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Extra-short Implants in Posterior Maxillary Vertical Atrophy with Low Bone Density: A Retrospective Analysis of Cases with Transcrestal Sinus Elevation and Insertion Torque ≤15 Ncm

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ABSTRACT

Objectives: The aim of the present study is to analyze the survival and clinical performance of implants inserted in complex scenarios (≤6,5 mm residual bone height), with reduced insertion torque, using the transcrestal sinus elevation technique.

Materials and Methods: A retrospective review was conducted of patients treated between 2017 and 2020 involving short and extra-short implants (BTI Biotechnology Institute, UnicCa® surface) placed in posterior maxillae with residual bone height ≤6,5 mm and final insertion torque ≤15 N cm. All implants were placed using the biological drilling technique at low speed, with transcrestal sinus elevation and grafting with autologous bone collected during drilling mixed with PRGF-Endoret. A two-stage protocol was followed, with second-stage surgery at 5 months and progressive loading. Radiographic evaluation of marginal bone loss was performed with standardized panoramic radiographs.

Results: Seventeen patients (20 implants) with a mean age of 60.8 years were followed-up for a mean of 5.9 years. No implant failures occurred, yielding 100% survival. Mean marginal bone loss was 0.45 mm mesially and 0.43 mm distally. Correlation between insertion torque and bone loss showed weak, non-significant trends.

Conclusions: Within the limitations of this study, extra-short implants placed with insertion torque ≤15 N cm in posterior maxillae with ≤6,5 mm residual bone height achieved excellent survival and minimal bone loss at medium-term follow-up.

Keywords: Transcrestal sinus elevation, Extra-short implants, Low insertion torque, Posterior maxilla, Marginal bone loss, Bone antropy.

1. Introduction

The rehabilitation of the posterior maxilla, particularly in cases with reduced vertical bone height, represents a considerable clinical challenge in implant dentistry. For decades, the most widely used technique to restore this region with implants has been the lateral sinus lift, generally followed by delayed implant placement after a healing period that allows for the formation of sufficient bone volume (1,2). Subsequently, the considerably less invasive transcrestal (osteotome) sinus elevation technique was developed. In selected cases, this allows for simultaneous implant placement during the same surgical procedure, provided that the residual bone offers adequate primary stability.

It is generally accepted that a minimum residual bone height of 4–5 mm may allow predictable implant placement with the transcrestal approach (3-4), although the exact threshold depends on bone quality, implant design, and the surgeon's technique (5-9).

Advances in implant design and the introduction of short and extra-short implants have expanded the indications for the transcrestal approach, reducing the need for more invasive procedures and minimizing associated morbidity, even in cases of severe vertical atrophy. Increasingly, implants are being placed with transcrestal sinus elevation in sites with progressively lower bone height (10-12). This technique involves accessing the sinus through the crest by preparing a new osteotomy into the sinus floor, detaching the membrane from this site, and inserting a short or extra-short implant, with or without adjunctive graft material, depending on the vertical gain required (13-14). With numerous variations regarding drilling sequences, drill types, and grafting materials, this procedure is now successfully established among the surgical options for the posterior maxilla with limited height (13-15).

One of the main challenges of this procedure is achieving primary stability, particularly in complex situations, such as limited residual bone (<5 mm) or poor bone density. When combined, these conditions represent a clinical borderline scenario (16,17). In such cases, obtaining high insertion torque is difficult and often impossible. The minimum torque required to ensure sufficient stability and prevent harmful micro-movements for osseointegration remains unclear. Some authors have suggested that values around 20 N cm may be appropriate (18-21). However, more recent studies have shown that implants placed with torque below 20 N cm may achieve comparable survival rates and maintain stable marginal bone levels. Clinical and histological investigations have confirmed that implants inserted with low torque can successfully integrate, without significant differences in bone-to-implant contact compared to implants placed with higher torque, provided that biological and biomechanical conditions are respected (22,23).

Nevertheless, international literature documenting the long-term clinical outcomes and survival of implants placed under such unfavorable conditions-low torque and limited residual bone- remains scarce (24-25).

