Long-term follow-up of 2.5mm NDIs supporting a fixed prosthesis

Narrow-diameter implants in premolar and molar areas

EDUARDO ANITUA, DDS, MD, PHD[1,2]

A narrow-diameter implant (NDI) is an implant with a diameter of less than 3.75 mm. The use of NDIs is an alternative to bone augmentation. Long-term studies of narrow-diameter implants with a diameter of less than 3.0 mm in posterior areas are still lacking. The purpose of the present product study was to analyze the long-term outcomes of 2.5-mm NDIs splinted to regular-size implants for supporting partial and complete fixed prostheses in posterior areas (molar and premolar).

[1] Private practice in oral implantology, Eduardo Anitua Foundation, Vitoria, Spain
[2] Clinical researcher, Eduardo Anitua Foundation, Vitoria, Spain

NDIs are clinically indicated for replacing maxillary lateral incisors and mandibular incisors [1]. The availability of an interdental space of less than 6 mm or a residual bone width of less than 5 mm are also indications for narrow-diameter implants [1]. NDIs have significantly reduced the need for bone grafting in completely edentulous patients [2], avoiding complications associated with alveolar bone augmentation such as prolonged healing time, additional cost and increased surgical morbidity [2,4]. In a recent study, *Pommer* et al. concluded that, while little in the way of evidence on patients' preferences regarding minimally invasive treatment versus bone augmentation surgery could be identified by within-study comparisons, patient satisfaction with non-graft solutions for implant-supported rehabilitations of completely edentulous jaws is generally high [5].

The long-term success of NDIs in the posterior maxilla and mandible is not well documented. A recent study of these implants in areas combined with a split-crest technique seems to indicate high implant survival rates (97 per cent) [6].

Ortega-Oller et al. showed in a meta-analysis that narrower implants (< 3.3 mm) have significantly higher failure rates than wider implants (≥ 3.3 mm) [7]. This could be influenced by other variables such as the type of prosthesis, the implant surface or the timing of prosthetic loading [7]. *Klein* et al. reported in a recent systematic review that the survival rate of implants with a diameter of less than 3 mm was above 90 per cent for observation times between one and three years [8]. For implants with diameters between 3.0 and 3.25 mm, the survival rate was above 93.8 per cent (observation times of one to five years). Implants with a diameter of 3.3 mm or more had survival rates of 88.9 to 100 per cent at observation times between one and twelve years. The most common causes of implant failure were a lack/loss of osseointegration and infection [1,9–10].

Based on the above, NDIs have success rates that are comparable to those of wider implants, not only in the anterior but also in the posterior regions. The present study was conducted to analyze the long-term outcomes of 2.5-mm NDIs as definitive implants for the rehabilitation of missing posterior teeth.

Material and methods

This article was written following the STROBE guidelines [11] and included patients treated at a single dental clinic in Vitoria, Spain.

Patients participating in the study met the following criteria:

- Both genders and over 18 years old;
- Completely or partially edentulous jaws treated with one or more 2.5-mm narrow-diameter implants due to insufficient bone ridge thickness (< 5 mm) or reduced mesiodistal space (< 6 mm);
- Implants inserted before July 2005;
- Implants inserted in posterior areas (premolar and molar).

A retrospective cohort study design was used.

Data acquisition

Patient records were examined to derive demographic data (gender, age), social habits (smoking, alcohol intake), relevant medical conditions and any history of periodontal disease. A database was created containing implant parameters (lengths, diameters and insertion torques) and localization. To assess implant survival, any implant lost due to biological (failure to achieve osseointegration or loss of acquired osseointegration) or biomechanical causes was considered a failure.

To quantify marginal bone loss (MBL), marginal bone levels were measured on the periapical radiograph taken just after the surgery and on the last available periapical radiograph. The radiographs were obtained using a paralleling technique with a film holder (Superbite; KerrHawe, Barcelona, Spain). MBL was measured on the periapical radiographs by computer software (Digora; Soredex, USA); a calibration of the periapical radiograph based on a known length (implant length) was performed. Once the radiograph was calibrated to a 1 : 1 measurement, eliminating the possible presence of magnification, measurements were made mesially and distally to the implants, calculating the distance between the uppermost point of the implant platform and the most coronal contact between the bone and the implant. The bone level recorded just after implant insertion was the basal value to compare with subsequent measurements over time.

