Original Article

Retention and wear of nylon matrix component in implant-supported overdentures based on insertion technique: A clinical trial

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Abstract

Objective: Attachments are used for connections between overdentures and dental implants. The maintenance of attachment components plays an important role in optimal clinical service of overdentures. This study aimed to compare the effects of overdenture insertion by hand pressure versus placement by clenching the jaws on the retention and diameter of resilient attachments.

Methods: Thirty patients with mandibular overdentures participated in this study. First, the patients were instructed to insert the overdentures with hand pressure. After 6 months, patients were recalled, the nylon matrix components of the attachments were replaced, and the patients were instructed to place the overdentures by clenching for the next 6 months. The retention and internal diameter of matrices were measured at baseline and at 6 and 12 months later. A universal testing machine was used to measure the residual retention, and a coordinate measuring machine was used to assess the matrix diameter. The retention loss and changes in matrix diameter were compared between the two techniques, using paired samples t-test.

Results: The results showed that retention loss was lower in the hand placement method than in the clenching method ($P<0.001$). The two insertion methods were not significantly different regarding the amount of diameter increase ($P=0.074$).

Conclusions: The residual retention of the matrices was significantly greater in the hand placement of overdentures along the longitudinal attachment axis, which may result in greater efficacy and longevity of implant overdentures.

Keywords: Dental prosthesis, Implant-supported, Mandible, Overdenture, Retention

Introduction

The retention, stability, and support of dentures decrease in patients with complete edentulism and alveolar bone resorption, causing discomfort and dissatisfaction in denture wearers especially those with mandibular dentures (1).

Implant-supported overdentures have been proven as efficient alternatives to conventional dentures for edentulous patients. Overdentures have been reported to improve denture retention, stability, function, and esthetics, mitigate residual alveolar ridge resorption, and increase patient satisfaction (2, 3).

The high success rate and survival rate of implant-supported overdentures have been well documented. Goodacre et al. (4) stated a higher survival rate of mandibular implant-supported overdentures compared with other types of implant-supported prostheses. Bergendal et al. (5) reported a 100% success rate for overdentures supported by two or multiple implants as anchorage. Usually, placement of at least two implants in the inter-mental foramina region would result in adequate function of mandibular overdenture against an opposing maxillary complete denture (6, 7).

Various attachments are used for mounting overdentures to dental implants, depending on the developed treatment plan. Attachments are categorized into two groups including resilient and rigid attachments concerning the amount and direction of movement. The resilient type is more commonly used for overdentures and is better accepted by patients (2,7). Ball attachment is one of the

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simplest types of resilient attachments, which can be used alone (stud attachment) or on a cast bar (bar and ball attachment) (3). After prolonged clinical usage, nylon components of attachments are worn and their retention and the stability of prostheses decrease, resulting in dysfunction and patient dissatisfaction (8,9).

The parameters involved in the selection of attachment type include the amount of retention required, morphology of the jaws, oral anatomy, quality of mucosal ridge, oral functions, and periodic examinations (10,11). Bar attachments may limit the movement of overdenture depending on their cross-sectional design and position (12,13). Also, bar attachments may be used alone or along with a ball attachment (bar and ball), depending on the treatment plan and available occlusal space. The retention and stability are provided by the nylon cap matrix incorporated in the overdenture structure. Nylon caps made of polyethylene (PE) are available in different sizes with various grades of hardness and retention (14).

The technique of insertion, magnitude, and direction of applied loads, masticatory habits, oral hygiene care, and maintenance of overdenture altogether can affect the amount and pattern of nylon matrix wear (15). Retention loss after matrix wear is the most common complication of overdentures (4,16).

Studies have shown that off-axial (horizontal and oblique) forces applied to overdentures are concerning because they exert greater stress on the implants and attachment components compared to axial forces (11,17). Differences in angulation of implants and the path of insertion of overdenture have significant effects on wear and retention loss of the nylon matrix and clinical service of the attachment. Also, the speed of retention loss is correlated with the level of wear of attachment surfaces (18-20). Wear, deformation, and subsequent retention loss occur at a slower rate in the parallel overdenture placement method.

