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Single Ultra-Short Implants (5.5 and 6.5 mm) for Single-Tooth Rehabilitation of the Mandibular First Molar with Immediate Loading. A Retrospective Study

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Abstract

Background: Extra-short dental implants have emerged as a reliable option for rehabilitating posterior areas with limited vertical bone availability. However, clinical evidence regarding their use as single-unit restorations under immediate loading protocols in the mandibular first molar region remains scarce. ***Purpose:*** To evaluate implant survival, marginal bone loss, and biological and prosthetic complications associated with single extra-short implants (5.5 and 6.5 mm) immediately loaded in the mandibular first molar position. ***Materials and Methods:*** A retrospective study was conducted including 19 patients rehabilitated with 19 extra-short implants placed in the mandibular first molar region between June 2019 and June 2023. All implants were restored with single screw-retained crowns on a unitary transepithelial abutment and immediately loaded within 24 hours. Implant survival and marginal crestal bone loss were assessed radiographically. The mean follow-up period was 38.6 ± 10.5 months. ***Results:*** No implant or prosthetic failures were recorded during the follow-up period, resulting in a cumulative survival rate of 100%. Mean marginal bone loss was 0.36 ± 0.13 mm mesially and 0.60 ± 0.16 mm distally. No clinically relevant biological complications were observed. ***Conclusions:*** Within the limitations of this retrospective study, immediately loaded single extra-short implants placed in the mandibular first molar region demonstrated favorable clinical outcomes. Careful case selection, conservative surgical protocols, and standardized prosthetic design appear to be key factors for achieving predictable results in this demanding clinical scenario.

Keywords: Immediate loading, Mandibular first molar, Marginal bone loss (MBL), Transepithelial abutment, Screw-retained crown, Retrospective study.

INTRODUCTION

Ultra-short dental implants have become established over recent decades as a predictable therapeutic alternative for the rehabilitation of posterior regions with limited vertical bone availability, avoiding more invasive bone regeneration procedures [1–5]. The international scientific literature supports their use, reporting survival rates and marginal bone stability comparable to those achieved with conventional-length implants, particularly in short- and medium-term follow-ups [6–10]. Several meta-analyses have systematically evaluated the clinical performance of ultra-short implants, generally defined as those with lengths ≤6 mm. In this context, Fernandes *et al.,*[11] observed survival rates of 93.12% for ultra-short implants compared with 95.98% for conventional implants, with no statistically significant differences. Similarly, the meta-analysis by Yu *et al.,*[12] found no significant differences in survival between ultra-short and longer implants at 1- and 3-year follow-ups. However, at 5 years, conventional-length implants showed a slightly higher survival rate, a difference that disappeared when long implants were placed in previously regenerated bone, suggesting a relevant role of bone quality and the associated surgical procedure. Ravida *et al.,*[13], in a systematic review comparing ultra-short implants (≤6 mm) with implants ≥10 mm, also found no statistically significant differences in survival at 1 and 3 years. In addition, ultra-short implants showed lower marginal bone loss from implant placement and from prosthetic loading, as well as a lower incidence of biological complications, shorter surgical time, and reduced treatment cost. In contrast,

longer implants exhibited a higher frequency of prosthetic complications, although of limited clinical relevance.

Nevertheless, a common limitation of many of these studies is the heterogeneity of the analyzed groups, which include both single and splinted implants, as well as partial and full-arch rehabilitations. From a biomechanical standpoint, it is reasonable to hypothesize that ultra-short implants restored individually may present a less favorable clinical behavior, particularly in anatomical locations subjected to higher functional loads, such as the posterior mandibular region [14–17]. This hypothesis has been addressed in several systematic reviews. Afrashetehfar *et al.,*[15] specifically analyzed short implants (5–9 mm) restored individually versus splinted implants, observing that single implants presented a 16% higher risk of failure than splinted ones; however, this difference was not statistically significant and inter-study heterogeneity was low. In contrast, the meta-analysis by Badaró *et al.,*[14], focused exclusively on single crowns supported by ultra-short implants (≤6 mm), found no significant differences in failure risk compared with conventional implants, regardless of whether prior bone augmentation procedures had been performed. In that study, the overall failure rate of ultra-short implants was 5.19%, with a progressive distribution according to follow-up time, and a notable prevalence of biological complications, particularly bleeding on probing and peri-implantitis.

Despite the growing body of evidence, there remains a lack of clinical studies that specifically and homogeneously analyze the behavior of ultra-short implants restored individually in the mandibular first molar position under standardized prosthetic protocols, particularly when immediate loading is applied. With the aim of providing clinical evidence in this biomechanically demanding scenario, a retrospective study was designed in patients rehabilitated with implants of 5.5 and 6.5 mm in length, restored individually with screw-retained prostheses on a unitary transepithelial abutment (Unit®), with immediate loading, following an identical prosthetic protocol. The primary objective of the study was to evaluate implant survival, marginal bone loss, and the associated biological and prosthetic complications for this type of rehabilitation.

