



Clinical Comparative Study of Retention for Single Versus Two-Implant Mandibular Overdentures Reinforced by PEEK Framework

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KEYWORDS

Retention, PEEK framework, Ball, Implant, overdenture.

ABSTRACT

Aim: This clinical work aimed to evaluate and compare retention force of single versus 2-implants mandibular overdentures reinforced by poly ether-ether ketone (PEEK) framework. **Subjects and methods:** sixteen completely edentulous participants were eligible for this study. Patients were randomly divided into two equal groups, for group I single implant was inserted in mandibular midline area, single ball abutment was threaded in place, each patient receive mandibular overdenture reinforced with PEEK framework. In group II, insertion of 2-implants in the mandibular canine region, two ball abutments were threaded in place, each patient receives mandibular overdenture reinforced with PEEK framework. The evaluation of retention was performed using digital force-meter device at time of overdenture insertion (T0) & three months later (T3). Both groups were compared with independent t- test. **Results:** at time of mandibular overdenture insertion (T0), two groups were recorded significant difference in retention forces. 2-implants with PEEK framework recorded higher retention forces compared to single-implant with PEEK framework (P value \leq 0.001). Significant difference in retention forces was recorded after 3 months between two different groups (P value \leq 0.001). Within group when compared mean retention values at (T0, T3) showed insignificant difference as in group I (P value 0.058) & in group II (P value 0.148). **Conclusion:** both single and 2-implants mandibular overdentures reinforced with PEEK framework can provide acceptable retention forces. Two-implant mandibular overdentures provide higher retention forces than single-implant mandibular overdentures during different evaluation periods.

INTRODUCTION

The prosthetic management of completely edentulous patients with ridges resorption has been a major challenge. Conventional complete dentures are prostheses that used to restore and maintain function of mastication, esthetics, speech, and social communication^[1]. Conventional complete dentures have been many complications as decreased retention and instability, increase gagging, pain, salivation problems, improper speech, mastication dysfunction, and finally esthetics unsatisfaction^[2].

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Implant-supported or implant-retained overdentures are recommended to overcome these complications as this line of treatment will enhance retention and stability, improve function and psychology, and overall promote oral function and comfort^[3]. Admittedly, the most popular treatment modality of edentulous patients is implant overdenture because of low cost and good long-term prognosis when compared to fixed implant-supported restorations^[4].

Many clinical trials suggested that implant-supported prosthesis is a favorable and excellent line of treatment for complete edentate's mandible. However, minimum implant numbers that needed and required for edentulism restoration is questionable. Single-implant mandibular overdenture (SIMO) is a simple treatment protocol. SIMO has decreased cost, decrease potential surgical risks and costs related to treatment when compared to overdenture designs having greater implant numbers^[5].

Using single implant mandibular acrylic resin overdenture to restore and rehabilitate edentulous mandible has some complication that must take in consideration. SIMO increase fracture in the area adjacent to the implant^[6]. Mainly, overdenture fracture occurs due to relieving the acrylic denture base for the attachment pick-up, this excessive relief leads to turn of the acrylic resin base. Also, single implant acts as overdenture fulcrum during its masticatory movements, leading to its deformation and fracture happened later^[7].

Rehabilitation of edentulous mandible with 2-implant overdenture has been the best treatment options for completely edentate's patients and considered a minimum standard for most edentulous patients^[8]. There are several attachment systems have been developed for implant overdentures support such as bars, magnets, balls, different cylindrical attachment types, fabricated according to materials, concepts and design forms^[9-10].

Overdenture retention and stability have been improved using attachments fabricated on implant

abutment. There are several considerations during attachment selection to gain the desired amount of retention including arch morphology, patient expectation, cost, and distribution of load to the implants and surrounding tissues^[11]. Ball and socket attachment considered as simple, most widely used, low cost, easily clean and handling, ease in changing the attachments, less sensitive technique, independent on implant position, wide range of movement, minimal chair side time needed, less inter-arch space, distribute functional forces, also, it preferred in case of advanced ridge resorption as it allow superior esthetic and phonetics^[12-13].