The aim of the present study was therefore to analyze the survival and clinical performance of implants inserted in complex scenarios (≤6,5 mm residual bone height), with reduced insertion torque, using the transcrestal sinus elevation technique.

2. Materials and Methods

A retrospective review was conducted of clinical records of implants placed between the second semester of 2017 and the first semester of 2020. Included cases were short and extra-short implants (Table 1) (BTI Biotechnology Institute, Vitoria, Spain, UnicCa® surface) placed in posterior maxillary sites with vertical bone atrophy, using transcrestal sinus elevation, and achieving a final insertion torque ≤15 N cm.

Before implant placement, all patients underwent pre-operative evaluation including diagnostic casts, intraoral clinical examination, and cone-beam computed tomography (CBCT) analyzed with dedicated software (BTI-Scan II). Bone density was automatically calculated by the planning software as the mean Hounsfield unit (HU) value within the three-dimensional volume occupied by the virtually planned implant in the CBCT section. Antibiotic prophylaxis consisted of 2 g amoxicillin orally one hour prior to surgery, combined with 1 g paracetamol as initial analgesia. Post-operatively, patients continued with 500-750 mg amoxicillin every 8 hours, adjusted for body weight, for a total of five days.

Implant placement was performed using the biological drilling technique, characterized by low-speed drilling without irrigation. The biological drilling technique consisted of low-speed drilling (150-200 rpm) without irrigation to preserve bone viability, following the protocol previously described by Anitua et al. (12,14,29). Sinus floor perforation was completed with a frontal-cutting drill specifically designed for this procedure, which allows removal of the sinus floor while preserving the integrity of the Schneiderian membrane (12-14). After exposing and elevating the membrane via the crestal access, implants were inserted using a surgical motor, with final seating manually completed using a torque wrench to ensure controlled adjustment and measure final torque. Autologous bone collected during drilling, embedded in PRGF-Endoret (BTI Biotechnology Institute, Vitoria, Spain), was used as grafting material for sinus elevation.

Due to low insertion torque, implants were left to heal in a two-stage protocol. After 5 months, second-stage surgery was performed, placing transmucosal abutments to fabricate a splinted screw-retained prosthesis using BTI® Multi-Im® multi-unit abutments. An initial progressive loading prosthesis was fabricated in resin with articulated bar structures, designed in slight infraocclusion, allowing functional, but controlled, load and reducing overload from parafunctions. The final prosthesis, fabricated with a CAD-CAM milled metallic framework veneered with ceramic, was placed between 6–8 months, following a conventional occlusal scheme.

After initial loading, a radiographic follow-up protocol was implemented using serial panoramic radiographs to evaluate peri-implant bone behavior and quantify crestal bone loss over time. Panoramic radiographs were obtained using a digital panoramic unit (Sirona Orthophos XG, Dentsply Sirona, Bensheim, Germany) operating at 70 kV and 8 mA, following the manufacturer's standard exposure protocol. All records were systematically documented in a data collection notebook designed for statistical analysis. The main variables analyzed were implant survival and crestal bone resorption at mesial and distal surfaces.

To ensure reproducibility of radiographs, patient positioning was rigorously standardized: a fixed stabilizer for glabella and chin, a bite block at the incisal region, and alignment of anatomical references with the midline, bipupillary plane, and Frankfurt plane, supported by laser guides. Feet were positioned on fixed floor markers for added stability.

Measurements were performed on digital radiographs calibrated with ImageJ software (v.1.53, NIH, Bethesda, MD, USA), using the known implant length as reference to correct magnification and allow precise linear measurements. Crestal bone loss was determined as the linear distance from the implant shoulder to the first bone-to-implant contact mesially and distally. An independent examiner performed all measurements to minimize bias. The implant was considered the unit of analysis for variables related to location, dimensions, and radiographic parameters, while patient-level variables (age, sex, medical history) were analyzed separately and correlations were evaluated using Pearson's r and Spearman's ρ, with significance set at $p < 0.05$. Normality of data distribution was assessed with the Shapiro-Wilk test. Implant survival was analyzed with the Kaplan-Meier method. Statistical analyses were performed using IBM SPSS Statistics for Mac, version 30.0 (IBM Corp., Armonk, NY, USA).