MATERIALS AND METHODS

A retrospective review was conducted of the clinical records of patients who received 5.5- and 6.5-mm-long implants restored individually in the mandibular first molar position (right and left) between June 2019 and June 2023, ensuring a minimum of two years of loading for the study group. Prior to implant insertion, antibiotic premedication was administered consisting of amoxicillin 2 g orally one hour before surgery and paracetamol 1 g orally as an analgesic. Each case was evaluated using a diagnostic wax-up and a three-dimensional assessment of the bone bed by cone-beam computed tomography (CBCT), complemented by digital planning software (BTI-Scan III). This approach allowed precise determination of the dimensions of the implant recipient site and estimation of bone density both within the intra-implant volume and in the surrounding bone corresponding to the thread contact area. This information enabled individualized adaptation of the drilling sequence [18], optimizing primary stability without generating excessive bone compression, and ensuring a conservative surgical protocol respectful of peri-implant bone tissue.

Implant placement was performed by the same surgeon using the biological drilling technique, at low speed and without irrigation [19]. All implants followed an identical loading protocol to allow a more homogeneous comparison. They were immediately loaded 24 hours after insertion with a resin crown on an interface screwed to a unitary transepithelial abutment (Unit®). Three months after initial loading, a definitive metal–ceramic prosthesis was fabricated, with a CAD-CAM–designed framework and subsequent ceramic veneering. Impressions for crown fabrication were taken either conventionally or digitally, always on the transepithelial abutment, attempting not to remove the initially placed abutment unless necessary due to soft tissue remodeling during the three months of loading. After placement of the definitive crown, patients were recalled at one month, three months, and subsequently every six months. At these follow-up visits, periapical radiographs were taken and clinical evaluation was performed. These radiographs were used to estimate crestal bone loss. A known reference length on the radiographs (implant length) was used to calibrate the measurements. After calibration, the software calculated the actual measurements (Digora for Windows, SOREDEX Digital Imaging Systems). Marginal crestal bone loss was calculated by measuring from the implant shoulder to the first site where bone–implant contact was evident. The reference for comparing radiographic records and estimating bone loss in each patient was the radiograph taken at the time of immediate loading.

Statistical analysis

A Shapiro–Wilk test was performed to assess the normal distribution of the data. The primary variable evaluated was implant survival, followed by crestal bone loss. Survival analysis was performed using the Kaplan–Meier method, and statistical analysis was carried out with SPSS v15.0 (SPSS Inc., Chicago, IL, USA). Qualitative variables were described by frequency analysis, and quantitative variables by mean and standard deviation.

RESULTS

Nineteen patients were recruited, in whom 19 implants were placed in the mandibular first molar position with immediate loading and single-unit rehabilitation. Of these patients, 9 were men and 10 were

women, with a mean age of 58 years (±3.8) at the time of surgery. Implant length was 5.5 mm in 26.3% of cases and 6.5 mm in the remaining 73.7%. Implant diameter ranged from 3.3 to 5.5 mm, with 3.75 mm being the most frequent (26.3%). All diameters and lengths are shown in Figure 1. Regarding location, 68.4% of implants were placed in position 36 and the remaining 31.6% in position 46. Analysis of the distribution of implant lengths and diameters according to mandibular position (36 and 46) showed a greater use of 6.5-mm implants in both locations, particularly in position 46 (Figure 2). However, due to the small sample size and imbalance between groups, these findings should be interpreted descriptively rather than inferentially. With respect to implant diameter, position 36 showed a median of 4.25 mm, with an interquartile range between 3.75 and 4.50 mm (±0.63). In position 46, the median was 4.00 mm, with an interquartile range of 3.88 to 4.20 mm (±0.47). There was substantial overlap of interquartile ranges between both positions, indicating a similar distribution of diameters used (Figure 3). All implants were immediately loaded within 24 hours after surgery using a unitary transepithelial abutment (Unit®) and a resin crown interface. Conventional impressions were taken in 11 of the 19 implants and digital impressions in the remaining 8. After three months, definitive metal–ceramic crowns were fabricated, also screw-retained via the unitary transepithelial abutment. The transepithelial abutment was replaced in only 3 cases due to a reduction in keratinized tissue. In the remaining 16 cases, the same transepithelial abutment was used for the definitive prosthesis, maintaining the seal and hermeticity achieved during immediate loading, as well as the epithelial attachments formed at that level.

