Tooth loss is a common consequence of periodontal disease, extensive caries, endodontic causes, and trauma. Intraosseous dental implants are generally preferred to replace the missing teeth, aiming to restore the function, phonation, and esthetic appearance of the patient.

In order to place an implant in an optimum three-dimensional position, a certain distance from anatomical regions such as maxillary sinuses and the mandibular nerve is required. Since the bone resorption after tooth loss may further decrease the bone volume, placing an implant with standard length may not be possible. In these cases, hard tissue augmentation procedures are generally undertaken. Vertical and horizontal bone augmentation methods, such as guided bone regeneration, sinus elevation, autogenous bone block graft, and distraction osteogenesis, have been used for such purposes with varying success rates.

In 1980, Boyne and James demonstrated a surgical approach, lateral sinus floor elevation, to increase the vertical dimensions in the posterior maxilla in patients.
with insufficient residual bone height. In the original method, the lateral sinus wall was used to approach the sinus, which was augmented using autogenous bone graft harvested from the iliac crest. The osteotome sinus floor elevation technique was then introduced as a single-stage less-invasive surgical technique and as a two-stage method for cases with residual bone height < 6 mm because of difficulty in achieving sufficient primary implant stability. Even though augmenting the atrophic posterior maxilla using either method became predictable surgical methods, these procedures need a long treatment time, require a high level of surgical skill, and are not cost-effective. On the other hand, significant complication risks, such as sinus perforation, edema and hematoma formation, acute/chronic infections, and oroantral fistula formation, are evident.

During the past decades, improvement in micro and macro characteristics of dental implants made it possible to produce implants with lengths down to 4 mm. Even though there is not an exact definition, short implants are generally used for implants < 8 mm, and other studies describe implants < 7 mm as extra-short implants. Short and extra-short implants have been used in many clinical situations to overcome the complications observed during the hard tissue augmentation procedures and to decrease the cost for the patient. A recent meta-analysis concluded that short implant placement alone was superior to regular implants placed in combination with lateral sinus floor elevation in patients with residual bone heights between 4 and 8 mm during a follow-up between 6 months and 5 years postloading. Furthermore, lateral sinus floor elevation in this patient group was not a suitable treatment option because of the high cost and the rate of complications observed. Meta-analyses and systematic reviews show that the clinical outcome of extra-short implants is comparable to that of regular implants alone or with vertical bone augmentation, and implants between 6.5 and 8.5 mm in length placed with osteotome sinus floor elevation provide similar outcomes compared with standard-length implants; however, it is still unknown whether extra-short implants placed in combination with osteotome sinus floor elevation in patients with insufficient residual bone height would result in comparable outcomes to those obtained with extra-short implants or regular implants alone.

The authors hypothesize that similar changes in crestal bone levels are observed around extra-short implants placed in conjunction with osteotome sinus floor elevation and around extra-short implants and regular implants placed in native bone. Therefore, the aim of the present study was to evaluate the radiographic and clinical outcomes of extra-short implants placed either with or without osteotome sinus floor elevation and to compare the results obtained with regular implants used to treat the edentulous posterior maxilla.

MATERIALS AND METHODS

Study Population
Systemically healthy, nonsmoker patients referred to Ege University, School of Dentistry, Department of Periodontology complaining of problems related to tooth loss in the posterior maxilla were included in the study. The inclusion criteria were as follows: > 30 years of age, having at least one tooth gap in the posterior maxilla with vestibule-oral alveolar crest width ≥ 6 mm; natural dentition or fixed prosthesis in the opposing arches of the surgical site; having at least 6 mm vertical space for the prosthetic reconstruction; and preferring implant-supported porcelain-fused-to-metal crowns as the treatment option. Current smokers, patients taking medications that can affect the bone metabolism or that have a negative effect on the postoperative healing process; patients with active periodontal disease, mucocutaneous diseases, sinus pathology/allergy, or history of any surgery in the edentulous area and in the sinuses; and patients who were edentulous for less than 1 year were excluded. It was calculated before the study that an effect size of 0.4 with alpha error of .05 and power of 80% for the three groups required a total of 63 implants, and in order to compensate for the dropouts, +25% implants were added.