3. Results

Seventeen patients (12 women, 5 men; mean age = 60.8 ± 12.4 years) received 20 short implants meeting the inclusion criteria. Two patients were smokers (≈5 and 25 cigarettes/day), and two exhibited bruxism (one moderate, one severe) with no other relevant parafunctions observed.

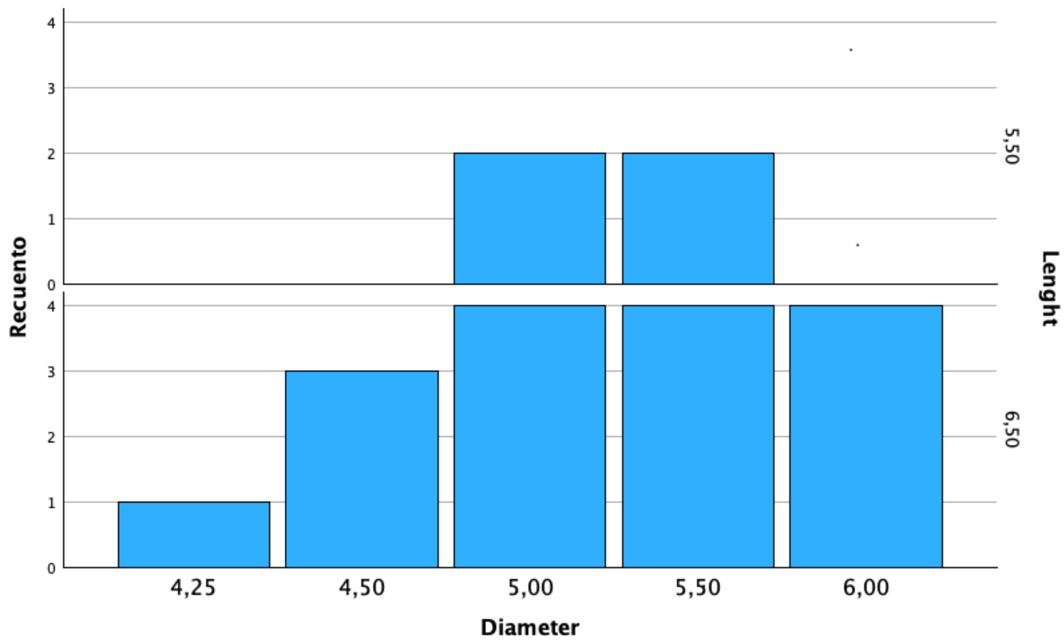

Figure 1: Distribution of implant diameters and lengths included in the study

Mean residual ridge height was 5.76 ± 0.55 mm (range 4.51-6.36 mm). Most implants were placed to replace the maxillary first molar (tooth 26) in 40% of cases, followed by teeth 16, 17, and 27 in 20% each. Implant length was 6.5 mm in 80% of cases and 5.5 mm in 20%. The most frequent diameters were 5.0 mm and 5.5 mm (30% each). Other dimensions are shown in Figure 1.

Mean bone density at implant sites was 260 ± 78.8 Hounsfield units HU. Mean final insertion torque was 10.25 ± 4.43 N cm (range 5–15 N cm). Figure 2 shows mean torque according to implant diameter, length, and bone density.

