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Locators versus magnetic attachment effect on peri-implant tissue health of immediate loaded two implants retaining a mandibular overdenture: a 1-year randomised trial

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SUMMARY This study aimed to evaluate peri-implant tissue health of immediate loaded two implants retaining a mandibular overdenture with either magnetic or locator attachment. Thirty two completely edentulous patients (20 males/12 females) were randomly assigned into two groups. Each patient received two implants in the canine area of the mandible using flapless surgical technique. Mandibular overdentures were immediately connected to the implants with either magnetic (group I, GI) or locator (group II, GII) attachments. Peri-implant tissue health was evaluated clinically in terms of plaque scores (PI), bleeding scores (BI), probing depth (PD), implant stability (ISQ) and interleukin-1-β (IL-1b) concentrations in peri-implant sulcular fluid. PI, BI and PD were measured at mesial, distal, buccal and lingual surfaces of each implant. Radiographic evaluation was performed in terms of vertical (VBL) and horizontal (HBLO) alveolar bone loss. Evaluations were performed 2 weeks (T0), 6 months (T1) and 12 months (T2) after overdenture insertion. Plague scores, PD, IL-1b, VBL and HBLO increased significantly with time. ISQ decreased significantly with time. BI showed no significant differences between observation times. GI recorded significant higher PI, ISQ and IL-1b at T2 compared to GII. GII recorded significant higher VBL than GI at T2 only. For HBLO, no significant differences between groups were noted. VBL and HBLO showed a significant positive correlation with PD. Locator attachments for immediate loaded implants retaining mandibular overdentures are associated with decreased plaque accumulation, decreased implant stability, decreased interleukin-1β concentration in peri-implant crevicular fluid and increased per-implant vertical bone loss compared to magnetic attachments after 1 year.

KEYWORDS: locator, magnets, attachments, implant, overdenture

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Introduction

According to McGill consensus statement (1), evidence exists suggesting that two-implant overdenture should become the standard of care for treatment of edentulous mandible. Published studies show that mandibular implant-retained overdenture provides significant enhancement in stability, retention, maximum biting force, patient satisfaction and quality of life (2–4).

Resilient splinted/unsplinted attachments that allow several types of movements have been developed for such overdentures (5). Owing to the smaller space requirements within prostheses, easy cleaning, more economical incentives and lower sensitivity to techniques, unsplinted attachments have been preferred to splinted attachments (6, 7). Some of these attachments provide vertical and hinge movements of overdentures such as: O/rings, ball and sockets with spacer, resilient telescopes and Locator attachments. Other attachments permit lateral and hinge movements such as magnetic attachments (5, 8).

The Locator® attachment was introduced in 2001. It became more popular in the last decade as an

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attachment for free-standing implants supporting overdentures (6). Compared to other unsplinted attachments, locators have: (i) low profile (can be used in a limited interarch distance) (9), (ii) dual retention (obtained from the inner and outer contact surfaces between matrices and patrices (10) and (iii) higher retentive force (11). Moreover, these attachments are self-aligning (11), can compensate for up to 40° implant disparallelism (10) and can be easily repaired and replaced (12).

Magnets offer several advantages including low profile (13), reduction in horizontal stress transmission to the implants (14) and reduction in the stress generated in the peri-implant bone during overdenture dislodgement (15). Moreover, magnets are less prominent, smoother and comfortable to the patients when the prostheses are absent from the mouth (16). They also do not disturb the surrounding gingival tissues (17).

The use of one-stage surgical procedure and immediate loading of implants by mandibular overdentures simplifies implant treatment (18), avoids instability and multiple relining of transitional prostheses during healing period (19), shortens dental rehabilitation time and achieves relevant patient satisfaction (20). However, mechanical stress applied to implants during the healing period may result in micromotions at implant/bone interface, thus interfering with the healing process (21).

Reviewing the literatures, comparison of peri-implant tissue health between locator and magnetic attachment of implant retained mandibular overdentures has not been concerned. The aim of this study was to compare peri-implant tissue health between two unsplinted low profile overdenture attachments with different mechanisms of action. The first is locator attachment, which provides vertical resiliency, and the other is magnetic attachment which allows lateral movement of the overdenture prosthesis. The null hypothesis was that there will be no significant difference between the two attachments.

