Research Article

ISSN 2639-9490

Oral Health & Dental Science

Impact of Inter-Implant Distance and Attachment Types on Mandibular Implant Overdentures: Evaluation of Retention and Chewing Efficiency at 25 mm Inter- Implant Distance

Aly F. Sallam[1], Fatma A. EL Waseef[2*], Wael Said Ahmed[3] and Nesreen El Mekawy[4]

[1]*B.D.S., Faculty of Dentistry, Mansoura University, Egypt.*

[2]*Associate Professor of Prosthodontics Department, Faculty of Dentistry, Mansoura University, Egypt.*

[3]*Associate Professor of Oral Surgery Department, Faculty of Dentistry, Mansoura University, Egypt.*

[4]*Professor of Prosthodontics Department, Faculty of Dentistry, Mansoura University, Egypt.*

[*]Correspondence:
Fatma A. EL Waseef, Associate Professor of Prosthodontics Department, Faculty of Dentistry, Mansoura University, Egypt.

Received: 14 April 2020; **Accepted:** 29 May 2020

Citation: Aly F. Sallam, Fatma A. EL Waseef, Wael Said Ahmed, et al. Impact of Inter-Implant Distance and Attachment Types on mandibular Implant Overdentures: Evaluation of Retention and Chewing Efficiency at 25 mm Inter- Implant Distance. Oral Health Dental Sci. 2020; 4(1); 1-6.

ABSTRACT

Background: *For implant overdenture therapy, implant positions are diverse and seemingly arbitrary; many based their evidence upon empirical information without evidence-based dental theory.*

Purpose: *The aim of the current study was to evaluate how far the interimplant distance and attachment type can affect the retention and chewing efficiency of implant supported mandibular overdentures using OT Equator and locator attachments.*

Materials and Methods: *18 completely edentulous participants were involved in this study. Each patient received new conventional complete dentures before implant positioning. Two implants were placed in the mandible with intercanine space of 25mm, using a stereolithographic template. After the healing period, the conventional dentures were converted into implant supported overdentures attached, with OT Equator attachments for (group A) and Locator attachments for (group B). Retention was evaluated for conventional complete dentures (T0), 3 months after overdenture delivery (T1) and 6 months later (T2) using digital forcemeter. Masticatory efficiency was also assessed at the same time intervals recorded for retention using two-colored chewing gum. Unmixed Fraction (UF) was then computed.*

Results: *The present study showed significant difference between the two groups as Locator group demonstrated significantly higher retention values than OT Equator group. The results of the study revealed significant statistical difference among the interval times for both groups. The values of retention increased significantly 3 months of overdenture delivery (T1) and then decreased after 6 months (T2) but not less than (T0). This study reported a non-statistically significant difference between the observation times at all chewing strokes except at 50 strokes (T0-T1) for group A. With respect to group B, statistically significant differences were only shown at all chewing strokes at (T0-T1). Upon comparing the two studied groups, the results reported no statistically significant difference at T1 and T2. Regarding T0, there were statistically significant differences between studied groups at all chewing strokes except for 5 & 30 strokes.*

Conclusions: *Inter-implant distance of 25 mm for 2-implant overdenture could be a reliable modality for edentulous mandible. Overdenture retained by Locator is a remarkable treatment respecting the retention and chewing efficiency.*

Keywords
2-implant overdenture, Retention, Chewing efficiency, OT Equator, Locator attachment.

Introduction

The traditional treatment modality of edentulism has been the fabrication of conventional complete dentures. Nowadays, implant-retained overdentures (IRODs) are the first choice of edentulous arches rehabilation, especially when finances prohibit placement of more implants [1]. Patently, authors advocated several advantages of overdentures as compared to traditional dentures including: considerably enhanced stability, increased retention and support, sensory feedback, preservation of vertical dimension, prevention of overclosure, oro-facial support, chewing efficiency, comfort and patient satisfaction [2].

Currently, different types of attachments can be used for implant overdentures. They are basically categorized into; splinted types (Bar attachment) and solitary types (studs, magnets, ball and socket, Locator and OT Equator). These attachments provide different degrees of denture movement. Ultimately, selection of attachment is genuinely influenced by; implant number, distribution and alignment, bone quality, arch shape, retention and denture design [3].