To assess the survival of the restorations, any complication that led to removal (screw loosening/fracture abutment/implant fracture/ceramic chipping/prosthesis fracture) was considered a failure.

Surgical procedures

All surgical procedures were performed by two experimented surgeons. Before the surgery, patients underwent routine dental scaling to start the implant treatment in adequate periodontal health. Radiographic evaluation was also performed to establish the treatment plan.

Patients received 2 g of amoxicillin (600 mg of clindamycin for allergic patients) 60 minutes before surgery and 1 g of acetaminophen 30 minutes preoperatively. Local anesthesia was achieved by the administration of articaine hydrochloride with epinephrine (1 : 100,000).

The implant sites were prepared using a low-speed drill (125 rpm) without irrigation [12,13]. Before placement, implants were carefully embedded in liquid plasma rich in growth factors prepared from patient's blood according to a protocol developed by the manufacturer (PRGF-Endoret; Biotechnology Institute BTI, Vitoria, Spain) to bioactivate the implant surface.

The restorations were made by the restorative dentist. In general, healing was allowed to continue for a minimum of three months, after which the healing abutments were connected. Shortly thereafter, the suprastructure was placed. An immediate-loading protocol was used for four patients (eight NDIs). The implants were loaded immediately only if they achieved an insertion torque of at least 45 Ncm.

Postsurgical clinical assessment

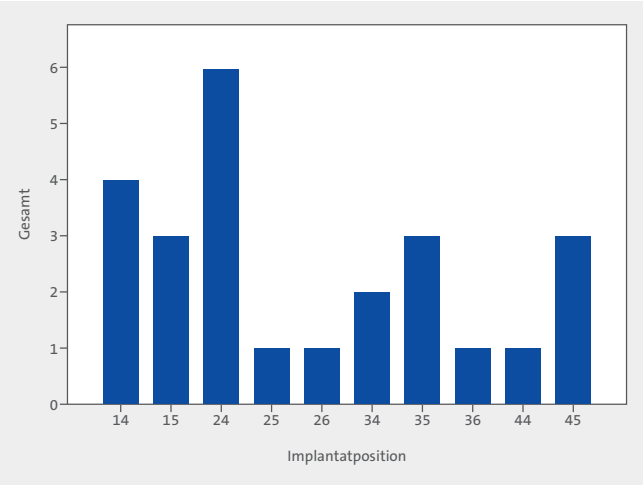
Once the surgical phase was completed, patients were scheduled for a series of periodic evaluations, consisting normally in one evaluation five to ten days after surgery and then at one month, at three months, at six months and once a year thereafter. The postsurgical assessment included different clinical assessments at each follow-up visit to verify the status of the implant (gingival health, restoration mobility, pain, infection, alveolar ridge resorption and any complications). Moreover, periodic panoramic and periapical radiographs were taken to verify the clinical status of the implants in the observation period.

Statistical analysis

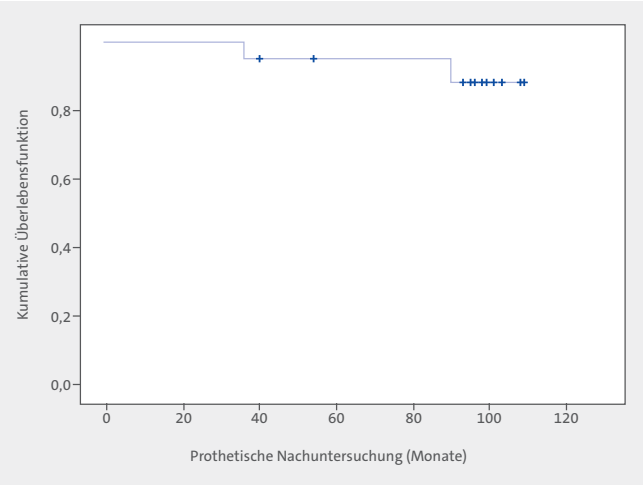
Data collection and analysis were performed by two independent examiners (not by the restorative dentist or surgeon). The patient was the statistical unit for the statistical description of demographic data, social habits, medical history and history of periodontal disease. Mean values, standard deviations and ranges were calculated for age, while relative frequency was calculated for the remaining patient-related variables. The implant served as the statistical unit for the description of implant length, diameter, location, insertion torque, marginal bone loss, survival and prosthetic parameters. Absolute and relative frequency distributions were calculated for qualitative variables, and means and standard deviations were determined for quantitative variables. The survival of implants and prostheses were evaluated with the Kaplan-Meier method. The SPSS v15.0 for Windows statistical software package (SPSS, Chicago, IL, USA) was used for statistical analysis.