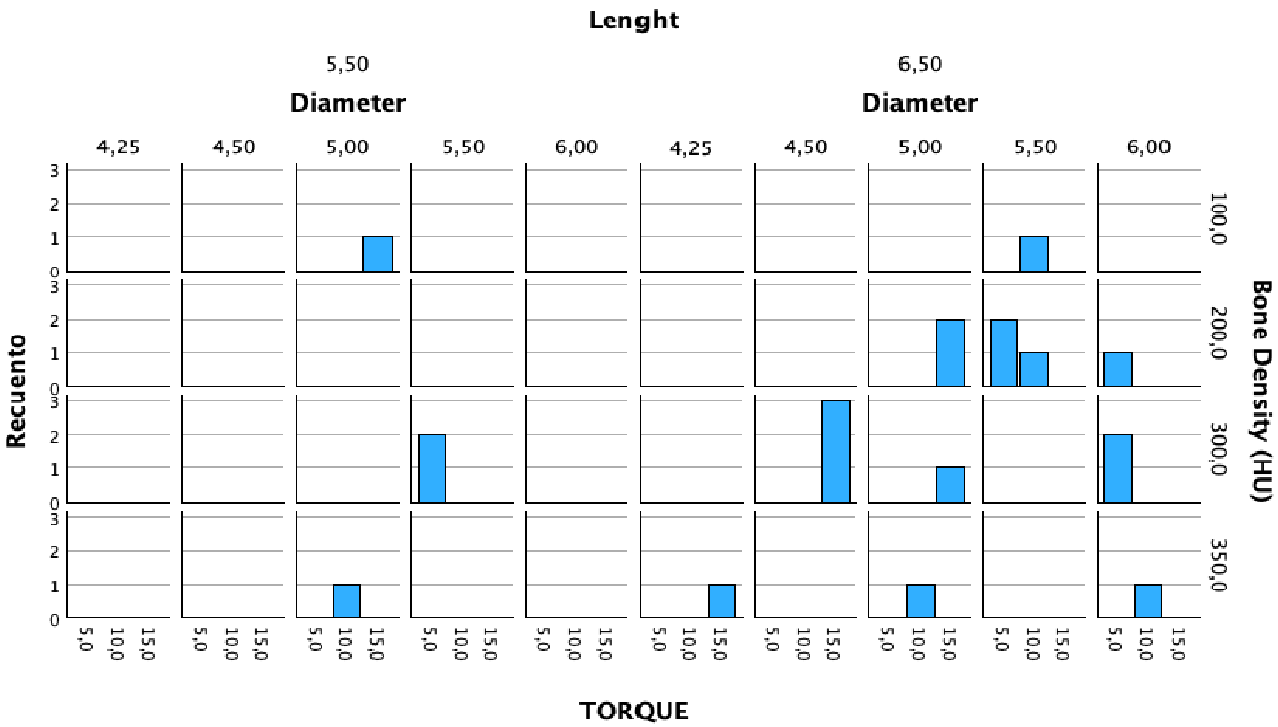

Figure 2: Mean insertion torque for each implant according to diameter, length, and bone density

Patients were followed up for a mean of 5.9 ± 0.75 years (range, 5-7.5 years). No failures were recorded during this period, yielding a survival rate of 100% (95% CI: 85.9-100%). These results should be interpreted with caution, given the limited sample size. All implants were splinted to other implants with slightly higher insertion torque values (20–30 N cm), and prostheses were screw-retained using multiple transepithelial abutments, with progressive loading performed in all cases.

At final follow-up, mean mesial bone loss was 0.45 ± 0.21 mm and mean distal bone loss was 0.43 ± 0.20 mm. Correlation analysis between insertion torque and marginal crestal bone loss revealed no statistically significant associations. For mesial bone loss, Pearson's r = 0.26 (p = 0.27) and Spearman's ρ = 0.28 (p = 0.23); for distal bone loss, r = 0.25 (p = 0.30) and ρ = 0.16 (p = 0.49). When considering mean mesial and distal bone loss, coefficients were slightly higher (r = 0.32; p = 0.17 and ρ = 0.34; p = 0.15), though not statistically significant. Although a weak positive correlation was observed between insertion torque and crestal bone loss (r = 0.32; p = 0.17 and ρ = 0.34; p = 0.15), the association was not statistically significant. These findings suggest a weak positive trend between insertion torque and crestal bone loss, but without sufficient evidence to establish a direct relationship in this sample (Figure 3).