The surgical plan was to place an extra-short implant (4 to 6 mm) with osteotome sinus floor elevation in areas with residual bone height < 4 mm, an extra-short implant alone where the residual bone height was between 4 and 7 mm, and a regular implant (8 to 10 mm) for areas ≥ 8 mm. All the treatment possibilities, including removable and fixed partial dentures, one-stage or two-stage hard tissue augmentation procedures, followed by regular implant placement were explained in detail to all participants. The study protocol complied with ethical principles, including the World Medical Association's Declaration of Helsinki, as revised in 2008, and the ethical approval was provided by the Ethics Committee of Ege University, School of Dentistry (No:16-2/1). Eligible individuals signed an informed consent statement, and the study protocol was initiated.

Preoperative Procedures
Oral, dental, periodontal, and endodontic health status of each individual was carefully examined clinically and radiologically on the orthopantomograms. Based on the initial periodontal status, the patients received...
either supragingival scaling and/or oral hygiene instructions. All the dental and endodontic pathologies were also treated, and the patients were recalled for examination 2 to 4 weeks after the final treatment session. The implant surgery was scheduled only when an optimum level of oral hygiene was maintained (full-mouth plaque and full-mouth bleeding scores < 15%). Probing pocket depths, clinical attachment levels, and full-mouth plaque and full-mouth bleeding scores of the dentition were evaluated, the impressions were taken, and acrylic stents were fabricated to facilitate correct positioning of the implants. All the implant sites and the lengths of the implants were decided preoperatively.

**Implant Surgery**

The surgical protocol was carried out by the same experienced surgeon (Ö.G.) following the surgical steps strictly. The surgical area was anesthetized using 2% lidocaine with 1:100,000 epinephrine using infiltration anesthesia. The soft tissue thickness over the alveolar crest corresponding to the center point of the implant site was evaluated by bone sounding using a sharp probe and an elastic endodontic stopper. The probe was pushed into the soft tissue until it reached the alveolar crest, and the position was marked with the elastic stopper. The probe was then gently removed, and the distance between the tip of the probe and the stopper was measured with a periodontal probe (UNC 15 Probe, Hu-Friedy) and rounded up to the nearest 0.5 mm.

A midcrestal incision was placed along the edentulous area and followed with sulcular incisions on neighboring teeth using a 15C blade (Swann-Morton). If there was a missing tooth on the distal aspect, 5- to 6-mm-long vertical releasing incisions were placed both on the vestibular and palatal sides. Underlying alveolar crest was minimally exposed by elevating a full-thickness flap, and the surgical stent was then used to mark the implant areas.

In the regular implant and extra-short implant groups, the first osteotomy depth slightly exceeded (0.5 to 1.0 mm) the length of the implant using a pilot drill at 600 rpm under saline cooling. Latch reamers at < 50 rpm and without irrigation were then used to enlarge the osteotomy. After reaching the final width corresponding to the same diameter of the implant, the implant sites were carefully rinsed with saline (0.9% NaCl), and press-fit implants (i-system implants, Novodent) were placed approximately 0.5 to 1 mm below the mesial and distal borders of the osteotomies. Polyether ether ketone (PEEK) covered plugs were then placed to seal the implant wells.