The mean follow-up time was 38.6 months (±10.5), ranging from 24 to 52 months. During this period, no implant failures were recorded, resulting in a cumulative survival rate of 100%. The mean mesial bone loss at the end of the follow-up period was 0.36 mm (±0.13), and the mean distal bone loss was 0.60 mm (±0.16).

Figures 4–17 illustrate one of the cases included in the study.

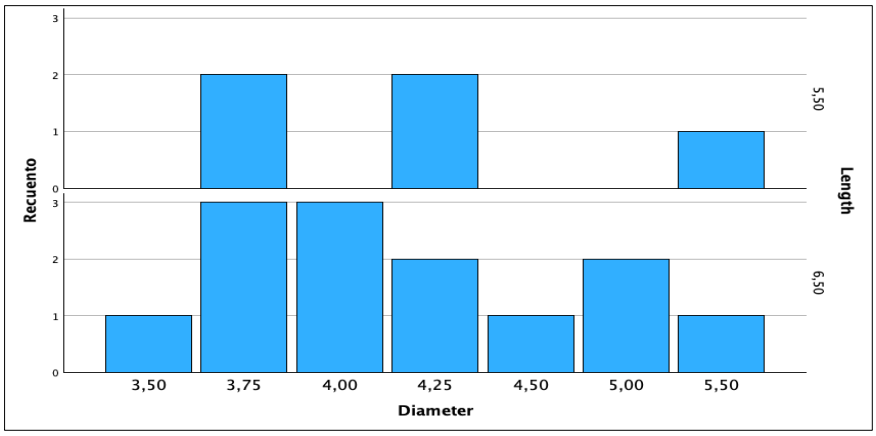


Figure 1: Diameters and lengths of the implants included in the study

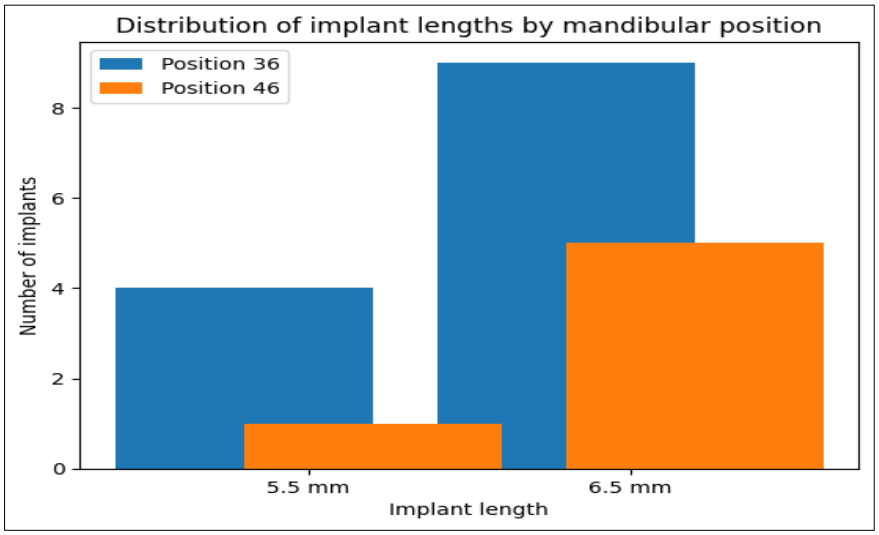


Figure 2: Distribution of implant lengths according to position, with a clear predominance of the 6.5-mm length in both cases