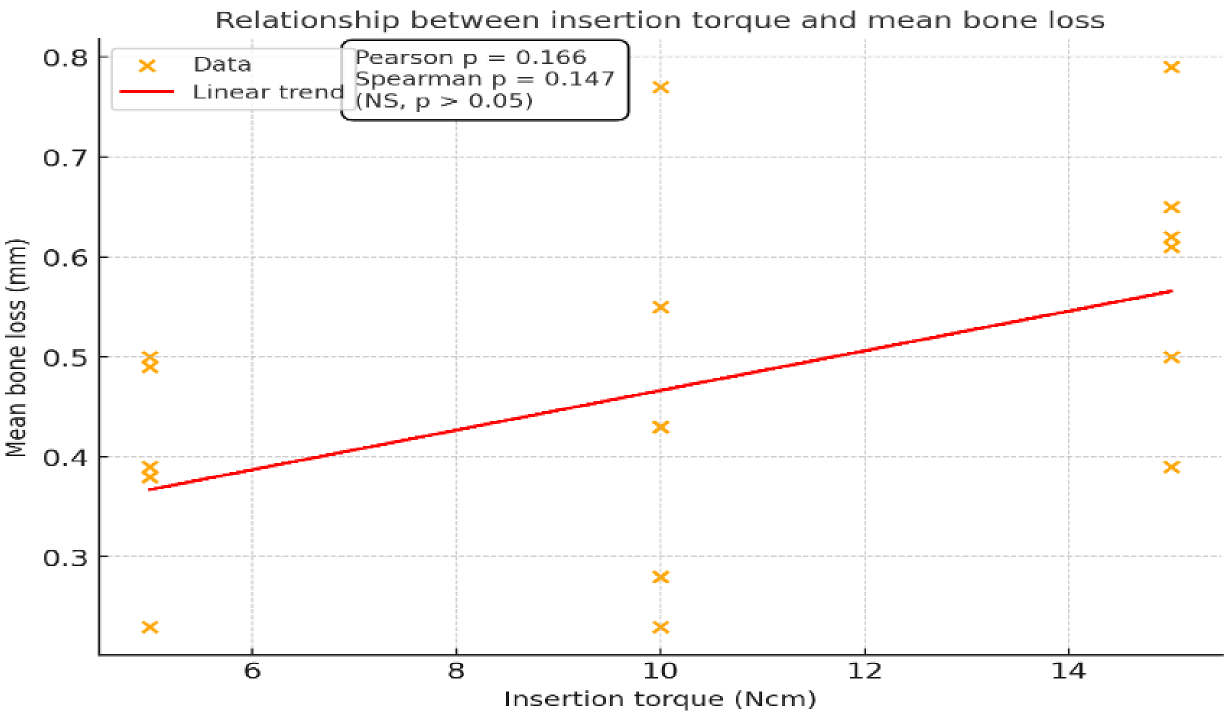

Figure 3: Correlation between insertion torque and marginal bone loss (mesial and distal). A weak positive trend was observed, though not statistically significant

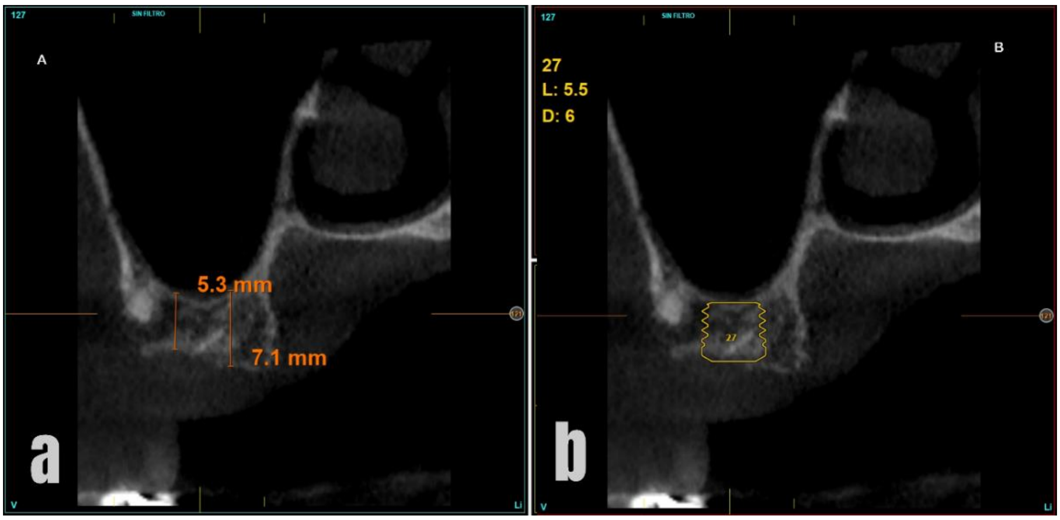

Figure 4: (a) Buccolingual CBCT sections showing alveolar bone measurements and (b) virtual implant planning for a 6-mm-long implant in the maxillary left second molar region