Evidence shows that the majority of nylon components are worn in the process of seating and retrieval of overdentures similar to the wear that occurs in function under load application (21-23). The manufacturers recommend the insertion of overdentures in a vertical path by using finger pressure. However, some patients prefer to insert their overdentures by clenching the jaws. It could be hypothesized that the insertion method, which provides more retention against dislodgement forces and less wear in attachments after six months, will be associated with more favorable parameters of oral function, and patient satisfaction. To investigate this hypothesis, a study was designed in which various insertion methods were compared using the amount of retention provided by the attachments in vivo.

The present study was designed to compare the effects of the insertion method of overdenture by hand pressure along the longitudinal attachment axis versus its seating only by the clenching of the jaws on retention loss and diameter increase (wear) of nylon matrix attachments in implant-supported mandibular overdentures.

Materials and Methods

Study design and participants

This clinical trial compared two overdenture insertion techniques by patients. The residual retention and wear of attachment components were compared with each other and with unused attachments after employing each technique for 6 months. Thirty edentulous patients who received mandibular implant-supported overdentures and maxillary complete dentures were selected for this study. They were all systemically healthy and signed informed consent forms. The study was approved by the ethics committee of Kerman University of Medical Sciences (IR.KMU.REC.1397.186).

The mandibular overdentures of patients included a cast substructure connected to a bar and ball attachment (with 2.2 mm diameter) supported by two or three implants and a stainless-steel housing to hold the nylon matrix (Figure 1). Before the study onset, patients had used the prostheses for over 6 months, and they were completely satisfied with them.

Clinical examinations were performed by a prosthodontist and routine radiographs were obtained for assessment of implants and oral mucosa. The fitness of overdentures was evaluated by using fast-set light body C silicone impression material (Speedex, Coltene Switzerland). If required, relining with Hard GC Reline (GC America, Illinois, USA) was performed chairside.

Interventions

The nylon matrices (extra soft retentive caps, yellow color, 500 g; Rhein 83, Bologna, Italy) were used for patients. The patients received instructions on how to use the overdentures and perform hygienic measures. They were requested to remove the overdenture after each meal, clean it, and place it back in their mouth. They were instructed not to use household cleansing agents for cleaning their overdenture and were asked to only use a toothbrush and liquid soap for this purpose. Subjects were instructed to remove the overdenture before sleep, clean it, and immerse it in a water container overnight. The frequency of insertion and removal was considered three times a day on average.

In the first session, new plastic matrices were placed in the overdenture housing, and the primary retention was measured. Next, the patients were instructed on how to place the overdenture using their fingers by applying vertical load (Figure 2). They were requested to use this technique of overdenture seating for 6 months. After 6 months, the patients were recalled, and the residual retention of overdenture with the existing caps was measured. Next, the used plastic caps were removed from the housing, coded, and replaced with similar new caps. This time, the patients were asked to insert their overdenture in place by clenching their jaws with no hand involvement (Figure 3). They were also requested to adhere to the same previous instructions regarding diet

and hygiene measures. After 6 months, the patients were recalled again and the residual retention of overdenture was measured. The matrices were also collected to assess changes in their diameter, which was considered as wear. Finally, new caps were replaced for patients.

Retention measurement

A universal testing machine (M350-10CT; Testometric ROCHDALE, England) was used to quantify the retention of attachments at three time points. For this purpose, a hard metal arm with a 90-degree angle was designed for attachment below the overdenture border. The arm was adjusted to move vertically at a speed of 3 mm/second. In the process of movement of the arm, the device applied vertical tensile load directly below the overdenture border until the attachments were disengaged. To fix the patient's head position in front of the device, a chin holder was used and adjusted based on the patient's height. The patients were requested to hold their chin still during the test (Figure 4).

