

EVALUATION OF BITING FORCE FOR THREE DIFFERENT PARTIAL DENTURE MODALITIES IN BILATERAL DISTAL EXTENSION CASES (CROSSOVER STUDY)

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ABSTRACT

The purpose of the present study was to assess the magnitude of biting force in three different partial denture designs.

Methodology: A total of ten patients with mandibular bilateral free end saddles without modification (Unmodified class I) were included in this study. All patients received three successive partial denture designs (conventional, extra-coronal attachment and posterior implant with bar attachment successively). Each design was used for 4 months intervals. The mean biting force was measured at the time of insertion and after 4 months for each design.

Results: One way ANOVA followed by Post Hoc test was made to check the significance within each group and between groups of different designs for the biting force measurements. The data revealed that the magnitude of biting force at insertion was 44.425 ± 6.21398 , 84.1050 ± 5.93779 and 129.1900 ± 7.92749 for conventional, extracoronal attachment and implant bar attachment design respectively, while after 4 month it was 49.4900 ± 5.41002 , 90.1850 ± 6.36713 & 142.5700 ± 7.49098 for conventional, extracoronal attachment and implant bar attachment design respectively.

Conclusion: Within the limitation of this study it can be concluded that:

1. Using a posterior implant with bar supporting and retaining removable partial denture is a viable treatment option for free end saddle cases.
2. Significant improvement in biting force occurred by changing the design from conventional to extra-coronal attachment and from extra-coronal to implant bar attachment.

KEYWORDS: Distal extension base, Extracoronal attachment, Implant bar attachment, Biting force.

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INTRODUCTION

Loss of posterior teeth can reduce oral function and affect nutritional status^(1,2), prosthetic treatment options for partially edentulous patients includes fixed and removable dental prosthesis⁽³⁾.

Distal extension bases have a problem of support due to the absence of the distal abutment, the difference of compressibility between mucosa and the periodontal ligament thus increasing torque forces on the distal abutments. Rotation of the distal extension base in a tissueward direction occurs during function under occlusal force⁽⁴⁾. Due to the mismatch of the viscoelastic responses between mucosa and the teeth this rotation potential always exists, the rotation of the denture base under function determines the occlusal efficiency of the partial denture⁽⁵⁾.

To protect the natural abutment from torquing during function, resilient extracoronal attachment may be used for distal extension bases allowing for a limited degree of distal rotation⁽⁶⁾. It also decreases stresses transmitted to the abutments as the forces are or near the long axis of the abutment⁽⁷⁾.

One of the most outstanding methods to control this rotation potential is to replace the missing distal abutments by using strategically placed distal implants to transform a Kennedy class I RPD into a tooth and implant assisted removable partial denture^(8,9).

Replacing missing teeth by conventional partial denture is associated with decreased bite force and patient satisfaction⁽¹⁰⁾, however, using dental implants combined with removable partial dentures enables the patients to have benefits from both the implant and the partial denture. In implant-supported partial dentures the destructive lever arm is minimized, bone is preserved, prosthetic retention increases and unaesthetic prosthetic components can be eliminated⁽¹¹⁾.

Removable partial dentures supported by

implants are significantly accepted than conventional partial dentures as it routinely improves the biting forces thus enhancing the masticatory function, also patient satisfaction is high in comparison with the conventional dentures.⁽¹²⁻¹⁵⁾

The magnitude of the biting force act as a major indicator of the masticatory system functional state. The efficiency of bite function depends on temporomandibular joint, muscles of mastication and dentition (whether natural or artificial)⁽¹⁶⁾. Bite force and its measurement for dental implant rehabilitation may become an integral part of the complete oral examination and assessment.^(17,18)

Several techniques and devices are used to assess the biting force, from which are the bite fork⁽¹⁹⁾, strain gauge transducers⁽²⁰⁾, portable hydraulic pressure gauges⁽²¹⁾, force-sensing resistors⁽²²⁾, pressurized rubber tube⁽²³⁾, pressure-sensitive sheets⁽²⁴⁾, foil transducers⁽²⁵⁾ and the gnathodynamometer⁽²⁶⁾.

