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Evaluation of Masticatory Activity and Occlusal Force in Mandibular Kennedy Class I Patients Before and After Rehabilitation with Removable Partial Dentures

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ABSTRACT

Purpose: was to compare the masticatory performance and maximum occlusal biting force for mandibular bilateral distal extension patients before and after removable partial denture rehabilitation to that of completely dentate individuals. **Materials and methods**: Ten partially edentulous patients with age ranged from (35-50) years. All patients had mandibular kennedy class I classification and completely dentulous maxillary arch. Each patient received a mandibular conventional removable partial denture. The electromyographic activity (EMG) and maximum bite force were evaluated for all patients before denture insertion then at delivery, after 2, 4 and 6 months respectively. **Results**: The results of this study showed that there were significant decrease in the electromyographic records while, there were significant increase in maximum bite force after denture insertion. **Conclusion:** Within the limitations of this study, the conclusions that could be obtained are that removable partial dentures improved patient's masticatory activity and maximum bite force which were better than prior to the constructions of prosthesis but these functions is usually improved to a lesser extent than that of the previous complete dentition.

KEYWORDS

Distal extention removable partial denture, electromyographic activity, maximum bite force.

INTRODUCTION

Partial tooth loss leads to acute disturbance of biostatic equilibrium of dental arch. Changes in the region of the remaining teeth such as tipping, drifting and elongation appear. Removable partial denture (RPD) is a non invasive treatment modality to restore partial tooth loss and preserve supporting structure of the remaining teeth, it is also considered a low cost solution for most of these problems [1].

- Paper extracted from a master thesis entitled " Evaluation of Masticatory Activity and Occlusal Force in Mandibular Kennedy Class I Patients Before and After Rehabilitation with Removable Partial Dentures."

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Dental loss can generate severe changes on maxillo-mandibular interaction, teeth positioning and dental arch shape, which may decrease the effectiveness of the masticatory system. After teeth replacement by dental prosthesis, It is unlikely that the biting force and the masticatory ability will return to their normal capacity. This may occur due to decrease in the masticatory muscles activity which act in a synergy [(2)].

Also the decrease of muscular activity can cause alterations on the type of muscle fibers, which tend to adapt to the new physiological state. The aim of dental prosthesis is to prevent these changes and reestablishment of the oral tasks such as (chewing, speaking, biting force, swallowing and aesthetic) [(3)]. Therefore, this study was designed to evaluate the effect of removable partial denture prosthesis on both electromyographic activity and maximum bite force.

MATERIALS AND METHODS

Ten partially edentulous patients with age ranged from (35-50) years. All patients had mandibular kennedy class I classification with the second premolars as last standing abutment teeth. The maxillary arch has complete set of teeth. The edentulous area of the mandible had enough width and height and covered with a firm and healthy mucosa. All patients accepted this dental dental treatment and informed about the steps of this study and signed a written concent with the Research Ethics Committee (REC) approval.

For each patient a removable partial denture has been has been made.

Evaluation of electromyographic activity.

The first EMG record was made before denture (RPD) insertion as a base line, then at delivery, after 2, 4 and 6 months. EMG recordings were made by (Nemus2) computer electromyography. Special cleaning and conductive paste used to remove dead skin and it also clean the skin from dirt and sweat. Thus produce high impedance allowing better electrode signal conduction. The patient seated, as close as possible 90^0 angle to the floor, with steady head, instructed to look at a reference front point and avoiding movement during measurements. For temporalis muscle: two electrodes were placed 1 inch posterior and 1inch superior to the outer canthus of the eye.

For masseter muscle: Two electrodes were placed on the most contractile part nearly mid way between the origin and the insertion of the muscle. The earth electrode was placed on the fore head. The patient was asked to relax and slightly open his mouth slowly with the electro-moyography recording the masseter muscle activity, until a straight base line was obtained. This procedure was repeated for each patient before starting any records. The electro- myographic activity was measured while the patient chewing carrots at both sides. Right and left recordings were done together at the same time.

Evaluation of maximum bite force by using "digital" occlusal forcemeter.

The first bite force measurement was made before denture (R.P.D) insertion as a base line, then at delivery, after 2, 4, 6 months. Bite force recordings were made by digital occlusal force meter (G M10; Nagano keiki, Tokyo, Japan). The patient was seated on a dental chair with his head un supported and positioned so that the Frankfort horizontal pla mne would be parallel to the floor.

The patient was explained about the procedure and asked to bite maximally when told, the bite force recorder was set at zero set before each record. The biting element should be cleaned with alcohol and encased in a rubber finger of gloves. The biting tube was placed parallel to the dental arch so that biting end was positioned at the first molar in case of the patient wearing the denture and positioned in premolar region in case of without wearing the denture. At the beginning of the test, the patient was asked to bite on the biting end maximally in order to make him familiar with the equipment and no measurements were taken. The readings were

displayed on a digital screen of the device.

