PROSPECTIVE CLINICAL EVALUATION OF MANDIBULAR OVERDENTURE UTILIZING TWO PREFABRICATED POST STUD ATTACHMENTS (INTRARADICULAR AND EXTRARADICULAR)

Gehan F. Mohamed

1. Assistant Professor, Department of Prosthodontic, Faculty of Dentistry, Menia University

ABSTRACT

Among the problems of edentulous patient are a lack of stability and a lack of retention plus diminished chewing ability. The preservation of at least two abutment in the arch to retain the prosthesis, has been proposed as a solution to these difficulties. The aim of this study was to evaluate clinically the mandibular overdenture utilizing two prefabricated posts, one intraradicular, (Reverse ball OT), and other extraradicular (pivot block ball OT) stud attachments. The evaluations were done through measuring the electromyographic activity of the muscle, the occlusal bite-force and the retention of the overdenture for week, 1, 3, 6 months follow-up period. Denture adjustments/complications and patient satisfaction with both designs of the attachment systems were also evaluated.

Twelve male patients were selected with two remaining canines in the mandibular arch and a completely edentulous maxillary arch. Patients were randomized divided into two equal groups to receive either sequence I, two pivot ball OT overdenture attachment followed by two reverse ball OT overdenture attachments or sequence 2, the pivot ball OT followed by the Reverse ball OT attachment.

Statistically, non significant effects were seen between the two attachment designs with respect to muscle activity, denture adjustments / complications and patient satisfaction. By time, the muscle activity significantly decreased in both attachment designs. Retention showed a significant difference between the attachment designs in favor to reverse ball OT. Also, their values significantly decreased by time in both attachment designs. Additionally, the occlusal bite force showed a significant values between the attachments in favor to pivot ball OT and it was significantly increased by time for both attachments. There was a moderate negative correlation between the retention and bite force at the early period of follow-up.

It was concluded that both attachments had a nearly uniform positive results. Ball OT had a better patient satisfaction, moderate muscle activity and high bite force. Reverse ball OT had a good retention and little denture adjustments/complications. Therefore, the patient condition and preference play a major role in the attachment selection.
INTRODUCTION

The preservation of one or more tooth roots to facilitate an overdenture has many advantages. Preservation of alveolar bone over time\(^{(1)}\), increase stability and efficiency of function, and maintenance of the proprioceptive sensory mechanism are of great benefit to the patient\(^{(2)}\). Additionally, the physiologic, chronologic, financial and emotional advantages of saving roots, are undeniable\(^{(3)}\). When roots remain to be utilize for overdenture, it should have a suitable angulation to the occlusal plane and with sufficient supporting alveolar bone\(^{(2-5)}\).

Auxillary retentive attachment to anchor the prosthesis and increase or provide retention have been promoted by several manufacturers\(^{(6)}\). There are a variety of overdenture attachment systems available such as intraradicular and supraradicular systems\(^{(7)}\), and resilient and non resilient systems\(^{(8)}\). Retention is offered by mechanical means composed of O-ring and balls or ball and socket and rare earth metal magnets\(^{(9)}\). Angulated attachments are also available\(^{(10)}\). The common characteristics of all systems consist of a root supported component (usually metallic) and a corresponding component (usually nylon, plastic or rubber) luted into the intaglio of the prosthesis\(^{(6)}\).

A primary reason for dental treatment is to restore oral function, especially mastication, bite force shows a positive relationship with masticatory performance and dietary selection, which is closely related to quality of life. Therefore, bite force has often been used as a variable for objectively evaluating masticatory function\(^{(11-14)}\). Factors reported to affect masticatory performance include age\(^{(15)}\), dental status\(^{(16,17)}\), salivary flow\(^{(18)}\), temporo-mandibular joint disorder\(^{(19)}\) and/or orofacial pain\(^{(20)}\). The maximum bite force also varies with skeletal craniofacial morphology, vertical facial relationships, the ratio between anterior and posterior facial height, mandibular inclination and gonial angle\(^{(21-23)}\).

The bite force recordings can be performed in a relatively simple way in the clinic. However, because maximum bite-force levels vary with record method, sex and age. It is important that the measurements to be compared with/against the appropriate reference values. The level of bite force is a result of the combined action of the jaw elevator muscles modified by jaw biomechanics and reflex mechanisms. Pain limits the maximum bite force and may thus impede the measurements, but this factor may also be useful in treatment control. The maximum bite force increases with the number of teeth present. Also the number of occlusal tooth contacts is an important determinant for the maximally attainable bite force\(^{(24,25)}\).

Bite force is often recorded with one or two transducers placed between pairs of opposing teeth during clenching\(^{(26)}\). This is a simple, direct method for clinical used, but it increased the bite height and leaves the rest of the dentition separated\(^{(27)}\). Pressure sensitive sheets, thin force-sensing resistors and strain gauges in dental reconstructions do not disturb the dental occlusion so much, but their recordings need far more preparation or computer calculation\(^{(28-30)}\).

There are several methods appear to be well suitable to assess the bite-force. Direct method have been reported for recording the maximum voluntary clenching, with numerous limitations including the possibility of dental fractures on the metal surfaces of the transducer, pain, discomfort and fear preventing a maximal performance in addition to the technical limitations of the instrument\(^{(31)}\).

An alternative method is to indirectly estimate bite forces by using some other physiologic variable known to be functionally related to force production. Electromyographic (EMG) activity of the surface elevator muscles of the mandible appears the best candidate. EMG potentials can be directly picked up from the cutaneous projection of the muscular belly in a non-invasive and not dangerous way. Subsequently, if some mathematical relationship between EMG potentials and force could be produced, an indirectly estimated force can be obtained\(^{(27,32)}\).

The assessment of retention of removable overdenture prostheses was performed using either subjective or objective method. The subjective methods usually, included patients and professional operators questionnaire,
while the objective methods involved the construction of devices based on physical and mechanical principles as levers, pullers, springs, dynamometers and strain gauges. Petropoulos et al., in 1997 compared the retention and release periods for implant overdenture attachments, they showed the stren gold ERA was the most retentive type of the stud attachment when subjected to both vertical and oblique forces, followed by the zest anchor and Nobel ball stud attachment. Moreover, Petropoulos and Smith, in 2002, studied the maximum tensile dislodging forces of implant overdenture stud attachments in vertical, oblique and anterior-posterior directions. The results showed the ZAAG (Zest Anchor Advanced Generation) attachment to be the most retentive for the peak load measurements when subjected to vertically and obliquely directed forces followed by standard ball type. For the anterior-posterior directed forces the ball attachment had the highest measured retentive force but this was not statistically different from the ZAAG. Naert et al., 2004 reported that the ball group type had the highest vertical retention of the stud overdenture attachment. Also, they mentioned that the patient had a great satisfaction with ball-O-ring and more complications and denture adjustments.