The aim of this study was to assess the magnitude of biting force in three different partial denture designs.

MATERIAL AND METHODS

A total of 10 patients were selected from the outpatient clinic of the removable prosthodontic department of Beni-Suef University. Patient's written informed consent was obtained before the beginning of this study. Male patients with the age ranging between 45-55 years were selected with the following inclusion criteria: Class I maxillary-mandibular relationship free from any systemic diseases that would affect the bone quality or post-operative healing, with no T.M.J. disorders, with completely edentulous maxillary arch opposed by bilateral free end saddles in the mandible and the ridge is well-moderately formed with healthy intact mucosa. All patients have available inter-arch space and cases with abnormal habits as bruxism or smoking were excluded.

Clinical procedures:

Intraoral visual and digital examination including checking the mucosa, inclination of the remaining natural teeth, periodontal evaluation, adequate lingual sulcular depth for placement of the major connector, presence of attached gingiva and mobility of the remaining teeth were tested especially those that will be used as abutments.

Preoperative periapical, panoramic radiographs, as well as cone beam computed tomography (CBCT) was done to check the bone height and density as well as to help in implant placement orientation in relation to the inferior alveolar canal.

Pre-prosthetic procedures were performed for each patient including periodontal treatment, through supra and sub-gingival scaling and root planning; all conservative procedures were performed as fillings and root canal treatment.

All patients received upper single denture constructed with the conventional technique opposed by lower three successive different partial denture designs. (Crossover study)

Steps of construction of design I:

Preliminary impression followed by initial surveying of study cast was made to detect the amount of undercut on the terminal abutments and the most appropriate path of insertion followed by drawing the partial denture design.

Intraoral mouth preparation was made according to the previously determined plane.

The final impression was recorded using medium body rubber base (Impregum™ F 3M ESPE, Deutschland GmbH, 41453 Neuss-Germany) followed by surveying of the master cast.

The master cast was modified and duplicated. On the duplicate cast the wax pattern was constructed, cast with cobalt-chromium alloy, finished and polished.

Trial insertion of the metal framework in the patient's mouth followed by jaw relation registration, mounting of the casts on semi-adjustable articulator, setting up of teeth, try-in of the waxed up partial denture followed by processing of the final denture base. The partial denture was inserted into the patient's mouth and final occlusal adjustment was made.

The biting force was measured bilaterally using occlusal force meter three times at the first molar region by an occlusal force meter which involves a hydraulic pressure device and a disposable polyvinyl cap (17 mm in width and 5.4 mm in height). The measuring range was 0–1000 N with an accuracy of ± 1 N (GM10, Nagano Keiki, Tokyo, Japan). The instrument was placed such that all bite forces were directed to the center. *Fig (1)*

The patients were instructed to bite as powerful as possible three times per side, with a rest time of 2 minutes in between. The maximum occlusal force recorded in Newton (N) was recorded. The mean of the three records was considered to be the patient's maximum biting force.

The biting force was measured for each patient at the time of denture insertion and 4 month later.



Fig (1) Patient biting on the occlusal force meter

Steps of construction of Design II:

After four months of using the skeleton type removable partial denture, the terminal abutments were prepared to receive a surveyed PFM crowns with an extracoronal OT attachment 1.8mm sphere (OT strategy/optional steady. Via E. Zago, Rhein83, Bologna, Italy) **Fig (2)** and a new skeleton-type removable partial denture was constructed with the same previous steps in addition to picking up the female nylon caps in the fitting surface of the denture by self-cure acrylic resin (Acrostone, England) Again biting force was measured for each patient at the time of denture insertion and 4month later.