Figure 5: Buccolingual CBCT section demonstrating the 6-mm implant in its pre-planned position

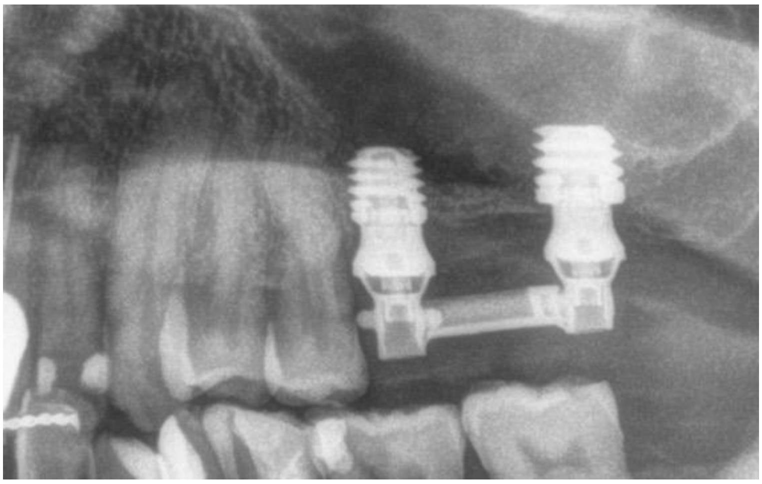

Figure 6: Standardized panoramic radiographic section showing the provisional resin restoration with the articulated bar structure seated on BTI® Multi-Im® multi-unit abutments

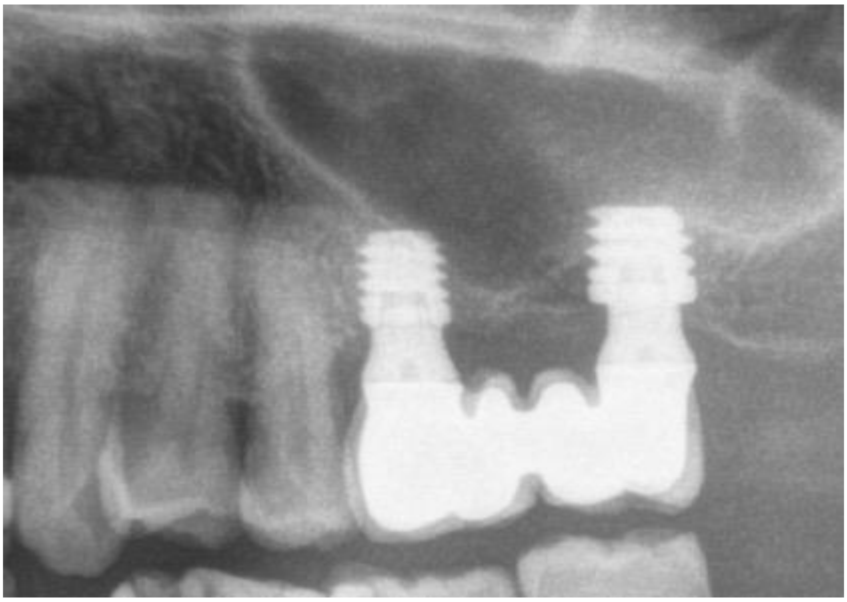

Figure 7: Standardized panoramic radiographic section showing the final metal-ceramic restoration seated on the definitive BTI® Multi-Im® multi-unit abutments

4. Discussion

The results of the present study demonstrate a 100% survival rate after a mean follow-up period of 5-9 years in short and extra-short implants placed in posterior maxillary sites with reduced residual bone height and a mean bone density of 260 HU. This finding is remarkable, considering that primary stability was low (torque values between 5 and 15 N cm, mean 10.25 N cm), a range in which the literature usually reports increased risk of failure when immediate or early loading protocols are applied.