Materials and methods

Patient selection

Thirty two completely edentulous patients (20 males/12 females) with maladaptive experience of wearing mandibular dentures were selected from the outpatient clinic of Prosthodontic Department, Faculty of Dentistry, Mansoura University, Egypt. This sample size was calculated to yield a power of 80% (alpha, two-tailed, was set at 0·05) using a computer programme (Power and pericision version 3, 2007*). The effect size was based on the results of a previous trial (22) on unsplinted implant retaining mandibular overdentures, which demonstrated significant difference in peri-implant clinical and radiographic parameters between groups. Patients were consecutively included in the study, provided that they fulfilled the following criteria: (i) sufficient bone height in the inter-foraminal region of the mandible, (ii) at least 4 months of healing after extraction and (iii) good denture hygiene. Exclusion criteria included systemic diseases that may compromise implant surgery (such as liver, kidney and blood disorders), diabetes mellitus, chemotherapy or radiation therapy, uncooperative patient and smoking. Patients accepted enrolment in this study after the protocol was explained and they all signed an informed consent. The patients were informed about the two treatment strategies that could be followed and were asked to participate in the study without prior knowledge of which treatment they were going to receive. They were stratified according to age, gender, symphyseal bone height measured on pre-operative panoramic radiograph, and period of mandibular edentulism. Patients were assigned equally to receive either magnetic (group I, GI) or locator (group II, GII) attachments using balanced randomization. Based on this assignment, 16 patients were included in each group. The study was conducted according to principles stated in the Helsinki Declaration and approved by local ethical committee. Table 1 shows the characteristics of the study sample after the balancing procedure.

Table 1. Characteristics of the study samples at the baseline

	GI (Magnetic attachment)	GII (Locator attachment)
Mean age (years)	63	62·2
Gender (male/female)	10/6	10/6
Mean symphyseal bone height (mms)	20·4	18·2
Mean period of mandibular edentulism (years)	5·6	7

*Biostat, Englewood, USA.

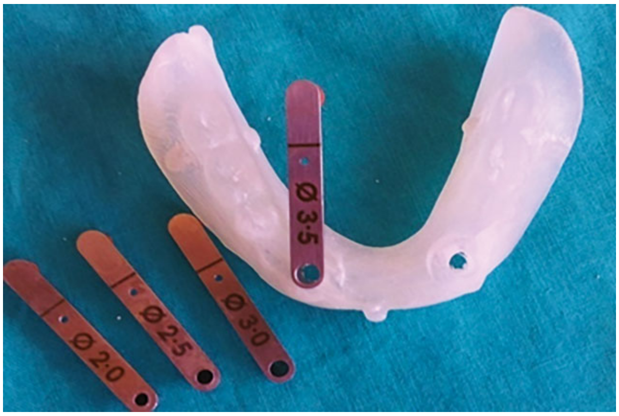

Fig. 1. A mucosal-supported stereolithographic surgical stent and successive diameter surgical sleeves.

Surgical and prosthetic procedures

For all patients, new conventional maxillary and mandibular dentures were constructed. A duplicate of mandibular denture was constructed to be used as radiographic stent. One millimetre pieces of gutta percha radiopaque markers were attached to the fitting surface of the duplicate denture (to estimate the thickness of oral mucosa during CT scan), to the polished surface of the denture (to estimate the thickness of the acrylic resin) and at proposed implant sites (canine areas). The stent was double scanned using cone beam computed tomography (CBCT, i- CAT Vision®[†]). The first scan was made with the stent out of the patient mouth and the second scan was performed while the patient wearing the stent. Then, a mucosal-supported Sterolithographic surgical guide was constructed using two data sets of both scans and 3D image-based treatment planning software (SimPlant View Crystal, version 13.0.0.66[‡]). An universal surgical kit including sleeves with increasing diameters was supplied with the mucosal-supported Sterolithographic surgical guide to be used during consecutive drilling (Fig. 1). All patients administered prophylactic antibiotics (2 g of amoxicillin 1 h before surgery) and mouth rinse with a 0·12% chlorhexidine digluconate (15 min prior to surgery).