Although mandibular retained overdentures with ball attachment system are an acceptable treatment option, routine maintenance is required to ensure successful long-term outcomes. Therefore, the denture adjustments and complications should be measured.

Desjardins, 1992 pointed out that when all prosthesis was introduced, concern was expressed not only in regard to treatment expense but also to the esthetic, phonetic, functional and hygienic limitations of these prostheses. Patient satisfaction was used to assess the efficacy of the different treatment modalities for patient.

In order to get more in sight in the long term treatment efficacy of different overdenture treatment strategies, a controlled clinical trials must be carried out. It was the purpose of this study to evaluate clinically the mandibular overdenture utilizing two prefabricated post stud attachments; one intraradicular (reverse ball OT), and the other extraradicular (pivot block ball OT). The evaluations were done through, measuring the electromyographic activity of the muscle, the occlusal bite force and the retention of the overdentures. Denture adjustments/complications and patient satisfaction with both attachment designs was also evaluated.

**MATERIALS AND METHOD**

Twelve male completely edentulous patients except for two mandibular canines, with age ranging between 45-60 years were selected from the outpatient clinic, Prosthodontic Department, Faculty of Dentistry, Menia University. All patient were evaluated before inclusion in this study through:

1. **History**

Patients were selected to be free from any systemic diseases e.g. diabetes, hepatitis as indicated by medical questionnaire fulfilled by the patient. Patient with history of allergy, bruxing or clenching were excluded. Also, patients with impaired psychological conditions were not included.

2. **Clinical examinations**

This was done through visual and digital examinations.

- Patients with any temporo-mandibular joint disorders were ruled out.
- The shape, size and horizontal relationships of the upper and lower arches were evaluated.
- The patient should be class I Angle's classifications.
- He should had sufficient inter-arch distance, which was necessary to ensure room for placement of the attachment within the existing mandibular dentures.
- The presence of any bony protuberance or tori on the ridges was noted to be excluded.
- The mucous membrane of the cheeks, lips, ridges, palate and tongue could be free from any signs of inflammation.
Patients with healthy firm mucosa covering the edentulous ridge were selected.
Patients with at least 6 months elapsed after last extraction could be selected.
The mandibular canines were checked to avoid cases with gingival inflammation.
Pocket depth was measured using periodontal probe.
Mobility was tested by subjecting the canines to bucco-lingual movements between the handles of two mirrors.

3. Radiographic examination:
Panoramic radiographs were performed to exclude the presence of any remaining root.
The periapical radiograph was made for the canines to detect the presence of any periapical pathosis and adequate bony support.

Necessary scaling and root planning were performed for the two canines. Patients were instructed to maintain proper oral hygiene. Treatment plan was presented to the patient and they were informed about the necessity for regular attendance. Canines were endodontically treated and reduced to be dome shaped 1mm above the gingival margin. All steps for construction of the overdentures were completed in the conventional manner.

A special spade drill was used to remove the desired depth of the gutta-percha with the aid of the plastic depth reference ring. The canal was sized with a pilot drill (Mooser burs, Rheinzv E Zagles 8-40 128 Bologna Italy). Patient were randomized divided into two equal groups to receive either sequence I, two pivot block normal size titanium ball OT post overdenture attachments (pivot block titanium ball OT Rhein 83 via E zago, 8401 28 Bologna Italy). Fig. (1), followed by two reverse titanium ball OT post overdenture attachments (reverse titanium ball OT, Rhein 83 via E Zago, 8-40128 Bologna, Italy). Fig. (2), or sequence 2, the reverse ball OT attachments followed by the pivot bock ball OT.

For the pivot block titanium ball OT attachments, the canal was cleaned and dried by air pressure and paper point. The pivot ball posts (males) were attached directly to the root canal of the canines with cement. (Ivoclar vivadent AG, FL-9494 Schaan/Liechtenstein). While for the reverse titanium ball OT attachments, a countersink bur was use to imprint the full circumference of their countersink collar. Then the canal was cleaned and dried as previously mentioned. The reverse ball posts (females) were snapped into the plastic tool and cemented in position using the previously mentioned cement.

For both groups, a low-viscosity silicone material (pressure spot indicator, coltene/whaledent Inc, Cuyahoga Falls, Ohio) was used to disclose interferences between the fitting surface of the denture and the attachment systems. Disclosed interference was removed with a bur.

Fig. (1): Pivot block titanium ball OT post stud attachments, a) its components, b) insertion in the canine intraorally
Prospective clinical evaluation

A protective disc (Rhain 83 via E, Zago, 8-40128 Bologna, Italy) was positioned around the ball OT and reverse ball OT to avoid infiltrations of the acrylic resin material during the direct picking up (43).

The stainless steel metal housing with elastic retentive caps were inserted on each ball OT posts and the retentive titanium male were snapped into each reverse ball OT posts. The denture coated with the low-viscosity silicone was placed intra-orally, and evaluated for any contacts with the attachment system. Undesirable contact was observed and carefully relieved in the denture.

A round bur was used to perforate the lingual portion of the denture opposite the attachments so that most of the excess acrylic resin can escape. White autopolymerizing acrylic resin (Tab 2000; Kerr Italia SPA, Salerno, Italy) was mixed and applied to coat the prosthetic housings. Use white acrylic resin so that the excess will be easily detected. The denture was seated in place with firm finger pressure and the patient was asked to occlude until polymerization is completed. Then the denture was removed from patient mouth and the excess acrylic resin was carefully scabed from the fitting and outer surfaces of the denture. Denture was inspected for the presence of any defects to be filled with self cured acrylic resin. Finishing and polishing of the dentures opposite the canines were performed. Patients were instructed on insertion, removal and maintenance of the prosthesis and they were motivated for proper oral and prosthesis hygiene.

After 6 months of monitoring and data collection for each patient with their first attachment system, all patient were recalled and the attachments were replaced with the other system. Monitoring and data collection continued for additional 6 months.

Data were independently and concurrently recorded by three prosthodontists. The data were collected at one week, one, three and six months after placement of each attachment system (44). Inter-examiner reliability tests were performed. The measurement bias was controlled by using the mean of the three examiner measurements as the variable for statistically analysis.