Results

A total of 25 narrow-diameter (2.5 mm) implants placed in 15 patients were included and evaluated. Twenty patients were female (80.0 per cent). The mean age at surgery was 53.15 ± 9.2 years. Four patients were smokers (20.0 per cent).

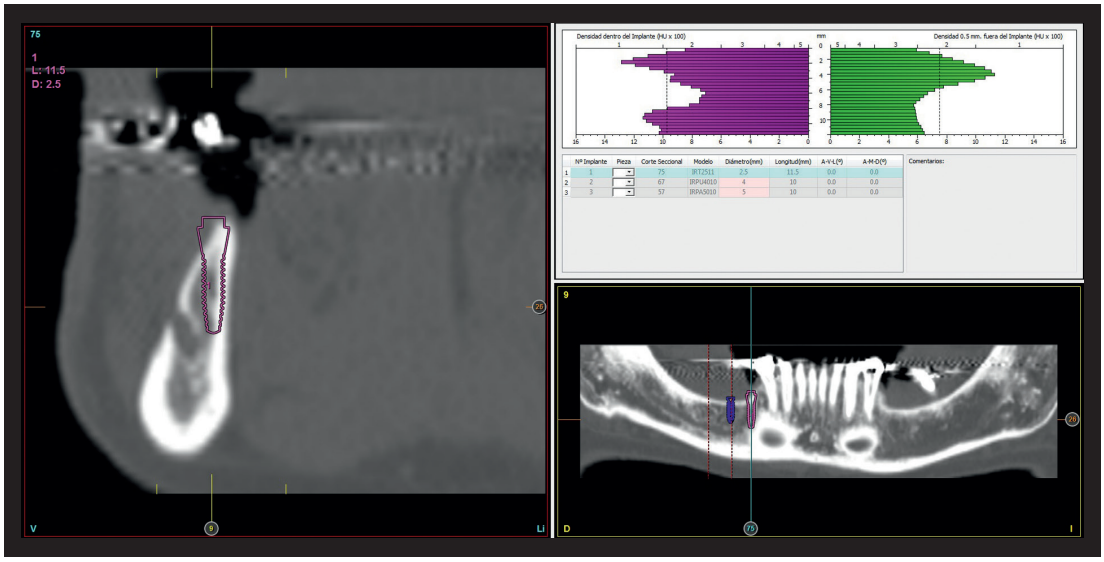


1 I Anatomical locations of the narrow-diameter implants included in this study.



2 I Cumulative survival rates of the prostheses.

3 I Cone-beam CT scan showing the severe horizontal atrophy at the position of the lower right second premolar. A Tiny implant was selected.



The lengths of the implants ranged between 11.5 and 15.0 mm. The implants' mean observation period was 6.5 ± 3.9 (0 – 9.5) years.

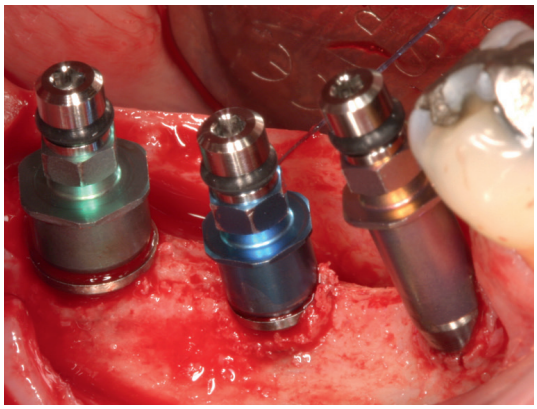
The mean observation time of the prostheses was 5.67 years (SD = 36.06). Figure 1 shows the anatomical locations of the implants. Fifteen implants (60 per cent) were placed in the maxilla and ten (40 per cent) in the mandible.