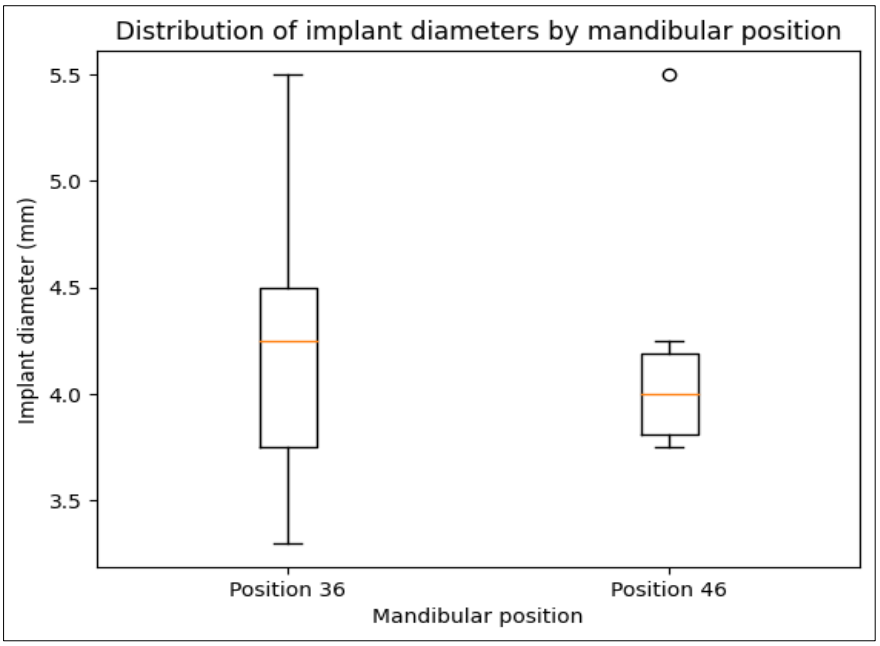
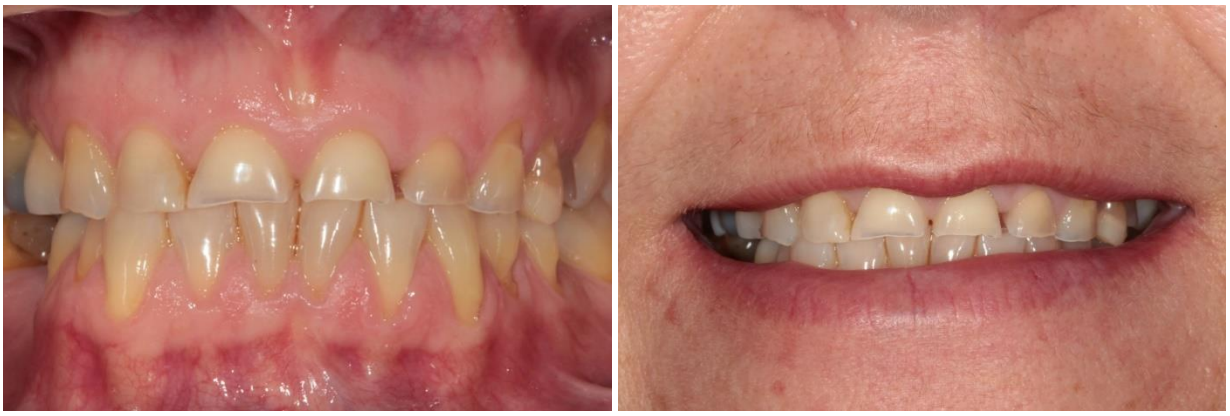
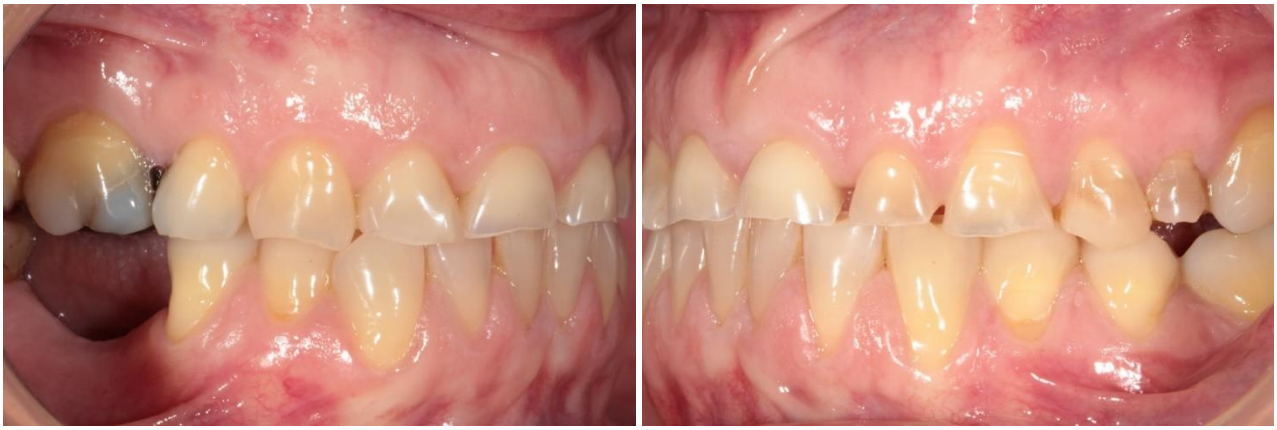


Figure 3: Distribution of implant diameters according to mandibular position (36 and 46). Medians and interquartile ranges show substantial overlap between both positions, with no clinically relevant differences in diameter selection



Figures 4–5: Initial frontal images of the patient taken at the first visit, showing anterior maxillary wear and reduced vertical dimension



Figures 6 and 7: Lateral photographs showing the edentulous space at tooth 46, to be restored with a short implant