The patients were recalled periodically at the previous follow up periods to evaluate; Firstly their mandibular overdenture retention using force measurement gauge (Digital Force Gauge Device Model 47544 with range up to 196.1 Newton Extech Instrument Cooperation, Taiwan; Measure Tension & Compression, pull and push); Secondly, activity of the superficial masseter and anterior temporalis muscles which were recorded using electromyographic device (Cadwell Excel High-Power EMG/EP device, USA); Thirdly, maximum bite force was determined for each patient using occlusal force meter (model GM, NaGONO Keiki Seisakusho, LTD, J.

Fig. (2): Reverse titanium ball OT post stud attachments, a) its components, b) insertion in the canine intraorally
Morita Corporation, 33-18-3-Chome-Torumi-Cho Suita City, Osaka 564-8650, Japan). Moreover, the prosthesis adjustments and complications were evaluated after three and six months follow-up. Patient satisfactions were also recorded at the end of each sequence, just before alternate attachment placement and patient preference were evaluated at the completion of the investigation.

**Retention Measurement**

Measurements of retention was made according to the method reported by Burns et al., 1995 (49). Using force measurement gauge Fig. (3).

The patient was seated in the dental chair in an upright position with the head resting firmly against the head rest. The mandibular overdenture was positioned correctly on the tissues and the patient was asked to rest his tongue passively in the floor of the mouth with its tip adjacent to the anterior denture teeth.

The pull end of the force gauge was connected to an 18 – gauge 15 cm long orthodontic wire that had a small distal hook. The wire hook was positioned under the mid labial flange of the denture without altering denture position or retention. The force gauge which connected to the denture via the orthodontic wire was pulled vertically until the denture was elevated. This force was measured in Newton and recorded as the denture’s retention. At each time period, 30 records from 3 inter-examiner prosthodontist were registered and collected (to take an average) for every patient to be considered as one reading. The patients were instructed to relax for one minutes between each record.

**Electromyographic Activity**

The activity of the masseter and temporalis muscles was evaluated for each patient, while wearing his denture. The electromyographic records were obtained after muscle adaptation, using EMG device (Fig. 4). Before each single record the patient was instructed to wear the denture at least two hours and to come early in the morning at the time interval between 9-11 am. The patient was asked to set in upright position with the head being in the same line with the body.

Alcohol applied on a piece of cotton was used to clean the skin surface of the patient’s face, where the surface electrodes were determined.

An individual transparent sheet was utilized. Each midline of the ready made sheets was made to coincide
Prospective clinical evaluation

with that of the patient’s face. Using a permanent ink marker, the nasion and the two alae of the nose were marked on the sheet while placed on the patient’s face. When connecting these three points, a triangle was obtained. This triangle was removed to give space for the nose. The sheet was again placed on the patient’s face while the nose passing through the created triangle space. The positions of the outer canthus of the eyes, the two angles of the mouth, the tragus of both ears and the most contractile sites of the four muscles were marked on the sheet. Holes were then drilled through the marks denoting the positions of the recording electrodes. In each subsequent visit, this sheet was used for accurate repositioning of the surface electrodes.

Six electrodes were used for each patient, four were fixed at the most contractile and palpable sites of the superficial masseter and anterior temporalis muscles of both right and left sites as predetermined on the sheet and two reference electrodes, one was fixed on the patient’s forehead and the last one on the skin of the neck. The inner sides of the electrodes were filled with a conductive gel and the electrodes were fixed on patient’s skin using adhesive tapes.

The activity of the four muscles was recorded in the following sequence:

Right masseter, Right temporalis, Left masseter and Left temporalis.

For each muscle, the patient was asked to perform the following:

• Chew soft food approximately equal sized pieces of banana (about one cubic centimeter in volume).
• Chew hard food (three pieces of peanuts were used).

The patient was instructed to place one piece per time in the same position of one side and chew it.

For each examination, three runs were made and the excel displays the mean and standard deviation for each parameter. Then the mean and standard deviation of the area were recorded. The patient was instructed to relax for 15 minutes, then do maximum voluntary clenching for three times. The highest observed EMG amplitude was used to scale the EMG signals, then the mean and standard deviation of the area are recorded. The mean value of the area during chewing soft and hard foods in relation to the mean value of the area for the same patient during maximum voluntary clenching (MVC) was expressed in percent to obtain the mean area percentage:

\[
\text{Mean area percentage} = \frac{\text{Mean Area}}{\text{Maximum voluntary clenching}} \times 100
\]

For each patient, the mean area percentage of both masseter and temporalis during chewing soft and hard foods was used in the statistical analysis.

**Bite force**

The bite forces were measured with an occlusal force meter instrument as shown in Fig. (5).

During testing, the patient was seated upright position on a dental stool without a back rest. The occlusal force meter and four wood tongue depressor were positioned bilaterally (one in each side of the mouth) in correspondence of the mandibular second premolars/first molars with a symmetric disposition (Fig. 6).
Before the actual data collection, all patients were allowed to familiarize with the measurement procedure and the instruments. The peak force measurements were displayed on the screen of a computerized interface. The bite force meter and four tongue depressor were positioned posteriorly in the mouth and the patients were asked to clench at different force levels which were displayed on the screen of the meter in kilograms. The actual peak value was recorded for further quantitative analysis. Between each force level, a minute of rest was allowed. During performance, the patient were encouraged to maintain the desired force level for all the test period and a buzzer will sound if the biting force has exceeded the set-point. For each patient at each time period, the mean of 10 record of the right and left sides were collected to be considered as one record and used in the statistical analysis.

The measurement error of the maximum bite force was calculated by the Dahlberg’s equation:

\[ D = \sqrt{\frac{\sum (d_i)^2}{2n}} \]

Where: 
- \( D \): Error
- \( d_i \): the difference between two repeated measures on the same patient
- \( n \): the number of couples of repeated measurements

**Prosthetic adjustments/complications:**

The adjustments and complications during the follow-up periods were registered and divided into; adjustments/complications in either pivot block ball OT or reverse ball OT attachment designs.

Adjustments and complications involved; attachments activation or replacement, minor occlusal adjustment, correction of overdenture borders, overdenture fracture, relining and the opposing denture relining or remade. The follow-up was done at 3 and 6 months after overdenture insertion at each sequence.

**Patient satisfaction:**

A patient satisfaction questionnaire was designed according to Burns et al., 1999. Patients were asked ten questions that pertained to their satisfaction with their current denture-attachment combination. This information was secured six months after each attachment placement i.e. at the end of each sequence.