Fig (2) PFM crowns with an extracoronal OT attachment

Steps of construction of Design III:

After four months of using the previous partial denture (design II), an implant 3.9 mm diameter and 12 mm in length (Dentis Implants, Dentis Co LTD. One Q-SL. Korea) were surgically placed at the 2nd molar area bilaterally (flapless technique) and implant abutments were screwed in place. The implant abutments were prepared to receive porcelain fused to metal crowns **Fig (3)**. The previously made porcelain crowns with the OT attachment on the terminal abutments were removed and a rubber base impression (Durosill, President Dental, Munchen- Germany) was taken and poured followed by fabrication of the wax pattern for the implant crowns as well as the crowns on terminal abutment teeth previously prepared, a bar plastic pattern with oval cross-section bar (OT bar multiuse, system Rhein 83, Via E, Zago Bologna. Italy) was positioned between the implant crowns & terminal abutment wax patterns aligned parallel to the plane of occlusion by the aid of the parallelometer. The assembly was then sprued, invested, burnt-out and cast followed by metal try-in of the crown-bar assembly in the patient's mouth.



Fig (3) Implant abutments prepared to receive PFM crowns



Fig (4) Final cementation of the crown-bar assembly in the patient's mouth

Porcelain was built-up on the metal crowns, fired, finished, glazed and placed in the patient's mouth followed by an overall rubber base impression;

the assembly was removed from the impression and finally cemented in the patient’s mouth **Fig (4)**. The impression was poured, and a duplicate cast was obtained for RPD construction.

After construction of the new skeleton removable partial denture and at time of denture insertion, direct pick-up of the retentive clip was done by self-cure acrylic resin (Acrostone, England) in the fitting surface of the denture. **Fig (5)**

Again biting force was measured for each patient at the time of insertion and 4month later.

Statistical analysis:

Statistical analysis performed with SPSS 20®, Graph Pad Prism® and Microsoft Excel 2016 with a



Fig (5) Final fitting of the skeleton RPD in the patient’s mouth

significant level set at $P \leq 0.05$. Data were presented as means and standard deviation (SD).

RESULTS

One way ANOVA test was made to check the significance between the three designs followed by Post Hoc test to reveal the significance between different designs at different follow-up periods.

Table (2) & Fig (6) shows that the mean biting force for the conventional design at the time of insertion was $44.4250+6.21398$ and after four month was $49.4900+5.41002$ and P-value was 0.158 (no significant difference).

The mean biting force for the extra coronal attachment design at the time of insertion was $84.1050+5.93779$ and after four month was $90.1850+6.36713$ and P-value was 0.049 (significant difference).

The mean biting force for the implant with bar-retained partial denture design at the time of insertion was $129.1900+7.92749$ and after four month was $142.5700+7.49098$ and P-value was 0.00 (significant difference).

The data also revealed a significant difference between the three designs at the time of insertion and after four months (P-value was 0.00)

TABLE (1) Significance between different designs

Biting force					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	161047.735	5	32209.547	735.827	0.000*
Within Groups	4990.151	114	43.773		
Total	166037.886	119			

*: Significant at $P \leq 0.05$

TABLE (2) Mean biting force between different designs at different periods

Time	N	Biting force			
		Conventional partial denture	Extra-coronal attachment retained partial denture	Implant with bar retained partial denture	Significance
Insertion	20	44.4250+6.21398	84.1050+5.93779	129.1900+7.92749	0,00 *
4 Month	20	49.4900+5.41002	90.1850+6.36713	142.5700+7.49098	0.00 *
Sig.		0.158	0.049*	0.00 *	

*: Significant at $P \leq 0.05$

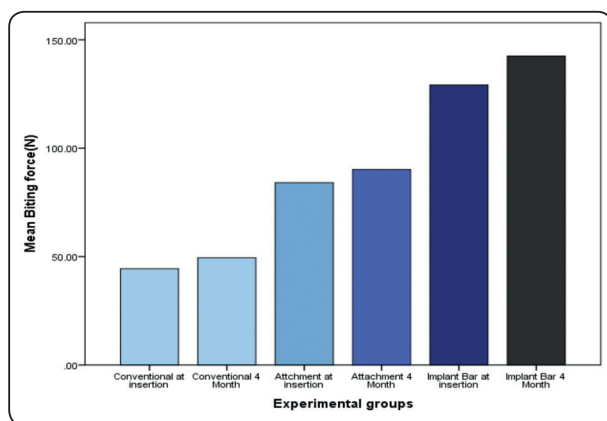


Fig (6) Bar chart showing the biting force between different designs at different follow-up intervals

DISCUSSION

The present study is a crossover study carried out to evaluate & compare the maximum biting force of three different partial denture designs rehabilitating mandibular Kennedy class I partially edentulous cases. The three designs were conventional partial denture, Partial denture retained by extra-coronal attachment and partial denture retained by implant with bar and clip attachment within the same subjects.