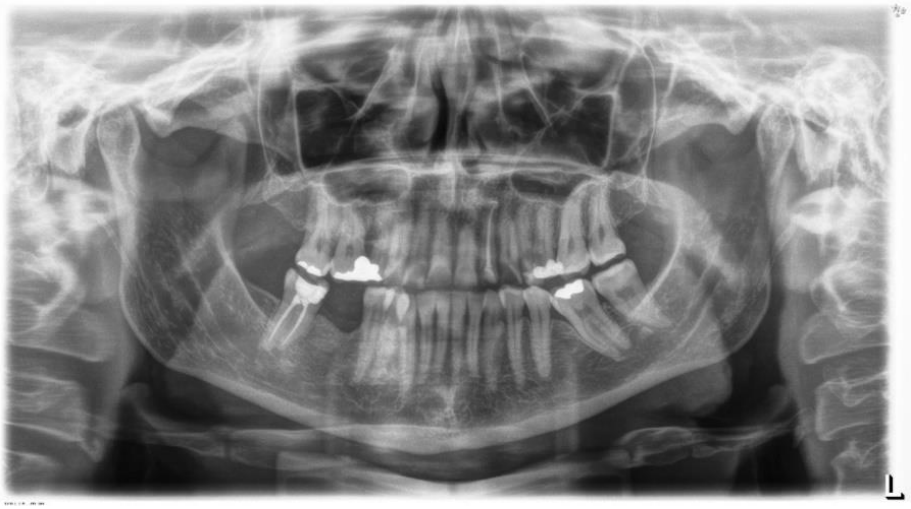


Figure 8: Initial panoramic radiograph showing absence of tooth 46.

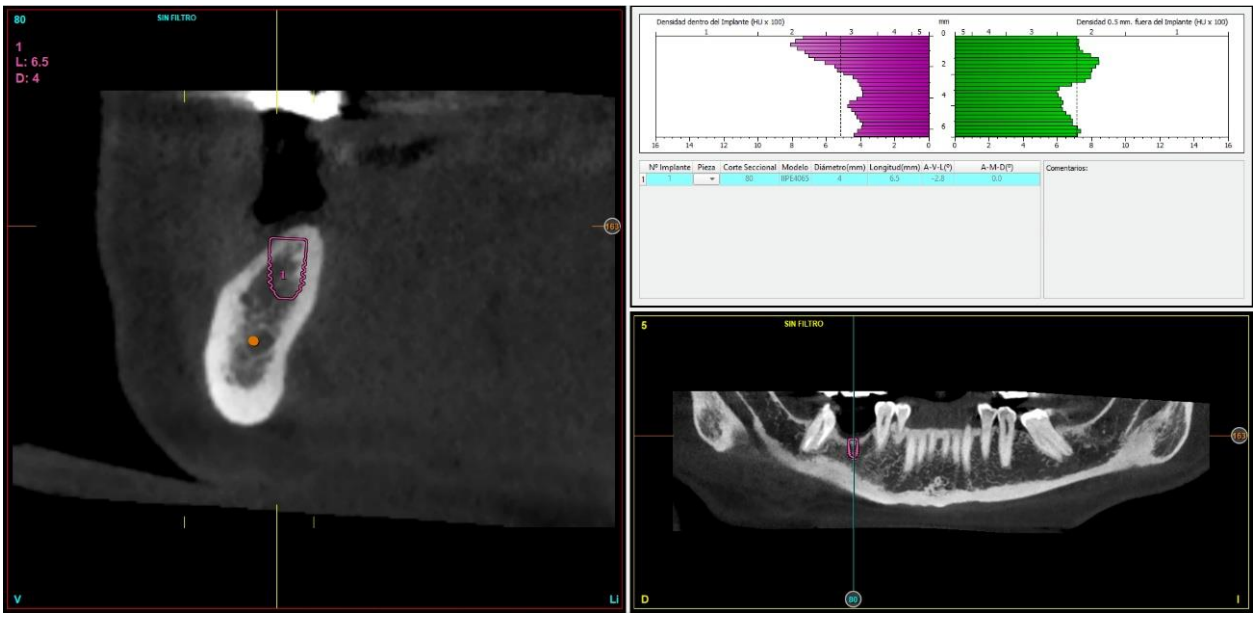
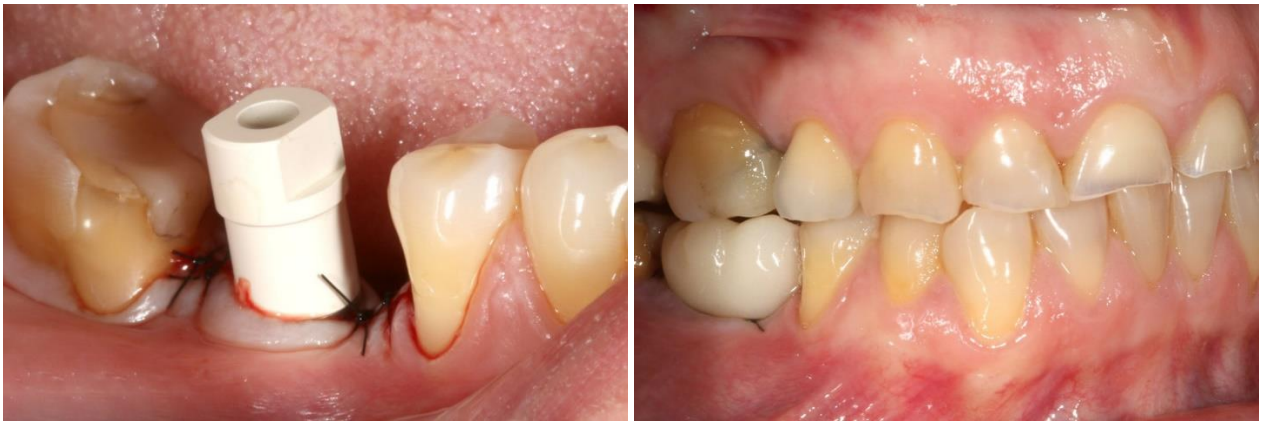


