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COMPARISON OF MARGINAL BONE LOSS IN CONICAL, CYLINDRICAL, AND PASSIVELY INSERTED PRESS-FIT DENTAL IMPLANTS DURING THE FIRST 3 MONTHS OF OSSEOINTEGRATION

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ABSTRACT

Background and Aim: This study investigated the effects of implant macrodesign on early marginal bone loss (MBL), a key predictor of implant longevity.

Materials and Methods: The MBL values of Bego Semandos® (Group I: conical), Straumann BL® – SLA modified surface (Group II: cylindrical), and I-System (Group III: press-fit) implants were measured on postoperative 3 months cone beam computed tomographic images at 6 points of each implant. The "total MBL" for each implant was calculated by averaging MBL at 6 points. The buccal and lingual MBL values were determined by averaging the measurements at 3 points on each side.

Results: A total of 57 implants were analyzed. No significant differences were observed in the average total MBL values between groups ($p>0.05$). The cylindrical implants showed significantly higher buccal MBL (0.30 ± 0.22 mm) than lingual MBL (0.17 ± 0.37 mm) ($p=0.048$). The conical and cylindrical implants exhibited insignificantly higher total MBL in the maxilla and mandible, respectively ($p>0.05$). Conical implants had an insignificantly higher total MBL in the anterior region than that in the posterior region ($p>0.05$).

Conclusions: Cylindrical implants may be avoided in alveolar crests with higher buccal resorption, to prevent early buccal MBL. Cylindrical and conical implant placements should be preferred in the maxilla and mandible, respectively, with proper countersinking. Cylindrical implants may minimize the early MBL in the anterior region. Although implant macrodesigns do not significantly differ in average total MBL levels, passive press-fit implants may ensure more homogeneous early MBL across both jaws and regions.

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INTRODUCTION

Dental implants are the most common tools used to replace missed teeth in contemporary dentistry. Long–term success of implants depends on oral hygiene status, smoking status, immunocompromised status, surgical technique, biocompatibility of the material, surface characteristics, macrodesign, and bone and gingiva quality and quantity. Furthermore, excellent osseointegration is the initial step in achieving long–term uneventful function.[1]

Excessive marginal bone loss (MBL) within the first 3 months indicates suboptimal osseointegration. An MBL of 0.45–0.86 millimeters is estimated during the first 3 months of osseointegration.[2,3] An initial MBL higher than the normal range ensures progressive peri–implantitis, resulting in early implant failure.[4] The existence of diabetes, an insertion torque of more than 40 Newton or less than 20 Newton, and early reopening of the implant for healing cap installation were risk factors for MBL.[2] Share stress is commonly responsible for the excessive peri–implant bone loss.[5] However, the macrodesign that lessens the share stress and alleviates MBL in the first 3 months of osseointegration has not been broadly revealed.

The present study was designed to determine whether the macrodesign of dental implants affects early MBL. For this purpose, the MBL amounts of conical, cylindrical, and passive press-fit implants were compared for the first 3 months of the osseointegration period. The null hypothesis posited the absence of any statistically significant difference among the average MBL values of the different implant macrodesigns.

MATERIALS AND METHODS

The present retrospective study was conducted in accordance with the STROBE guidelines with the approval of the Non-Interventional Clinical Research Ethics Committee of Hacettepe University (approval no: 2024/14–28), following the Declaration of Helsinki on Medical Research on Human Subjects.

The primary outcome is the average MBL values of the implants. The sample size was determined using G*Power version 3.1.9.7 software (Heinrich Heine University, Düsseldorf, Germany) at a significance level of 0.05 and an effect size of 0.71, with a statistical power of 95%. The effect size was established based on a previous study.[6]