Furthermore, fractures mainly happened due to repeated denture base flexion under small loads. These Repetitive forces leads to microscopic cracks development in biomechanical stress concentration regions, and denture base fracture happened. Moreover, it was found that the thinnest areas of acrylic resin are deemed surrounding copings of overdentures leads to denture base fracture. Since, biomechanical stresses are concise to the thinnest areas of acrylic resin, due to all drawbacks the denture reinforcement is mandatory^[14]. There are many reinforcement approaches of the denture base have been introduced like rubber reinforced polymethyl methacrylate, metal reinforcement (CR-CO), fillers as carbon fiber, glass fiber, Nylon, Hydroxyapatite (HA), and nanoscale reinforcement materials^[15].

Newer materials can be integrated with overdenture attachment systems. Recently, PEEK and polyether ketone ketone (PEKK) have been widely used in implant and restorative dentistry^[16]. PEEK is an innovative material has been used successfully in the medical and orthopedics over the last years. PEEK has several advantages as good mechanical and electrical properties, biocompatible so, it has been widely used as an alternative to conventional materials^[17].

PEEK frameworks have been used to prevent denture base fracture. The reinforcement can be



obtained by PEEK material as it is high performance polymer. PEEK material has many characters as bio-inert, tissue compatibility, non-cytotoxic, not thermal conductivity and not reacted intraorally with saliva as PEEK has a property of chemical resistance^[18].

The most important requirements that must be achieved and obtained during treatment of edentulous patient is prosthesis retention, due to its denture function and finally patient satisfaction obtained^[11]. Therefore, this clinical work aimed to evaluate and compare the retention force of single versus 2-implant mandibular overdentures reinforced by PEEK framework. The null hypothesis was that no difference will be present in retention values of single-implant versus 2-implant mandibular overdentures reinforced with PEEK framework.

MATERIALS AND METHODS

Patient selection

A total of sixteen edentulous patients were eligible for this study from the outpatients' clinic of the Removable Prosthodontics Department, Faculty of Dentistry, Mansoura University, Egypt. This present work has been accepted and approved by Faculty Ethics Committee (No, A1401122). All patients informed about the detailed treatment plan and visits needed for follow-up, after that signed written consents were obtained.

The inclusion criteria dictated that; all participants had adequate bone quantity and quality of residual alveolar ridge bone quantity at the region anterior to mental foramen, residual ridge covered with firm healthy mucosa, Angle's class I patients were eligible with normal maxilla-mandibular relationship, a tentative jaw relation was performed and used to verify acceptable inter-arch space.

Exclusion criteria implied; the selected participants free from any systemic disorders that hindering Osseointegration process such as

uncontrolled diabetes mellitus, bone diseases as osteoporosis, or hemophilia, temporomandibular joint disorders or impaired neuromuscular control, head and neck radiation, Para functional habits such as bruxism, heavy smoking, and alcoholism.

Baseline characteristics of the two groups are listed in (Table 1).

Pre-surgical procedures: For all participants

- Preoperative CBCT was performed to evaluate bone height in mandibular anterior region. This height was measured from crest of the residual alveolar ridge to the inferior border of mandible.
- Conventional complete dentures (maxillary & mandibular) were constructed with artificial acrylic teeth arrangement following lingualized balanced occlusion.
- Duplication of mandibular denture was performed with a clear auto-polymerized acrylic resin to fabricate the mandibular surgical template.

Patients grouping:

Edentulous participants were randomly classified into 2 equal groups into:

- Group I: eight participants received a conventional maxillary denture and single-implant mandibular overdenture (SIMO) reinforced by PEEK framework.
- Group II: eight participants received a conventional maxillary denture and two-implant mandibular overdenture reinforced by PEEK framework.

Surgical procedures:

- For group I: a single implant (T6 implant from NucleOSS, Turkey, 13mm length×3.2mm diameter) was surgically inserted in the mandibular midline area following the two-stage surgical protocol. Cover screws were then attached to the dental implant and the wound closure was

performed. Corresponding to the implant, the mandibular denture has been relieved and relined by applying a tissue conditioning material (Viscogel, Dentsply) followed by refining of occlusion.

- For group II: Two dental implants (T6 implant from NucleOSS, Turkey, 13mm length×3.2mm diameter) were inserted bilaterally in mandibular canine region using standardized two-stage surgical protocol. Cover screws were then attached to the implants and the wound closure was performed.