In the extra-short implant + osteotome sinus floor elevation group, a 1- to 2-mm-deep osteotomy was prepared and enlarged with the latch reamers, similar to the other groups. When the final diameter was reached, a slight vertical force was applied to deepen the osteotomy with the same diameter i-reamer at 30 rpm and without irrigation. The i-reamer has a specifically designed tip that slowly deepens the osteotomy and collects autogenous bone particles, and when it touches cortical bone, such as the maxillary sinus floor, the efficacy of the drill decreases and provides tactile sensation to the practitioner. After each millimeter of deepening, the sinus floor was checked visually, and when the cortical bone was visible, or sinus membrane was partially exposed, sinus osteotomes at the same diameter were gently tapped with a manual mallet until a greenstick fracture was formed on the sinus floor. If the sinus floor resisted the tapping force, the osteotomy was slightly deepened, and the procedure was repeated until the sinus membrane was elevated approximately 2 to 3 mm. The sinus membrane integrity was confirmed with Valsalva maneuver, and rehydrated inorganic bovine bone particles < 1 mm³ (Zoe Step Biomaterials) were slightly inserted. A PEEK sinus cap was placed into the implant well extraorally and pushed into the osteotomy until the sinus cap touched the alveolar crest. If a dead space was formed under the sinus cap depending on the anatomy of the alveolar crest, particularly when an even surface was not present, sharp scissors were used to remove that portion of the cap. All the surgical steps for the implant placement were in line with the manufacturer’s instructions.

Periosteal incisions were placed to eliminate the flap tension and to provide primary wound closure using 4-0 PTFE sutures (Golnitr).

**Postoperative Procedures**

All the patients received antibiotics 1 hour before the surgery and for 5 days postoperatively (amoxicillin and clavulanic acid, BID 2 g preoperatively and 1 g postoperatively). Patients were instructed to keep the surgical area out of function and to brush the neighboring teeth with a soft dental brush (GUM Delicate Post-surgical toothbrush, Sunstar Americas). The surgical field was evaluated on the fifth day, and the sutures were removed on the 10th day. Patients were then seen weekly by the end of the first month and monthly thereafter until the implants were uncovered at the fourth month. The prosthetic stage was initiated 1 month after the stage-two surgery, and porcelain-fused-to-metal crowns with a porcelain thickness of 1 mm on the occlusal surface were fabricated. The patients were then recalled every sixth month for evaluation during the follow-up.

**Follow-up Measurements**

Probing pocket depth, clinical attachment level, full-mouth plaque score, and full-mouth bleeding score
measurements were repeated 6 and 18 months postloading. Standardized periapical radiographs were taken using a film holder (Endo-Bite) and a phosphorus plate (Sorodex) at baseline (on the day of loading) and repeated at 6 and 18 months postloading. All the radiographs were taken by the same examiner (M.E.K.) using the long-cone parallel technique and standardized exposure times (60 kV, 7 mA, 0.125 seconds). The radiographs were saved as high-resolution digital images using random numbers for naming. Implant apex, implant-abutment interface, first bone-to-implant contact on the mesial and distal sides, implant diameter, implant length, and relative crown length were marked over each image by linear lines (Fig 1). The images were then analyzed by image analysis software (ImageJ for Windows, National Institutes of Health). The length or the diameter of each implant was used for image calibration and to transform the image pixels into millimeters. The repeatability of the digital measurements was tested using the first 15 radiographs, which were analyzed twice with at least 5-day intervals (Cohen’s Kappa 0.90, data not shown).

Crestal bone levels were measured as the dimensions between the first bone-to-implant contact and the implant-abutment interface on the mesial and distal aspects, and the mean value for each implant was calculated. The changes in crestal bone levels between the two evaluation time points were calculated by subtracting the earlier crestal bone level measurement from the later follow-up measurement, and therefore, the positive values indicated the crestal bone loss and the negative values indicated the bone gain between the calculated time points. Since all the crowns had 1 mm porcelain thickness on the occlusal surface, the crown length was calculated by adding 1 mm to the relative crown length. The crown-to-implant ratio was the value of crown length/implant length, and the sinus elevation amount in the osteotome sinus floor elevation group was the difference between the baseline residual bone height value and the follow-up measurement.