The research was conducted on 3 months postoperative Cone Beam Computed Tomography (CBCT) images of patients who underwent dental implant surgery using Bego Semandos® (BEGO GmbH & Co. KG, Bremen, Germany) (Group I: conical macrodesign), Straumann BL® – SLA modified surface (Institut Straumann AG, Basel, Switzerland) (Group II: cylindrical macrodesign), and I-System (Novodent SA, Yverdon Les Bains, Switzerland) (Group III: press-fit macrodesign) implants at Hacettepe University, Faculty of Dentistry, Department of Oral and Maxillofacial Surgery between 01/01/2018 and 01/08/2024. Patients with high-risk cardiovascular and pulmonary diseases, smoking habit, an immunocompromised status such as a history of organ transplantation, malignancy, chemotherapy, radiotherapy, corticosteroid usage, antimetabolite agent intake, uncontrolled diabetes, pregnancy, lactation, oral contraceptive intake, and bone augmentation at the implant site were excluded from the study. Groups I and II had dental implants that required some degree of primary stabilization force during insertion (active implants), while group III did not (passive implant).

All dental implants were placed following the proper drilling procedure, in accordance with each firm's placement protocol. The coronal margin of each implant was placed at the same level as that of the alveolar crest. All implants were inserted by the 2-stage and delayed placement protocols following tooth extraction, and the soft tissues were primarily closed using 3.0 silk material (Doğsan Medical Materials Co., Trabzon, Turkey) after the placement of cover screws. All patients received 500 mg amoxicillin tablets (Largopen®, Bilim İlaç San. Tic. Aş., İstanbul, Turkey) 3 times daily, 550 mg naproxen sodium tablets (Apranax Fort®, Abdi İbrahim İlaç San. Tic. Aş., İstanbul, Turkey) twice daily, and 0.12% chlorhexidine mouthwash (Andorex®, Humanis Sağlık Aş., İstanbul, Turkey) 3 times daily for 7 days postoperatively. Patients allergic to penicillin were administered 150 mg clindamycin tablets twice daily. Following a 3 months healing period, the osseointegration status of the implants was examined using CBCT image acquisition before prosthetic loading.

All CBCT images were acquired using the i-CAT Next Generation system (Imaging Sciences International, Hatfield, PA, USA). To ensure uniformity, a laser beam was used to standardize the head positions of all patients. The CBCT device had the following technical specifications: tube voltage of 120 kVp, tube current of 5 mA, pulsed radiation exposure time of 7 seconds, voxel sizes of 0.125 mm (for 8x8 cm and 16x4 cm), and Field of Views of 0.20 mm and 0.25 mm.

All measurements were performed by the same practitioner on the 3 months postoperative CBCT images using the CS 3D Imaging (version 3.8.6) software (Carestream Dental LLC, Atlanta, USA). To calculate the MBL values, 3 cross-sections passing through the midline; 1.2 mm distal and mesial of the midline were used for each implant. For each section, a line that passed from the midpoint of the apex to the midpoint of the coronal margin of the implant was determined as the mid-axis of each implant. A line perpendicular to the mid–axis was drawn on the coronal margin of the implants and was described as an implant coronal marginal line. The perpendicular distances of the adjacent marginal bone to the coronal marginal line on the buccal and lingual aspects of the implants were measured on the aforementioned 3 CBCT image sections for each implant (Figure 1). The average MBL at the six points was determined as the total MBL value of each implant. For each implant, buccal and lingual MBL values were calculated by determining the mean MBL measurements at 3 points on the buccal and lingual sides, respectively. Total MBL values were compared between the groups. Buccal and lingual MBL values were statistically compared within groups to reveal the marginal bone loss pattern of each macrodesign. The total MBL values of the implants inserted in the maxilla and mandible were compared within groups to reveal the osseointegration performance of each macrodesign in the different jaws. The total MBL values of the implants inserted in the anterior (teeth 1, 2, and 3) and posterior (teeth 4, 5, 6, and 7) regions were statistically compared within groups to reveal the osseointegration performance of each macrodesign in different locations.

To evaluate intra–examiner reliability, a one–way interclass correlation coefficient (ICC) model was used in a confidence interval of 95%. The same examiner performed measurements on 15 randomly selected implants twice, with a 3-week interval between measurements. The correlation coefficients for both assessments ranged from 0.942 to 0.981. The interclass correlation coefficient (ICC) exhibited excellent reliability (ICC = 0.962 ± 0.012; 95% confidence interval, CI).