Delayed implant loading was performed for 17 implants (68 per cent). The implants were loaded 8 ± 4 (4 – 21) months after placement insertion. Five implants (32 per cent) were submitted to immediate loading protocol.

Regarding the type of prosthesis, twelve implants (48 per cent) supported fixed partial bridges, whereas twelve implants supported four screw-retained complete prostheses (48 per cent) and the one remaining implant was restored with a cemented single crown (4 per cent).

For the assessment of long-term MBL, only those cases were considered where the last available periapical radiograph had been taken at least seven years after insertion. Twenty-one implants (mean observation period of 8.9 ± 0.5 years) that satisfied this requirement were analyzed. The mean MBL was 0.64 ± 0.64 (0.00 – 1,95) mm on the mesial side and 0.66 ± 0.62 (0.00 – 2.19) mm on the distal side.

The survival rate was 100 per cent for the implants. Two prostheses failed during the observation period. The prosthetic complications were ceramic fracture in one patient and connector fracture in another patient. This resulted in a prosthetic survival rate of 92.0 per cent (Fig. 2). Figures 3 and 4 illustrate the clinical situation of a patient involved in the study before, right after and ten years after (?) the treatment with a narrow diameter implant.



4 | The insertion of a Tiny implant at the position of the lower right second premolar and two implants at the position of the first and second molar.

Discussion

87.0 per cent of the implants have been followed for more than three years and 60 per cent for more than seven years. No implant failed during the observation period, resulting in a survival rate of 100 per cent. *Renouard* and *Nisand* reported an implant survival rate of more than 90 per cent for 3.0-mm and 3.3-mm implants in a review [14]. *Sohrabi* et al. similarly concluded that the survival rate of NDIs is generally higher than 90 per cent and that the failure rate appeared to be higher in small-diameter implants of less than 13 mm in length [15]. *Klein* et al. reported that available studies on dental implants under 2.5 mm in diameter reported survival rates between 90 and 100 per cent [8].

In a recent meta-analysis by *Ortega-Oller* et al., the majority of the analyzed studies (implants less than 3.3 mm in diameter) have also reported survival/success rates higher than 90 per cent [7]. However, the results of the meta-analysis have shown higher failure rates for implants with a diameter under 3.3 mm than for implants with a diameter of 3.3 mm and more. The authors related this outcome to the fact that NDIs are usually placed in complicated clinical scenarios and therefore carry a higher risk of fracture [7]. Interestingly, according to that review, failure is more probable if the implants are loaded before three months after insertion or if they have a smooth implant surface [7].

In the present study, the survival rate of NDIs was comparable to standard implants. The high survival rate of the NDIs could be related to the fact that the implants placed in this study had a roughened surface. Furthermore, 26 implants were loaded after 8 ± 4 months after implant insertion; none of them failed.

Abutment screw loosening is one of the most common prosthetic complications reported by clinical studies on NDIs [8]. This complication could be the result of different factors such as component misfit, inadequate tightening, settling of the screw, inadequate screw design or excessive loading [16]. The absence of screw loosening in this long-term follow-up study could be related to the fact that all implants (except one) were splinted by a fixed prosthesis.

Splinting multiple implants has been reported to minimize the lateral force on the prosthesis, to enhance force distribution and to reduce the stress on the implants [17,18]. Thus, splinting of 2.5-mm implants would protect the implants from excessive loading and prevent implant/abutment screw fracture.

In this study, all the implants were inserted in posterior areas. In this type of rehabilitation, the risk of implant "fatigue" fractures exists [19,20]. *Freitas-Junior* et al. concluded in a biomechanical study that single NDI are less reliable than standard implants or two NDIs supporting single crowns in the molar region [21]. In our study, the implant survival rate was 100 per cent, and no biomechanical complications occurred. Measurements of marginal bone loss around the NDIs showed a mean of less than 1 mm for the implants with observation periods of more than seven years after insertion. This would indicate the absence of excessive mechanical loading on the 2.5-mm implants. Similar results were reported by *Wang* et al. [22].

This study suffers from the limitation of a retrospective study design and a small sample size. The retrospective study provides evidence of lesser strength than the evidence derived from prospective or randomized clinical trial. There is also a dependency on the availability and accuracy of medical/dental records.

