Vertical augmentation with interpositional blocks of anorganic bovine bone vs. 7-mm-long implants in posterior mandibles: 1-year results of a randomized clinical trial

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Abstract
Objectives: To evaluate whether 7-mm-long implants could be an alternative to longer implants placed in vertically augmented posterior mandibles.

Materials and methods: Sixty patients with posterior mandibular edentulism with 7–8 mm bone height above the mandibular canal were randomized to either vertical augmentation with anorganic bovine bone blocks and delayed 5-month placement of ≥10 mm implants or to receive 7-mm-long implants. Four months after implant placement, provisional prostheses were delivered, replaced after 4 months, by definitive prostheses. The outcome measures were prosthesis and implant failures, any complications and peri-implant marginal bone levels. All patients were followed to 1 year after loading.

Results: One patient dropped out from the short implant group. In two augmented mandibles, there was not sufficient bone to place 10-mm-long implants possibly because the blocks had broken apart during insertion. One prosthesis could not be placed when planned in the 7 mm group vs. three prostheses in the augmented group, because of early failure of one implant in each patient. Four complications (wound dehiscence) occurred during graft healing in the augmented group vs. none in the 7 mm group. No complications occurred after implant placement. These differences were not statistically significant. One year after loading, patients of both groups lost an average of 1 mm of peri-implant bone. There no statistically significant differences in bone loss between groups.

Conclusions: When residual bone height over the mandibular canal is between 7 and 8 mm, 7 mm short implants might be a preferable choice than vertical augmentation, reducing the chair time, expenses and morbidity. These 1-year preliminary results need to be confirmed by follow-up of at least 5 years.

Rehabilitation of the partially edentulous posterior mandible with removable dentures can be unsatisfactory for patients due to instability, creating discomfort and affecting their ability to eat and speak. An implant-supported prosthesis could be the ideal option, although alveolar resorption can result in the lack of sufficient bone volume and close proximity to the inferior alveolar nerve, presenting a difficult clinical situation for positioning endosseous implants. A bone height of 10–12 mm is generally considered to be the minimal amount of bone required to place implants of “sufficient” length, 9–11 mm long, which are most likely to generate good long-term results and to minimize the risk of permanent damage to the alveolar inferior nerve (das Neves et al. 2006). Often times, however, the amount of re-
sidual bone above the mandibular canal is<br/><10 mm, and implant rehabilitation is<br/>considered at a higher risk of failure [das Neves et al. 2006].

To address a case of reduced bone height in the posterior mandible, three approaches have been proposed: (1) vertical augmentation, (2) surgical displacement of the alveolar inferior nerve and (3) placement of short implants, 8 mm or less.

Several techniques are currently being used to vertically augment the posterior mandible, and of these, the following have been tested in randomized clinical trials [RCTs]: various vertical-guided bone regeneration procedures [Chiapasco et al. 2004, 2007; Merli et al. 2007; Fontana et al. 2008], alveolar distraction osteogenesis [Chiapasco et al. 2004, 2007], onlay bone grafting [Chiapasco et al. 2007] and the use of interpositional bone grafts [Bianchi et al. 2008, Felice et al. 2008, Felice 2009a, 2009b, 2009c]. Both autogenous bone and bone substitutes can be used, but a pilot study [Felice et al. 2008, 2009c] has suggested that Bio-Oss blocks might be preferable to autogenous bone harvested from the iliac crest as interpositional grafts because patient discomfort is reduced. While all these augmentation procedures can yield favourable outcomes, they can be associated with significant postoperative morbidity and complications, and are expensive and time-consuming [Esposito et al. 2009].

An alternative technique to bone vertical augmentation is transposition of the alveolar inferior nerve, which provides space for placement of longer implants [Rosenquist 1994]. This procedure is technically demanding and can be associated with a sensible number of permanent loss of nerve sensitivity and therefore is seldom used nowadays. Nerve transposition procedures have never been evaluated in proper comparative trials and their efficacy is purely conjectural.