The magnitude of vertical load (in Newtons) required for dislodgement of overdenture from the attachments was measured (Figure 5) and recorded by the operator in the

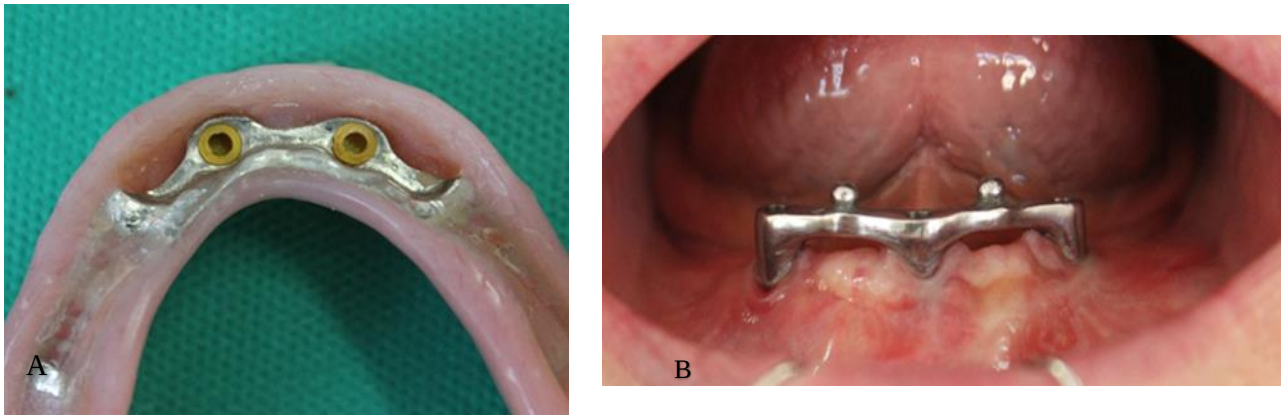

Figure 1. A: The mandibular overdenture of a patient including a cast substructure for connection to a bar and ball attachment (with 2.2 mm diameter). B: The implants and the stainless-steel housing to hold the nylon matrix.

Figure 2: Placing the overdenture using hand pressure and applying vertical load

Figure 3: Insertion of overdenture by clenching of jaws with no hand involvement

Figure 4: Fixing the patient's head in front of the retention measurement device, using a chin holder adjusted based on the patient's height

first session (immediately after placement of new components), and 6 months after practicing each insertion technique (hand placement and clenching). For further accuracy, each measurement was repeated three times, and the mean value was recorded.

Wear measuring device

To assess the deformation and change in the internal diameter of the matrix, the specimens were measured by a coordinate measuring machine (LH87; Wenzel, Germany) and Metrosoft 360 software. The coordinate measuring machine was a precise contact measuring device with 0.1 µm accuracy, which had a 1.8 x 1 cm table and a sensitive probe. The probe can scan the entire length and width of the table by two horizontal and vertical arms (Figure 6). A ball with a standard diameter is present at a specific site on the table to three-dimensionally calibrate the position of the probe after each time of its replacement. The device was kept in an isolated room equipped with an air conditioning system to maintain a constant temperature and humidity at all times. The probe can identify the coordinates of the center of each circle relative to the standard ball, and also the out-of-circularity rate, which refers to the amount of difference of superficial points of the measured circle relative to an ideal circle with a similar radius. The probe tip contacts the internal superior surface of the matrix in several points and draws a circle with the same radius on the computer monitor. The obtained dimensions of the matrices in the three groups were then recorded in micrometers and the changes in diameters were calculated (Figure 7).

Statistical analysis

The Shapiro-Wilk test was used to assess the normality of data distribution (P>0.05). The overdenture retention loss and the change in the internal diameter of the matrix attachments were calculated by subtracting the values obtained after 6 and 12 months from the baseline values. The variables were compared between the two groups using the paired sample t-test. A P-value less than 0.05 was considered statistically significant. SPSS 21 software (SPSS, Chicago, Illinois, USA) was used for data analysis.

