotest.

Plaque index, bleeding index, gingival index and probing index were assessed at (mesial, distal, buccal and lingual) implant and abutment tooth surfaces using pressure sensitive plastic periodontal probe (VIVACARE, TPS periodontal probe, Italy) and the mean of four sites of implant was recorded and subjected for statistical analysis. Periotest (Periotest S MedizintechnikGulden , Germany) device was used to measure the degree of implant mobility. Incorrect pulses are eliminated to ensure reliable and reproducible measurements. Periotest values ranged from -8 to 0 indicated good osseointegration, while values from +1 to +9 indicates that clinical examination is required, and values ranged from +10 +50 indicate osseointegration is insufficient.

Statistical analysis

The SPSS statistical package version 22 (SPSS Inc., Chicago, IL, USA) was used. Shapiro-wilk test was used to diagnose the normal distribution of data. Plaque scores (PI), Bleeding scores (BI), and gingival scores (GI) data were non parametric, while Probing depth (PD) and mobility (PTVs) data were parametric. Comparison between observation times for non parametric data was performed by Freidman test followed by Wilcoxon signed ranks test for multiple comparisons. Comparison between observation times for parametric data was performed by Repeated measure ANOVA followed by Bonferrroni multiple comparison. Comparison between groups and between abutments and implants was performed by Mann Whitney test fornon parametric data and by independent samples t-test for parametric data. P is significant if <0.05 at confidence interval 95%.

Results

The results of this study revealed that (Tables 1&2):

1-Withtime, the (PI) values of implants and abutment teeth increased significantly after the first 3 months, then decrease significantly at the end of the 6th month after the insertion of the mandibular distal extension removable partial overdenture.

2- The (GI) values of abutment teeth in both groups increased significantly after the first 3 months, then decreased significantly at the end of the 6th month after insertion of the mandibular distal extension removable partial overdenture.

3 –The (PTVs) values of abutment teeth of both groups decreased significantly with time.

4-The (GI), (BI) indices, and (PTVs) values of abutment teeth increased significantly with time in group Iin comparison to group II.
5-The (GI), (BI) indices values of implants in both groups increased at the end of the first 3months of study with no significant differeances.
6-The (PD) values of implants at both groups increased at the first 3 months then decrease at the end of the 6th month of insertion of the mandibular distal extension removable partial overdenture.
7-The (GI), (BI) indices, and (PTVs) values of implants increased significantly with time in group I compared to group II.

Discussion

In this study, with time, in both groups, plaque index (PI) values of implants and abutment teeth increased significantly after the first 3 months, then decrease significantly at the end of the 6th month after the insertion of mandibular distal extension removable partial overdenture. This may be attributed to the insufficient oral hygiene after overdenture insertion resulting from the patient's lack to perform self-care with a relatively inaccessible cleaning of implants and abutment teeth. Increased plaque accumulation was in agreement with Walter et al. [13] who found that plaque formation around implants seems to be one of the major clinical problems in implant-assisted overdentures. Chen and Darby [14], mentioned that dental plaque was present around implants and this attributed to low levels of dental hygiene self-care achieved by the patient. Lang et al. [15], confirmed that plaque aggregation may threaten the soft tissue around the implants and abutment teeth and may cause gingival inflammation.

Gingival index (GI) of abutment teeth in both groups increased significantly after the first 3 months, then, decreased significantly at the end of the 6th month after insertion of the mandibular distal extension removable partial overdenture. This may be correlated to the increased plaque accumulation as revealed from increased PI values. In fact, a positive, statistically significant correlation between these variables was found. That is, as PI increases, GI tends to increase [16].Another explanation for this result may be relatedto the first contact ofthe denture to the patient's soft tissue, which may be combined with some inflammation in the mucosa and periodontium supporting the abutment teeth. Teeth involved in removable partial denture (direct and indirect retainers) are more prone to gingival diseases than non-involved teeth. The increase in probing depth noted suggests that it is caused by gingival oedema resulted from dental biofilm accumulation and consequent gingival inflammation [16]. On the other hand, reductions in GI at the 6th month may have occurred because of the effect of the motivation performed later.

