Comparison of the Retention of Ball Retained Overdentures in Most Anterior and Posterior Implant Positions at the Symphysis Region

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Abstract

Objective: The aim of this study was to compare retention of implant-tissue supported overdentures with ball attachments in the most anterior and posterior implant positions at the symphysis region.

Methods: An acrylic resin model of edentulous mandible with no undercuts was fabricated. Two pairs of implants, two by two, were placed symmetrically in the most anterior and posterior positions in the anterior mandible. Two were placed at 5mm distance from the midline in anterior positions while the other two were inserted 5mm mesial to mental foramina in posterior positions. A metallic overdenture was made on the model precisely. Then overdenture housing was prepared on the framework and joined to it. The ball abutments were screwed into the pair of implants in different positions and the complex of attachment housing and clinical insert was attached to the overdenture housing. Five samples were tested for each position. Zwick testing machine applied and measured tensile forces in vertical direction for each sample. Maximum Dislodging Force (MDF) was recorded at the moment of complete dislodgement of overdenture from the model. Independent sample t-test was used to analyze the data and results were reported by confidence coefficient of 95%.

Results: There was no statistically significant difference in retention of implant-tissue supported overdentures in the most anterior and posterior positions of implants at symphysis region (P>0.05).

Conclusion: The amount of retention is the same at the most anterior and posterior positions of implants in anterior mandible.

Key words: Overdenture, Retention, Ball attachment

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Introduction:

Despite the decreased number of edentulous patients, the demand for complete dentures is still high (1). At present, a high percentage of prostodontic treatments target completely edentulous patients. A successful complete denture treatment, in spite of clinical expertise and following the guidelines, greatly depends on the patient’s response and his/her compatibility. Restoring the function and esthetics are important factors that should be considered in any prostodontic treatment. When restoring function in complete denture therapy, retention and stability play a major role and according to the literature, they are the most effective factors on patient’s satisfaction (2, 3). These two factors are scientifically defined as follows (4, 5).

Retention: is defined as the resistance against vertical dislodging forces (in a direction opposite to the path of insertion).

Stability: is defined as the resistance against oblique and anterior posterior dislodging forces (in directions other than the path of insertion). A standard complete denture is a conventional treatment. The most common complaints in this
type of treatment are retention and stability issues that become worse with the inevitable process of bone loss and ridge atrophy. In order to overcome this problem, various methods have been suggested such as vestibuloplasty, bone grafting, ridge augmentation and implant placement (6,7).

Overdenture is a type of denture fabricated on the occlusal surface of root or implants. Successful application of implants and osseointegration techniques has resulted in using them as an anchorage like roots for increasing the retention and stability of the denture (8). In contrast to the complete dentures, implant-supported overdentures have a predictable success rate. At the same time, they perfectly serve the functional and esthetic needs of patients. A researcher believes that standard complete denture treatment will be replaced with implant-supported overdentures in near future (9).

Implant-tissue supported overdentures can be a good substitute for a standard complete denture due to the low number of implants required, simple surgical technique, easy insertion and lower costs. In addition, with the help of prefabricated attachments, it provides optimal retention and stability (9).

For an implant-tissue supported mandibular overdenture, implants are usually placed in between the two mental foramina bilaterally at both sides of the midline. Mental foramen in most cases is located apical to the second mandibular premolar or between apices of the first and second premolars(10). Before exiting the mental foramen, the mental nerve can extend up to 3 mm mesial to the mental foramen and form a loop (anterior loop); therefore, posterior implant surface should at least have a 5 mm distance from the foramen (11). When using Bar-clip attachments, the minimum distance required between the implants is 12 mm so that there would be enough room for placement of the retentive parts (12).