For each patient, two 13 × 3·7 mm implants[§] were inserted in the canine area using the non-submerged flapless surgical approach and the Sterolithographic surgical guide. Magnetic (Steco Titanmagnetics®[¶]) and Locator[§] abutments for GI and GII, respectively, were mounted in the internal hex of the implants using the insertion key and torque wrench (30 N cm^{-1}) (Fig. 2). The fitting surface of the mandibular dentures opposite to the abutments was adequately relived and two small holes were made in the lingual surface of the denture to allow escape of excess acrylic resin material during the pick-up procedure. Positioning sleeves (GI) and white locator blocking ring (GII) were placed over magnetic and Locator abutments, respectively. Denture magnets (GI) and Locator metal housing with black processing insert (GII) were positioned over their corresponding abutments and picked up to the fitting surface of the mandibular denture using self-cure acrylic resin while patient occludes in centric relation (Fig. 3). For GII, the black processing inserts were replaced by male nylon inserts. These inserts are supplied in different colours according to the amount of retention; blue (extra

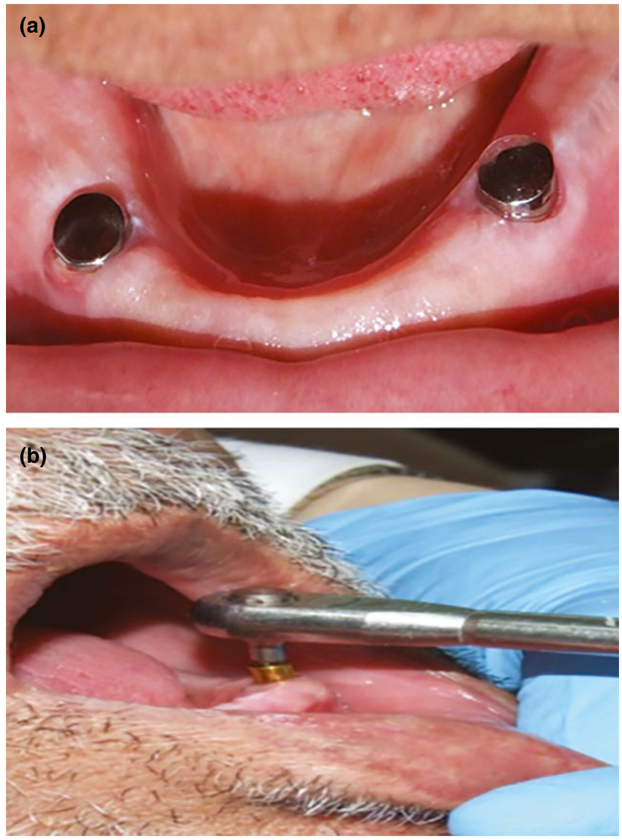

Fig. 2. The magnetic (a) and Locator (b) abutments in place intra-orally.

[†]Imaging Sciences International, Hatfield, PA, USA.

[‡]Materialize, Leuven, Belgium

[§]tioLogic, Dentaurum, Germany.

[¶]steco-system-technik, GmbH&Co. KG, Germany.