The denture satisfaction scales had a response format that ranged from 0 to 2: [0]: (DS) dissatisfied; there are major problems. [1]: (PS) partially satisfied; there are some minor problems. [2]: (CS) completely satisfied; there are no problems. The satisfaction variable was formed by adding the scores from the ten questions. The range was from (0) very dissatisfied to (20) to totally satisfied (Fig. 7).

At the end of the second sequence period i.e. completion of the investigation, each patients responded to a preference questionnaire that allowed them to comment on their retrospective evaluation of all treatment conditions experienced during the investigation (Fig. 8).
Denture Satisfaction

Subject name:  
Date:  
Score:  

1. Are you satisfied with your appearance when wearing your dentures?  
   CS ☐  PS ☐  DS ☐

2. Are you satisfied with how well you can speak?  
   CS ☐  PS ☐  DS ☐

3. Are you satisfied to use the denture easily?  
   CS ☐  PS ☐  DS ☐

4. Are you satisfied with how well your maxillary denture stable in place?  
   CS ☐  PS ☐  DS ☐

5. Are you satisfied with how well your mandibular denture stable in place?  
   CS ☐  PS ☐  DS ☐

6. Are you satisfied with how well your maxillary denture retained?  
   CS ☐  PS ☐  DS ☐

7. Are you satisfied with how well your mandibular denture retained?  
   CS ☐  PS ☐  DS ☐

8. Are you satisfied with the comfort of your denture from the point of ease to keep the mandibular denture clean?  
   CS ☐  PS ☐  DS ☐

9. Are you satisfied with the comfort of you denture from the point of noticed odor?  
   CS ☐  PS ☐  DS ☐

10. Are you satisfied with how well you can chew with your denture?  
    CS ☐  PS ☐  DS ☐

Fig. (7) Denture satisfaction questionnaire
### Comparative denture satisfaction questionnaire to measure patient preference

**Subject name:**

**Attachment used first:**  Ball OT  [Box]  Reverse OT  [Box]

**Date:**

1. Overall, with which attachment were you best satisfied?
   - Ball OT  [Box]
   - Reverse OT  [Box]
   - Both same  [Box]

2. Which attachment was easiest to get used to?
   - Ball OT  [Box]
   - Reverse OT  [Box]
   - Both same  [Box]

3. Which attachment provided the best denture retention?
   - Ball OT  [Box]
   - Reverse OT  [Box]
   - Both same  [Box]

4. Was the ball OT attachment better than no attachment at all?
   - Yes  [Box]
   - No  [Box]

5. Was the reverse OT attachment better than no attachment at all?
   - Yes  [Box]
   - No  [Box]

6. With which attachment were you best able to chew?
   - Ball OT  [Box]
   - Reverse OT  [Box]
   - Both same  [Box]

7. With which attachment were you best able to speak?
   - Ball OT  [Box]
   - Reverse OT  [Box]
   - Both same  [Box]

8. Which attachment allowed the greatest amount of movement of the lower denture over the gum tissue?
   - Ball OT  [Box]
   - Reverse OT  [Box]
   - Both same  [Box]

9. From question 8, do you consider this movement to be desirable or undesirable?
   - Desirable  [Box]
   - Undesirable  [Box]

10. Which attachment was easiest to keep clean?
    - Ball OT  [Box]
    - Reverse OT  [Box]
    - Both same  [Box]

11. Did you experience any odor from your denture?
    - Yes  [Box]
    - No  [Box]

12. If you answered yes in question # 11, with which attachment system did you notice odor?
    - Ball OT  [Box]
    - Reverse OT  [Box]
    - Both same  [Box]

13. What do you like about the Ball OT attachment?
    (Write in response)

14. What do you dislike about the Ball OT attachment?
    (Write in response)

15. What do you like about the Reverse OT attachment?
    (Write in response)

16. What do you dislike about the Reverse OT attachment?
    (Write in response)

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**Fig. (8):** Comparative denture satisfaction questionnaire to measure patient preference
All data obtained were gathered, tabulated and statistically analyzed.

**Statistical analysis**

Three-ways analysis of variance with repeated measures on two factors was used to compare the two designs of attachment at different groups. There was no difference between the groups. So ignore the groups and the comparison were done between the two attachment designs. Two-ways analysis of variance with repeated measures on two factors was used to compare between the pivot block ball OT and the reverse ball OT post stud attachment designs regarding the retention, the muscle activity and the bite force values. McNemar chisquare test was used to analyse the data obtained from the prosthesis adjustments and complications of the pivot ball OT to compare it with the reverse ball OT attachment posts. Mann-witney non parametric t-test was also used to evaluate the difference obtained from the patient satisfaction data of both pivot ball OT and reverse ball OT attachments. The values were considered statistically significant at p≤0.05. Moreover, pearson correlation coefficients test was done to correlate between the retention, muscle activity and bite force parameters at different follow-up periods.

**RESULTS**

The twelve completely edentulous male patient except for two canines at the mandible received two designs of prefabricated post stud attachment, (1- pivot block ball OT, 2. Reverse ball OT) was used alternatively in two sequence in two groups. No failure was detected during the one year follow-up.

The follow-up periods were one week, one, three and six months for evaluating the retention, the muscle activity and the bite force of both attachment designs. Denture adjustments/complications were evaluated for each design after three and six months. Patients satisfaction was evaluated for each design after 6 months and patient preference was monitored at the completion of the experiment, after 12 months.

**Retention:**

Statistical analysis of the collected mean values of the retention was done to compare between the block ball OT and reverse ball OT attachment in both groups at different follow-up periods. The results revealed a significant difference in the design where the reverse ball OT attachment should higher retentive values. As the mean values for pivot ball OT and reverse ball OT were 15.0±0.7 and 15.7±1.2 for one week, 14.3±0.9 and 15.2±1.1 for one month, 13.5±0.8 and 14.5±1.3 for three months and 12.7±1.0, and 13.6±1.4 for six months follow-up periods respectively.

There was a significant decrease in the values of retention by time in each design. The change occurred with time is same in both design Fig. (9)

![Fig. (9): Comparison between the recorded mean values of retention for pivot block ball OT and reverse ball OT attachment at different follow-up periods](image)

**Muscle activity:**

Eight EMG records were made for each patient as follows; four times periods for pivot ball OT attachment post overdenture (one week, one, three and six months from muscle adaptation) and another four times periods for reverse ball OT attachment post overdenture (one week, one, three and six months from muscle adaptation).