Figure 9: Implant planning cross-section. A 6.5-mm-long and 4-mm-diameter implant was selected, sufficient to restore tooth 46 while preserving the bone bed



Figures 10 and 11: Digital workflow records following surgery and placement of the provisional resin prosthesis 24 hours after initial surgery

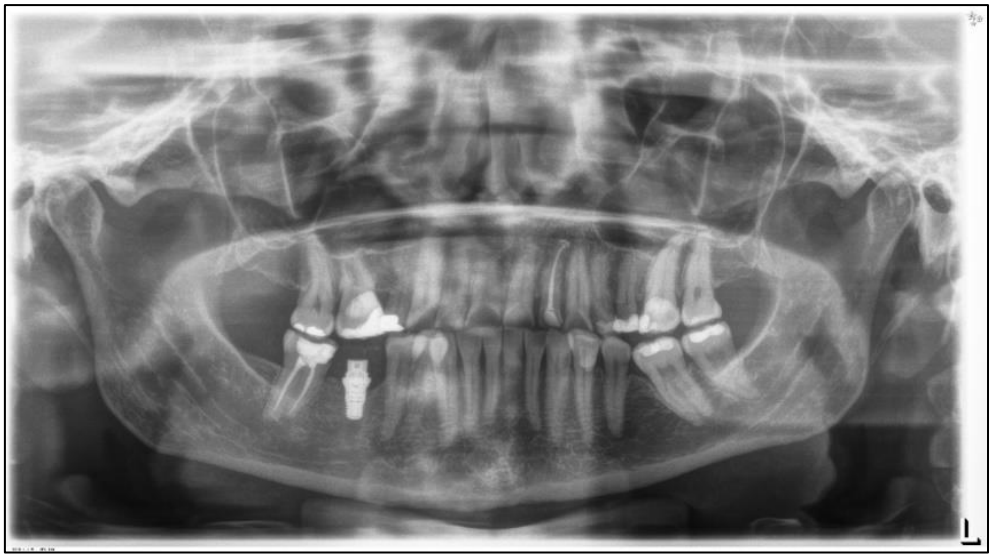


Figure 12: Panoramic radiograph showing the implant and provisional crown immediately after placement, using an expanded unitary transepithelial abutment