After that a series of three successive recordings were taken and noted. A rest period of one minute was given between each record to prevent muscle fatigue. Mean of the three recordings was taken as the maximum bite force (MBF). These procedures were done at the left side as mentioned. The data was collected, tabulated and statically analyzed.

RESULTS

All Patients sharing in this study were well motivated to complete the follow-up schedule. EMG and maximum bite force records for all patients and their statistical analysis were tabulated in tables (1-3) and graphically illustrated in figures (1-3).

For Masseter muscle EMG gradually increased with denture insertion and after 2 months, then gradually decreased after 4 and 6 months as shown in table (1), figure (1).

EMG of temporalis muscle gradually increased with denture insertion and after 2 months, then gradually decreased after 4 and 6 months as shown in table (2), figure (2).

The bite force gradually increased by time, to reach its highest level at 6 months as shown in table (3), figure(3).

Table (1): *Comparison of mean values of each record for masseter muscle at different time intervals.*

Time	Mean	Std. Dev	95% Confidence Interval for Mean		Min	Max	F	P
			Lower Bound	Upper Bound				
Before denture insertion	149.85[b]	30.13	128.30	171.41	103.79	197.17	4.268	.005*
At delivery	185.29 a,b	43.86	153.92	216.66	126.90	263.70		
After 2 months	209.11a	67.58	160.76	257.45	142.89	318.75		
After 4 months	166.02a,b	49.22	130.81	201.23	100.77	239.95		
After 6 months	133.0b	23.70	116.05	149.95	98.76	176.87		

**Significant at p<0.05*

Tukey's post hoc test: means sharing the same superscript letter are not significantly different.

Table (2): *Comparison of mean values of each record for temporalis muscle at different time intervals.*

Time	Mean	Std. Dev	95% Confidence Interval for Mean		Min	Max	F	P
			Lower Bound	Upper Bound				
Before denture insertion	103.34b	32.38	80.18	126.51	58.41	162.02	5.930	.001*
At delivery	142.30a	32.15	119.30	165.30	75.76	178.97		
After 2 months	152.99a	29.88	131.62	174.37	89.30	195.37		
After 4 months	122.75 a,b	23.94	105.63	139.88	73.46	156.07		
After 6 months	105.61b	22.92	89.21	122.01	53.60	128.90		

**significant at p<0.0*

Tukey's post hoc test: means sharing the same super script letter are not significantly different.

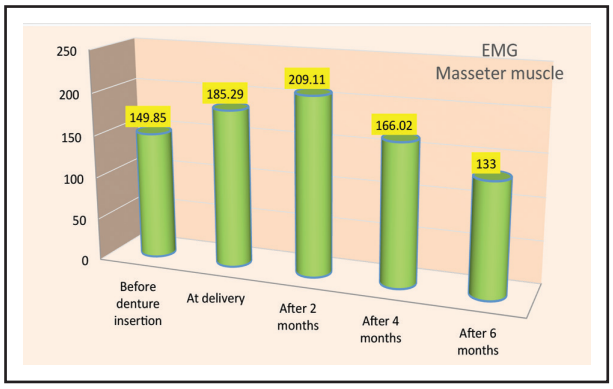

Fig. (1): Column chart showing mean values of each record for masseter muscle at different time intervals.

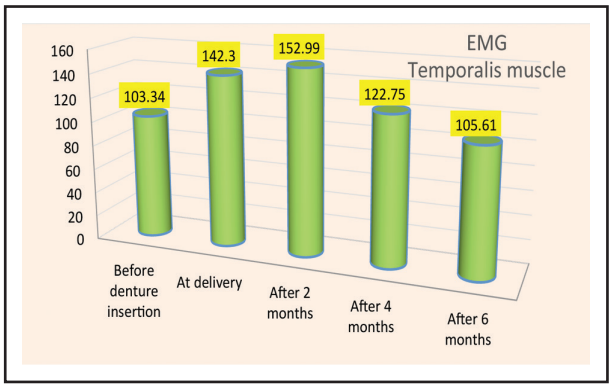

Fig. (2) : Column chart showing mean values of each record for temporalis muscle at different time intervals.