Periotest (PTVs) values of abutment teeth of both groups decreased significantly with time. This may be due to the decrease of initial inflammation with time after insertion of implant-assisted removable partial overdenture. The osseointegrated implants usage in association with removable partial dentures increase denture support, retention, and stability, as it limits the denture movement towards the supporting tissues and provides reduction of the tension forces generated on the abutment teeth, favoring the maintenance of the supporting structures [17]. In addition, Pellizzer et al. [18] stated that stress relief on the periodontal ligament is expected when an implant is associated with a removable partial denture, because a decrease in the lever arm on the supported teeth is expected.

The gingival (GI), bleeding (BI) indices, and (PTVs) values of abutment teeth increased significantly with time in group I in comparison to group II. This may be attributed to the more stress applied by Aker clasp (with distal occlusal rest) on abutment teeth. On the other hand, the mesial occlusal rest of reverse Aker clasp may be the cause of decreasing the stress (tipping) on the distal abutment tooth by directing the loads vertically along the long axis of the tooth.

Gharechahi et al. [19] stated that Aker clasp in distal extension base partial dentures applies extra stress on distal extended abutment in unfavorable (distal) direction, which is greater than tooth tolerance that causes bone resorption. The horizontal and lateral stress on abutment teeth may cause or favour the breakdown of periodontal structures and increase tooth mobility [20]. Mesial occlusal rest decreases the tipping of the distal abutment tooth and reduces the stress applied on the alveolar ridge [21], transferring the chewing forces more perpendicular to the ridge than to the distal occlusal rests. Hence, the gingival mucosa of the abutment tooth was better protected [22]. In addition, Kratochivil [23] stated that mesial occlusal rests direct the loads vertically along the long axis of the tooth where it is better able to withstand them.

The gingival (GI), bleeding (BI) indices values of implants in both groups increased at the end of the first 3months of this study with no significant differeances.This may be due to the presence of inflammation and increased plaque index (PI) values during this period of the study. Karoussis et al. [24] mentioned that increased bleeding on probing may be the result of the increased plaque and inflammation due to poor oral hygiene.

Probing depth (PD) values of implants at both groups increased at the first 3 months, then, decreased at the end of the 6th month of insertion of the mandibular distal extension removable partial overdenture. This may be due to the increased inflammation and oedema during the initial period after implant insertion (one stage surgery) that resulted either from the post-surgical risk of bacterial infection or micro-movements on the bone-implant interface. Perez et al. [25] advised using the two-stage surgical technique for implant placement in order to avoid fibrointegration areas and the post-surgical risk of bacterial infection, to maintain an environment with absence of forces or micro-movements on the bone-implant interface and to favor the bone remodeling and apposition on the dental implant surfaces. In addition, this may be due to the localized remodeling and resorption in the peri-implant alveolar bone resulting from full functional occlusal loading of the implants. This was in accordance with the study performed by Last et al. [26] who confirmed that full functional occlusal loading of implants by prosthesis is expected to bring about localized remodeling. Such effects would be expected to be more marked initially, but to have reached equilibrium in longer-serving functional implants.

Gingival (GI), bleeding (BI) indices, and periotest values (PTVs) of implants increased significantly with time in group I compared togroupII. This result may be due to the mesially placed occlusal rest with reverse Aker clasp which is more favorable than the distally placed occlusal rest with Aker clasp; reducing stress on the alveolar ridge and consequently the stress on implant inserted in this residual ridge. The mesial placement of occlusal rest provides an axis of rotation that directs applied forces in a more vertical direction [27]**,** decreases the tipping of the distal abutment and reduces the stress on the alveolar ridge [21]. While the distal rest in conjunction with circumferential retainers develop greater horizontal forces within the supporting structures [27]**.**

Another explanation of this result may be the linear distribution of vertical load on the residual alveolar ridge in case of mesial occlusal rest of reverse Aker clasp. During application of occlusal load, the mesially placed occlusal rest serve as a rotational center. As the distance from the rotational center to the denture base increases, the associated radius becomes larger, and the accompanying arc becomes more linear [9]**.**

This also may be due to the less effective action of indirect retainer during rotational tissue away movement in group I. As the distance between the retentive fulcrum line (passing through the clasp retentive tip) and the indirect retainer (cingulum rest) is shorter in case of Aker clasp than that of reverse Aker clasp. Consequently, the less effective indirect retainer in group I allows for some rotational tissue away movement, and loss of contact between the denture base and implant which makes the denture base acting as a hummer on the implant during tissue-ward movement. When a distal extension removable partial denture is subjected to dislodgment, the associated fulcrum line passes through the tips of the retentive clasps**,**the greater the distance between the fulcrum line and the indirect retainer, the more effective the direct retainer will be [9].