Non-parametric tests were applied because of the non–normally distributed data according to the Shapiro–Wilk test. Descriptive statistics are reported in terms of median and interquartile range (iqr). The variables within groups were statistically compared using the Wilcoxon signed-rank test. The variables among the groups were statistically compared using the Kruskal Wallis test and the Dunn's post hoc test. In all assessments, statistical significance was determined at $p<0.05$. Analyses were performed using the SPSS version 21 software (IBM Co., Armonk, NY, USA).

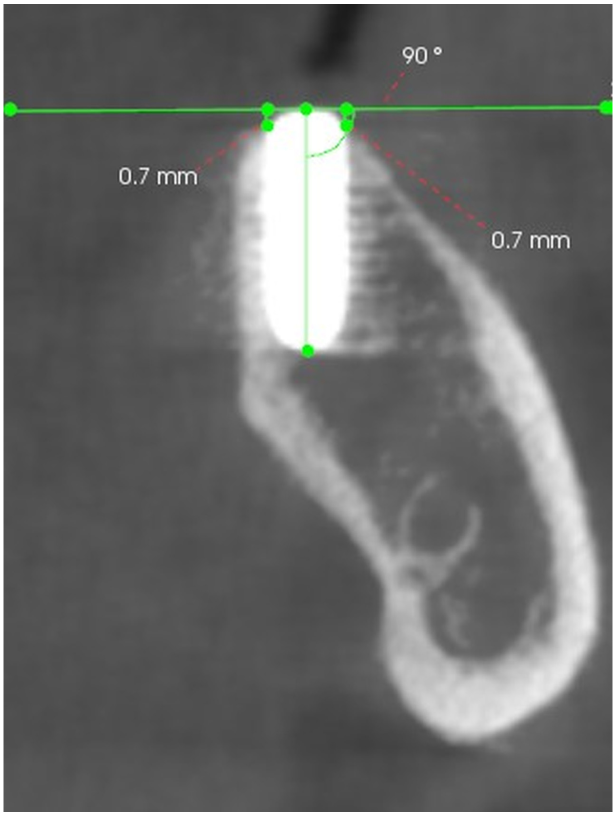

Figure 1. Assessment of buccal and lingual marginal bone loss using the CBCT cross-section intersecting the implant's midline in group II.

RESULTS

Three implants in 3 patients were excluded from groups I (1 implant in 1 patient because of failure), II (1 implant in 1 patient because of subcrestal placement), and III (1 implant in 1 patient because of subcrestal placement). A total of 57 dental implants were included in the study, which were inserted in 14 patients (4 males, 10 females; median age: 54.50; iqr of age: 24.25; age-range: 32 – 73 years). Groups I, II, and III each had 19 implants. The median of the diameter and length of the implants in groups I, II, and III were 4.10 – 10.00, 4.10 – 10.00, and 4.00 – 8.00 mm, respectively. No significant differences were observed in the diameter and length values of the groups.

The median and iqr total MBL value for all implants was 0.21 and 0.40 mm. The median total marginal bone loss values of groups I, II, and III are shown in Table 1. No significant difference was observed among the total marginal bone loss values of groups I, II, and III.

The median buccal and lingual MBL values of groups I, II, and III are shown in Table 2. In group II, buccal MBL values were significantly higher than the lingual MBL values (P = 0.048). The median total MBL values of the implants inserted in the mandible and maxilla in groups I, II, and III are shown in Table 3. No significant difference was found between the total MBL values of the implants inserted in the mandible and maxilla in groups I, II, and III.

The mean total MBL values of the implants inserted at the anterior and posterior locations are shown in Table 4. No significant difference was found between the total MBL values of the implants inserted in the anterior and posterior locations in groups I, II, and III.