The data obtained for each overdenture design were summarized and reported in the form of mean area percentage (M.A.P.) which represents the total integrated muscle activity.
Temporalis muscle activity

A. Chewing hard food

The mean value of the mean area percentage of the temporalis muscle activity during chewing hard food were 87.7±1.3, 84.7±1.6, 81.0±1.3 and 76.9±1.2 for pivot ball OT at one week, one, three and six months follow-up period respectively. While the mean values of the mean area percentage of the same muscle were 87.7±1.4, 83.7±1.4, 81.5±1.5 and 76.9±1.3 for reverse ball OT at one week, one, three and six months follow-up respectively.

Statistical analysis of these results showed no significant difference during chewing hard food between pivot ball OT and reverse ball OT design at any follow-up periods. However, there was a significant decrease in the muscle activity in each design by time but not with the same values Fig. (10).

Masseter muscle activity

A. Chewing hard food

The mean value of the mean area percentage of the masseter muscle activity during chewing hard food were 88.7±1.2, 84.6±0.9, 78.9±0.9 and 74.3±1.1 for the pivot ball OT attachment while for the reverse ball OT attachment were 88.7±1.4, 84.4±1.1, 78.7±1.1, and 74.2±1.0 at one week, one, three, and six months follow-up periods respectively.

Difference in these values was not statistically significant. However, there was a significant decrease by time in each design and it occurred with same change in both design. Fig. (12).

B. Chewing soft food

The mean value of the mean area percentage of the masseter muscle activity during chewing soft food were 73.9±1.2, 70.5±1.3, 67.2±1.2 and 63.1±1.0 for pivot ball OT, while for the reverse ball OT were 74.0±1.3, 70.5±1.3, 67.0±1.4 and 63.2±1.2 at one week, one, three and six months follow-up periods respectively.
No statistical significant differences were recorded between both design at any follow-up periods. A significant decrease of the muscle activity by time was recorded in each design and it occurred with same change in both design (Fig. 13).

Statistical analysis of the result revealed a significant difference between the two designs where the pivot ball OT attachment showed higher biting force values. There is also a significant increase in the values of the bite force by time in each design. This change occurred with time is same in both design (Fig. 14).

Bite force:

The measurement error according to Dahlberg’s equation for the maximum bite force was (6.2%) within the acceptable range <10%\(^{(49)}\). The recorded mean values of biting force for pivot ball OT and reverse ball OT attachment were 7.55±0.7 and 6.32±1.5 for one week, 10.0±1.2 and 8.87±1.7 for one month, 13.16±1.2 and 11.12±2.1 for three months, and 15.81±1.6 and 14.18±2.2 for six months follow-up periods respectively.

There was no correlation between the previous parameters at all time period, except a moderate (-ve) correlation between the retention and the biting force values was recorded (-0.61r) at one week follow-up period for both designs. Moreover, after one month follow-up period, at the reverse ball OT design, a moderate (-ve) correlation was obtained (-0.60r) between the retention and biting force values.

Adjustments and complications

Table (1) shows the number and percent of the patient required denture adjustments and complications at three and six months follow-up periods.

The dissimilar signals are responsible for the comparison between the pivot ball OT and reverse ball OT attachments regarding the variables of adjustments.
The higher percent of the patients required an adjustment for their denture was observed with pivot ball OT attachment design (50). The most frequent adjustment was attachment activation, overdenture relining and opposing denture relining. The percentage of the patients required an attachment activation and minor occlusal adjustment decreased by time. While, the other adjustment variables as correction of overdenture border, overdenture fracture and relining and opposing denture relining or remade were increased by time.

For attachment activation 33.3% of the patient with ball OT in comparable to 8.3% of patients with reverse ball OT required activate of the attachment at 3rd month of follow-up period. These percentages decreased to 16.7% & 0% for ball OT and reverse ball OT designs by 6 month respectively. The results also revealed that higher percent of the patients with ball OT design required either overdenture relining (41.7%) or opposing denture relining after 6 month of the follow-up period. While, minor occlusal adjustment were the most extensive adjustments and complications associated with the reverse ball OT attachment (25%).

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<th>Time Variables</th>
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<td>Reverse ball OT</td>
<td>Ball OT</td>
<td>No. (%) of Pt</td>
<td>P-value</td>
<td>Reverse ball OT</td>
<td>Ball OT</td>
<td>No. (%) of Pt</td>
<td>P-value</td>
<td></td>
</tr>
<tr>
<td>Attachment activation / replacement</td>
<td>+</td>
<td>+</td>
<td>3(25.0)</td>
<td></td>
<td>+</td>
<td>+</td>
<td>5(41.7)</td>
<td>0.479</td>
<td></td>
</tr>
<tr>
<td></td>
<td>+</td>
<td>-</td>
<td>1(8.3)</td>
<td></td>
<td>+</td>
<td>-</td>
<td>0(0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>+</td>
<td>4(33.3)</td>
<td>0.371</td>
<td>-</td>
<td>+</td>
<td>2(16.7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>-</td>
<td>4(33.3)</td>
<td></td>
<td>-</td>
<td>-</td>
<td>5(41.7)</td>
<td></td>
<td></td>
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<tr>
<td>Minor occlusal adjustment</td>
<td>+</td>
<td>+</td>
<td>1(8.3)</td>
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<td>+</td>
<td>+</td>
<td>2(16.7)</td>
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</tr>
<tr>
<td></td>
<td>+</td>
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<td></td>
<td>+</td>
<td>-</td>
<td>3(25.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>+</td>
<td>2(16.7)</td>
<td></td>
<td>-</td>
<td>+</td>
<td>1(8.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>-</td>
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<td>0.371</td>
<td>-</td>
<td>-</td>
<td>6(50.0)</td>
<td></td>
<td></td>
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<tr>
<td>Correction of overdenture borders</td>
<td>+</td>
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<td>+</td>
<td>+</td>
<td>1(8.3)</td>
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<td></td>
</tr>
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<td>2(16.7)</td>
<td></td>
<td>-</td>
<td>+</td>
<td>3(25.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>-</td>
<td>7(58.3)</td>
<td>0.617</td>
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<td>-</td>
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<td></td>
<td></td>
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<tr>
<td>Overdenture fracture</td>
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<td>+</td>
<td>0(0)</td>
<td></td>
<td>+</td>
<td>+</td>
<td>0(0)</td>
<td>0.617</td>
<td></td>
</tr>
<tr>
<td></td>
<td>+</td>
<td>-</td>
<td>1(8.3)</td>
<td></td>
<td>+</td>
<td>-</td>
<td>2(16.7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>+</td>
<td>0(0)</td>
<td></td>
<td>-</td>
<td>+</td>
<td>2(16.7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>-</td>
<td>11(91.7)</td>
<td>0.046</td>
<td>-</td>
<td>-</td>
<td>8(66.7)</td>
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<tr>
<td>Overdenture relined</td>
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<td>+</td>
<td>1(8.3)</td>
<td></td>
<td>+</td>
<td>+</td>
<td>1(8.3)</td>
<td>0.450</td>
<td></td>
</tr>
<tr>
<td></td>
<td>+</td>
<td>-</td>
<td>1(8.3)</td>
<td></td>
<td>+</td>
<td>-</td>
<td>2(16.7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>+</td>
<td>3(25.0)</td>
<td></td>
<td>-</td>
<td>+</td>
<td>5(41.7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>-</td>
<td>7(58.3)</td>
<td>0.617</td>
<td>-</td>
<td>-</td>
<td>4(33.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opposing denture relining/remade</td>
<td>+</td>
<td>+</td>
<td>0(0)</td>
<td></td>
<td>+</td>
<td>+</td>
<td>1(8.3)</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>+</td>
<td>-</td>
<td>2(16.7)</td>
<td></td>
<td>+</td>
<td>-</td>
<td>3(25.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>+</td>
<td>1(8.3)</td>
<td></td>
<td>-</td>
<td>+</td>
<td>4(33.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>-</td>
<td>9(75.0)</td>
<td>0.248</td>
<td>-</td>
<td>-</td>
<td>4(33.3)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* p-value ≤ 0.05 were considered statistically significant
Statistical analysis of these results using McNemar chi-square test revealed no significant difference between the designs at the follow-up periods.