Another explanation of this result may be due to the location of the implants in the first molar region with aconsiderable length of the distal extension saddle, posterior to the implants (at which the fulcrum line passes); as a result, the rotational tissue-ward movement of the prosthesis, posterior to this fulcrum, may exert different stress on implants and abutment teeth of both groups. In case of Aker clasp, retentive arm tips will engage more undercuts associated with this rotational movement and applying much force on the supporting implants. While in reverse Aker clasp, retentive arm tips will disengage the undercuts and allow rotational tissue-ward movement with sharing of the force between implants and residual ridge posterior to implants.

The implant-supported removable partial dentures had greater occlusal force than the conventional removable partial dentures. The center of the occlusal force of the implant-supported removable partial dentures was positioned distally compared to the conventional removable partial dentures [2]. Rangert et al. [28] stated that maximal occlusal forces applied and tolerated vary greatly according to implant position in the arch. Unfavorable force distribution, and increased force magnitude, as seen in the posterior areas of the jaws, may produce biomechanical overload on the supporting bone**.** Peri-implant bone loss, and loss of integration have been among the most commonly reported complications [29]. In addition, Phoenix et al. [9] mentioned that in distal extension cases when implants were used for support, placing the implant more anteriorly could result in potentially detrimental cantilever forces on the implant which by turn cause peri-implant bone loss. To avoid the direct loading force on the short implant, the short implant should be placed away from the first molar area and should be as distal as possible to eliminate the cantilever effect [30].

Conclusion

Long term follow-up studies with larger number of patients and more investigation methods are recommended for comparing between these two treatment modalities.

Table 1: Comparison of tissue health parameters of abutment teeth between groups and between different observation times.

	at time of overdenture insertion (T0)	3 months after overdenture insertion (T3)	6 months after overdenture insertion (T6)	Freidman test (p value)
1. plaque index				
Group I/M (min-max)	.00 (.00-.00)	.50 (.00-1.0)	.00 (.00-.00)	.00*
Group II/M (min-max)	.00 (.00-.50)	.12 (.00-.5)	.00 (.00-.25)	.023*
Mann Whitney test (p value)	.39	.82	1.0	
2. Gingival index				
Group I/ M (min-max)	.50 (.25-1.00)	.75 (.50-1.25)	1.50 (1.00-2.0)	.059
Group II/M (min-max)	.50 (.25-1.0)	.62 (.25-1.25)	.62 (.25-1.25)	.51
Mann Whitney test (p value)	.51	.00*	.00*	
3. Bleeding index				
Group I/M (min-max)	.50 (.25-1.00)	.75 (.25-1.25)	.50 (.25-1.00)	.69
Group II/M (min-max)	.50 (.00-1.0)	.50 (.00-.50)	.25 (.00-.50)	.31
Mann Whitney test (p value)	.19	.055	.002*	
4. Probing depth				
Group I/X±SD	1.4000 ±.61237	1.6250 ±.47507	1.6000 ±.42164	.018*
Group II/X±SD	1.3000 ±.40483	1.4250 ±.45720	1.4000 ±..45720	.93
Mann Whitney test (p value)	.051	.16	.073	
5. Mobility				
Group I/X±SD	-4.1000 ±.73786	-4.0 ±3.51030	-3.2000 ±.78881	.58
Group II/X±SD	-3.2000 ±.78881	-4.2000 ±.78881	-5.2000 ±.78881	.46
Mann Whitney test (p value)	.052	.78	.00*	

M: median; min: minimum, maximum, X: mean, SD: standard deviation * p value is significant at 5%.