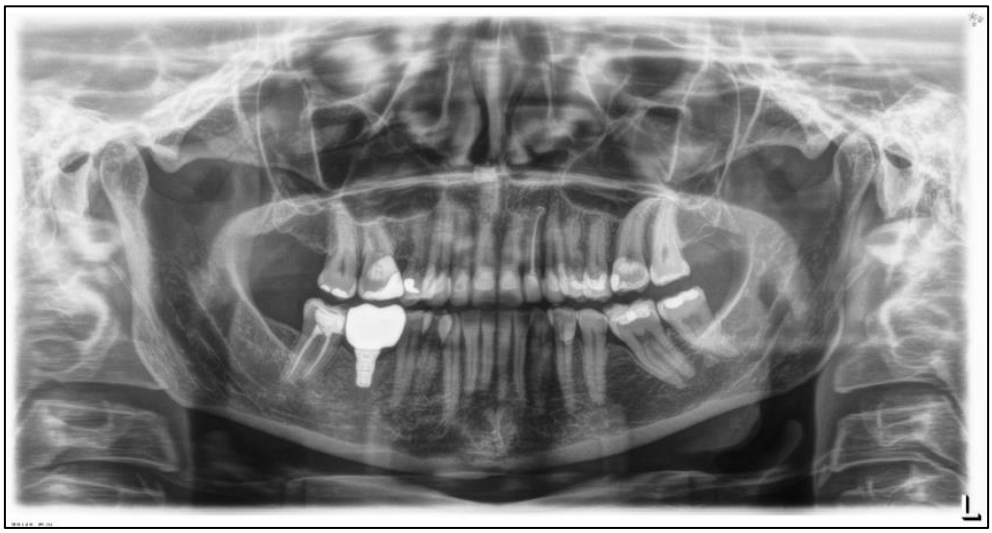
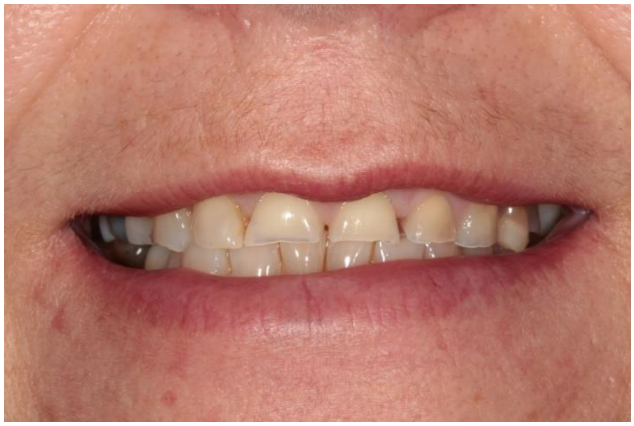
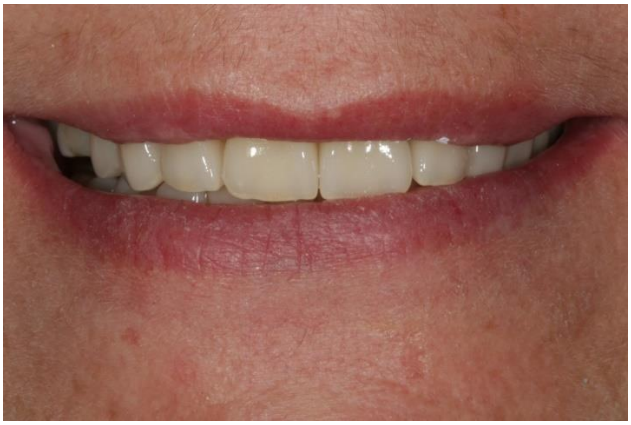
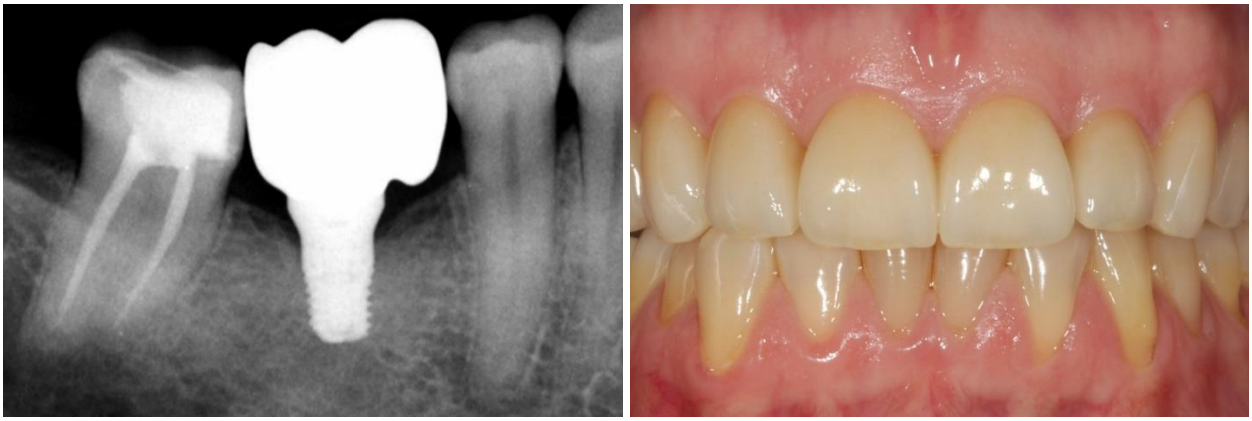


Figure 13: Radiograph with the definitive prosthesis two years after placement of the immediate-loading crown, also showing rehabilitation of the anterior maxillary segment to restore lost vertical dimension





Figures 14 and 15: Initial and final images of the patient showing recovery of vertical dimension



Figures 16 and 17: Final radiograph at three years of follow-up and corresponding clinical image

DISCUSSION

Single-unit rehabilitation of ultra-short implants in posterior mandibular regions represents one of the most biomechanically demanding clinical scenarios [14,16]. This challenge arises from the combination of reduced implant length, high occlusal loads, and a non-splinted restoration, factors that have been associated in the literature with a higher risk of crestal bone loss and implant failure compared with conventional-length implants or splinted rehabilitations [20].