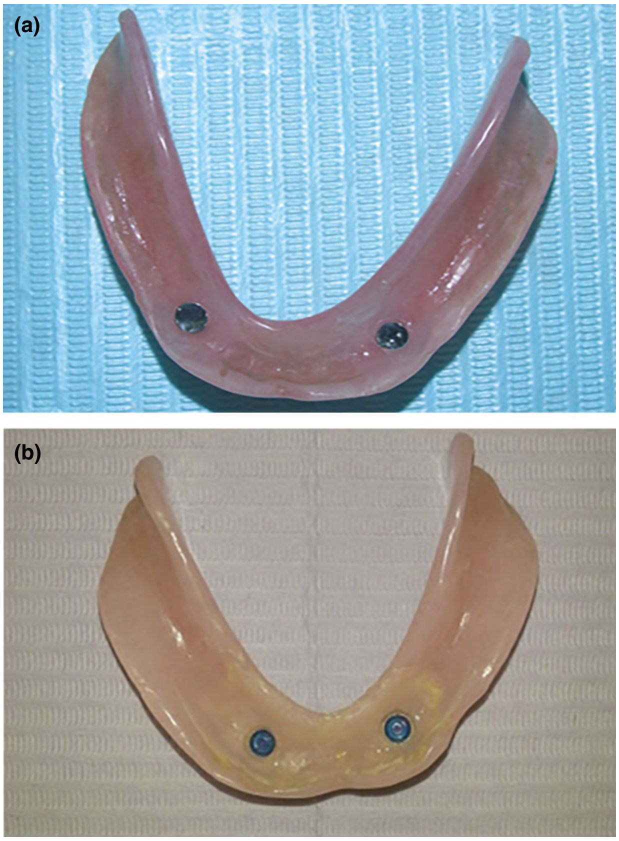

Fig. 3. The fitting surface of magnetic (a) and Locator (b) retained mandibular overdenture.

Fig. 4. Fixation of the SmartPeg to the implant's inside threads.

light retention), pink (light retention) and transparent (medium retention). The blue insert was inserted first, then replaced by pink or clear inserts when the retention is reduced.

After overdenture insertion, patients were instructed for oral hygiene measures. The patients were recalled every 3 days in the first 3 weeks for denture adjustment and occlusal refinement.

Evaluation of peri-implant tissues

Evaluation of peri-implant tissue health was performed 2 weeks after overdenture insertion (T0), 6 months (T1) and 12 months (T2) after insertion.

Clinical evaluation. Plaque scores (PI) and Bleeding scores (BI) were assessed using the Modified plaque and bleeding indices (23). Using a calibrated plastic periodontal probe**, the distance between marginal border of the peri-implant mucosa and the tip of the probe was measured and considered as pocket depth (PD) (24).

Implant stability was assessed using resonance frequency analysis. The resonance frequencies were measured with the Osstell® device instrument†† and expressed with ISQ (implant stability quotient in kHz). The SmartPeg was screwed to the inside threads of the implant fixture using a mounting tool (Fig. 4). The measurement probe stimulated the SmartPeg magnetically without actually being connected to it. ISQ scale ranges from 1:100. The higher the ISQ value, the more stable the implant. The measurements were performed three times and the mean was subjected to statistical analysis.

For measurement of interleukin-1β (IL-1b), the peri-implant crevicular fluid samples were collected using commercially available periopapers (Periopaper‡‡). The samples sites were gently air-dried and carefully isolated with cotton rolls to prevent samples from being contaminated with saliva. For each time of measurement, paper strips were inserted in the labial surface of peri-implant crevice carefully until mild resistance was felt, and left for 30 s (Fig. 5). Care was exercised to avoid mechanical injury of the tissues. Any strip contaminated with blood was discarded. Paper strips were immediately placed in eppendorf tubes. Each tube with the paper strip was weighted before and after sample collection for peri-implant fluid volume calculation (25). Peri-implant crevicular fluid was extracted by centrifugation and

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††Integration Diagnostics Ltd., Oslo, Norway.

‡‡Oraflow Inc., New York, USA.

Fig. 5. Collection of peri-implant crevicular fluid using periopapers.

all samples were stored at −30 °C. Levels of IL-1β in peri-implant crevicular fluid were detected using sandwich ELISA technique (enzyme-linked immunosorbent assay).

Radiographic evaluation. Intraoral radiographs were made using the long cone paralleling technique. Film holder was used to maintain the film-implant distance and cone implant distance standardised. A modification was done by drilling a hole in the film holder above implant's position, and the holder was secured in position by the long screw of the impression coping (26). Crestal alveolar bone changes were determined along vertical and horizontal planes. For vertical alveolar bone changes, the distance between point A and point B indicated vertical bone level (DIB) in mm (AB line) (Fig. 6). For horizontal alveolar bone changes, the distance between point C and the implant perpendicularly indicated horizontal bone level (HBL) in mm. Vertical and horizontal bone losses (VBL and HBLO, respectively) were calculated by subtracting bone level values (DIB and HBL) at T1 and T2 from values at T0. Alveolar bone changes (vertical and horizontal bone loss) were measured at mesial and distal surface of each implant and the mean was subjected to statistical analysis.