Short implants could be a simpler, cheaper and faster alternative to augmentation procedures, if they can be shown to result in similar success rates. The definition of “short” implants is controversial because some authors consider as “short” all those implants with a length within the range of 7–10 mm [das Neves et al. 2006], whereas other authors consider as “short” those implants with a designed intra-bony length of 8 mm or less [Renouard & Nissand 2006]. Nevertheless, it is commonly perceived that implants 7 mm or shorter do not have a good long-term prognosis when compared with longer implants. While it is reasonable to use longer implants when bone heights allow it, it remains unclear how to proceed in the presence of residual bone height ranging between 5 and 8 mm. Would it be preferable to use short implants or longer implants in vertically augmented bone? Although preliminary findings suggest that short implants may be a better alternative to various bone augmentation procedures [Stellingsma et al. 2004; Cannizzaro et al. 2009; Esposito et al. 2009; Felice 2009a, 2009b], long-term follow-up evaluations are indicated to draw definitive conclusions.

The aim of this randomized-controlled clinical trial was to compare the outcomes of partial fixed prostheses supported by 7 mm short implants [NanoTite] with prostheses supported by 10 mm or longer implants placed in posterior mandibular ridges vertically augmented with an interpositional block of anorganic bovine bone [Bio-Oss]. The present investigation reports the postloading outcomes following a preliminary 4-month report [Felice 2009a] and includes implant survival, complications and peri-implant marginal bone-level assessment to 1 year after loading. At the protocol stage, it was planned to follow the patients up to 5 years after loading. The present article is reported according to the CONSORT statement established to improve the quality of reports of parallel-group randomized trials [http://www.consort-statement.org/], enabling readers to understand the clinical trial design, conduct, execution interpretation and validity of its results.

Material and methods

Patient selection

Patients eligible for inclusion were any patient 18 or older, with partial edentulism in the posterior mandible having a residual bone height of 7–8 mm and a thickness of at least 5.5 mm above the inferior alveolar canal, treatment planned to receive two to three adjacent implants. To quantify the amount of available bone above the alveolar inferior canal, a preoperative computer

![Fig. 1. (a) Preoperative dental computed tomography scans used to evaluate patient eligibility: 7–8 mm of bone above the superior border of the mandibular canal with a thickness of at least 5.5 mm. (b) Preoperative periapical radiograph of a posterior mandible subsequently randomized to receive short implants. (c) Preoperative periapical radiograph of a posterior mandible subsequently randomized to be augmented for placing longer implants.](image)
tomography (CT) scan was used to determine a patient’s eligibility [Fig. 1a–c].

Exclusion criteria consisted of the following: (1) general contraindications to implant surgery, (2) lack of opposite occluding dentition in the area intended for implant placement, (3) acute infection in the area intended for implant placement, (4) with extraction sites healed for <3 months in the area intended for implant placement, (5) active periodontitis, (6) poor oral hygiene and motivation, (7) irradiation in the head or the neck area within the past year, (8) current chemotherapy for malignancy, (9) under treatment or past treatment with intravenous bisphosphonates, (10) uncontrolled diabetes, (11) pregnant or lactating, (12) substance abuse, (13) psychiatric disorders or unrealistic expectations, (14) participation in other clinical trials interfering with the present protocol, (15) having been referred to the patients’ general practitioners, (16) having realistic expectations, (17) participation in other clinical trials interfering with the present protocol, (18) participation in other clinical trials interfering with the present protocol, (19) participation in other clinical trials interfering with the present protocol, (20) participation in other clinical trials interfering with the present protocol, (21) participation in other clinical trials interfering with the present protocol.

Patients who were recruited and met the inclusion criteria were divided into three groups based on the number of cigarettes they reported to consume per day: non-smokers, light smokers (<10 cigarettes per day) and heavy smokers (≥10 cigarettes per day).

Patients were recruited and treated in three different private practices by the same operators [P. F. performed all the surgical and P. C. all the prosthetic procedures], using similar and standardized procedures.

