The aim of this study was to analyze horizontal bone augmentation using the tenting screw technique in the posterior mandible. Included subjects had a 3-mm bone width and 9-mm bone height, measured by CBCT. After the surgical approach, two to four screws were inserted, leaving 4 mm of extraosseous space; reconstruction was achieved using allogeneic biomaterial and leukocyte- and platelet-rich fibrin together with an absorbable membrane. After 4 months, a new CBCT scan was obtained to compare the bone gain and implant placement. Early and secondary stability were measured by the implant stability quotient (ISQ); prosthetic load was performed 16 weeks later. Student t test was used to compare bone gains and implant stability, with significance set at P < .05. Fourteen subjects and 27 surgical sites initially exhibited a mean bone width of 2.95 ± 0.75 mm. Four months after augmentation, the bone width was 7.15 ± 1.87 mm, confirming a significant bone gain (4.2 ± 1.26 mm). Twenty-seven implants were placed with a minimum insertion torque of 35 Ncm; the primary stability was 69.3 ± 7.16 ISQ, and the secondary stability was 75.9 ± 3.29 ISQ (P > .05). It may be concluded that the tenting screw technique is predictable in terms of bone gain and that it facilitates implant stability. Int J Periodontics Restorative Dent 2021;41:e147–e155. doi: 10.11607/prd.5137

Various techniques are available for horizontal bone augmentation; some of them are controversial, but no clinical difference has been demonstrated.1 The use of biomaterials in bone augmentation, including carriers and particle size as important variables, is well established2,3; on the other hand, new research shows the important roles of platelet-rich fibrin (PRF),4 polymers,5 and other materials in bone formation.

In 1989, Dahlin et al6 published the use of a Teflon membrane to create new bone around the implant, showing good results; in 1995, Mellonig and Nevins7 explored guided bone regeneration (GBR), revealing the early success of the technique with a focus on maintaining the space as the key factor. Mellonig and Nevins7 included the decision trees based in patient factors, defect anatomy, presurgical, surgical, and postsurgical factors. Ten years later in 2006, Wang and Boyapati8 described the principles to perform GBR, and Urban et al9 later included parameters for horizontal and vertical augmentation in complex cases.

The tent screw pole technique, tunneling technique, and GBR using titanium-reinforced polytetrafluoroethylene have been compared, showing no statistical differences in implant placement after bone reconstruction was significantly increased using the tent pole.
technique performed with biomaterials. In terms of complications, membrane exposure represents the main problem.

Urban et al demonstrated that the use of particulate autogenous bone plus xenografts and fixed resorbable membranes for subsequent implant placement resulted in a 5.68-mm increase in bone and 100% success for implant stability. Geurs et al reported a bone gain in a 5.68-mm increase in bone and subsequent implant placement resulted in a 5.68-mm increase in bone and 100% success for implant stability.

The aim of this research was to analyze (1) horizontal bone augmentation in the posterior edentulous mandible using the tenting screw technique with allograft, and leukocyte- and platelet-rich fibrin (L-PRF) and (2) subsequent primary and secondary stability of the implants.

Materials and Methods

This prospective study was designed at the San Bernardo Health Center of the Universidad de los Andes (Santiago, Chile). All subjects agreed to participate in the study and signed an informed consent form. The research was approved by the ethical committee of the Universidad de los Andes.

American Society of Anesthesiologists Class I or II men and women undergoing dental implant treatment in the posterior mandible were included. All participants exhibited good oral hygiene and were discharged from periodontal treatment prior to dental implant treatment. Subjects showed tooth loss in the premolar or molar areas with a minimum height of 9 mm from the mandibular canal and a maximum bone width of 3 mm observed in CBCT scans. Subjects with osteoporosis, users of drugs related to bone metabolism, smokers, subjects with active periodontal disease, and subjects with medical records of cancer, chemotherapy, or radiation therapy were excluded.

Twenty-four hours prior to surgery, each patient was treated with amoxicillin (1 g/12 hours, 7 days) or azithromycin (500 mg/24 hours, 6 days). Immediately prior to the surgery, 100 mg ketoprofen was administered intravenously, and oral nonsteroidal anti-inflammatory drugs were used postoperatively.

During surgery, eight tubes of venous blood were obtained; six were additive-free 10-mL tubes covered with silica (BD Vacutainer, BD Diagnostics) and processed in an IntraSpin centrifuge (Intra-Lock) at 2,700 rpm/498 cycles for 12 minutes. Fibrin clots were extracted, placed in a sterile metal box, and compressed to generate PRF membranes. Two samples were collected in additive-free 6-mL tubes (Vacutette, Greiner Bio-One) and centrifuged at 2,700 rpm for 3 minutes to obtain fibrinogen fluid.