Statistical Analyses
A statistical software package (GraphPad Prism version 8.0.0 for Mac OS X, GraphPad Software) was used for the analyses of whole data and for calculation of the mean and standard deviations. The distribution of all parameters was validated using the D’Agostino-Pearson omnibus normality test. The differences between the groups for patient age, implant length and diameter, crestal bone level and crestal bone level change, residual bone height, crown length, soft tissue thickness, and crown-to-implant ratio were compared using mixed-effect analysis, with the Geisser-Greenhouse correction and Tukey’s multiple comparison test, with individual variances computed for each comparison. Within-group comparisons were done by repeated-measures one-way analysis of variance (ANOVA) test, and Tukey’s multiple comparisons test was used for the pairwise comparisons. Correlations between the radiographic findings, implant and prosthetic variables, crestal bone level, and crestal bone level change values were evaluated by Pearson correlation test using the pooled data obtained from extra-short implant and regular implant groups, which shared the same interventions. A significance level of α = .05 was accepted in all the statistical tests.

RESULTS
A total of 30 patients (15 men, 15 women, age range: 30 to 73 years) were included in the study, and all the patients finalized the study protocol. Mean probing pocket depth and clinical attachment values were < 2 mm, and full-mouth bleeding and plaque scores were < 15% throughout the study (data not shown). One minor membrane perforation during osteotome sinus floor elevation was detected, but the implant was placed successfully. However, another major perforation prevented the placement of the implant. The extra-short implant + osteotome sinus floor elevation group, extra-short implant group, and regular implant group received 29, 27, and 24 implants, respectively. One implant was excluded because of postoperative infection in the extra-short implant group, two implants were excluded because of nonosseointegration in the extra-short implant + osteotome sinus floor elevation group (both with flap dehiscences over the sinus cap), and one implant was excluded in the regular implant group because of postoperative infection. There were no other biologic and prosthetic
complications during the follow-up period; therefore, 96.3%, 90%, and 95.83% of the implant sites that were planned to receive an implant before the first surgery in the extra-short implant, extra-short implant + osteotome sinus floor elevation, and regular implant groups, respectively, completed the study. The amount of sinus elevation achieved in the extra-short implant + osteotome sinus floor elevation group was 3.38 ± 1.17 mm at the 18th month.

Demographic variables, implant specifications, and site characteristics of the groups are demonstrated in Table 1. Age, sex, implant sites, and crestal bone levels at baseline were similar between all groups. Residual bone height was significantly lower in the extra-short implant and in the extra-short implant + osteotome sinus floor elevation groups compared with the regular implant group (crown length: \( P < .05 \) for both, crown-to-implant ratio: \( P < .001 \) for both, implant length: \( P < .0001 \) for both, and residual bone height: \( P < .01 \) for both, crown length: \( P < .05 \) for both; crown-to-implant ratio: \( P < .001 \) for both).

Crestal bone level values were similar between all groups at baseline and 6 months; however, it was significantly higher in the regular implant group compared with the extra-short implant + osteotome sinus floor elevation group at 18 months (\( P = .028 \)). Crestal bone level in the extra-short implant group was significantly lower at baseline compared with 18 months (\( P = .008 \)), and it was significantly lower in the regular implant group at baseline and 6 months compared with 18 months (\( P < .0001 \) and \( P = .021 \), respectively) (Table 2).