The principles outlined in the Declaration of Helsinki on clinical research involving human subjects were adhered to. All patients received prophylactic antibiotic therapy: 1 g of amoxicillin + clavulanic acid (or erythromycin 500 mg if allergic to penicillin) starting the night before the intervention, and twice per day for a total of 7 days. All patients were treated under local anaesthesia using Articain with adrenaline 1:100,000. No intravenous sedation was used.

For the augmentation procedure, a surgical template was used to indicate the planned implant position. A paracrestal incision was made through the buccal mucosa respecting the emergence of the mental nerve, and as the mucoperiosteal flap was retracted, tension on the mental nerve was carefully avoided. A horizontal osteotomy was made approximately 2–4 mm above the mandibular canal using piezosurgery (Mectron Piezosurgery Device™, Mectron S.p.a., Carasco Genoa, Italy). Two oblique cuts were made in the coronal third of the mandibular bone with the mesial cut at least 2 mm distal to the last tooth in the arch. The height of the osteotomized segment was to be at least 3 mm to allow the insertion of a stabilizing screw without risking the fracture of the distracted bone segment. The segment was elevated sparing the lingual periosteum, and the bovine bone block was modelled to the desired height and shape to fill the site and interposed between the raised fragment and the mandibular basal bone.

Titanium miniplates and miniscrews (Gebrüder Martin GmbH & Co. KG, Tuttingen, Germany) were used to fix the osteotomized crestal bone to the basal bone. Gaps in the vertical osteotomy were filled with particles from the blocks. The grafted area was covered with a resorbable barrier (Bio-Gide™, Geistlich Pharma AG). Periosteal incisions were made to release the flaps coronally as needed and were sutured with Vicryl 4.0 sutures (Ethicon FS-2, St-Stevens-Woluwe, Belgium) until the incisions were perfectly sealed.

Ibuprofen 600 mg was prescribed to be taken two to four times a day during meals, as long as required. Patients were instructed to use Corsodyl gel 1% twice a day for 2 weeks and then 0.2 chlorhexidine mouthwashes twice a day for up to the second month, to have a soft diet for 1 week and to avoid brushing and trauma on the surgical sites. Removable prostheses were not allowed. Patients were seen after 3 days for follow-up examinations and sutures were removed after 10 days. Patients were recalled for additional postoperative check-ups 1, 2, 3 and 4 months after the augmentation procedure. Five months after augmentation, a CT scan was taken to plan implant placement.

**Implant placement**

Two grams of amoxicillin (or erythromycin 500 mg) was administered 1 h before implant placement. After local anaesthesia, crestal incision and flap elevation, the miniplates were removed at the grafted sites, and when needed, knife-edge ridges were debrided when required.

**Augmentation procedure**

All patients received prophylactic antibiotic therapy: 1 g of amoxicillin + clavulanic acid (or erythromycin 500 mg if allergic to penicillin) starting the night before the intervention, and twice per day for a total of 7 days. All patients were treated under local anaesthesia using Articain with adrenaline 1:100,000. No intravenous sedation was used.

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**Fig. 2.** The Bio-Oss block was placed as an interpositional graft and was stabilized between the two bone segments with miniplates and screws.
were flattened to reach a thickness of at least 5.5 mm. Two to three 7-mm-long (short implant group) or 10-mm-long implants or a longer implant (augmented group) were inserted under prosthetic guidance using a surgical template. NanoTite (External Hex, Biomet 3i, Palm Beach, FL, USA)-surfaced straight-walled titanium alloy (Ti6Al4V) implants, 4 mm in diameter with an external connection (Biomet 3i), were used. NanoTite implants are dual acid etched and then partially covered (about 50% of the surface) with nanoscale calcium phosphate crystals; this surface modification procedure is termed discrete crystalline deposition. The operator used 7-mm-long implants for the test group, but was free to choose lengths (10, 11.5, 13 and 15 mm) for the augmented group. The standard placement procedure as recommended by the manufacturer was used. Drills with increasing diameters (2, 2.8, 3.5 and when needed 4.3 mm) were used to prepare the implant sites. Implant sites were slightly underprepared and the surgical unit was settled with a torque of 25 N cm. In all cases, the platform of the implants was placed supracrestally so that the neck of the implant (0.6 mm in height) was not embedded into bone. According to a two-stage protocol, cover screws were placed and flap closure was obtained with Vicryl 4.0. Intraoral radiographs (baseline) were made using the paralleling technique (Fig. 3a and b). In the case the bone levels around the study implants were hidden or difficult to estimate, a second radiograph was made. Ibuprofen 600 mg was prescribed to be taken two to four times a day during meals, as long as required. Patients were instructed to use 0.2% chlorhexidine mouthwash for 1 min twice a day for 2 weeks, to have a soft diet for 1 week and to avoid brushing and trauma on the surgical sites. No removable prosthesis was allowed. Sutures were removed after 10 days.