Corresponding to the implant, the mandibular denture has been relieved and relined by applying a tissue conditioning material (Viscogel, Dentsply) then occlusion refining was done.

After 3 months of Osseo-integration period, a tissue punch was used to expose dental implants, then the healing abutments were placed for two weeks until the gingival tissue and gingival collar properly healed and formed. After 2 weeks, healing abutments were removed, and ball abutments (Nucleoss dental abutment) were threaded in place (Figure 1a, b).

Prosthetic procedures

For each patient the following steps were performed:

- A preliminary impression was taken to the lower arch using irreversible hydrocolloid
- Custom tray made from self-cured acrylic resin material (Acroston, self-cure acrylic resin) was fabricated and holed above the implant for open tray impression technique.
- Border molding was done by using green compound sticks (compound Kerr, USA) to trace the extensions of the flanges. The transfer coping was screwed into the implant. Custom tray was checked up intra-orally to make sure that the transfer didn't interfere with insertion and removal.
- Muco-compressive impression technique was carried out using zinc oxide impression material (Cavex Outline ZOE) and transfer coping was picked up then implant analogs were attached to the transfer coping with fixation screw and the final impression was poured with extra hard stone (Super-Cal IV, COE laboratories Inc, USA) to obtain master cast.
- The final mandibular cast was secured to the scanner (3Shape 3D Dental Scanners) and scanned to obtain Standard Triangulation Language (STL) file. Consequently, STL file was transferred to the software (3Shape A/S, Copenhagen, Denmark) to start designing process of framework for both groups.
- A tentative stereolithographic 3D printed resin framework was constructed for both groups by

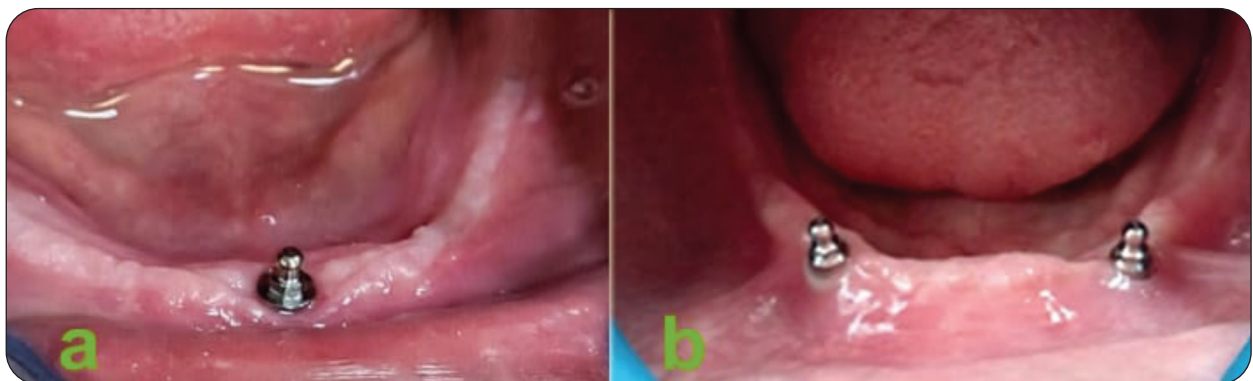


Fig. (1) a: Single ball abutment threaded in place. b. two ball abutments threaded in place.

employing rapid prototyping technology. This tentative framework was checked intra-orally for both groups.

- PEEK frameworks can be fabricated by injection molding techniques^[19], as follows: after scanning of the mandibular master cast, the PEEK framework was performed by conventional lost wax technique. This wax model was made by using CAD\CAM machine (Ceramill map 400, Amann Girrbach, Koblach, Austria), invested, PEEK granules (BioHPP, Bredent GmbH, granular form) have been brought to investment mold reservoir, the melting procedure was done. Pressing of melting PEEK granules (PEEK press system & blue light of press system) was accomplished. The mold was cooled and deinvested. Then the PEEK framework was disconnected from the sprues and finished as usual manner.
- PEEK frameworks were tried intra-orally for both groups.
- Maxilla-mandibular relations were recorded. Mounting the casts on articulator (Dentatus) and setting of artificial acrylic teeth (Viva dent) were done.
- After processing, final single-implant mandibular overdentures (SIMOs) reinforced with PEEK framework (group I) and final two-implant mandibular overdentures reinforced with PEEK framework (group II) were delivered to patient and adjustment of occlusion was done.