Misch in 2008 introduced different methods for fabrication of implant supported mandibular overdentures and explained how to fabricate an OD-1 overdenture with two independent implants. According to him, the points B and D (approximate locations of lateral and canine teeth) were better locations for implant placement than points A and E (approximate location of the first premolar)(13). Literature review revealed lack of sufficient investigations in this regard. In most studies 2 implants placed in the anterior mandible have been evaluated without mentioning their exact location. In some other studies, the 2 implants are placed in a distinctive distance but no specific reason has been offered for choosing this particular location.

There are lots of controversies regarding selecting the appropriate location for implant placement. Implant location is mostly selected based on personal experience and clinical expertise of the dentist rather than scientific findings.

This study aimed to compare the retention of implant-tissue supported overdentures with ball attachment at the most anterior and posterior implant positions in the anterior mandible.

Methods:

In this in-vitro experimental study we considered a hypothetical equilateral triangle with 5 cm sides and 4 points for application of forces (the 3 corners and the barycenter). Phases of study were as follows:

A- Fabricating the test model: In order to imitate mandible, a model of mandible was fabricated using acrylic resin. A medium sized mandibular master cast with an oval arch belonging to a patient was modified in a way that all the undercuts were relieved and its borders were extended. Therefore, the prepared model
matched the size of the hypothetical triangular pattern and we were able to apply the forces. After taking an impression from the master cast using agar (Dandiran, Tehran, Iran), the final model was prepared using transparent self-cure acrylic resin (Meliodent, Heraeus Kulzer, Germany). Four holes were made on the model symmetrically on both sides of the midline in the anterior mandible parallel to each other using milling machine (Paraskope M, Bego, Bremen, Germany). Anterior holes were made at 5 mm distance from the midline. Therefore, there was adequate space for placement of prosthetic components. The posterior holes were made at 5 mm distance from the approximate location of mental foramen. The distance between the external borders of the implants at one side of the ridge was 12 mm. Two pairs of internal hex implants of the BioHorizons system (PGR 4012, BioHorizons, USA) with 4 mm diameter and 12 mm length were placed into the holes and fixed using the same acrylic resin. All the measurements were done on this model. Since there is no undercut in the edentulous areas, retention would be provided only from the anterior segment where the implants were placed.

B- Fabricating the framework: For fabrication of the framework, a secondary cast was made from the acrylic model and framework design was transferred on it and waxed up. The design included an anterior frame and 2 saddles on the posterior ridges. The anterior frame would cover the implants and was the place for acrylic housing. Its internal surface was sand blasted using a sandblasting device (Bego, Korostar, Germany) for attachment to the housing.

Based on the mentioned primary design, 4 rings were formed on the framework. Two rings on the saddles and 2 on the anterior and posterior walls of the frame (Figure 1). Height of the rings was adjusted in a way that the highest points in all of them would be in the same level and force would be applied equally. Eventually, a chrome-cobalt framework (Dentaurum, Ispringen, Germany) was fabricated to serve as the denture base.

![Figure 1- Framework design and the equilateral triangle on the cast. Arrows indicate the location of rings on the framework](image)

C- Fabrication of the overdenture housing: It is the acrylic part of the overdenture which will be fixed inside the frame part of the framework. Its goal is to activate the attachment. A mockup was made on the model using light cure acrylic resin (VIMC, Vita, BadSackingen Germany). The mockup was placed into the denture duplicating flask containing condensation silicone impression material (Zetaplus, Zhermack, Italy). Twenty minutes later when the putty was set, the flask was opened and the mockup was removed. Powder and monomer liquid of the heat-curing transparent acrylic resin (Meliodent, Heraeus, Germany) were mixed according to the manufacturer’s instructions and poured into the impression taken from the mockup inside the flask. The flask was soaked in warm water for 60 minutes. The fabricated overdenture was adapted to the model and framework after polishing and was attached to the framework using selfcure transparent acrylic resin (Meliodent, Heraeus, Germany). Therefore, at all phases, framework and overdenture housing were used as a one piece unit (Figure 2). Ball attachment set (BCAS, BioHorizons, USA) was used for attaching the overdenture to the
implants and included 3 components:
- Ball attachment (PGBAT, BioHorizons, USA)
- Pink clinical insert (BCIP, BioHorizons, USA
- Attachment housing (BCAHT, BioHorizons, USA)