Prosthetic procedures
After 4 months of submerged healing, implants were exposed, manually tested for stability and an impression with the pick-up impression copings was taken. Provisional screw-retained reinforced acrylic restorations rigidly joining the implants were delivered on prefabricated abutments (Biomet 3i). Occlusal surfaces were adjusted in slight contact with the opposite dentition.

Fig. 3. (a) Periapical radiograph taken at implant placement of a patient treated with 7 mm short implants. (b) Periapical radiograph taken at implant placement of a patient treated with vertical augmentation to place longer implants.

Fig. 4. (a) Periapical radiograph taken at implant loading of a patient treated with 7 mm short implants. (b) Periapical radiograph taken at implant loading of a patient treated with vertical augmentation to place longer implants.
Intraoral radiographs of the study implants were taken (Figs 4a and b). Four months after the delivery of the provisional prostheses, implants were manually tested for stability and definitive metal–ceramic restorations rigidly joining the implants with occlusal surfaces in ceramic were delivered on titanium-based UCLA abutments (Biomet 3i). Intraoral radiographs of the study implants were taken (Fig. 5a and b).

Patients were enrolled in an oral hygiene programme, with recall visits every 4 months for the entire duration of the study. Follow-up evaluations were conducted by an independent outcome assessor (G. P.) together with the surgeon (P. F.).

Outcome measures
This study tested the null hypothesis that there were no differences between the two procedures against the alternative hypothesis of a difference.

Outcome measures were:

1. Prosthesis failure: planned prosthesis that could not be placed due to implant failure(s) and loss of the prosthesis secondary to implant failure(s).

2. Implant failure: implant mobility or removal of stable implants dictated by progressive marginal bone loss or infection. The stability of individual implants was measured at abutment connection, at delivery of the provisional prostheses (4 months after implant placement), at delivery of the definitive prostheses (4 months after delivery of the provisional prostheses) and 1 year after loading after prosthesis removal, by tightening abutment screws with a torque of 15 N cm.

3. Any biological or prosthetic complications.

4. Time (days) needed to fully recover mental sensitivity after the augmentation procedure (augmented group) and implant placement (short implant group) This outcome was reported in a previous publication [Felice 2009a].
Peri-implant marginal bone levels evaluated on intraoral radiographs taken using the paralleling technique at implant placement (Fig. 1a and b), at delivery of the provisional prostheses (Fig. 2a and b) and 1 year after loading (Fig. 3a and b). Radiographs were scanned digitized in JGP, converted to TIFF format with a 600 dpi resolution, and stored in a personal computer. Peri-implant marginal bone levels were measured using the UTHSCSA Image Tool 3.0 (The University of Texas Health Science Center, San Antonio, TX, USA) software. The software was calibrated for every single image using the known implant length. Measurements of the mesial and distal bone crest level adjacent to each implant were made to the nearest 0.01 mm and averaged at the patient level and the at the group level. The measurements were taken parallel to the implant axis. Reference points for the linear measurements were: the most coronal margin of the implant collar and the most coronal point of bone-to-implant contact.