Results

A total of 30 consecutive patients, comprising 13 males and 17 females with a mean age of 58 years (range: 42-75 years), completed the study. The mean value of baseline retention was 28.32±1.6 N.

The retention and diameter of the used nylon components were subtracted from the unused values to obtain the amount of retention loss and the change in the internal diameter of the matrices. Table 1 presents the mean and standard deviation (SD) of the retention loss and diameter alteration in the two techniques of overdenture placement

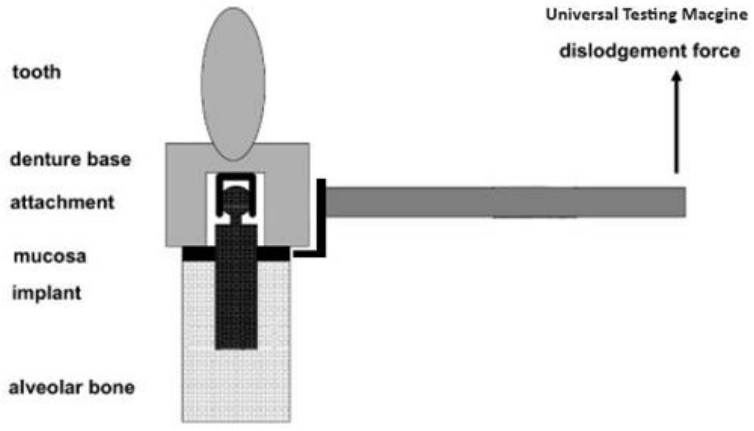

Figure 5: A schematic view of the retention measuring process

Figure 6: The coordinate measuring machine with its probe and two horizontal and vertical arms

Figure 7: The obtained dimensions of the matrices measured by coordinate measuring machine (CMM)

Table 1: The mean and standard deviation (SD) of the retention loss (N) and diameter increase (micrometer) in the two methods

	Retention loss			Diameter increase		
	Mean ± SD	Minimum	Maximum	Mean ± SD	Minimum	Maximum
Hand placement method	15.51±5.63	5.41	29.04	0.14±0.05	0.06	0.29
Clenching method	18.09±7.13	4.87	31.76	0.17±0.08	0.06	0.50
P-value	<0.001*			0.078		

Statistically significant differences were noted at P<0.05*.

A paired sample t-test revealed a significantly greater retention loss in the clenching method than in the hand placement method of overdentures (P<0.001). However, the two methods had no significant difference regarding the increase in the diameter of nylon matrix attachments (P=0.074).

Discussion

The current results showed that retention loss was significantly greater in the clenching method. Deformation and diameter increase of plastic caps were also greater in the clenching method but the findings in this regard were insignificant.

In this clinical study, the mean value of baseline retention was 28.32±1.6 N. Pigozzo et al. (19) suggested a minimum of 4 to 7 N load for acceptable function and comfort of mandibular overdentures. Studies on the required load for overdenture retention have generally reported values between 1 to 85 N for the commonly used attachment systems with an acceptable vertical retention force of 7 to 30 N for overdentures. However, Setz et al. (20). suggested a stricter value of 20 N for the most efficient function of overdentures.

An in vitro study by Salehi et al (21) compared the locator and ball attachments and concluded that the design of implant-supported overdenture and the distance of attachments from each other affected the retention of attachments. In the present study, patients with overdentures supported by the cast bar and ball system were included to eliminate the confounding effect of attachment type and design on retention. Also, the location, angulation, and height of attachments were equal and symmetrical.

In this study, the duration of attachment use was 6 months. In vitro studies have usually used 540 to 10,000 cycles, corresponding to 6 months to 9 years of clinical use of overdenture with a mean insertion and removal frequency of 3 times/day (22). Winkler et al. (10) reported that the clinical efficacy of plastic matrix was 3 to 6 months. Generally, primary retention loss occurs after 500 cycles. Thus, a 6-month period appears to be adequate for the assessment of the effect of the insertion method on retention loss (23,24).