Table (3): *Comparison of maximum bite force of patients at different time intervals.*

Bite force	Mean	Std. Dev	95% Confidence Interval for Mean		Min	Max	F	P
			Lower Bound	Upper Bound				
Before denture insertion	110.30[d]	18.60	96.99	123.61	80.00	131.00	126.92	0.00*
At delivery	153.10[c]	18.96	139.53	166.67	130.00	187.00		
After 2 months	175.30[c]	16.17	163.74	186.86	154.00	196.00		
After 4 months	252.20[b]	31.64	229.57	274.83	216.00	308.00		
After 6 months	311.60[a]	24.67	293.95	329.25	264.00	348.00		

**significant at p<0.05*

Tukey's post hoc test: means sharing the same superscript letter are not significantly different.

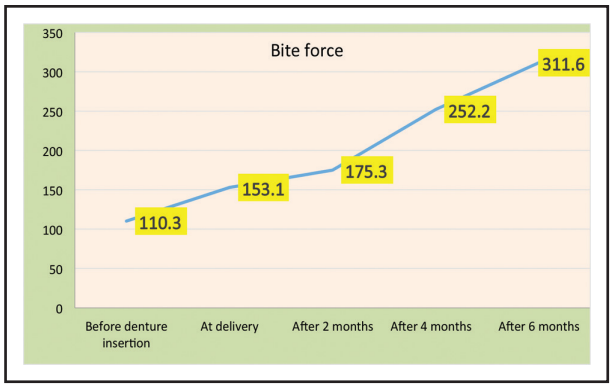

Fig. (3) : Line chart showing mean values of bite force at different time intervals.

DISCUSSION

In this study all selected patients were healthy and free from any systemic disorder that may adversely affect the oral cavity and muscle function and enhancing bone resorption thus affects the results of this study [4].

All patient's ages ranged from (35-50) years and all of them were females to avoid muscle atrophy due to senility and to avoid the difference in muscle activity between different sexes as it is higher in males than females. Patients with temporo-mandibular joint dysfunction were excluded to avoid any disturbance in muscle behavior [5,6].

This study was carried out on patients having mandibular kennedy class I with the second premolar as last standing abutment bilaterally. Crown morphology of the mandibular second premolar generally displays features favorable to design of metal frame work elements related to this tooth. First, the non-occluding mesiolingual portion of the occlusal table of this tooth allows for a convenient mesial rest seat with minimal tooth preparation. Second, The crown is tilted lingually and usually smaller compared with the mandibular first premolar. These factors favor a simplified clasp assembly design for this tooth in the form of mesial rest, proximal plate and the buccal retentive element in the form of I- bar clasp [7].

Patients had an opposing dentulous maxillary arch in attempt to standardize the magnitude of forces falling on the lower teeth and the lower partial denture , which is important factor in determining the amount of bone resorption and also affects on both bite force and muscle activity [8]. The residual ridge had enough width and height and covered with firm and healthy mucosa free from any signs of inflammation or ulceration to provide denture support, retention and stability [9].

The oral hygiene is one of the most important factors affecting the gingival health, so patients with poor oral hygiene or those could not be motivated to maintain proper oral hygiene were excluded from this study. Strict instructions for oral hygiene measures and frequent follow up which are key factors for the long term service of partial dentures and the longevity of abutments. The general principles of the design were that the denture should not interfere with natural cleaning and daily oral hygiene [10,11].

To establish a good experimental base line, clinical and radiographic examination were made prior to denture construction, as an attempt to have good abutments with healthy periodontal condition, proper crown root ratio and adequate alveolar bone support [12].

In order to obtain a fair experimental data, all patients contributing to this study received removable partial dentures constructed following the same procedures , and using the same materials. Also all (R.P.D) were similarly designed and exhibited the same component [13].

The occlusal rest seats prepared on the abutment teeth were triangular in shape, to provide adequate bulk for the metal, and the depth was slightly increased towards the center in order to direct the occlusal forces along the long axis of the abutment tooth and to prevent the proximal slippage. The floor of the rest seat was spoon shaped with no sharp edges to reduce the lateral stresses conveyed to the abutment teeth through the occlusal rest [14,15].

The mesially placed occlusal rest offered several advantages including forward tipping of the abutments, allowing the neighboring teeth to share the load, altering the length of the lever arm, consequently, the stresses transmitted to the abutment teeth were decreased in addition to the loads were evenly distributed on the saddle [13,14].

The RPI clasps used in this study fulfilled the criteria of stress releasing clasp and were among the clasps recommended for distal extension bases to disengage the abutments on function .[16] An auxillary occlusal rests prepared on the distal of the occlusal surfaces of first premolars to gain indirect retention which prevents the retentive clasp tips from becoming a fulcrum around which the prosthesis could rotate when forces move the denture base away from the tissue [17].

The metal framework design with lingual bar major connector offered a simple design and minimal contact with the remaining teeth and soft tissues. Patients selected for this study were suitable for lingual bar major connector, they had 8 mm or more between gingival margin and the floor of the mouth. Thus, the simplicity of the design of the partial denture was considered in this study to offer long term maintenance of teeth and soft tissues [18].