One dentist (G. P.) not involved in the treatment of the patients performed all clinical and radiographic assessments without knowledge of group allocation, and therefore the outcome assessor was blind; however, the Bio-Oss-augmented sites could be identified on radiographs because they appeared more radio-opaque and the implants were longer.

Statistical analysis
The sample size was calculated for the primary outcome measures (implant failure): a two-group continuity-corrected $\chi^2$-test with a 0.05 two-sided significance level will have 80% power to detect the difference between a proportion of 0.1 and a proportion of 0.3 for patients experiencing at least one implant failure (odds ratio of 3.857) when the sample size in each group is 72. However, it was decided to recruit only 30 patients in each group. A computer-generated restricted randomization list was created. Only one investigator (M. E.), who was not involved in the selection and treatment of the patients, was aware of the randomization sequence and had access to the randomization list stored in a password-protected portable computer. The randomized codes were enclosed in sequentially numbered, identical, opaque, sealed envelopes. After eligible patients enrolled in the trial signed the informed consent forms, envelopes were opened sequentially. Therefore, treatment allocations were concealed to the investigators in charge of enrolling and treating the patients.

All data analysis was performed according to a pre-established analysis plan, with a biostatistician with expertise in dentistry analysing the data without knowledge of the group codes. The patient was the statistical unit of the analyses. Differences in the proportion of patients with prosthetic failures, implant failures and complications (dichotomous outcomes) were compared between the groups using Fisher’s exact probability test. Differences in means at the patient level for continuous outcomes (bone levels) between groups were compared by $t$-tests. Comparisons between each time points and the baseline measurements were made by paired tests, to detect any changes in the marginal peri-implant bone levels. An analysis of covariance was used to compare the mean radiographic values at loading and 1 year, with the baseline value as a covariate. All statistical comparisons were conducted at the 0.05 level of significance.

Results
Sixty patients were considered eligible and were consecutively enrolled in the trial. For additional information about non-eligible patients, please look in the previous publication [Felice 2009a]. All patients were treated according to the allocated interventions. One patient from the short implant group dropped-out after she decided to have the prosthesis fabricated in Croatia for financial reasons, and subsequently did not return follow-up evaluations. The data of all the remaining patients were evaluated in the statistical analyses.

Deviations from the protocol consisted of:

- Augmented group: In three patients, the Bio-Oss blocks fractured into many pieces at placement and in two patients no clinical bone gain was obtained such that only 7-mm-long implants had to be placed.
- Short implant group: Two coronal implant threads remained exposed at implant placement and a titanium mesh, stabilized with the cover screw, was used to regenerate new bone.

- In a number of patients, primarily those in the short implant group, implants become exposed during healing most likely due to supra-crestal placement. For only four patients in the short implant group, and 24 patients in the augmented group, a surgical exposure of the implant was necessary.

Patients were recruited and subjected to vertical bone augmentation from June 2007 to April 2008. The last final prosthesis was inserted in December 2008. The follow-up of all patients was 1 year after implant loading (Fig. 7a and b).

Patient demographics are presented in Table 1. Sixty-one implants were placed in the augmented group and 60 in the short implant group and there were no apparent significant baseline imbalances between the two groups.

Table 2 summarizes the primary outcomes showing that three implants in three patients failed in the augmented group and one implant in the short implant group with all failures occurring before loading. The differences in the proportions of implant failures were not statistically significant [Fisher’s exact test $P = 0.07%$ and $0.62 \quad 95\% \ CI = 0.23 \text{ to } 0.08$]. Three control and one test prostheses could not be placed according to the time frame specified in the protocol. At the time of this 1-year report, two of the control group patients do not wish to have their failed implants replaced and therefore do not have definitive prostheses.

No permanent paraesthesia of the alveolar inferior nerve occurred. Four complications (dehiscence) occurred in four patients of the augmented group vs. none in the short implant group and all were observed between 10 and 30 days after the augmentation procedure. The difference in proportions is not statistically significant [Fisher’s exact test $P = 0.112$; difference in proportions $= 0.133 \quad 95\% \ CI = 0.009 \text{ to } 0.297$]. No other complication occurred up to 1 year after loading.