Ball attachment as the key portion is screwed into the implants. Complex of attachment housing and clinical insert is the keyway portion of the attachment in the overdenture. When these 2 parts are involved, overdenture is attached to the implants. Ball attachment was screwed into the implants. Complex of attachment housing and clinical insert was placed on the ball attachment. After adjusting the parallel path using a surveyor (MEDIZINTECHNIK, KRUPP, Germany), the complex was fixed in that position with wax. On the other hand, overdenture housing was pierced at the implant locations and overdenture was fixed on the model with glue. Then, self-cure transparent acrylic resin was added to the location of holes surrounding the attachment housing up to its borders. In between various stages of the test, by carving the acrylic resin, the complex of clinical insert and attachment housing was removed and new samples were placed.

Figure 2- Adapting the overdenture on the model after placing the samples inside the overdenture housing

D- Performing laboratory tests: Z020 series universal testing machine (Zwick, Roell, Germany) was used for performing the tests (Figure 3) with a crosshead speed of 51 mm/min which was similar to the speed of denture movement during mastication (4, 5). The acrylic model was fixed to the lower platform of the device in a way that vertical forces would be applied completely in the direction of the overdenture's path of insertion. On the other hand, an S shape 15.5 cm metal hook connected the load cell to the upper part of the device. Load cell hooks perfectly matched the overdenture rings.

A piece of polyester thread (Kiancord, Tehran, Iran) was used for connecting the platform load cell to the overdenture. For measurement of vertical forces, the cord attached the load cell hooks to the corresponding overdenture rings two by two and finally the two free ends were ligated to each other. This method of suturing the cord was used with the aim of equal distribution of forces. The applied vertical force was indicative of overdenture retention. The device measured the forces in newton unit (N) and depicted it as a diagram with its pick indicating the MDF index (Maximum Dislodging Force) which appears at the time of complete dislodgement of overdenture from the model.

Figure 3- Zwick universal testing machine used for applying and measuring the force

For statistical analysis, first we ensured the normal distribution of data using Kolmogorov Smirnov test (P>0.05). Then, independent t-test
was used for evaluation of the vertical force for each of the anterior and posterior positions. SPSS version 11.5 software was used for all statistical analyses.

**Results:**

As mentioned above, considering the normal distribution of data, independent sample t-test was used for evaluation of the vertical tensile force at the two desired positions.

The mean± standard deviation of retention at anterior and posterior positions was 25.0340±7.47602 and 5.83428±24.5020 N, respectively. As the obtained figures show, retention at the anterior position was greater than in the posterior position. However, this difference was not statistically significant (P>0.05).

![Figure 1- Error bar, mean and 95% confidence interval of the vertical force at anterior and posterior positions](image)

**Discussion:**

Overdenture retention can be assessed from 2 aspects:

1- Patient’s opinion: is the feeling that the patient has about his/her overdenture

2- Dentist’s opinion: which is based on the characteristics of the edentulous ridge and the attachments used

In this study, we evaluated the effect of location of implants on the overdenture retention and thus we provided the dentist’s opinion.

According to the literature, overdenture moves in many directions in the oral cavity during mastication at the mean speed of 51 mm/min (4, 5). Overdenture movement in the mouth due to functional forces is a complex three dimensional movement. In order to analyze this movement at in-vitro conditions, we have to break it down into simpler smaller components and evaluate each one separately.

In this study, we evaluated the overdenture movement at vertical direction. When applying vertical force, the point of effect would be at the barycenter of the model which is also the location of the central ring on the overdenture. Such force will move the overdenture towards the force direction which is opposite to the path of insertion and may result in its dislodgment.