Pick-up procedures

- On the top of each ball abutment an indelible pencil transferable mark was done, then the mandibular denture was seated for determining the exact position of attachment housings.
- Recesses in the intaglio surface of the mandibular denture were prepared to accommodate attachment housings. The contact between attachment housing and denture base should not be found.
- Pick-up of ball abutment to the intaglio surface of the mandibular overdenture reinforced with PEEK framework for each group was accomplished using an auto-polymerized acrylic resin (Acroston, cold-cure acrylic resin) and asked patient to bite in centric occlusion to avoid any increase in vertical dimension. Finally, occlusion refining was performed (Figure 2 a, b).

Retention force measurement:

- Evaluation of retentive force of single and two-implant mandibular overdentures reinforced with PEEK framework were measured immediately from overdenture insertion (T0) and three months later (T3) by measuring and assessing the maximum dislodging force that allows separation between overdenture and its attachment. The retention force measurement was performed by a digital force-meter device^[20] (Mecmesin Corp, Virginia, USA) as follows:

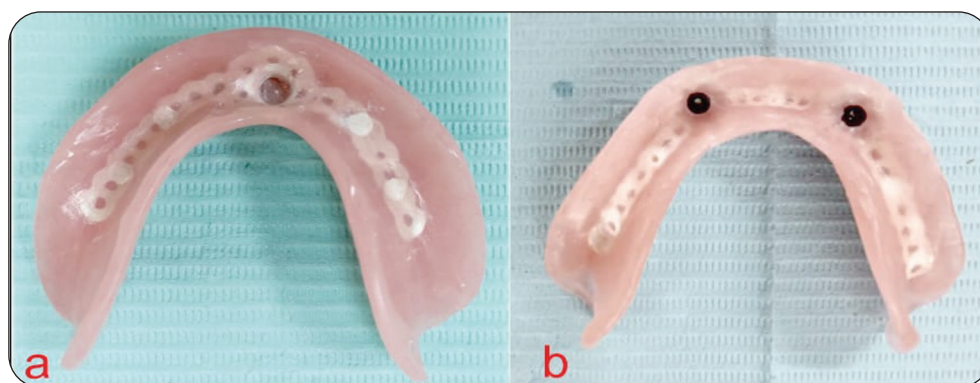


Fig. (2) a. Pick-up of single implant mandibular overdenture reinforced with PEEK. b. pick-up of two-implant mandibular overdenture reinforced with PEEK.

Denture and patient preparation

- At horizontal high of canine and first molar areas, there are 4 right angle metal hooks were attached bilaterally to the polished surface mandibular overdenture. Ask patient to seat in an upright position with the chin resting at the chin rest of force-meter device, mandibular overdenture was in place while opposing maxillary denture was removed to prevent its possibility of fracture while force-meter fork allowed to be under the 4 hooks.
- The wheel of force-meter was rotated this allow the device to move vertically until the overdenture was removed from its place. The force-meter reading was recorded.
- The force was recorded in Newton & measured as retention. For each participant, the test was repeated five times to obtain five records, the mean of which was then calculated. The data was collected and analyzed.

Statistical analysis:

Statistical Package of Social Science SPSS program with standard version 21 (SPSS Inc., Chicago, IL, USA) was used for data analysis and the normality of data was tested using Shapiro test.

For normally distributed data, continuous variables were presented as mean \pm SD (standard deviation). The 2 groups were compared with

independent t- test. the threshold of significance is fixed at 5% level. When ($p \leq 0.05$), the results were considered significant. The smaller p-value obtained, the more significant are the results.

RESULTS

Table 1 presented baseline characteristics of two studied groups.

Table 2 & figure 3 presented the mean retention values immediately after mandibular overdenture delivery T0, three months later T3 of overdenture use of both groups. Comparisons between both groups revealed significant difference in initial retention forces T0 and significant difference at T3 later as ($P \leq 0.001^*$).