The change in crestal bone levels between baseline to 6 months and baseline to 18 months were similar for all groups (\( P > .05 \)); however, crestal bone level changes between 6 and 18 months were significantly lower in the extra-short implant + osteotome sinus floor

### Table 1  Demographic Variables, Implant Specifications, and Site Characteristics of the Groups at Baseline

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Extra-short implant (n = 26)</th>
<th>Extra-short implant + osteotome sinus floor elevation (n = 27)</th>
<th>Regular implant (n = 23)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>53.00 ± 10.6</td>
<td>50.44 ± 8.46</td>
<td>49.77 ± 11.72</td>
</tr>
<tr>
<td>Male/Female</td>
<td>7/11</td>
<td>10/9</td>
<td>6/7</td>
</tr>
<tr>
<td>Molar/Premolar</td>
<td>10/16</td>
<td>11/16</td>
<td>11/12</td>
</tr>
<tr>
<td>Soft tissue thickness</td>
<td>2.83 ± 0.90</td>
<td>2.63 ± 0.95</td>
<td>2.72 ± 0.90</td>
</tr>
<tr>
<td>Residual bone height</td>
<td>6.47 ± 1.14*</td>
<td>3.23 ± 0.71*</td>
<td>10.90 ± 1.72</td>
</tr>
<tr>
<td>Implant length</td>
<td>5.31 ± 0.79†</td>
<td>5.33 ± 0.734†</td>
<td>8.52 ± 0.90</td>
</tr>
<tr>
<td>Implant diameter</td>
<td>5.21 ± 0.64†</td>
<td>5.15 ± 0.56†</td>
<td>4.54 ± 0.40</td>
</tr>
<tr>
<td>Crown length</td>
<td>14.64 ± 2.8†</td>
<td>14.21 ± 2.58†</td>
<td>11.88 ± 2.43</td>
</tr>
<tr>
<td>Crown-to-implant ratio</td>
<td>2.84 ± 0.82†</td>
<td>2.75 ± 0.77†</td>
<td>1.41 ± 0.32</td>
</tr>
<tr>
<td>Crestal bone level</td>
<td>0.27 ± 0.31</td>
<td>0.32 ± 0.36</td>
<td>0.42 ± 0.40</td>
</tr>
</tbody>
</table>

*Significant difference between groups with extra-short implant + osteotome sinus floor elevation and regular implant groups (\( P < .0001 \) for both).
†Significant difference between groups with extra-short implant and regular implant groups (\( P < .0001 \) for both).
‡Significant difference between groups with regular implant group (implant length: \( P < .0001 \) for both; implant diameter: \( P < .01 \) for both; crown length: \( P < .05 \) for both; crown-to-implant ratio: \( P < .001 \) for both).

### Table 2  Crestal Bone Level and Crestal Bone Level Change in the Study Groups

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Follow-up</th>
<th>Extra-short implant (n = 26)</th>
<th>Extra-short implant + osteotome sinus floor elevation (n = 27)</th>
<th>Regular implant (n = 23)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crestal bone level Baseline</td>
<td>0.27 ± 0.31†</td>
<td>0.32 ± 0.36</td>
<td>0.42 ± 0.40†</td>
<td></td>
</tr>
<tr>
<td>6 mo</td>
<td>0.46 ± 0.45</td>
<td>0.41 ± 0.36</td>
<td>0.64 ± 0.55†</td>
<td></td>
</tr>
<tr>
<td>18 mo</td>
<td>0.54 ± 0.46</td>
<td>0.43 ± 0.35</td>
<td>0.90 ± 0.66*</td>
<td></td>
</tr>
<tr>
<td>Crestal bone level change</td>
<td>0.19 ± 0.44</td>
<td>0.09 ± 0.41</td>
<td>0.21 ± 0.42</td>
<td></td>
</tr>
<tr>
<td>Baseline–6 mo</td>
<td>0.27 ± 0.42</td>
<td>0.11 ± 0.39</td>
<td>0.48 ± 0.51</td>
<td></td>
</tr>
<tr>
<td>6–18 mo</td>
<td>0.08 ± 0.46</td>
<td>0.02 ± 0.29†</td>
<td>0.27 ± 0.46</td>
<td></td>
</tr>
</tbody>
</table>

*Significant difference with extra-short implant + osteotome sinus floor elevation group (\( P = .028 \)).
†Significant difference with regular implant group (\( P = .003 \)).
‡Significant difference within group with 18th month (\( P = .008 \) for extra-short implant; \( P < .0001 \) and \( P = .021 \) for regular implant group for baseline and 6th month, respectively).