In all patients, mandibular RPDs are opposed by complete dentures in the maxilla with bilateral balanced occlusal scheme, which creates occlusal harmony, standardizes the amount of force applied on the lower prosthesis from the opposing occlusion and improves load distribution. This also avoids potentiating parafunctional activity which has been suggested to increase bone loss around implants (27, 28)

Mandibular bilateral distal extension cases were selected in this study as they are more common than the maxillary ones, due to the general pattern of tooth loss. Furthermore, mandibular distal extension cases are considered the most difficult to receive satisfactory and comfortable dentures due to support problems and smaller denture base area in relation to the functional load (29, 30)

Osseointegrated implant is not mobile under occlusal forces compared to the natural teeth that possess at least 30µm physiologic mobility(31), hence the displacement under the occlusal force will be quite different, so rigid connection between implants and natural teeth is not recommended in fixed bridges.

On the other hand; concerning partial overdentures, connection between denture base and implants are more flexible than that of fixed prostheses because the only function of the distal implant is to act as a vertical stopper to resist the rotation potential that occurs at the distal end of the denture base during vertical loading, moreover the presence of resilient clip -bar connection allows for less stresses on the distal implant. Thus, the overdenture would be quite safe.

The distal support may prevent rotation of the distal part of the saddle during functional loading; consequently, it maintains a continuous precised contact relationship between the opposing occlusal tables during function. This may maintain the masticatory force at a constant level, therefore the efficiency of food penetration is optimized.

Bite force measurements are considered one of the most important indicators for the assessment of masticatory performance in different prosthetic designs.

Biting force measurements within the three different designs showed no significant difference between the right and left side this can be attributed to that all patients involved in this study don't have a preferable chewing side and all the patients used both sides eventually during eating with their partial dentures.

The mean biting force within groups showed that there was a significant difference between the three different partial denture designs in favor of the implant with bar and clip design giving the higher mean values of biting force. The presence of posterior implant provides posterior support to the partial denture which allows for stabilization of the partial denture so consequently improves the biting force in this design. This agrees with Ohkubo C et al⁽³²⁾ who compared the masticatory movements, occlusal force, and patients' preferences of implant-supported RPDs to conventional RPDs and recommended the use of distal implant to improve chewing by conventional distal- extension RPDs.

Meanwhile, the partial denture design with extra-coronal attachment showed higher results than conventional partial denture design but lesser than that of implant bar supported design, this can be explained by the presence of extra-coronal ball and socket attachment allowing for some degree of resiliency protecting the torqueing action that can be exhibited by the conventional partial denture on the terminal abutment. Also, the splinted effect of the terminal abutments may be one of the reasons that increase the biting force for this design and decreasing the torqueing action on these abutments.

Regarding the effect of time in the three designs, the conventional and extra-coronal attachment designs showed non statistically significant difference between the biting force at the time of insertion and after four month. Regarding the implant bar-retained design; there was a statistically significant improvement of the biting force after

four month. This improvement can be attributed to the effect of osseointegration of the implants which improves the biting force measurements. Moreover, the occlusal contact areas are significantly increased by the implant support due to the minimum displacement of the distal- extension RPD; both stronger occlusal force and the greater contact area may contribute to the improved chewing capacity of the implant-supported RPD.⁽³³⁾

CONCLUSIONS

Within the limitations of this study, it can be concluded that

1. Using a posterior implant with bar supporting and retaining a removable partial denture is a viable treatment option for free end saddle cases.
2. Significant improvement in biting force occurred by changing the design from conventional to extra-coronal attachment and from extra-coronal to implant bar attachment.

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