Both groups gradually lost marginal peri-implant bone in a highly statistically significant way [$P < 0.001$] at loading and 12 months after loading [Table 3]. At loading, patients with short implants lost an average of 0.58 mm peri-implant bone vs. 0.16 mm for patients with long implants [Table 4]. One year after loading, patients of both...
groups lost an average of 1 mm of peri-implant bone [Table 4]. There was no statistically significant difference between the two groups for peri-implant bone loss, when an analysis of covariance was applied \((P = 0.90)\).

**Discussion**

This trial was designed to assess which of two techniques would be the most effective approach to treat posterior mandibles with 7–8 mm of residual bone height over the mandibular canal for rehabilitation with implant-supported partial fixed bridges. Seven-millimetres-long implants were compared with a vertical bone augmentation procedure using interpositional blocks of anorganic bovine bone, considered to be one of the most predictable vertical augmentation procedures [Felice et al. 2008; Esposito et al. 2009]. Even with similar results, a procedure associated with fewer complications and discomfort, which is simpler and cheaper and that could allow a functional rehabilitation in less time would be preferable. Both techniques were able to achieve the planned goals, but short implants did so in a shorter time, with less morbidity and at a lower cost. For two patients, the augmentation procedure was a failure because it failed to gain enough bone to allow the placement of longer implants, although no visible complication occurred. This was probably caused by the fracture of the Bio-Oss blocks. In fact, in both cases, the blocks broke into pieces while being placed in position. The vertically lifted bone segment possibly collapsed because the fragmented bone substitute did not have the capacity to hold it in the proper position. It is therefore recommended to use a new block if the one being used breaks down into pieces. It would be also interesting to evaluate the performance of other types of bone substitute blocks that may have an improved physical strength. No additional complication or implant failure occurred between 4 and 12 months after loading. All complications, four dehiscences, occurred in the augmented group during the healing phase of the grafts. At least in two patients, it can be speculated that an infection was present, which caused a partial loss of the augmented bone, and in one case, the failure of an implant. The augmentation procedure not only required an additional healing time of 5 months, but was also associated, in a highly statistically significant manner, with more patients experiencing some postoperative paraesthesia of the alveolar inferior nerve. In fact, 16 patients (57%) had transient postoperative paraesthesia vs. only two patients (7%) in the short implant group [Felice 2009a]. The augmentation procedure is also more technically demanding than placing short

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**Table 1. Patient and intervention characteristics**

<table>
<thead>
<tr>
<th></th>
<th>Augmented (n = 30)</th>
<th>Short implants (n = 30)</th>
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<tbody>
<tr>
<td>Females</td>
<td>15</td>
<td>23</td>
</tr>
<tr>
<td>Mean age at implant insertion (range)</td>
<td>55 (43–67)</td>
<td>56 (40–83)</td>
</tr>
<tr>
<td>Smokers</td>
<td>11 light</td>
<td>11 light + 1 heavy</td>
</tr>
<tr>
<td>Mean residual bone height above the mandibular canal at patient recruitment</td>
<td>7.8 mm</td>
<td>7.7 mm</td>
</tr>
<tr>
<td>Total number of inserted implants</td>
<td>61</td>
<td>60</td>
</tr>
<tr>
<td>Number of implants placed with &lt; 25 N·cm torque</td>
<td>12 (6 patients)</td>
<td>4 (2 patients)</td>
</tr>
<tr>
<td>Mean length of the placed implants</td>
<td>11.2 mm</td>
<td>7 mm</td>
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**Table 2. Summary of the main results up to 1 year after loading**

<table>
<thead>
<tr>
<th></th>
<th>Augmented (n = 30)</th>
<th>Short implants (n = 29)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prosthesis failures</td>
<td>3 (n = 30)</td>
<td>1 (n = 29)</td>
</tr>
<tr>
<td>Implant failures (all before loading)</td>
<td>3 (n = 30)</td>
<td>1 (n = 29)</td>
</tr>
<tr>
<td>Augmentation procedure failures</td>
<td>2 (n = 30)</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Complications before implant placement</td>
<td>4 (n = 30)</td>
<td>0 (n = 30)</td>
</tr>
<tr>
<td>Complications after implant placement</td>
<td>0 (n = 30)</td>
<td>0 (n = 29)</td>
</tr>
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</table>
implants. One of the main difficulties is the management of the soft tissues to maintain sufficient blood supply to the cranially displaced bone segment and to close the wound without too much tension to minimize the risk of wound dehiscence.