**Patient satisfaction**

The summarized scores of the patient satisfaction for both designs after 6 months of denture insertion tested along with the median and range (Table 2). The statistical analysis using Mann-Witney non-parametric t-test revealed no significant difference for the pivot ball OT versus reverse ball OT post attachment. However, the pivot ball OT had a statistically significant increase in satisfaction relative to reverse ball OT from the point of denture hygiene with p-value of 0.01. The patient preference data, which represent a retrospective comparison of the different overdenture treatments for each patient, are listed in Table (3).

**TABLE (2) Analysis of patient satisfaction data: comparison of pivot block ball OT and reverse ball OT**

<table>
<thead>
<tr>
<th>Variable</th>
<th>No. of pt</th>
<th>Designs</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Ball OT</td>
<td>Reverse OT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Median (range)</td>
<td>Median (range)</td>
</tr>
<tr>
<td>Appearance</td>
<td>12</td>
<td>1.5 (0-2)</td>
<td>2 (0-2)</td>
</tr>
<tr>
<td>Ability to speak</td>
<td>12</td>
<td>2 (0-2)</td>
<td>2 (0-2)</td>
</tr>
<tr>
<td>Easy to use denture</td>
<td>12</td>
<td>2 (0-2)</td>
<td>1 (0-2)</td>
</tr>
<tr>
<td>Stability of maxillary denture</td>
<td>12</td>
<td>1 (0-2)</td>
<td>1 (0-2)</td>
</tr>
<tr>
<td>Stability of mandibular denture</td>
<td>12</td>
<td>1 (0-2)</td>
<td>2 (0-2)</td>
</tr>
<tr>
<td>Retention of maxillary denture</td>
<td>12</td>
<td>1 (1-2)</td>
<td>1 (0-2)</td>
</tr>
<tr>
<td>Retention of mandibular denture</td>
<td>12</td>
<td>2 (0-2)</td>
<td>1.5 (0-2)</td>
</tr>
<tr>
<td>Easy to keep clean</td>
<td>12</td>
<td>1.5 (0-2)</td>
<td>0 (0-2)</td>
</tr>
<tr>
<td>Odor</td>
<td>12</td>
<td>1 (0-2)</td>
<td>1 (0-2)</td>
</tr>
<tr>
<td>Ability to chew</td>
<td>12</td>
<td>1 (0-2)</td>
<td>1 (0-2)</td>
</tr>
</tbody>
</table>

* p-value ≤ 0.05 were considered statistically significant
TABLE (3) Summary of comparative denture satisfaction data

<table>
<thead>
<tr>
<th>Question</th>
<th>Option</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Overall, with which attachment were you best satisfied?</td>
<td>Ball OT</td>
<td>4</td>
<td>33.3</td>
</tr>
<tr>
<td></td>
<td>Reverse OT</td>
<td>2</td>
<td>16.7</td>
</tr>
<tr>
<td></td>
<td>Same</td>
<td>6</td>
<td>50.0</td>
</tr>
<tr>
<td>2. Which attachment was easiest to get used to?</td>
<td>Ball OT</td>
<td>5</td>
<td>41.7</td>
</tr>
<tr>
<td></td>
<td>Reverse OT</td>
<td>3</td>
<td>25.0</td>
</tr>
<tr>
<td></td>
<td>Same</td>
<td>4</td>
<td>33.3</td>
</tr>
<tr>
<td>3. Which attachment provided the best denture retention?</td>
<td>Ball OT</td>
<td>2</td>
<td>16.7</td>
</tr>
<tr>
<td></td>
<td>Reverse OT</td>
<td>1</td>
<td>8.3</td>
</tr>
<tr>
<td></td>
<td>Same</td>
<td>9</td>
<td>75.0</td>
</tr>
<tr>
<td>4. Was the Ball OT attachment better than no attachment at all?</td>
<td>No</td>
<td>1</td>
<td>8.3</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>11</td>
<td>91.7</td>
</tr>
<tr>
<td>5. Was the Reverse OT attachment better than no attachment at all?</td>
<td>No</td>
<td>3</td>
<td>25.0</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>9</td>
<td>75.0</td>
</tr>
<tr>
<td>6. With which attachment were you best able to chew?</td>
<td>Ball OT</td>
<td>2</td>
<td>16.7</td>
</tr>
<tr>
<td></td>
<td>Reverse OT</td>
<td>2</td>
<td>16.7</td>
</tr>
<tr>
<td></td>
<td>Same</td>
<td>8</td>
<td>66.7</td>
</tr>
<tr>
<td>7. With which attachment were you best able to speak?</td>
<td>Ball OT</td>
<td>3</td>
<td>25.0</td>
</tr>
<tr>
<td></td>
<td>Reverse OT</td>
<td>3</td>
<td>25.0</td>
</tr>
<tr>
<td></td>
<td>Same</td>
<td>6</td>
<td>50.0</td>
</tr>
<tr>
<td>8. Which attachment allowed the greatest amount of movement of the lower</td>
<td>Ball OT</td>
<td>4</td>
<td>33.3</td>
</tr>
<tr>
<td>denture over the gum tissue?</td>
<td>Reverse OT</td>
<td>3</td>
<td>25.0</td>
</tr>
<tr>
<td></td>
<td>Same</td>
<td>5</td>
<td>41.7</td>
</tr>
<tr>
<td>9. From question 8, do you consider this movement to be desirable or</td>
<td>Desirable</td>
<td>5</td>
<td>41.7</td>
</tr>
<tr>
<td>undesirable?</td>
<td>Undesirable</td>
<td>7</td>
<td>58.3</td>
</tr>
<tr>
<td>10. Which attachment was easiest to keep clean?</td>
<td>Ball OT</td>
<td>6</td>
<td>50.0</td>
</tr>
<tr>
<td></td>
<td>Reverse OT</td>
<td>2</td>
<td>16.7</td>
</tr>
<tr>
<td></td>
<td>Same</td>
<td>4</td>
<td>33.3</td>
</tr>
<tr>
<td>11. Did you experience any odor from your denture?</td>
<td>No</td>
<td>8</td>
<td>66.7</td>
</tr>
<tr>
<td></td>
<td>Ye</td>
<td>4</td>
<td>33.3</td>
</tr>
<tr>
<td>12. If you answered yes in question 11, with which attachment system</td>
<td>Ball OT</td>
<td>1</td>
<td>25.0</td>
</tr>
<tr>
<td>did you notice odor?</td>
<td>Reverse OT</td>
<td>1</td>
<td>25.0</td>
</tr>
<tr>
<td></td>
<td>Same</td>
<td>2</td>
<td>50.0</td>
</tr>
</tbody>
</table>