To make the L-PRF block, the PRF membranes were segmented into multiple smaller fragments of 1 to 2 mm, and mixed with a bone substitute material (Puros Cortical, Zimmer Biomet), mixing two membranes with 0.5 g of biomaterial (50:50 in volume). The fibrinogen fluid was added to the mix and placed on the mandibular bone for approximately 1 minute to realize manipulation and adaptation.

The surgery was conducted under local anesthesia (Fig 1). A full-thickness lateral flap was designed with a supracrestal incision and extension on the mesial tooth in the edentulous area (Fig 2). Deep incisions were made in the buccal periosteum to secure the extension requirement of the soft tissue for passive closing over the grafted material; the lingual flap was mobilized with detachment in the lower zone. A free flap was obtained in the buccal and lingual zones.

Superficial milling of the cortical bone was performed, and monocortical perforations were made on the buccal area. In total, two to four screws (1.5-mm screw, Artfix Implants) were inserted, and 4 mm of extraosseous space was maintained to obtain bone augmentation in the area. The screws were inserteded 45 degrees from the occlusal plane. The defect was filled with L-PRF block, and the entire 4-mm space under the screws made intimate contact with the cortical bone. The surgical site was covered with a resorbable collagen membrane (Biomend Extend, Zimmer Biomet) that was previously trimmed according to the size from the lingual side without tooth contact; the membrane was placed over the graft without use of fixation. The L-PRF membrane was installed over the resorbable membrane. Antibacterial Vicryl Plus 4-0 (Ethicon, Johnson & Johnson) sutures were used at the site.

Sixteen weeks after the reconstructive technique, a new CBCT
Fig 1  Outline of the sequence of the study’s treatment and evaluations.

Fig 2  Clinical sequence for the tenting screw technique. (a) Surgical site with monocortical perforations. (b) Insertion of screws with 4 mm of extraosseous space. (c) Position of the biomaterial with L-PRF reaching the surface of the screws. (d) Placement of absorbable membrane adapted to the site. (e) Placement of L-PRF membrane over the collagen membrane. (f) Fixed prosthesis 10 months after baseline. (g) Radiographic view at the 12-month follow-up showing no problems in the peri-implant bone.
scan was obtained to determine horizontal bone gain, and dental implants were placed. The surgical approach used a supracrestal linear incision and partial mobilization of the flap (Fig 3). The screws were removed, and the drilling sequence was realized for the implants (Zimmer Tapered Screw-Vent MTX surface, Zimmer Biomet; Fig 3) using a drill with a 3.75-mm diameter and 8- or 10-mm height, decided according to the surgical site. Implant primary stability was evaluated by insertion torque and implant stability quotient (ISQ). Sixteen weeks later (32 weeks after the reconstructive technique), a second surgery was performed, and the implants were loaded with a single screw or splint prosthetic system according to the specific indication of each case.

Data were analyzed with Shapiro-Wilk test to determine distribution. Student t test was used to compare the widths of the ridge and stability of the implants. P < .05 was considered to be statistically significant for both tests.

Results

Fourteen patients (10 women, 4 men) aged between 45 and 73 years (mean: 56.8 ± 7.8 years) were included in this study. The surgical sites for the 27 dental implants were at the canine level (n = 1), first premolar (n = 1), second premolar (n = 10), first molar (n = 11), and second molar (n = 4).

Fig 3 Clinical sequence for the placement of implants at augmented sites. (a) Movement of the flap and removal of the screws placed in the first surgery. (b) Reconstructed site, ready for implant surgery. (c) Implant insertion according to the protocol established for each case.

Fig 4 Tomographic images that indicate the phase prior to regeneration (left side) and the condition 4 months after the reconstruction (right side) at four different sites from different patients. Note that horizontal augmentation was performed in all patients.
Initially, the bone width was between 1.2 and 4.0 mm (average: 2.95 ± 0.75 mm). Four months after horizontal augmentation, the width was between 3.79 and 10.05 mm (average: 7.15 mm ± 1.87 mm), revealing an average bone gain of 4.2 ± 1.26 mm (Table 1). The difference obtained was significant (P = .03). In terms of volume, the bone gain was between 1.12 and 167.75 mm², with an average of 46.9 ± 32.79 mm² (Fig 5).

No intraoperative complications were associated with the surgical technique; no suture dehiscence or exposure of the membranes was recorded. In four sites, exposure of the screw head was observed after 2 months and was maintained with local measures until the second surgery; these sites showed a thin

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Values shown are widths, measured in millimeters.
*FDI tooth numbering system.
periodontal biotype. Paresthesia was observed in only one patient and was related to the manipulation of the flap, improving at 2 weeks postsurgery.