Statistical analysis

Between-group comparisons for all tested parameters (PI, BI, PD, PTVs, VBL and HBLO) were performed using Mann–Whitney *U* test since the data did not meet the criteria of normality in distribution of variance. SAS macro programme LD_F1 for non-parametric

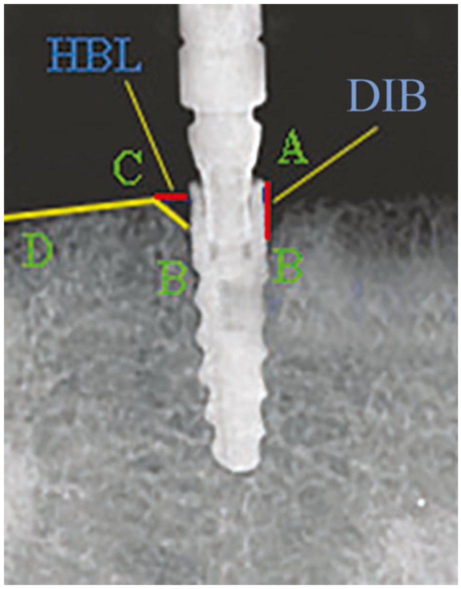

Fig. 6. Traced peri-apical radiograph: A; the implant-abutment junction, B; first bone to implant contact, C; marginal bone level [which represents the intersection point of a tangent to the horizontal bone crest (CD line) and another tangent to the crater-shaped defect (CB line)], DIB; vertical bone level, HBL; horizontal bone level.

longitudinal data (Brunner–Langer test) (27) was used to detect significant differences between observation times. Wilcoxon's signed-rank test for two related samples was used to compare between observation times in the same group. The Spearman correlation test was used to find possible relations between PI, BI, PD, PTVs and marginal bone loss (VLO, HBLO). The data were analysed using SAS® software version 9.2[§§]. *P* value was significant if <0·05.

Results

Two patients (one patient in each group) could not complete the study, yielding a 6·2% dropout rate in both groups. In group II, one patient had one of the implants failed after 6 months (T1), resulting in 96·9% survival rate in this group. The failed implants were removed and the overdenture was retained by one Locator attachment. Another patient in group I was excluded because of an inability to regularly attend the evaluation process due to severe illness. No implant failures occurred in group I (survival rate was 100%). The two groups were compared before

[§§]SAS Institute, Cary, NC, USA.

Table 2. Comparison of clinical parameters between the observation times

	First observation	Second observation	Third observation	Brunner-Langer test (*P* value)
Plaque scores				
Magnets (X ± s.d.)	0·47 ± 0·50a	0·67 ± 0·59b	0·87 ± 0·69c	0·003*
Locators (X ± s.d.)	0·47 ± 0·50a	0·65 ± 0·52b	0·56 ± 0·50a,b	0·032*
Bleeding scores				
Magnets (X ± s.d.)	0·07 ± 0·26a	0·10 ± 0·30a	0·10 ± 0·30a	0·89
Locators (X ± s.d.)	0·05 ± 0·22a	0·05 ± 0·22a	0·05 ± 0·22a	1·0
Probing depths				
Magnets (X ± s.d.)	1·15 ± 0·49a	1·70 ± 0·60b	2·45 ± 0·63c	0·00*
Locators (X ± s.d.)	1·16 ± 0·48a	1·77 ± 0·61b	2·40 ± 0·74c	0·00*
Implant stability- ISQ				
Magnets (X ± s.d.)	72·20 ± 2·14a	68·60 ± 1·26b	68·20 ± 1·61b	0·00*
Locators (X ± s.d.)	70·60 ± 3·06a	65·40 ± 4·08b	64·20 ± 3·55c	0·00*
Interleukin 1 β concentration				
Magnets (X ± s.d.)	161·32 ± 73·86a	205·61 ± 18·22b	240·87 ± 22·34c	0·00*
Locators (X ± s.d.)	164·01 ± 87·20a	154·55 ± 75·15a	213·70 ± 28·42b	0·00*

X; mean, s.d.; standard deviation, **P* value is significant at 0·05. Different letters indicate significant difference between observation times (Wilcoxon signed-ranks test, $P < 0{\cdot}05$).

treatment for variables mentioned in Table 1 using Mann–Whitney test, with no significant differences detected.