Table 2: Comparison of clinical tissue health parameters of implants between groups and between different observation times.

	at time of overdenture insertion (T0)	3 months after overdenture insertion (T3)	6 months after overdenture insertion (T6)	Freidman test (p value)
1. plaque index				
Group I/M (min-max)	.00 (.00-.00)	.50 (.00-1.0)	.00 (.00-.00)	.048*
Group II/M (min-max)	.00 (.00-.50)	.4 (.00-.5)	.00 (.00-.25)	.024*
Mann Whitney test (p value)	.58	.51	.14	
2. Gingival indix				
Group I/M (min-max)	.50 (.25-.50)	1.00 (.50-1.0)	.50 (.25-.50)	.007*
Group II/M (min-max)	.50 (.25-1.0)	.62 (.25-1.00)	.42 (.25-1.00)	.001*
Mann Whitney test (p value)	.24	.040*	.049*	
3. Bleeding index				
Group I/M (min-max)	.50 (.25-.50)	1.00 (.50-1.0)	1.00 (.50-1.0)	.096
Group II/M (min-max)	.50 (.25-.50)	.75 (.50-1.00)	.50 (.25-.75)	.068
Mann Whitney test (p value)	1.0	.049*	.006*	
4. Probing depth				
Group I/X±SD	.9500 ±.34960	1.0750±.37361	1.1250±.42898	.15
Group II/X±SD	.9500 ±.42164	1.0750 ±..44175	1.0750 ±.44175	.092
Mann Whitney test (p value)	.93	1.0	.82	
5.Mobility				
Group I/X±SD	3.7000 ±.94868	2.5000 ±.31180	2.7000 ±.94868	.001*
Group II/X±SD	3.7000 ±.94868	2.7000 ±.94868	1.2000 ±1.13529	.002*
Mann Whitney test (p value)	1.0	.29	.005*	

M: median; min: minimum, maximum, X: mean, SD: standard deviation * p value is significant at 5%

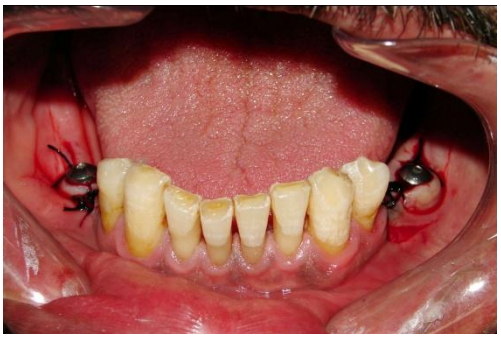

Figure.1: Careful closure of mucoperiosteal flap with multiple sutures after screwing the healing abutment.

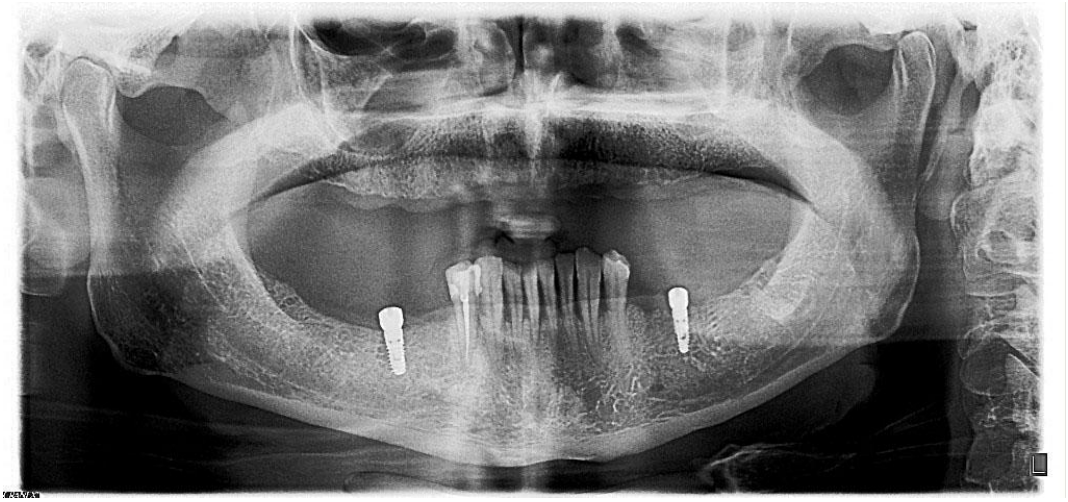

Figure 2: Dgital panoramic x-ray to verify position and orientation of fixtures on both sides.

Figure.3: Metal frameworks for group I and group II.

Figure.4: The resin flowed through the hole in the base was flushed with the polished surface

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