This study showed that overdenture retention is similar at the most anterior and posterior positions of implants within the inter-foramina region. Literature review revealed that there is no study on the effect of location of implants on retention and stability of implant-tissue supported overdentures. Implants can be placed at different locations within the distance between the two mental foramina. An effective factor on this distance is the type of attachment used. In case of using bar attachment, a minimum of 12 mm distance between the implants is required (12). Also, since the lingual space is occupied, there would be a limitation for moving the implants away from each other. But if using bar attachment, there would be no limitation in the distance between implants within the inter-foramina region unless for the damaging reciprocal forces applied on the implants which
will become greater as this distance increases (13). Minimum space required between the implants in case of using ball attachment would be 3 mm (14).

According to a general law, single bar is usually used with an ideal length of 20-22 mm and along with two clip-riders. In order to use this, there should be 24-26 mm space between the center of 4 mm diameter implants (15).

Studies conducted on the subject of implant-tissue supported overdentures have selected various distances. Van Kampen in 2003 (16), Petropoulos in 1997 and 2002 (5, 17) and Tabatabaian in 2010 (4) placed the implants at the symphysis region without mentioning a specific distance or location of a particular teeth with the aim of evaluating different attachments at in-vitro conditions.

Burns in 1994 in an in-vitro study on implant-tissue supported overdentures with magnet and O-ring attachments only mentioned the location of implants to be in the anterior mandible (2).

In an in-vitro study conducted in 1998 by Setz to evaluate the retention of prefabricated attachments, the distance between the external margins of implants was reported to be 22 mm (18). Botega in 2004 evaluated retention force and fatigue strength of bar and ball overdenture attachment systems and suggested a 22 mm distance between the center of implants (19).

Naert in 1991 in a clinical study for evaluation of implant-tissue supported overdentures with different attachments selected the location of canine teeth in the mandible for insertion of implants (20). In most studies on different attachment systems, apart from the study design and methodology, the minimum space required for bar attachment has been considered when selecting the location of implants. However, no specific study has been performed regarding the distance of independent implants from the ball attachment. Therefore, we could not find any similar study to compare our results with. Our methodology was in accord with those of Petropoulos et al, in 1997 (17) and 2007 (5) and Tabatabaian et al, in 2010 (4). Petropoulos et al. (2007) used the same method to evaluate MDF in different stud attachment systems and retention of various overdenture attachments. Tabatabaian et al, (2010) in another study with the same method, compared retention, stability and wear in 3 different attachment systems in implant-tissue supported overdentures. In the mentioned studies, forces were applied using a chain. For doing so, length and weight of chains should be equal at all positions so that the forces could be applied equally. This requires same size chain rings which makes it difficult to achieve.

In this study we used platform load cell and a cord to apply the forces equally. Lighting the cord also helped the normal distribution of forces in vertical, oblique and anterior posterior directions. In addition, there was no need for adjusting the length of cord and matching the test conditions (elimination of the confounding variable).

The cord we used instead of a chain was a combination of 2 threads twisted together which is used in tire manufacturing industry and has several types. The type we used in this study was made of polyester and had the cutting surface area of 0.407 mm². Its resistance against tension was estimated to be about 160 N/mm.

In this study we used pink nylon insert which has a moderate retention compared to other types (soft retention) and is the most commonly used form in a clinical setting. Using this type of cap may be the reason why we did not find any significant difference in retention between the most anterior and posterior positions of implants at the symphysis region. If we use other types i.e. firm or extra soft retention, a different result may be obtained. Further investigations are
required on this subject.

In the present study by measuring the vertical force we only assessed the retention of overdenture. But in the oral cavity, functional forces are applied in various directions and retention and stability should both be evaluated. Thus, another study is recommended to address this issue.

**Conclusion:**

Overdenture retention was assessed under vertical tensile force and the following conclusion was made with confidence interval of 95%:

The retention of overdenture was similar in the most anterior and posterior implant positions in between the mental foramina.

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**References:**