Comparison of clinical parameters (PI, BI, PD, ISQ and IL-1b) between observation times are presented in Table 2. In group I, PI, PD and IL-1b increased significantly with time (Brunner-Langer test, $P < 0{\cdot}050$). ISQ decreased significantly after 6 months. BI showed no significant differences between observation times. In group II, PD and ISQ increased significantly with time. PI increased significantly at T1 and decreased again. IL-1b decreased at T1 and increased significantly again at T2. BI showed no significant differences between observation times. Multiple comparison of PI, BI, PD, ISQ and IL-1b between three observation times are presented in Table 2. For PI, no difference was found between T0 and T2 or between T1 and T2 for locator attachment. For ISQ, no difference was found between T1 and T2 for magnets. For IL-1b, no difference was found between T0 and T1 for Locator attachments. All other observation times (T0, T1 and T2) differ significantly in PI, BI, PD, ISQ and IL-1b between each other (Wilcoxon signed-rank test, $P < 0{\cdot}05$).

Comparison of PI, BI, PD, ISQ and IL-1b 1β between groups are demonstrated in Table 2. GI (magnets) recorded significant higher PI and ISQ than GII (locators) at T2 (Mann–Whitney test, $P < 0{\cdot}05\%$). GI also recorded higher IL-1b at T1 and T2 compared to GII. BI and PD did not significantly differ between groups.

Comparison of radiographic parameters (VBL and HBLO) between observation times are presented in Table 3. VBL and HBLO increased significantly at T2 compared to T1 for both groups (Wilcoxon signed-rank test, $P < 0{\cdot}05$). Comparison of VBL and HBLO between groups are presented in Table 3. GII (locators) recorded significant higher VBL than GI (magnets) at T2 only (Mann–Whitney test, $P < 0{\cdot}05\%$). No significant difference in VBL between groups was observed at T1. For HBLO, no significant differences between groups were noted at T1 or at T2. VBL and HBLO showed a significant positive correlation with PD (Spearman correlation, $P < 0{\cdot}05$). No significant

Table 3. Comparison of radiographic parameters between observation times

	Second observation	Third observation	Wilcoxon signed-ranks test (*P* value)
Vertical bone loss (VBL)			
Magnets (X ± s.d.)	0·44 ± 0·07	0·68 ± 0·09	0·005*
Locators (X ± s.d.)	0·48 ± 0·20	0·99 ± 0·34	0·007*
Horizontal bone loss (HBLO)			
Magnets (X ± s.d.)	0·41 ± 0·07	0·62 ± 0·07	0·005*
Locators (X ± s.d.)	0·43 ± 0·12	0·64 ± 0·18	0·022*

X; mean, s.d.; standard deviation, **P* value is significant at 0·05.

correlation between other clinical parameters and bone loss (VBL and HBLO) was detected.

Discussion

Among the types of implant attachment, two types were used in this study: (i) magnetic attachment, which allows greater horizontal movements with no vertical resiliency, and (ii) locator attachment, which allows vertical resiliency with limited hinge and no horizontal movements. The implant survival rates of locator retained overdentures were 96·9% after 1 year. A similar survival rate was also observed in a previous study (26) for immediate loaded implants with locator retained mandibular overdenture. However, the survival rate of the implants in magnetic retained group (100%) was higher than those obtained by Pae *et al.* (28) for immediate loaded implants with magnetic retained mandibular overdentures.

Plaque scores increased significantly with advance of time in both groups. A similar increase in plaque scores was reported in other studies for magnetic (29) and locator (26) attachments. This may be due to the resiliency of both attachments, which allow denture movements and accumulation of food particles and plaque under the denture. Another explanation may be attributed to the decreased awareness caused by increased patient age which affects oral hygiene practice of the patients (22). Magnets recorded significant higher plaque scores than locators after 1-year follow-up. A similar finding was reported in another study (29) in which the authors found that magnets attract microbial plaque. By contrast, Ceruti *et al.* (30)., in a similar observation period, noted minimal plaque accumulation around magnetic attachments.