Locator attachment has dual retention, being self-aligning, resilient and is available in different colors having different retention values. In addition, they are durable and have some built-in angulation compensation besides, repair and replacement are easy and fast. While OT Equator attachment is designed to provide maximum retention with this low vertical profile. This offers multiple solutions for overdenture treatment planning where interocclusal space limitations are encountered [4].

Interimplant distance is a fundamental and crucial factor in overdenture planning. It may cause constraints of the desired positioning and angulation of the dental implants. Additionally, it affects the retention of overdenture. Even so, to what extent its impact on the attachment has been poorly reported. Some researchers postulated and specified that 16 mm is the minimum for interimplant distance.

Nonetheless, 19 mm was considered the distance that is always utilized, while 31 mm is thought to be the maximum one. However, a 29 mm value was deduced to be better suited for anatomic limitations such as the mental foramina location and the mandibular arch curvature [5,6].

Different factors contribute to the success of an implant supported overdenture, including the fitness and precision of dentures and the retentive scope of its attachment system to provide a long-term functionality [7,8]. Admittedly, retention could be one of the most serious factors in determining patient satisfaction [9,10].

A number of studies have already evaluated both Locator and OT Equator attachments [11,12] for implant overdentures IODs. Yet, a little information is available in the literature regarding the impact of interimplant distance. Hence, the current study aimed to evaluate IODs retention and chewing efficiency using either Locator or OT Equator attachment at 25mm interimplant distance.

Material and Methods

18 participants were chosen in the current study from the Prosthodontics Department, Faculty of Dentistry, Mansoura University.

They were eligible in accordance to the following criteria: had completely edentulous arches, normal maxillomandibular relationship, at least 25 mm mandibular intra-foraminal distance, mandibular canine areas had enough bone quantity and quality to receive at least 11.5 mm length implant with 3.5 mm diameter. Participants were omitted if they had systematic disorders affecting bone resorption e.g. diabetes mellitus and osteoporosis, history of parafunctional habits, heavy smoking and alcoholism, TMJ disorders or poor neuromuscular control, head and neck radiation.

The study was accepted by Ethics committee of Mansoura University, Faculty of Dentistry. All the patients have signed written consents after being informed about the treatment plan in details and the required follow-up appointments.

Patients groups

The enrolled patients were identified into two groups;
Group A: The overdentures were retained by OT Equator attachments (Rhein 83, Italy) with yellow insert Figure (1a).

Group B: The overdentures were retained by locator attachment (Neo-biotech, Korea) with pink insert Figure (1b).

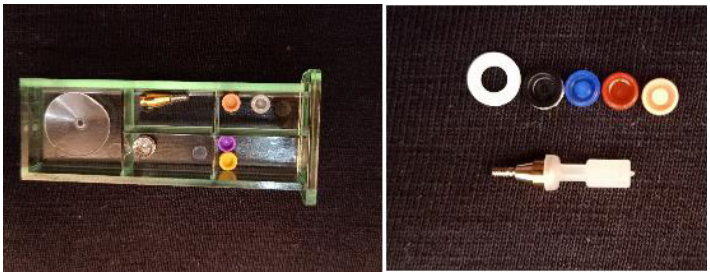

Figure 1: (a): OT Equator, **(b):** Locator.

Surgical and Prosthetic procedures

For each participant, new complete denture with balanced occlusal bilateral contact was designed. The participants used their dentures for at least one month to allow for muscles adaptation to the dentures. The patients were recalled for baseline retention measurement (T0). Planning of implant placement surgery was performed. By using computed tomography (CT) scans, a stereolithographic surgical template was designed to help for implants installation (Figure 2). Two implants (Neo- biotech, Korea) were bilaterally placed in the canine areas following standardized 2-stage submerged surgical protocol.

The mandibular denture was relined by soft liner (Acrostone,

Egypt). Three months later, by using the implant guide, circular tissue punch was performed at the location of each fixture. OT Equator attachments for group A and Locator for group B were secured to the implants using 30 Ncm torque (Figures 3a, b).