There were no statistically significant differences, or different trends, for peri-implant marginal bone loss 1 year after loading between the two groups, with both groups losing 1 mm of bone from the baseline (implant placement). This result indicates that 1 year after loading, 7-mm-long implants are maintained in function by 5.2 mm of mean direct bone-to-implant contact as seen on periapical radiographs. The 1 mm of peri-implant bone loss observed in this study after 1 year postloading is slightly higher compared with observations in another similar trial in which posterior mandibles were augmented with an interpositional iliac crest bone graft (≈0.82 mm) and Bio-Oss blocks (≈0.52 mm) [Felice 2009c]. It is unlikely, however, that this small difference of 0.5 mm would give rise to any clinical significance.

Our findings are in agreement with three other RCTs testing the same hypothesis (Stellingsma et al. 2005; Cannizzaro et al. 2009; Felice 2009b). One RCT reported in three articles (Stellingsma et al. 2003; Stellingsma et al. 2004; Stellingsma et al. 2005) compared fully atrophic edentulous mandibles with a symphyseal bone height of 6–12 mm augmented with an interpositional graft from the iliac crest and four “longer” implants with four “short” implants, 8–11 mm long, supporting overdentures followed up for 2 years postloading.

Table 3: Mean radiographic peri-implant marginal bone levels between groups and time periods

<table>
<thead>
<tr>
<th>Implant placement</th>
<th>Loading*</th>
<th>1 year after loading*</th>
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<tbody>
<tr>
<td></td>
<td>N Mean (SD)</td>
<td>N Mean (SD)</td>
</tr>
<tr>
<td>Short implants</td>
<td>0.79 (0.41)</td>
<td>0.63, 0.95</td>
</tr>
<tr>
<td>Long implants</td>
<td>0.65 (0.28)</td>
<td>0.55, 0.76</td>
</tr>
</tbody>
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*All changes from baseline statistically different (P < 0.001).

Table 4: Comparison of the mean changes in peri-implant marginal bone levels at different time periods between groups

<table>
<thead>
<tr>
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<th>Baseline – loading</th>
<th>Baseline – 1 year after loading</th>
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<tbody>
<tr>
<td></td>
<td>N Mean (SD) 95% CI</td>
<td>N Mean (SD) 95% CI</td>
</tr>
<tr>
<td>Short implants</td>
<td>29 – 0.50 (0.30)</td>
<td>0.69, 0.46</td>
</tr>
<tr>
<td>Long implants</td>
<td>30 – 0.55 (0.29)</td>
<td>0.69, 0.45</td>
</tr>
<tr>
<td>P-value for groups</td>
<td>0.90*</td>
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</table>

*Analysis of covariance at loading and 1 year after loading with baseline as a covariate.

In the augmented group, there were statistically more implant failures (five patients out of 20 experiencing implant failures vs. none), and more postoperative pain and complications, in addition to the obvious differences in the necessary hospital occupancy, time and expense to complete the treatment. Some of the complications that occurred were serious including a life-threatening haemorrhage, causing a massive sublingual oedema that left the patient hospitalized in intensive care for 3 days, a necrosis of the graft causing failure of all the four inserted implants and two cases of permanent unilateral dysaesthesia. All of these complications, with the exception of one permanent dysaesthesia, occurred in the vertically augmented group. The authors concluded that short implants were the best treatment solution for those patients. However, the definition they used of short implants is not universally accepted. While 8 mm implants are short, 9, 10 and 11 mm implants are not usually considered to be “short”.