According to the present results, the retention loss and diameter increase were greater in the clenching technique than in the hand placement, although the difference in diameter increase was not significant between the two techniques of inserting overdentures. These findings indicate that overdenture placement by hand causes less physical damage to plastic components. The difference in retention loss between the two techniques may be due to the angle of insertion of overdenture. It may be assumed that the angle of insertion with hand is lower than the angle of insertion with clenching of the jaws. In other words, insertion with hand is often parallel to the longitudinal axis of attachments and results in less wear and deformation of the matrix.

The outcomes of this study are in agreement with the results of Ortegon et al. (25). showed that ball attachments parallel to the path of insertion had maximum residual retention after 3,500 cycles of placement. Al-Ghafli et al. (26). demonstrated that by an increase in the angle of the path of insertion relative to the attachments, the retention loss increased. The clinical service of plastic matrix increased in angles close to parallel. Yilmaz et al. (27) indicated that angular difference > 30º in the use of single attachments caused extensive destruction of plastic matrix and retention loss. However, Stephens et al. (28). reported that the effect of implant angle on attachment retention loss was not significant after 5500 cycles of placement at 0 to 20-degree angles.

Branchi et al. (29). in their in vitro study suggested that in clinical conditions, vertical loads such as the forces applied during insertion and removal of overdentures alone are not the main reason for retention loss of attachments because they do not cause fatigue as much as that caused by horizontal masticatory forces and parafunctional habits. In the present study, the patients were standardized regarding the clinical conditions of overdenture, hygiene control, and diet during the two 6-month periods to eliminate the effect of confounding factors on the results.

The increase in diameter of the matrix attachments represents the wear of these components. In this study, the amount of wear was not influenced by the effect of the insertion method; although the difference was close to significant. Vafaie et al. (30). evaluated the wear of O-ring and plastic caps based on the number of implants and time passed since the use of overdenture. They showed that the increase in matrix diameter was significant over time, and correlated with the number of implants (30). Significant results could have been obtained in the present study if the current sample size was larger. Also, the patients were only evaluated for 6 months in this study; the difference in wear may become significant over longer assessment periods.

The material of nylon caps determines their physical and behavioral properties. At present, the majority of caps present in the market are made of polyethylene, which has several grades of hardness. Also, they have a smaller cross-sectional area at the orifice, which results in deformation, roughness, and tear of this area following load application over time, leading to loss of function in retaining the overdenture. Recently, Poly Ether Ketone Ketone (PEKK) was introduced to the market, and the caps made of it have shown superior physical properties (31).

Since the majority of studies on the efficacy of attachments have been conducted *in vitro*, they have not addressed the effects of placement technique and patient function. In the present clinical trial, the overdentures were subjected to actual masticatory forces in the presence of saliva. The patients inserted and removed the overdentures by themselves over a relatively long period. This study design can provide more accurate information regarding the behavior of the attachment matrix in different placement techniques of overdentures.

A limitation of this study was the short duration of follow-up (6 months). Also, the participants had a positive history of previous overdenture use, and thus, they might have been acquainted with a particular placement technique. Thus, it is possible that they used a different technique of insertion during the study period by mistake. Evaluating only the cast bar and ball system is another limitation of this study. Furthermore, the order of hand pressure followed by clenching was the same in all 30 patients.

Future long-term studies are recommended on first-time denture wearers to better reveal the effect of overdenture placement techniques on the results. Evidence shows that females often better adhere to oral hygiene measures and have lower masticatory forces. Thus, this parameter and a statistical comparison between genders should be addressed in future studies. Furthermore, different elastic materials used for the attachment matrix should be assessed concerning comfort of use by patients and patient satisfaction.

Conclusions

The present study showed that placement of overdenture with the hand along the longitudinal attachment axis resulted in greater residual retention over time, which can prolong the clinical service of the plastic matrix. This suggests that the correct technique of overdenture insertion with hand should be instructed to patients and

they should be asked not to insert their overdenture by clenching the jaws.

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