DISCUSSION

MBL occurs between 1.06 and 1.22 mm in the first 12 months of osseointegration of the dental implants.[7,8] In the following years, the amount of bone resorption stabilizes to an average of 0.1 mm per year. More than 50% of the MBL during the first 12 months of osseointegration occurs in the first 3 months of healing.[9] This outcome makes the first 3 months of implant osseointegration vital for long–term success. To achieve ideal healing with minimal bone resorption, the osseointegration performance of different implant macrodesigns should be investigated in detail. The present study revealed that conical, cylindrical, and passive press–fit implant designs did not have significantly different total MBL values during the first 3 months of osseointegration. The results are coherent to the outcomes of Su YH et al.[10] that reveals conical and cylindrical implants do not have significantly different MBL in the first 3 months of healing. However, a comparison of the MBL of press–fit passive implants with active conical or cylindrical implants is lacking in the literature. The present study proves that the press–fit implant design does not significantly reduce MBL values in the first 3 months of osseointegration compared to active conical or cylindrical implants.

When MBL patterns of different implant macrodesigns were compared, only cylindrical implants had significantly higher resorption values on the buccal side in the present study. In the literature, when a cylindrical implant was immediately inserted to the socket following tooth extraction, MBL was observed significantly higher in the buccal side coherent to the present study.[11] Implants are placed in a more palatal location and have a larger gap on the buccal side between the bone and implant in the immediate insertion protocol. This may have caused higher buccal bone resorption during the immediate insertion of cylindrical implants. The present study proves that early resorption of the buccal alveolar bone occurs significantly higher than that of the lingual bone, even though the implants are inserted into the alveolar crest in a more central position for the delayed placement protocol. A thick cortical bone provides higher resistance to resorption in peri–implant area.[12,13] It has been shown that cortical bone thickness is higher on the lingual side of the mandible and maxilla.[14] Hence, this could be the reason for the significantly higher resistance to resorption in the lingual bone during the osseointegration period of the cylindrical implants in the present study.

Even though existence of proportionally higher cortical bone provides lesser dental implant failure rates in long term,[15] it causes more MBL than bone tissues with a higher spongiosa component.[16,17] Higher cortical bone existence generates higher insertion torque values.[18] A higher insertion torque was responsible for the increased early MBL.[19,20] In the present study, conical and cylindrical implants generated higher MBL in the maxilla and mandible, respectively, although the differences between the jaws were insignificant in each macrodesign. For conical implants, the surgical site preparation process for all mandibular implants was finalized with marginal cortical bone preparation using proper countersink drills in accordance with the instructions provided by the manufacturer. However, this procedure was not performed for cylindrical implants inserted in the mandible and maxilla if the insertion torque did not exceed 40 N. Countersinking may provide placement of conical implants with ideal insertion torque values, which could be the reason for the insignificantly lower MBL values of the conical implants inserted in the mandible. Higher cortical bone existence without a countersinking procedure could be the reason for the insignificantly higher MBL value for cylindrical implants inserted in the mandible.

While several studies have revealed that dental implants inserted in the posterior region have significantly higher early MBL levels than those in the anterior region,[21] others have shown that there is no significant difference between the early MBL levels of implants inserted in the posterior and anterior regions.[22] The present study revealed that conical implants have insignificantly more MBL in the anterior region than in the posterior region. Maxillary and mandibular anterior regions have thinner cortical and cancellous bone than the posterior regions of the jaws.[23,24] Furthermore, anterior regions of the jaw have more cortical components,

Table 1. Median total marginal bone loss values of the groups

	Group I	Group II	Group III	Comparison of all Groups (Kruskal Wallis with Dunn's post hoc test) P Value
Median TMBL	0.23 (0.68)	0.20 (0.18)	0.21 (0.41)	0.654

TMBL: Total Marginal Bone Loss, the values were given as median (interquartile range)

Table 2. Median buccal and lingual marginal bone loss values of the groups

	Group I		Comparison Within Group I (Wilcoxon) *P* Value	Group II		Comparison Within Group II (Wilcoxon) *P* Value	Group III		Comparison Within Group III (Wilcoxon) *P* Value
	Buccal	Lingual		Buccal	Lingual		Buccal	Lingual	
Median MBL	0.00 (0.34)	0.20 (1.02)	0.600	0.27 (0.35)	0.00 (0.24)	0.048*	0.13 (0.62)	0.00 (0.41)	0.087

* $P < 0.05$, MBL: Marginal Bone Loss, the values were given as median (interquartile range)