Figure 2: Sterolithographic surgical stent intraorally.

Figure 3: (a): OT Equator with a protective disk, **(b):** Locator metal housing with white block-out spacer.

For all participants, the attachment metal housings were picked up intraorally to the intaglio surface of the mandibular overdenture using autopolymerized acrylic resin (Acrostone Dental Factory, Egypt) (Figures 4a, b). Two small openings in lingual surfaces of the denture were made to permit escaping of acrylic resin surplus through picking-up procedure. Denture bases around the attachments were relieved enough (about 0.5 mm) to preclude any interferences that may burden the implants. Occlusion adjustments were carried out after relining. Each patient was boosted with good oral hygiene instructions, besides, leaving the denture out at night. All participants were scheduled for follow-up recalls.

Figure 4: a: OT Equator housing after pick-up, **(b):** Locator housing after pick-up.

Retention Evaluation

Retention of madibular overdentures were evaluated for each patient at (T0: with conventional denture, T1: three months after overdenture insertion and T2: six months after overdenture insertion) using digital force-meter. According to Burns et al. [13], two hooks were fixed at the buccal flange; one on each side (midway between 2nd premolar and 1st molar areas). Orthodontic st.st wire was adapted to both hooks passing horizontally over the denture teeth. The pull end of the digital force-meter has been connected to the orthodontic wire. The force meter was then pulled upward till the denture lost its retention and moved vertically, then the reading was recorded. The needed peak force for dislodging the overdenture was measured in Newton. That measurement was repeated 3 times and the mean was calculated.

Evaluation of chewing efficiency

Conforming to Schimmel et al. [14], a commercially available two-colored (pink & white) chewing gum (Trident, Mondelez Egypt Foods, Fulla gum, Egypt.) were used for the assessment of masticatory performance. Strips of both colours were cut and stuck together giving test strips of 30 × 18 × 3 mm made from one white and one pink piece. The patients chewed each of the test samples for 5, 10, 20, 30 and 50 chewing strokes, respectively. The patients were instructed to stop chewing with their mouths closed. Then the chewed gum was trimmed to 1 × 50 × 50 mm strip. To diminish the effect of fatigue, an interval of at least 1 minute was imposed between the different tests.

The overall duration of the experiment was almost 8 minutes. By using a flatbed scanner (Epson Expression 1600 Pro, Seiko Epson Corp., Nagano, Japan), each trimmed specimen was scanned at a resolution of 500 dpi and analyzed by the operator (DH) using View Gum software. All images were imported into View Gum software (dHAL Software, Kifissia, Greece, www.dhal.com). Unmixed fraction (UF) was computed. Standard deviation of hue (SDHue) was determined from calculation sent to excel, and exported to be statistically analysed by SPSS (SPSS Inc., Chicago, IL, USA).

Results

Comparison of retention between the 2 studied groups before overdenture insertion (T0), 3 months after overdenture insertion, (T1), 6 months after overdenture insertion (T2) using Student t test, is presented in Table (1). There is a statistically significant difference between the two groups at T1 & T2 (0.012 & 0.004 respectively). While T0 showed non statistically significant difference between them.

Table 1: Comparison of retention b etween the studied groups.

Retention	T0	T1	T2
Group A (OT Equator) X ± SD	1.65 ± 0.21	4.30 ± 0.28	3.90 ± 0.14
Group B (Locator) X ± SD	1.45 ± 0.21	7.50 ± 0.42	6.65 ± 0.21
Test of Significance	t=0.94 p=0.45	t=8.88 p=0.012*	t=15.25 p=0.004*

Student t test * significant at 5% level of significance.

Chewing efficiency

Group A (OT Equator attachment)

Upon comparing the chewing strokes in the group, Repeated Measures ANOVA test demonstrated non-statistically significant differences between the observation times at all chewing strokes except at 50 strokes (T0-T1) (Table 2).

Table 2: Comparison of chewing efficiency change of group A (OT Equator) at different observation times.

Chewing strokes	Observation times		
	T0-T1	T0-T2	T1-T2
5 times	0.21	0.27	0.13
10 times	0.31	0.44	1.0
20 times	0.27	0.79	0.41
30 times	0.19	0.83	0.31
50 times	0.02*	0.42	0.23

Paired t test* statistically significant ($p<0.05$).