A recent RCT [Felice 2009b] compared implants 5 mm in length and 6 mm in diameter, placed in atrophic posterior jaws, with 10 mm or longer implants placed in vertically augmented mandibles or in maxillary sinuses augmented with granular Bio-Oss placed according to a two-stage lateral window approach. Residual bone heights were 5–7 mm in the mandible and 4–6 mm in the maxilla. In a study of a split-mouth design, 30 partially edentulous patients [15 mandibles and 15 maxillae] were included. Four months after loading, only two implants failed in two patients, one from each group. Of these, only one implant failed in the mandible and was a longer implant placed into a vertically augmented site.

Interestingly, one RCT [Cannizzaro et al. 2008] also suggested that it is possible to immediately load 7-mm short implants identical to those used in the present investigation, even if placed flapless or in postextractive sites, when implants were placed with an insertion torque > 40 N cm.

Another RCT [Cannizzaro et al. 2009] compared 8-mm-long hydroxyapatite-coated implants placed in crestally augmented maxillary sinuses, with longer implants placed in sinuses grafted with 50% particulated autogenous bone and 50% Bio-Oss according to a one-stage lateral window procedure. All implants were loaded 45 days after implantation. Although 1-year results showed no statistically significant differences, more implants failures and more serious complications occurred in the group augmented using the lateral approach for receiving longer implants. It should be emphasized, however, that comparisons of short implants between the upper and lower jaws should be made very carefully due to different anatomical conditions, which may affect the final results.

While there are some obvious differences among the present trial and those mentioned above (i.e. use of different types of grafts in different locations and how “short” implants are defined), the results of all these studies are in substantial agreement, suggesting that short implants could be a preferable solution over an augmentation procedure to place longer implants in the short term. The main question is whether the 1-year advantage of short implants is maintained over time. In fact, it may be possible that after some years short implants could fail more often due to marginal bone loss or overload. Only longer follow-up evaluations will provide an answer to this question.

Up until now, the performance of 7-mm implants has appeared to be less successful, with failures of about 10% reported at the implant level according to a literature review [das Neves et al. 2006]. It could be speculated that the new implant surface with discrete calcium phosphate deposition (NanoTite) of the implants used this and another investigation [Cannizzaro et al. 2008], together with an improved surgical technique, i.e. high implant insertion.
torque, might have played an important role in the improved success rates observed in these more recent trials. Histological human findings also showed a faster and improved bone-to-implant contact when comparing NanoTite implants with titanium Osseotite control implants (Goerne et al. 2007; Orsini et al. 2007). This is just a hypothesis that needs to be tested with appropriately designed clinical trials.

The main limitation of the present trial is the small sample size that, in any case, was sufficient to show a statistically significant difference in the speed of recovery of mental sensitivity (Felice 2009a). In addition, when combining the present findings with those of other similar trials in a meta-analysis [Esposito et al. 2009], statistically significantly more failures and complications were observed when longer implants were placed in vertically augmented mandibles. It should also be recognized that this is the only trial on this topic published so far with a larger sample size. Nevertheless, trials with larger sample sizes and longer follow-ups are needed to confirm or reject these preliminary findings.

Because in the present investigation both the augmentation and the short implant approaches to atrophic posterior mandibles were tested under real clinical conditions, and patient inclusion criteria were broad, the results can be applied with confidence to a wider population with similar characteristics. On the other hand, the surgeon was experienced with both techniques and this factor might limit the extrapolation of the results.

Conclusions

Both treatment approaches for rehabilitation of atrophic posterior mandibles, the interpositional bovine block grafting or the placement of 7-mm-long implants, achieved good and similar results. When the residual bone height over the mandibular canal is between 7 and 8 mm, 7-mm short implants might be a preferable choice because the treatment is faster, cheaper and associated with less morbidity. These preliminary 1-year postloading results must be confirmed by trials with larger sample sizes and longer follow-ups.

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References


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