Table 3. Median marginal bone loss values of the groups for mandible and maxilla

	Group I		Comparison Within Group I (Wilcoxon) *P* Value	Group II		Comparison Within Group II (Wilcoxon) *P* Value	Group III		Comparison Within Group III (Wilcoxon) *P* Value
	Mandible	Maxilla		Mandible	Maxilla		Mandible	Maxilla	
Median TMBL	0.17 (0.20)	0.35 (0.71)	0.109	0.29 (0.17)	0.16 (0.13)	0.104	0.39 (0.58)	0.20 (0.34)	0.715

TMBL: Total Marginal Bone Loss, the values were given as median (interquartile range)

Table 4. Median marginal bone loss values of the groups for posterior and anterior regions

	Group I		Comparison Within Group I (Wilcoxon) *P* Value	Group II		Comparison Within Group II (Wilcoxon) *P* Value	Group III		Comparison Within Group III (Wilcoxon) *P* Value
	Posterior	Anterior		Posterior	Anterior		Posterior	Anterior	
Median TMBL	0.17 (0.64)	0.44 (1.12)	0.225	0.21 (0.14)	0.18 (0.18)	0.484	0.18 (0.41)	0.25 (0.00)	0.655

TMBL: Total Marginal Bone Loss, the values were given as median (interquartile range)

particularly in the mandible.[25] A thin bone with a higher cortical component is a risk factor for early MBL.[26] In light of the present study, a conical implant design may increase the risk of early MBL in anterior regions with narrow alveolar bones and should be avoided in the anterior regions.

In the literature, significantly higher insertion torque and primary stabilization values can be achieved in conical implants than in cylindrical implants.[27] However, higher insertion torque values resulted in significantly higher bone resorption values during osseointegration. Hence, providing optimum osteointegration is a very thin line, and macrodesign of the implants affects osseointegration parameters such as insertion torque and implant stability quotient.[19,20] The present study provides valuable outcomes for choosing different macrodesigns in different jaw locations to achieve ideal osseointegration and reveals that the passive press-fit implant design provides a more homogenous MBL pattern in different jaws, locations, and aspects of the adjacent alveolar bone.

Several studies have revealed that subcrestal placement increases the success of passive implants.[28-30] Subcrestal placement can provide protection from undesired force exposure during osseointegration and can minimize the risk of micromovement that can cause failures. However, crestal placement of passive implants did not significantly increase the failure rate compared with active implants in the present study. The present study did not include any patients who had one– or double–jaw total implant restorations in the passive implant group. Therefore, all patients have an existent occlusion, which could protect the passive implants from destructive forces during the first 3 months of osseointegration. Further studies should be performed to reveal the potential effects of total or partial edentulism on the osseointegration success of passive implants placed at the marginal crest level.

The initial cortical and spongiosa bone thicknesses and the adjacent soft tissue status of the recipient sites were not evaluated prior to implant insertion in the present study. The relationship between implant diameter and MBL was not investigated. Furthermore, the MBL values were not calculated according to the thread design and microsurface characteristics of the implants. A longer observation period could reveal the potential effects of various abutment and prosthesis designs on the MBL and implant longevity. More comprehensive outcomes can be obtained with a larger sample size. Further studies should be performed on the MBL of various implants inserted in regions that have previously undergone bone or soft tissue augmentation using different techniques.

CONCLUSION

Within the limitations of the present study, the use of cylindrical implants can be avoided in alveolar crests with higher existent resorption at the buccal side to prevent progressive MBL in the same aspect. If cylindrical implants are used in the mandible, the minimum adjacent buccal marginal bone thickness may be increased to 2 mm because of the increased risk of buccal bone resorption. Conical and cylindrical implants can be chosen for the mandible and maxilla, respectively, and a countersinking procedure should not be skipped when cylindrical implants are inserted in the mandible to minimize MBL. Cylindrical implants may be administered in the anterior region to minimize early MBL. Passive press-fit implants are not superior to active cylindrical or conical implants in reducing MBL during the osseointegration period.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

ETHICS STATEMENT

The present study was approved by the Non-Interventional Clinical Research Ethics Committee of Hacettepe University (approval no: 2024/14–28).

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