Biomechanical and clinical studies have shown that splinting short or ultra-short implants in the posterior mandible significantly reduces stress transmitted to peri-implant bone, improving load distribution and decreasing crestal stress [15,21–24]. In this regard, Talreja *et al.,*[20] reported that splinted short implants exhibited significantly lower micromovement and bone stress concentration compared with single implants, particularly under oblique loading. However, when rehabilitation is performed on a single-unit basis, optimization of other parameters becomes critical. Implant diameter is one of the most relevant factors in this context. Several studies have demonstrated that wider-diameter implants significantly reduce biomechanical stress in cortical bone, especially in single restorations, compared with narrow implants (≤3.3 mm), regardless of implant length [25,26]. Finite element models have shown that an increase of 0.5–1.0 mm in diameter can reduce crestal bone stress by up to 20–30%, which is clinically relevant in borderline situations such as those addressed in the present study [26,27].

Similarly, the surgical protocol used for implant bed preparation has been shown to directly influence primary stability and medium- to long-term bone response. Density-adapted, conservative drilling protocols aimed at preserving peri-implant bone have demonstrated better outcomes in terms of primary stability without inducing excessive bone compression, an aspect that is particularly critical for ultra-short implants [28–32]. Longitudinal clinical studies have reported survival rates above 95% when these protocols are combined with appropriate diameter selection and precise control of insertion torque [32,33].

From a prosthetic perspective, the use of an intermediate transepithelial abutment in single-unit rehabilitations has been associated with lower marginal bone loss compared with direct-to-implant restorations [34–38]. This effect has been attributed to stabilization of the biological seal, reduced repeated manipulation of the implant–abutment connection, and improved functional load distribution [38–41]. Comparative clinical studies have reported differences of up to 0.3–0.4 mm less crestal bone loss in rehabilitations with an intermediate abutment compared with direct-to-implant restorations in follow-ups exceeding three years [36,42,43].

In the present study, single ultra-short implants demonstrated favorable clinical behavior, with a mean follow-up of 47 ± 12 months, and no implant or prosthetic failures. Mean marginal bone loss was 0.15 ± 0.5 mm, clearly lower than that reported in most studies on single short implants, where average crestal bone loss typically ranges between 0.3 and 0.9 mm in similar follow-ups [13,14]. These results suggest that the combination of a conservative surgical protocol, appropriate diameter selection, and a standardized prosthetic design may mitigate the biomechanical disadvantages inherent to this type of rehabilitation [43].

Regarding anatomical location, Svezia *et al.,*[44] observed a higher failure rate in single short implants placed in the mandible (5.6%) compared with the maxilla (0%), although without statistically significant differences. These data support the hypothesis that the posterior mandibular region represents a more biomechanically critical environment, consistent with other studies reporting higher occlusal loads and cortical bone density in this area.

Evidence regarding immediate loading of single ultra-short implants in the posterior mandible remains limited. The study by Sivolella *et al.,*[45] reported an overall survival rate of 89% at five years, with slightly

higher values for immediately loaded implants (94%) compared with conventionally loaded ones (87%). However, immediate loading was associated with greater mean marginal bone loss (increase of 0.21 mm), whereas the use of an intermediate abutment was associated with a significant reduction in crestal bone loss (–0.23 mm). Although derived from a heterogeneous group, these findings suggest that immediate loading may be feasible but requires strict control of surgical and prosthetic factors. Other studies on immediate loading of single implants in the posterior mandible, although not exclusively focused on ultra-short implants, have reported survival rates above 95% and marginal bone loss below 1 mm at 3–5 years of follow-up, provided that strict criteria for primary stability and occlusal control are met [46, 47–49].

Available data therefore suggest that immediate single-unit rehabilitation of ultra-short implants in the posterior mandible may be considered a predictable clinical option in selected cases, provided that biomechanical, surgical, and prosthetic factors are optimized. Nevertheless, the scarcity of homogeneous prospective studies with long-term follow-up highlights the need for further research to more precisely define the clinical limits of this therapeutic strategy.

CONCLUSIONS

Overall, the results of the present study, interpreted considering the available scientific evidence, suggest that single-unit rehabilitation of ultra-short implants in the posterior mandibular region can be a reliable clinical option when cases are carefully selected and strictly controlled surgical and prosthetic protocols are applied. Optimization of implant diameter, the use of conservative drilling protocols based on bone density, and the application of transepithelial abutments appear to play a key role in peri-implant bone stability, even in biomechanically unfavorable situations. Nevertheless, given the limited available evidence and the retrospective nature of the study, these findings should be interpreted with caution. Prospective, controlled studies with long-term follow-up are required to more precisely define the clinical limits and indications of immediate single-unit loading of ultra-short implants in the posterior mandible.

Conflict of interest:

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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