All data are presented as mean ± standard deviation (mm).
elevation group compared with the regular implant group ($P = .003$). There was no significant difference in crestal bone level changes within group comparisons in any of the groups and at any of the evaluation time points ($P > .05$) (Table 2).

There was no significant correlation between the crestal bone level, change in crestal bone level and residual bone height, implant length and diameter, crown-to-implant ratio, and crown length ($P > .05$) (data not shown).

**DISCUSSION**

In the present clinical study, the short-term clinical outcome of bone-level extra-short implants (4 to 6 mm) placed either in the native bone or in conjunction with osteotome sinus floor elevation was evaluated for the first time, and the outcomes were compared with each other and regular implants. Previous studies compared extra-short implants placed in pristine bone with regular implants alone, regular implants placed with osteotome sinus floor elevation or lateral sinus floor elevation, and after vertical ridge augmentation, aiming to answer the question of whether extra-short implants can provide similar outcomes to regular implants placed under different clinical scenarios. Furthermore, and in contrast to these studies, the authors of the present study aimed to evaluate the effect of osteotome sinus floor elevation when used with extra-short implants in sites with insufficient residual bone height to place an extra-short implant. Within the limits of the authors’ knowledge, there are no published data so far for bone-level extra-short implants placed with sinus floor elevation, and therefore, the effect of osteotome sinus floor elevation on crestal bone levels and survival rates of extra-short implants were evaluated for the first time in the present study.

Even though the survival rates for implants scheduled for implant placement in the extra-short implant, extra-short implant + osteotome sinus floor elevation, and regular implant groups were 96.3%, 90%, and 95.83%, respectively, the survival rate for all implants after loading was 100%. The survival rates of the implants in the extra-short implant and regular implant groups in the present study are in line with a recent meta-analysis that reported 96.69% and 97.5% individual survival rates for the extra-short and long implants, respectively. Although not significant, the lowest success rate was in the extra-short implant + osteotome sinus floor elevation group, in which two implants were not osseointegrated, probably because of the graft material used and/or because of the dehiscence formation caused by the sinus caps, which could have affected the vascularization of the overlaying flaps during the early healing period. It is more likely that the flap dehiscence was the main cause since there were no other failures in primary healed sites in the same group. Therefore, primary wound healing seems to be important in decreasing the failure rate of extra-short implants placed with osteotome sinus floor elevation. In a study by Taschieri et al., implants between 6.5 and 8.5 mm were defined as “short” and placed using osteotome sinus floor elevation and pure platelet-rich plasma and compared with standard-length implants up to 5 years. The authors reported a similar outcome for the study groups and recommended the use of short implants with the osteotome sinus floor elevation technique for the rehabilitation of the atrophic posterior maxilla. In the present study, extra-short implant placement with osteotome sinus floor elevation resulted in similar clinical and radiographic outcomes for 18 months and was reported for the first time. Even though the results of the present study cannot be compared with those of Taschieri et al. due to the differences in group definitions, it may be suggested that osteotome sinus floor elevation can be a treatment option in areas where the residual bone height is not sufficient to accommodate a short or extra-short implant alone.

In the present study, residual bone heights for the extra-short implant and extra-short implant + osteotome sinus floor elevation groups were $6.47 \pm 1.14$ mm and $3.23 \pm 0.71$ mm, respectively, which were far below the recommended limit of 8 mm to perform a sinus floor elevation procedure. Contrary to that recommendation, the residual bone heights in sites of both extra-short implant groups were < 8 mm, and all areas with residual bone height < 4 mm received an extra-short implant with osteotome sinus floor elevation, except one area with a major membrane perforation, and the patients were successfully treated in the present study. In line with the previously published data, the current findings may suggest that sinus floor elevation may not be necessary in sites with residual bone height < 8 mm as recommended previously, and osteotome sinus floor elevation can be used with extra-short implants to treat the implant sites with residual bone height < 4 mm.