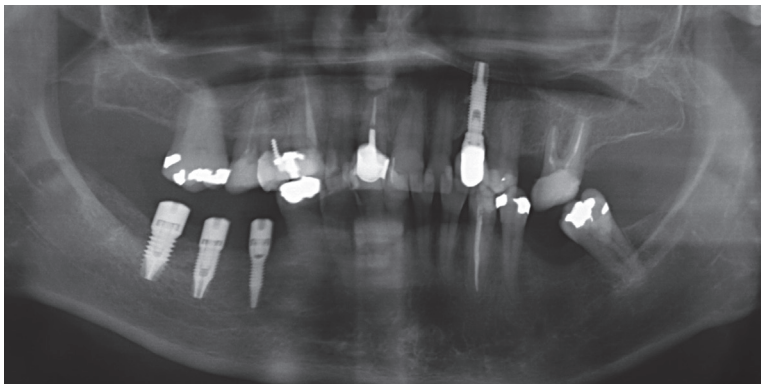
Conclusions

The use of narrow-diameter implants in the posterior narrow alveolar ridge could constitute a minimally invasive alternative to bone augmentation. NDIs of 2.5 mm yielded high survival rates over a long-term observation period. This outcome could be related to the fact that these implants were all splinted to other implants by a fixed prosthesis. This prosthetic configuration may have minimized the probability of implant and prosthesis failures. Figures 5 to 10 illustrate different stages of treatment in different patients included in the present product study.

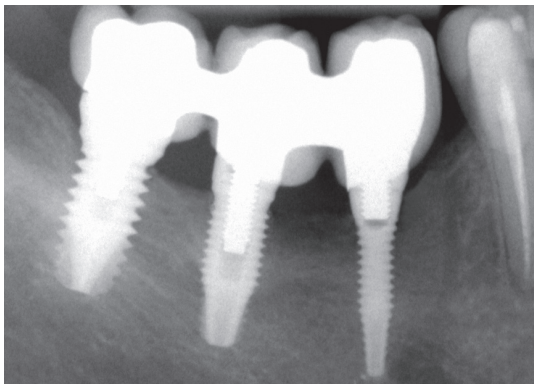
The references are available at www.teamwork-media.de/literatur

Contact address

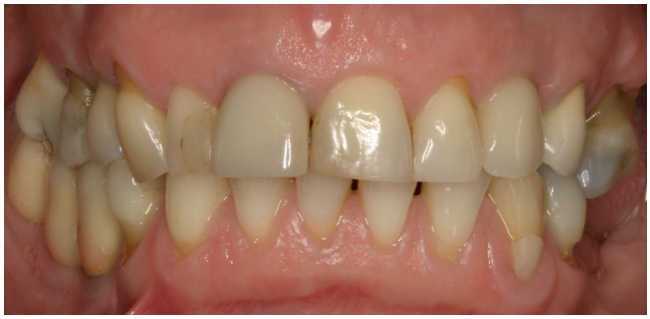
Dr Eduardo Anitua
Eduardo Anitua Foundation
C/ José Maria Cagigal 19
01007 Vitoria · Spain
eduardoanitua@eduardoanitua.com