Group B (locator attachment)

When comparing the chewing strokes in the group, Repeated Measures ANOVA test exhibited non-statistically significant differences between the observation times at all chewing strokes except at (T0-T1) observation time ($p<0.05$) (Table 3).

Table 3: Comparison of chewing efficiency change of group B (Locator) at different observation times.

Chewing strokes	Observation times		
	T0-T1	T0-T2	T1-T2
5 times	0.04*	0.31	0.23
10 times	0.04*	0.15	0.21
20 times	0.02*	0.19	0.17
30 times	0.05*	0.25	0.06
50 times	0.009*	0.242	0.239

Paired t test * statistically significant ($p<0.05$).

Table 4 showed comparison between the 2 groups with respect to UF for different chewing strokes at (T0), (T1) and (T2) using Student t test.

Statistically significant differences were reprted between the two groups at all chewing strokes except at 5 & 30 strokes at (T0). Whereas at (T1) and (T2), no statistically significant difference was noticed between studied groups at all chewing strokes.

Table 4: Comparison of chewing strokes between studied groups at (T0), (T1) and (T2).

Groups (T0)	5 strokes	10 strokes	20 strokes	30 strokes	50 strokes
Group A (OT Equator) X ± SD	0.142 ± 0.02	0.111 ± 0.01	0.092 ± 0.013	0.081 ± 0.01	0.063 ± 0.01
Group B (Locator) X ± SD	0.202 ± 0.002	0.184 ± 0.003	0.154 ± 0.004	0.121 ± 0.004	0.111 ± 0.001
Test of significance	t=4.12 p=0.054	t=7.76 p=0.01*	t=6.27 p=0.02*	t=3.83 p=0.06	t=8.68 p=0.013*
Groups (T1)	**5 strokes**	**10 strokes**	**20 strokes**	**30 strokes**	**50 strokes**
Group A (OT Equator) X ± SD	0.11 ± 0.005	0.103 ± 0.006	0.081 ± 0.02	0.061 ± 0.02	0.039 ± 0.006
Group B (Locator) X ± SD	0.107 ± 0.006	0.099 ± 0.004	0.082 ± 0.007	0.057 ± 0.01	0.043 ± 0.003
Test of significance	t=0.75 p=0.53	t=0.70 p=0.56	t=0.06 p=0.95	t=.22 p=0.84	t=0.71 p=0.55
Groups (T2)	**5 strokes**	**10 strokes**	**20 strokes**	**30 strokes**	**50 strokes**
Group A (OT Equator) X ± SD	0.124 ± 0.009	0.106 ± 0.006	0.093 ± 0.007	0.083 ± 0.006	0.054 ± 0.001
Group B (Locator) X ± SD	0.169 ± 0.027	0.143 ± 0.017	0.116 ± 0.021	0.099 ± 0.017	0.076 ± 0.021
Test of significance	t=2.27 p=0.152	t=2.93 p=0.10	t=1.47 p=0.28	t=1.29 p=0.33	t=1.46 p=0.28

Student t test * statistically significant ($p<0.05$).

Discussion

This study revealed significant differences between observations times for both groups, the values of retention increased significantly 3 months after attachment connection. This could be explained that overdentures stability and retention enhanced by implants and attachments [15]. Subsequently, the retention values then decreased after 6 months of attachments connection but not less than baseline measurements. This might be attributed to wear stimulation effects as proclaimed by Rutkunas et al. [10]. This agreed with Alsabeeha et al. [16] who previously studied the effect of wear and material change on several attachment systems and designs.

Likewise, Locator was reported to be increased in its retention. That was in accordance to Kobayashi et al. [7]. In this study, the initial mean retention was 33.5 ± 9.77 in the first 10 cycles, then proceeded by a sharp increase in retention up to cycle 100 (51.9 ± 13.06 N). According to the authors, the retentive properties enhancement of the attachment system was unexpected. It might be pointed out by the effect of the first cycles which could cause irregularities in the body of the nylon insert, increasing the friction between the nylon insert and the abutment. The dual retention feature of Locator along with the relatively wider surface area of its nylon insert must help in magnifying the effect of friction between the two components.