Regarding marginal bone loss, the mean values observed in our study (0.45 mm mesially and 0.43 mm distally) after almost 6 years of follow-up are below what is typically described as expected physiological remodeling (≈1.5 mm during the first year and 0.2 mm annually thereafter) (24,25). In studies of short implants in the posterior maxilla, bone loss between 0.5-1.2 mm after 5 years has been reported (26,27), placing our results in the lower range of bone resorption.

A relevant finding was the observed trend between insertion torque and crestal bone loss, with weak positive correlations ($r = 0.32$ for mean mesio-distal loss), although not statistically significant. This pattern is consistent with studies suggesting that high torque values may induce greater marginal remodeling. Clinical investigations have shown that insertion torques exceeding 50-55 Ncm are associated with significantly greater marginal bone loss and soft tissue recession (22,28). Similarly, experimental studies in animal models have demonstrated that excessive compression during implant insertion may reduce bone perfusion, induce osteocyte necrosis, and promote marginal remodeling (11,31,32).

In low-density bone, such as that of the posterior maxilla (D3-D4, <400 HU), this effect may be more pronounced. It has been reported that under such conditions, vascularization is more limited and the crestal cortical bone is thin, so even moderate torque values may cause excessive compression of trabecular bone, resulting in increased remodeling and marginal bone loss (20,32,33). Our findings, although not statistically significant, support this hypothesis: implants placed with torques close to 15 N cm showed slightly higher bone loss than those inserted at 5 Ncm, consistent with the idea that in highly porous bone, pursuing higher torque as a goal for primary stability may not be beneficial.

It is noteworthy that despite the low torque values, survival rates were excellent. This may be attributed to several factors: the use of short and extra-short implants with macro-geometry designed to maximize bone contact; the systematic splinting of implants, which distributed occlusal loads; and the progressive loading protocol, which likely facilitated bone maturation around the implant while avoiding early overload. Recent studies also support that implants inserted with low torque (<20 N cm) may achieve survival rates comparable to those placed with higher torque, provided that they are splinted and subjected to controlled loading protocols (19,21,34-38).

The strength of this study lies in documenting, with medium-to-long follow-up, the clinical and radiographic behavior of implants placed with particularly low torques in reduced-density bone. Few international studies have reported outcomes in such a specific scenario, which highlights the clinical relevance of our findings. However, limitations include the small sample size and the absence of a control group with higher torque values in the same bone conditions.

However, this study presents certain limitations that should be acknowledged. The relatively small sample size limits the generalizability of the results and reduces the statistical power to detect potential associations. Furthermore, all surgeries were performed by a single experienced operator, which, although ensuring consistency in the surgical protocol, may not reflect the variability found in broader clinical practice. In addition, while the mean follow-up of nearly six years allows mid-term evaluation, it does not permit conclusions about long-term outcomes. Future studies with larger cohorts, multiple operators, and extended observation periods are needed to confirm and expand these findings.

Overall, our data suggests that in low-density bone (~260 HU), achieving high insertion torque is not only unnecessary for implant survival, but may even be associated with increased marginal bone remodeling. This aspect deserves further investigation in multi-center studies with larger sample sizes to confirm the dose–response relationship between torque, bone density, and marginal bone loss.

5. Conclusions

The findings of this study indicate that short and extra-short implants placed in low-density posterior maxillary bone show excellent survival rates and reduced marginal bone loss after long-term follow-up. The slight trend toward increased resorption in cases with greater compression of the implant bed suggests that, in porous maxillary bone, excessive compaction may be counter-productive. Thus, long-term success appears to depend more on careful biological handling than on achieving high initial compression.

Conflict of Interests

E.A. is the scientific director of BTI Biotechnology Institute, a dental implant company that investigates in the fields of oral implantology and PRGF-Endoret technology.

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