Table 3 presented mean retention values within group at T0, T3 after following up of overdenture delivery, it showed that insignificant difference for both groups as at T0 (P value= 0.058) and at T3 (P value= 0.148).

Table (1) Baseline characteristics of two studied groups.

Age (y)	57.6 \pm 5.71	56.4 \pm 5.32
Male/female (n)	6/2	4/4
Previous mandibular dentures (n)	1.3 \pm 1.04	1.6 \pm 1.19

X; mean, SD; standard deviation

Table (2) Comparison of retention values between group I&II at T0&T3 from overdenture delivery.

		X	SD	Min	Max	T Test	P Value
T0	Group I	6.14	0.74	4.7	7.1	7.40	$\leq 0.001^*$
	Group II	9.26	0.93	7.9	10.7		
T3	Group I	5.23	0.86	3.9	6.8	6.72	$\leq 0.001^*$
	Group II	8.71	1.19	7.2	10.2		

X; mean, SD; standard deviation, *significant at 5% level of significance.



Table (3) Within group I&II comparison of retention values at T0&T3 from overdenture delivery.

		X	SD	Min	Max	Paired T Test	P Value
Group I	T0	6.14	0.74	4.7	7.1	2.26	0.058
	T3	5.23	0.86	3.9	6.8		
Group II	T0	9.26	0.93	7.9	10.7	1.62	0.148
	T3	8.71	1.19	7.2	10.2		

X; mean, SD; standard deviation, *significant at 5% level of significance.

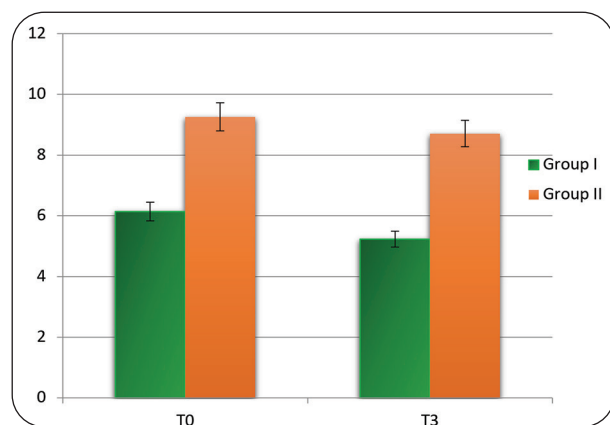


Fig. (3) Comparison of retention values between group I&II at T0&T3 from overdenture delivery.

DISCUSSION

The results of the present study showed a statistically significant difference in retention forces between single and two-implant overdenture reinforced with PEEK framework at (T0& T3) from mandibular overdenture insertion. This could be attributed to stability and retention of implant supported overdenture is greatly impacted by implant number and position as the increased number of implants will increase retention and stability of implant supported overdenture^[21].

On the other hand, it has been recognized that for many patients the importance of fewer implants as a price saving strategy features a merit. In some cases, however, the use of two-implants is suggested to provide greater overdenture stability and retention^[22].

The choice of attachment type mainly depends on the amount of retention it provides. As well as the attachment type affect both implants and dentures survival rates^[23].

Accordingly, the most common attachment used for un-splinted implants is ball attachment. This type of attachment system is effective, practical, and low cost. Also, it has some drawbacks like high-profile design that result in high concentration of stress patterns at the ball's neck transmitting significant quantities of stress to the bone and implant. The other downside of ball attachment is the resin and metal clips can wear easily, thus reducing prosthesis retention^[22].

After three-months (T3) of mandibular overdenture insertion, still there was statistically significant between both groups but the decreased retention values were found. This is in line with van Kampen et al.^[24] who evaluated retention force, they declared that after 3 months of overdenture function, the retention force was lost.

In the current study, retention decreases with time. These results coincided with the results of El Syad et al^[11] and Hammas et al^[25] who measured decrease in retention values over time.

Kurtulus et al.^[26] affirmed that, when recording initial retention forces at the time of insertion (T0), they found that the retention was significantly higher compared to all subsequent measurements in all studied samples. As ball and stud attachments

permit and allow vertical displacement forces that vary from 7 to 31 N based on in-vivo studies.