It was currently reported by Santoro and Pippi that the mean intrasinus bone gain after 3 years of osteotome sinus floor elevation was 4.24 mm when grafting materials were used. The amount of sinus elevation achieved at 18 months in the present study, however, was $3.38 \pm 1.17$ mm and was lower than reported previously, probably because the extra-short implants needed a limited amount of sinus floor elevation where the mean baseline residual bone height was $3.23 \pm 0.71$ mm. Taken together with the reported intrasinus bone gains after osteotome sinus floor elevation,
it can be suggested that only a residual bone height = 1 mm, or even less, might be sufficient to place an extra-short implant in conjunction with osteotome sinus floor elevation, and the need for the lateral sinus floor elevation technique might be questioned at least for 18 months.

Despite having significantly lower implant lengths and significantly higher crown-to-implant ratios and implant diameters in the extra-short implant groups, significantly higher crestal bone loss was observed in the regular implant group compared with the extra-short implant + osteotome sinus floor elevation group only. These findings may demonstrate that the implant length and diameter, crown-to-implant ratio, residual bone height, and osteotome sinus floor elevation technique alone may not negatively affect the crestal bone levels around the implants, at least in the short term. This assumption is further supported by the nonsignificant correlations between the studied parameters in the present study and by others, who proposed that crown-to-implant ratio did not alter the survival rates and crestal bone level changes around the implants. Finite element studies have demonstrated a reduction in the crestal bone strain when the implant diameter is increased. It has also been reported that implant diameter is more important than implant length in improving the stress distribution. Since the mean diameters of extra-short implants used in the present study were significantly higher than regular implants, the stress could have been distributed without causing biologic complications, even in the presence of high crown-to-implant ratios. On the other hand, the highest crestal bone loss between the two time points in the present study was 0.48 ± 0.51 mm in the regular implant group, which can be accepted as quite low, and therefore, the statistically significant differences both between and within the groups might be clinically irrelevant. It was demonstrated in a recent meta-analysis that implants with soft tissue thickness > 2 mm showed less crestal bone level change, and it was suggested that 2 mm may be the relevant threshold level. The mean soft tissue thickness in all groups in the present study was similar and above that limit, so the soft tissue thickness could have decreased the crestal bone level changes in all the groups.

Quaranta et al compared the total surface area of different implant designs and showed that the macro-characteristics of similar-sized implants may significantly affect the total surface area. Goiato et al evaluated the behavior of six short implants with different thread designs and demonstrated that the stress distributions were not similar. Wilhelm et al investigated the secondary stability of different commercial short implants by measuring the amount of displacements in a self-developed biomechanical hexapod measurement system. Based on the results obtained from 11 implant geometries, the authors concluded that the geometry of the short implants directly affected their stability in bone. Since the macro-characteristics of the commercially available extra-short implants vary widely, the results of the present study may not be applicable and differ for extra-short implants with different geometries, even in similar clinical conditions. It should also be noted that the groups in the present study were not randomly assigned, and the inclusion criteria for each group was dependent on predefined site-specific characteristics, which may not be present in many clinical scenarios. Therefore, the results based on the convenience samples and the short-term follow-up in the present study should not be taken as guidelines for treatment and should be interpreted with caution.

CONCLUSIONS

Bone-level extra-short implants (4 to 6 mm) either placed in native bone or in conjunction with osteotome sinus floor elevation may provide similar clinical and radiographic outcomes, if not better, compared with those obtained using regular implants in the rehabilitation of the edentulous posterior maxilla, at least for 18 months postloading. Implant dimensions, crown length, crown-to-implant ratio, residual bone height, and osteotome sinus floor elevation may not affect the crestal bone level change around extra-short implants, at least in the short term.

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