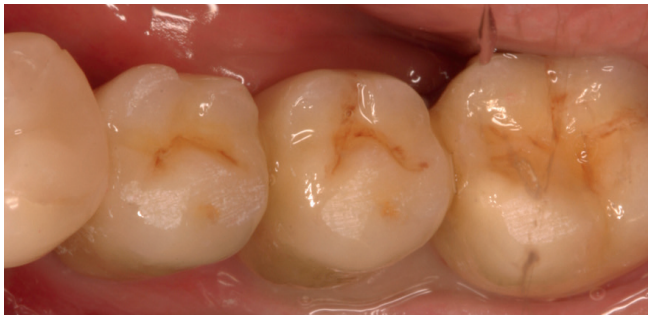


5 I Post-surgery panoramic radiograph showing a one-stage implant placement. Healing abutments were connected.

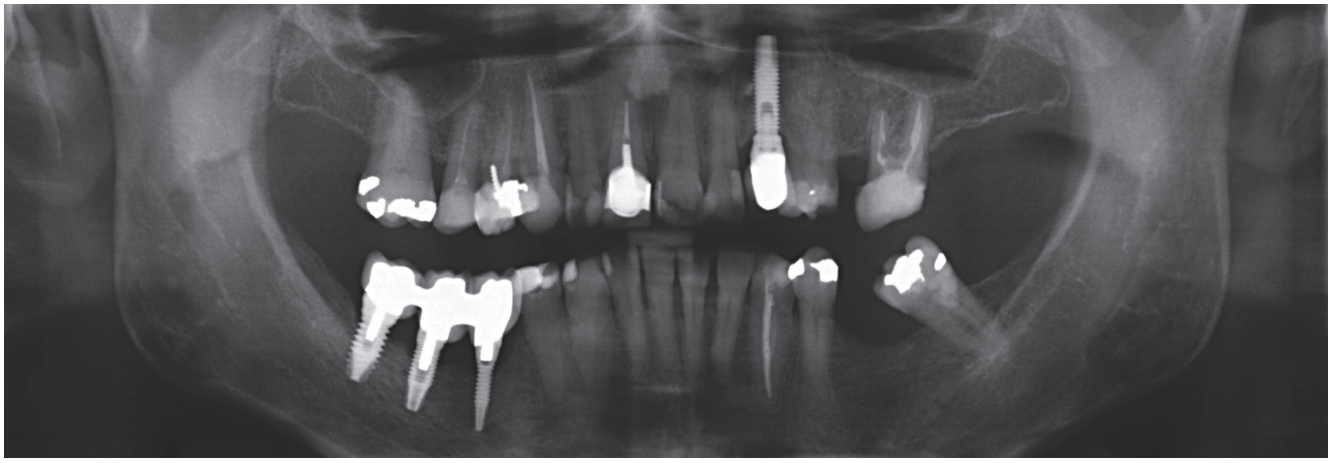


6 I Placement of the cement-retained bridge at three months after implant insertion.

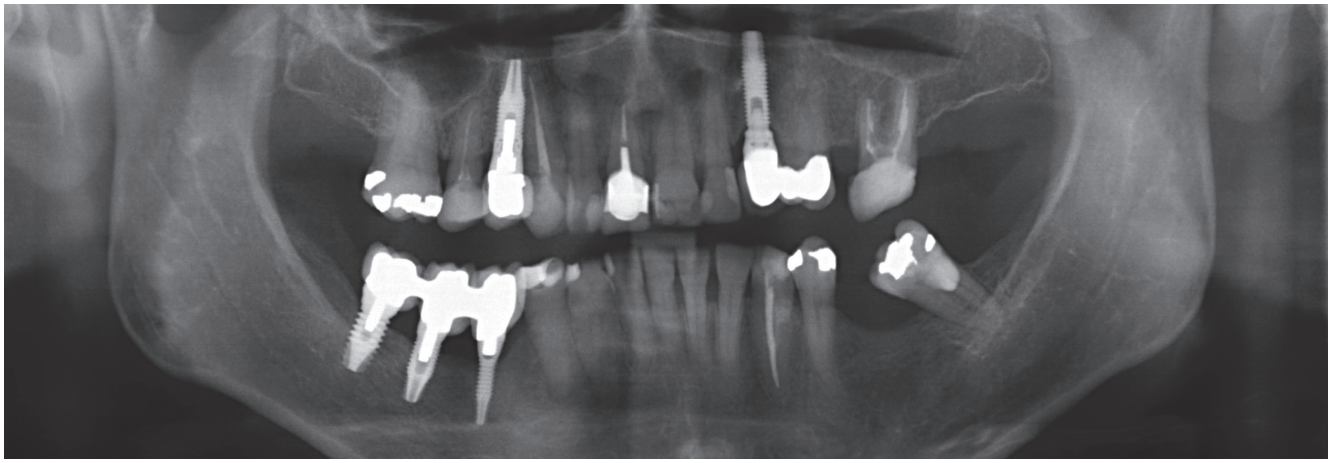




7 and 8 I A definitive implant-supported bridge in the lower right posterior mandible.



9 I A panoramic radiograph at two years ...



10 I ... and at five years after implant loading.