The decreased retention values after T3 of overdenture delivery is attributed to attachment system. This result is coincided with Arora et al^[27] who affirmed that the ball attachments tend to wear over time of clinical use and thus, lose retention. Wear occurs primarily during insertion and removal of overdentures, function, and parafunctional activities. With time, an alternation of attachments retention force is expected, this reduced retention leads to more maintenance visits and finally reduced patient satisfaction^[11]. Other findings were that wear of attachments often occurred because of mechanical loading like mastication and insertion-removal of the prosthesis^[28].

In addition to Sharaf et al^[29], they explain the retention loss was associated with deformation which results during insertion and removal of overdentures lead to wear of nylon of attachment. Many researches were performed to assess retention values of overdenture attachments affirmed that attachments lose their retention gradually as ball attachments nylon housings are more susceptible to fatigue then wear occurred and finally loss of retention.

Ibrahim et al^[18] found that, overdentures reinforced with PEEK framework was greater denture base adaption than overdentures reinforced with Co-Cr framework. So, PEEK is applicable as reinforcing material that offers superior mechanical properties. Overall, in this study the null hypothesis was rejected.

CONCLUSIONS

Within the limitations of this short-term study, it could be concluded that:

- From retention point of view, both single and 2-implant mandibular overdentures reinforced with PEEK framework provide and allow an acceptable retention force.

- Two-implant mandibular overdentures provide higher retention forces when compared to single-implant mandibular overdentures at time of insertion T0 and after three months later T3.

CONFLICT OF INTEREST

No conflicts of interest have been explicitly stated by the author.

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دراسة مقارنة اكلينيكية لتثبيت بغرسة مقارنة بغرستين لاطقم الصناعية المدعمة بشبكة من البيك

هبة وجيه ابوزيد *

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الملخص:

الهدف: يهدف هذا العمل السريري إلى تقييم ومقارنة قوة الاحتفاظ للأطعمة الزائدة في الفك السفلي المفردة مقابل غرستين معززة بإطار كيتون الإيثر المتعدد البيك (PEEK).

المواد والطرق: كان ستة عشر مشاركاً غير متملقين مؤهلين لهذه الدراسة. تم تقسيم المرضى بشكل عشوائي إلى مجموعتين متساويتين ، بالنسبة للمجموعة الأولى. تم إدخال غرسة مفردة في منطقة خط الوسط للفك السفلي . وتم ربط دعامة الكرة المفردة في مكانها . ويتلقى كل مريض زائدة في الفك السفلي معززة بإطار PEEK. في المجموعة الثانية . تم إدخال غرستين في منطقة كلاب الفك السفلي. وتم تثبيت دعامتين كرويتين في مكانهما . ويتلقى كل مريض غطاء فكي سفلي مقوى بإطار PEEK. تم إجراء تقييم الاستبقاء باستخدام جهاز رقمي لقياس القوة في وقت الإدخال الزائد (T0) وبعد ثلاثة أشهر (T3). تمت مقارنة المجموعتين مع اختبار T- مستقل.

النتائج: في وقت إدراج الفك السفلي الزائد (T0) . تم تسجيل مجموعتين فرق كبير في قوى الاحتفاظ. -2/الغرسات مع إطار PEEK سجلت قوى احتفاظ أعلى مقارنة بالغرسة المفردة مع إطار PEEK (قيمة P 0.001). تم تسجيل فرق كبير في قوى الاستبقاء بعد 3 أشهر بين مجموعتين مختلفتين (قيمة P 0.001). ضمن المجموعة عند المقارنة بين متوسط قيم الاحتفاظ عند (T0 ، T3) أظهر اختلافاً ضئيلاً كما في المجموعة الأولى (قيمة P 0.058) وفي المجموعة الثانية (قيمة P 0.148).

الاستنتاج: يمكن أن توفر أطقم الأسنان الزائدة الفكوية المفردة والثنائية المزروعة بإطار PEEK قوى احتجاز مقبولة. توفر أطقم الأسنان الزائدة في الفك السفلي ثنائية الغرسات قوى احتفاظ أعلى من أطقم الأسنان الزائدة الفكوية المفردة خلال فترات التقييم المختلفة.

الكلمات المفتاحية: الثبات ، شبكة البيك ، كره ، غرسة ، طقم صناعي مثبت .