Final impression for removable partial denture was made by "rubber base" impression materials, because it is the only materials that can record undercuts of the edentulous ridges with high accuracy and regaining its shape and dimensional stability after its removal[19] The functional impressions were made using "zinc oxide–eugenol "impression material to the saddle area due to difference in the compressibility between the residual ridge and the abutment teeth .

It was essential that the framework was seated completely and finger pressure was applied to rests only never press the tray itself. Care should be taken to prevent any of the impression material from getting trapped under the rest. Finger pressure on the tray can cause lifting of the frame work off the teeth and adversely affect the impression .[8]

The altered cast impression technique was necessary to ensure that the metal frame work and the base were related in the same relationship as that which exists between the abutment tooth and the supporting mucosa when the base has an occlusal force applied, this technique has the potential benefits of reducing the number of post operative visits, preserving the residual ridge, improving stress distribution, decreasing food impaction and decreasing the torque of abutment teeth, all of which lead to proper function , patient comfort and preserve oral health [20,21].

Co-Cr alloy is the most commonly used for casting metallic restorations. They are an important economical alternative to gold alloy, owing to decreased cost and improved mechanical properties. Metal base dentures display excellent strength to volume ratios and can be casted in thin sheets maintaining their rigidity and fracture resistance. The metallic denture bases are more tissue tolerant[22].

The masseter and temporalis muscle were chosen for representing the masticatory muscle activity, since they are the largest and strongest muscle which play a major role in mandibular movement and accessible during recording with surface electrodes. The electrodes were placed on areas of the greatest lateral distention of the temporalis and masseter muscles, which represent the most contractile part of the muscle [23].

Surface EMG employs surface electrodes which are non-invasive and painless and they record the broad range of activity of entire muscle. Electromyography recording were performed with patients seated in the relaxed upright position to avoid the effect of head posture on the reading. Before placing the electrodes on skin, it must be ensured that the skin is clean and dry. The skin must be cleaned by using alcohol and then it should be dried if necessary, shave excess body hair. Cleansing of the skin is useful to provide EMG recordings with low noise levels and obtain signals of good quality[24,25].

The EMG activities of the masseter and temporalis muscles were evaluated after two months from denture delivery to allow denture settling, adaptation and muscle accommodation. Records were made for the masseter and temporalis muscles bilaterally at each time period of follow up to avoid variation in the activity of the recorded muscles as a result of variation in the preferable chewing side for each patient [26].

The measurement of maximum bite force (MBF) was done by occlusal forcemeter and done for both right and left side to avoid variations occurs due to the preferable chewing side. To assess (MBF) of the (RPD), the force transducer was positioned on the occlusal surface of the artificial first molar for each patient for standardization [27,28].

The electromyographic activity of both masseter and temporalis muscles showed gradually increase with denture insertion and after 2 months and then decreased after 4,6 months from denture insertion. This finding is supported by those found by Ferreira et al. in all of prosthesis users [29].

This increase in the electromyographic activity during the initial measurement may be contributed to the adaptation period to the new prosthesis so, greater attention was recommended to the patients during chewing. They were instructed to choose soft foods and eat small bites. These instructions were probably determinant for the better balance

of the muscle activities 2 months after the RPDs installation [30].

The reduction on the muscle activity may contribute to prevent parafunctional habits and articular dysfunctions. The muscular activity reduction usually occurs due to the afferent nociceptors activation, and may end by inhibiting the muscle contraction as a protection reflex due, for example, a new prosthesis installation [31].

The masseter muscle is the most active muscle during the chewing process. This activity was noticed in this study at the fourth month after dental prosthetic rehabilitation. The difference between right and left masseter and temporalis muscles were recorded. This difference may be found in most of cases, since patients usually prefer one side rather than the other during chewing, independently of age, gender or food type, even after myofunctional therapy [32].

The biting force significantly increased as the period after denture delivery increased. This is because of more denture adaptation by time and also due to the absence of the immediate and delayed complaints of denture insertion as time elapse. This was noticed when comparing the bite force values for different follow-up periods (values at 2 months are less than values at 4 months which are less than 6 months) in both right and left sides.

This increase in the biting force after denture insertion and during the follow-up periods occurs due to increased the occlusal contacts between the opposing teeth and the number of posterior teeth loaded during the biting action.[33]

CONCLUSION

Within the limitations of this study, the conclusions that could be obtained are that removable partial dentures improved patient's masticatory activity and maximum bite force which were better than prior to the constructions of prosthesis but these functions is usually improved to a lesser extent than that of the previous complete dentition.

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