DISCUSSION

There is speculation that the use of attachments overdenture may render a treatment outcome that is superior to even the best-made conventional overdenture. This attachment overdentures have demonstrated a positive influence on retention, stability and tissue response\(^{[48,51]}\). Both Ball group and zest anchor had a higher vertical retention of the overdenture\(^{[56,58]}\) with the least soft tissue complications and a little overdenture adjustment. Patient satisfaction was not affected by the attachment mechanism\(^{[59]}\). That why this study was aimed to compare between two prefabricated post type of attachment.

Only male patients participated in this study to avoid the effect of female hormonal changes on oral mucosa\(^{[50]}\) and bone\(^{[55]}\). Also, the maximum bite force is generally higher in men than in women because of men’s longer jaw dimensions. In addition, the greater bite force in men seems to correspond with a greater diameter and cross-sectional area of the type II fibers in the masseter muscle\(^{[50]}\).
The attachment types were switched from one to the other in a predetermined sequence for data collection, which provided an ideal experimental design because the dentures were unaltered throughout the investigation. It was encouraging that results remained constant for each attachment type regardless of crossover sequence. There are many variables to be considered when choosing a prefabricated post overdenture attachment system. Among these variables are the length of the retained root or roots (crown/root ratio), its configuration, and the quality and quantity of alveolar bone. In addition, the angulations of the root to the occlusal plan, the root proximity to other roots, the musculature of the patient and the chewing patterns must be examined. This could explain why the two prefabricated post inserted in the same tooth and patient. Moreover, maximum bite force dependent on, age, number of natural teeth and craniofacial morphology. Therefore the comparison between both designs were performed on the same patients.

The prefabricated metal posts have a big advantages over the customized cast posts. This related to the exact fit made by special pilot drills and the high metallergic strength in the cross-sectional area. They require minimal enlargement of the canal space, hence they strengthen the tooth rather than weaken it. Being relatively more ductile, it absorbs more of the transmitted forces therefore transmitting less stresses to the supporting structures.

Blocking-out was done around the prefabricated posts in both designs to avoid lateral contact with the outpolymerizing acrylic resin used in the direct picking up. Moreover, this small blocked-out space allows for the resilient function of the attachments. The direct technique for picking-up of the attachment intraorally is simple, economic, quick and allows the patient to retain the prosthesis immediately.

The use of the bite force meter and four wood tongue depressor positioned on the posterior teeth bilaterally performed directly on the occlusal surfaces. The bite force meter instrument positioned on the posterior teeth (Molars and premolars) gives a larger area for the stabilization of the sensor surfaces.

Canines were used as abutments owing to their strategic position in the arch and their strong roots, thus provide good denture support and stability. They also help in preserving bone in the anterior region of the dental arch which is more susceptible to resorption. Moreover, canines are amenable to endodontic treatment, they are the last teeth to be lost, and are considered the most important proprioceptive organ of all oral structures because receptors in the periodontal ligament modify the activity of the masticatory muscles and thus the bite force. Utilizing of canines in the lower arch with their greater level of bone support, will help to resist the multidirectional forces generated during masticatory and non-masticatory teeth contact. Hosny, 1982 added that selection of lower canines are preferred as they have greater shelf life in the patient’s mouth more than any other teeth.

Masster and Temporalis muscles were chosen for representing the masticatory muscle activity since they are the largest and strongest masticatory muscles and thus play a major role in mandibular movement, in addition to their accessibility during recording. Records were made for the masseter and temporalis muscles bilaterally at each time period of follow-up, collected and the mean was calculated to avoid variation in the activity of the recorded muscles as a result of variation in the preferable chewing side for each patient. Besides, the activity in both sides will be nearly the same as the mandible is one unit, so for one side to move by the action of the muscles, the other side should also move.

There is also an increase in muscle activity with severe biting force and the maximum muscle effort was very close to or at the intercuspal position. This explains why the maximum voluntary clenching (M.V.C.) used in equation to calculate the mean area percentage for every patient at each follow-up period.
Chewing hard food showed higher integrated activity than chewing soft food, as hard food (peanuts) needs heavy biting force to be crushed into pieces, while the soft food (bananas) did not necessitate any or great muscle activities. This explains the higher activity of masseter and temporalis muscles during chewing hard food which agrees with the results obtained by Nagasaw et al., 1979\(^{68}\) who found that chewing fresh raw carrots and peanuts showed higher activity than chewing kamaboko. This was also in accordance with Kapur, 1975\(^{69}\) who found that chewing crisp wafers showed higher activity than chewing soggy wafers. Generally speaking there is a gradual decrease in EMG activity of the masseter and temporalis muscles in both attachment designs. This means that the patient was accommodated to the denture and he could control it well to the extent that he did not need that much muscular activity to masticate either soft or hard food.