The present study elaborated significant difference between the two groups as Locator exhibited significantly more retention than OT Equator group.

According to the reports of Satti et al. [15], Locator with pink nylon insert recorded higher retention values than OT Equator with clear insert. Their study concurred with our study in spite of using yellow insert with OT Equator instead.

In this sense, our results are in consistent with Gonuldas et al. [12]. They compared retention forces between (locator with clear nylon insert), (OT Equator with yellow insert) and (ball attachment with orange insert) using two implant (22 mm distance) into custom-

made acrylic resin. The study approved that locator has higher initial retention than OT Equator and ball attatchment. This also was confirmed by Minguez-Tomas et al. [11].

Moreover, Kleis et al. [17] elaborated that when comparing Locator and other attachments as ball attachment, Locator reported a higher rate of maintenance and no retention problem was recorded primarily but after multiple pulls the retentive values are reduced significantly. This might be the explanation of the slight decrease of the retention and chewing performance with locator attachment during the follow up intervals.

The present study reported that retention values for the Locator system and OT Equator system after 3 months of insertion were 7.5 ± 0.42 N and 3 ± 0.28 N respectively. Whereas after 6 months of insertion; 6.65 ± 0.21N for locator and 3.9 ± 0.14N for OT Equator. Our results seemed to be comparable to Pigoza et al. [18]. They speculated that retention of 5-7 N is enough to keep an overdenture stable. Accordingly, the results of the current study deemed to be acceptable for maintaining overdenture stability for locator group while for OT Equator group these values did not.

The current study proved that masticatory function could be enhanced by increasing retention and stability of the overdentures according to type of attachment used. This was concurred with Van Kampen et al. [19]. The authors assured that the attachment type impact the retention and stability, eventually, oral function of the prosthesis. This was also confirmed by Caloss et al. [20]. They concluded that instability of the denture probably precludes denture wearers from completely benefit of their jaw muscles, even with two implants supporting the mandibular dentures.

Another possible explanation is that, as chewing cycles number increased for the same patient, the result is better mixing between particles of the two colored chewing gum.

Besides, unmixed fragments UF decreased with advance time. This was coping with the hypothesis of Weijenberg et al. [21] and Van der Bilt et al. [22]. They endorsed that good oral function relies on the retention, stability and the attachment of the denture. The longer time the chewing gum sample was chewed the less surface of the picture it covers. They added that high (UF) were showed before attachment connection and decreased significantly at time of overdentures insertion due to the high degree of color mixture.

More and more mixing between two-colored chewing gums particles was produced by increasing the chewing cycles number for the same patient. This is concurred with Schimmel et al. [14]. Moreover, these results were in agreement and assured by Bhat et al. [23] and Elsyad et al. [24].

Notably, the clinical impact of interimplant distances on overdentures has been validated in several studies. The results of this study could be attributed to the interimplant distance used (25 mm) which rendered to be acceptable in other studies [5,6,25-29]. Shayegh et al. [6] demonstrated that Interimplant distances could impact the initial retention of locator attachments. Additionally, they revealed a little difference in retention by comparing the distances of 23 and 29 mm. Nonetheless, distance of 23 mm was correspondent with superior retention. With regard to the speed of retention decrease, the 23 mm distance was associated with better performance. Notwithstanding, Tabatabaian et al. [25] declared that interimplant distance neither affected the vertical retention nor oblique resistance however, it affected anterior-posterior resistance.

Nevertheless, El Mekawey and Yosry Elhawary [26] assessed implant overdentures after one year of clinical use. They affirmed that both Locator and OT Equator retentive male inserts revealed significant surface deformities and wear as well. They added that wear of both attachments inserts was more noticeable with 25 mm interimplant distance than with 19 mm interimplant distance.

Conclusion

Within the limitations of this short -term study:

- Inter-implant distance of 25 mm for 2-implant overdenture with could be a reliable modality for edentulous mandible.
- Overdenture retained by Locator is a remarkable treatment respecting the retention and chewing efficiency.

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