Probing depths significantly increased with advance of time in both groups. The increased PD could be related to increased peri-implant vertical bone resorption with time and peri-implant soft tissue enlargement (22, 26). Implant stability quotient values significantly decreased after 6 months in both groups. However, the ISQ values in this study remain within the range reported for successfully integrated implants (57–82) (31). The decreased ISQ values may be attributed to continuous bone remodelling occurred after loading, which decreases the bone-implant anchorage (28). The immediate loading of non-splinted implants in this study may increase micromovements and marginal bone loss which may affect implant stability (25). Similarly, Pae *et al.* (28), in a 1-year clinical study conducted on magnetic retained implant overdentures, found a decrease in the ISQ values after 6 months. In this study, magnetic attachment showed higher implant stability than locator attachment after 1 year. This may be attributed to the increased vertical bone loss with locators compared to magnets as confirmed by the results of this study.

In this study, Interleukin-1 β (IL-1b) was measured in peri-implant crevicular fluid as an indicator for inflammatory process of implant supporting structure. IL-1b plays a role in the initiation and progression of connective tissue breakdown (32, 33). IL-1b significantly increased after 1 year in both groups. This could be attributed to the increased plaque index and soft tissue inflammation that may occurred in both groups with time. For the same reason, IL-1b was higher with magnetic attachments than locators. The results suggest that inflammatory mediator such as IL-1b may be present in peri-implant crevicular fluid even though bleeding index did not significantly increased with time.

In this study, both vertical (VBL) and horizontal (HBLO) peri-implant bone loss were evaluated because the peri-implant crater shaped defect resulted from crestal bone loss had both vertical and horizontal dimensions. Evaluation of both vertical and horizontal bone loss was used in several studies (22, 24, 34, 35). Vertical bone loss and HBLO increased significantly with time for both groups. The increased bone loss may be due to bone response after immediate prosthesis loading, which is attributed to healing and reorganisation combined with function stresses (36). The forces acting on two unsplinted implants supporting overdentures increase the magnitude of the bending moment due to prosthesis movement with subsequent increase in bone turnover (5). Akca *et al.* (37) reported that early mechanical environment in bone around implants might impair the initial healing when two unsplinted implants are planned to support immediately loaded mandibular overdentures. However, the mean bone loss after 1 year for both groups remains in the normal range of values reported in literature (1 mm in the first year) (38, 39).

Locators were associated with significant higher VBL than magnets after 1 year. This may be explained by the difference in movements provided by each attachment. The dual retention property of locator attachment, which comes from friction between the inner and outer surface together with limited lateral and hinge movement (40), may be responsible for transferring more moment loads to the implant, thus contributing to increased bone loss. In line with this explanation, Celik & Uludag (41) noted greater peri-implant stresses with Locator when compared to ball and bar attachments used for three implants supporting mandibular overdenture. On the other hand, magnetic attachment provides unrestricted lateral movement and excellent force transfer characteristics (8, 14). Magnetic attachment exerts slight moment loading of implant which may be partly explained by the denture shift upon load application in the chewing area (5).

Bone loss (vertical and horizontal) showed a significant positive correlation with probing depth. In line with this observation, Quirynen *et al.* (42) reported positive correlations between bone levels recorded on radiographs and the extent of peri-implant probe penetration. The absence of correlations between other clinical parameters and bone loss suggests that these parameters are of limited clinical value in assessing and predicting future peri-implant bone loss.

Conclusion

Within the limitation of this study regarding the short follow-up time and the relatively small sample size, it could be concluded that Locator attachments for immediate loaded implants retaining mandibular overdentures are associated with decreased plaque accumulation, decreased implant stability, decreased inter leukin-1β concentration in peri-implant crevicular fluid and increased per-implant vertical bone loss compared to magnetic attachments after 1 year.

Conflict of interest

None declared. The study was self-funded by the authors.

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