Theoretically, the functional activity of the muscles in general is affected by some systemic and local factors that can affect the muscles and TMJ. Among the local factors; the polished surface of the denture and the position of the teeth which affect greatly the EMG activity of such muscles. It was proved that support and stability are the main factors affecting the muscles activity and not the denture retention as proved by Perrez et al., 1985\(^{70}\) who said that neither denture retention nor occlusal scheme affect the masticatory ability of denture wearers significantly. However, the support and stability of the overdenture was enough to give better chewing of soft and hard food. Chorabe, 1994\(^{71}\) mentioned that minimal effort is usually accompanied with minimal muscle activity. This simply explains the decrease in muscular activity in the present study. Rapid muscle adaptation and achievement of patient’s comfort were possibly the main reasons for the non-significant difference of both masseter and temporalis muscles activity during chewing soft or hard food between both attachment designs, therefore the increase of retention by the use of reverse ball OT attachments did not affect the muscle activity.

Mericske-stern, 2000 \(^{72}\) analysed chewing function during the maximum biting forces in three dimensions clinically on mandibular overdentures connected to implants by ball attachments. It was detected that low forces were observed in the vertical and bucco-lingual directions. Transverse or horizontal forces reached 100% to 300% of the vertical force magnitudes. This lead to the assumption that vertical chewing forces acting on the denture were transmitted with higher extent to the residual ridges than to the implants if overdentures were connected by means of ball attachments. This gives a good explanation for the result of current study why by time, there was an increased need for overdenture border adjustment, relining and fracture repair since there was by time an increase of the ridge resorption when using the ball systems with ball OT or reverse ball OT.

Ball nylon female cap liner fits tightly and seems to allow little room for resiliency when the nylon part is exposed to the oral fluids. It is subjected to wear, allowing a greater freedom of motion\(^{79}\). When the retention of the mandibular overdentures utilized pivot ball OT, was largely decreased, the nylon parts were exchanged aiming to preserve the denture stability. So the overdenture adjustments regarding the attachment activation, occurred at higher percent at the first three months with ball OT design leading to increase of the denture movement that may affect the opposing denture, increasing its movement, subsequent lead to upper ridge resorption and increase the upper denture relining. In contrast to reverse ball OT, the male portion was metallic and snaped into metallic females, so the wear occurred at a lower rate. After exchange of this nylon parts, the need of attachment activation or replacement decreased at the next three months. Moreover the patient was more trained to use his denture at the second period of follow-up. Also the muscle was more adapted to the dentures. Numerous authors\(^{39,47,56,52,72,74-76}\) reported that the common prosthodontic complications in attachment overdenture were replacement of the ball housing or activation of the attachment, relining of the mandibular overdentures and maxillary complete dentures that confirm what obtained in the results of this study.
Usage of both the ball OT and reverse ball OT attachment in this study seemed to provide patient satisfaction through improvement of appearance and speech. Better patient satisfaction results were gained with pivot ball OT design concerning easy to clean so the denture was odor free. This attachment design reduced the amount of post insertion care\(^{(77)}\). Discomfort reported with reverse ball OT design may be due to difficulty in cleaning the female portion that account for presence of a bad odor. Patient satisfaction questionnaire was used to reflect patient’s opinions and level of satisfaction with the treatment which would assist clinicians and patients in selection of the most suitable treatment modality that suite individual need\(^{(41,78,81)}\). Data from this investigation showed that patient were equally satisfied with no significant difference between the pivot ball OT and reverse ball OT at the end of each sequence (6 months). There was some divergence, when questions about preference were asked after the patient had accustomed with both attachments, over 40% of the respondents preferred the pivot ball OT to the reverse OT as easy to use. Moreover, 50% of the patients preferred the pivot ball OT incomparable to 16% for the reverse OT regarding easy to keep clean and remained odor free during the course of the investigation. These results agreed with Burn et al., 1995\(^{(48)}\).

Petropoulous and Smith, 2002\(^{(37)}\) showed that the zest anchor advanced generation attachment (Intraradicular) be the most retentive one for the peak load measurement when subjected to vertically directed forces. Additionally, they mentioned that the next retentive one was the regular ball attachment (extraradicular). This confirm the result of this study as the reverse ball OT attachment design had a higher retentive values than the pivot ball OT at all the follow-up periods. The decrease in retention of both ball designs by time could be due to the wear or corrosion occurred between the mating parts of the attachments\(^{(38)}\).

There was a moderate negative correlation between the bite force and the retention of the reverse ball OT design after one week and one month of follow-up periods (-0.6r). This explain why the value of the bite force of the reverse ball OT design was significantly decreased than that for pivot ball OT design inspite of the retention value for the reverse ball OT was higher than that for pivot ball OT design. This relationship could be declared as increase patient satisfaction with good retentive overdenture could lower the effort exerted on biting.

Mao et al., 1996\(^{(82)}\) and Ferrario et al., 2004\(^{(83)}\) mentioned that there is a close relationship between the bite force and the electromyographic activity of the jaw elevator muscles (the temporalis, the masseter and the medial pterygoid muscles) during isometric contractions. The same record was obtained in this study; where the pivot ball OT attachment had a relatively higher values of the muscle activity and biting force than the reverse ball OT.

**CONCLUSIONS**

**Based on the results of this current study**

The following can be concluded

- The electromyographic muscle activity of the studied muscles showed marked reduction along the whole follow-up periods in both designs of attachment with no difference of muscle activity between them.

- The retention decreased by time in both attachment designs. The reverse ball OT showed higher retentive value than the pivot ball OT.

- In contrast, the bite-force values increased by time in both attachment designs. The pivot ball OT had a higher value of biting force than that for the reverse ball OT.

- There was a negative correlation between the retention and bite-force values in both attachment designs at the early periods of follow-up.

- No statistical difference occurred between the pivot ball OT and the reverse ball OT regarding the denture adjustments/complications and patients satisfaction.

- Pivot ball OT need more denture adjustments/
complications regarding attachments activation, overdenture relining and opposing denture relining at 3 months period, then it decreased at 6 months period. Reverse ball OT required more occlusal adjustment of their denture at both 3 and 6 months periods. While overdenture borders correction, relining, fracture and opposing denture relining were increased by time with both attachment designs.

- Pivot ball OT attachment showed a high score for easy to clean denture attachment in the patient satisfaction questionnaire filled out at the end of each sequence (just before alternate attachment placement). On completion of the evaluation period for both attachment systems, a strong preference for the pivot block ball OT attachment system was found.

REFERENCES


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