All implants (n = 27) were placed. The insertion torque of the implants ranged from 35 to 70 Ncm (average: 55.6 ± 10.17 Ncm). ISQ assessment revealed a variation between 55.5 and 81 (average: 69.34 ± 7.12) in the primary stability of the implants, and between 69 and 80 (average: 75.9 ± 3.29) in the second surgery prior to the prosthetic load (Fig 6). No significant differences were noted between the two times (P > .05). Follow-up was performed in the oral health maintenance program, which is typically offered to the patients in the final stage of their treatment. No complications were observed in the surgical site; all implants were maintained in function at the 3- and 6-month follow-ups.

**Discussion**

Bone grafts and substitutes are used to improve the functional and esthetic results and augmentation using intraoral autogenous block is one of the most studied techniques, showing high success rates. However, a second surgical site, an increase in morbidity, and an increase in surgical time are disadvantages. Chiapasco and Casentin created a classification to define bone defects, and the tenting screw technique could be used following these orientations and classifications.

Horizontal augmentation increases its indication for using CBCT to provide the real bone morphology as the defect anatomy is an important variable for technique selection in bone regeneration. The present results show the real potential of the tenting screw technique to obtain volumes and widths suitable for implant placement. This confirms the findings of de Groot et al., who demonstrated that the tent pole technique was significantly better for bone gain in long-term follow-ups.

In the present study, an average bone gain of 4.2 ± 1.26 mm and an average volume increase of 46.9 ± 32.79 mm³ were demonstrated. Mellonig and Nevins, and later Wang and Boyapati, reported principles related to GBR success including primary wound closure, space maintenance, stability of the clot, and angiogenesis. At the beginning of the present study, cases exhibited a bone width close to 3 mm, which provides bone tissue with an adequate blood supply and is necessary in any reconstructive technique. Bone widths < 3 mm probably shows poor irrigation, which could adversely impact the success of this technique.
Additionally, Urban et al\textsuperscript{25} explained anatomical conditions of this area, demonstrating that tension-free flap closure is an important factor in bone augmentation techniques. The present observed complications included exposure of the screw head in four sites without failure of the graft and related to a thin periodontal biotype at 2 months postsurgery. The use of PRF has increased in recent years,\textsuperscript{4} and some investigations support the use of PRF for soft tissue repair.\textsuperscript{26}

Geurs et al\textsuperscript{12} described a patient series for horizontal augmentation with slow resorption membranes, allograft, and a thermoplastic carrier and reported a bone gain of 2.4 to 5.2 mm, which is similar to the present results. In a similar study,\textsuperscript{27} an allograft and a degradable thermoplastic carrier covered by a resorbable membrane were used in the horizontal augmentation of 73 patients, achieving an average bone gain of 3.5 mm (range: 3 to 6 mm) at the 6-month follow-up. Other studies used GBR,\textsuperscript{28} demonstrating an average bone gain close to 3.2 mm (range: 2.2 to 4.2 mm). In the present case series, the authors believe that the resorbable membrane and the screw could help maintain the space, size, and shape of the graft and that the use of PRF could help in soft tissue recovery, showing synergy in the technique.

Urban et al\textsuperscript{9} used a combination of autogenous bone, anorganic bovine bone, and resorbable membrane in horizontal augmentation, obtaining 5.68 mm in bone gain. All implants were placed without complications in the follow-up period.

The present results demonstrated a 4.2-mm bone gain. Differences from Urban et al\textsuperscript{9} could be related to the following: (1) Urban et al used particulate autogenous bone mixed with biomaterials, and the present case series used only biomaterial and PRF to build the new alveolar ridge; and (2) Urban et al’s membrane fixation method could help to create and effectively maintain the space, whereas in the present case series, a well-adapted resorbable membrane was used without fixation and instead using a 4-mm extraosseous screw, which could limit bone gain.

The use of biomaterials could be more versatile than block autogenous bone; bone gain achieved using an intraoral block is close to 3.5 mm because the intraoral donor site cannot provide thicknesses greater than 4 mm (to avoid neurologic or morphologic alterations), and the maximum gain is related to the size of the structural bone graft.\textsuperscript{29,30} Considering these patterns, 4-mm bone gain with the technique described in the present research seems suitable and efficient for placement and maintenance of implants.

After the tenting screw technique, 27 implants were placed without complications. Waechter et al\textsuperscript{31} installed implants in the native posterior mandible without reconstructive techniques, presenting a primary stability (ISQ) of 67.86 for conical implants and 62.62 for cylindrical implants. After 90 days, new measurements revealed ISQ values of 78.61 for conical implants and 76.62 for cylindrical implants, indicating an ISQ increase of approximately 20 in both cases. The present results in grafted sites exhibited stable but lower results at the 4-month follow-up, with an ISQ increase of 6 ± 4 (P > .05). However, clinical predictability was identified, as implants were loaded without problems in the follow-up period.

The tent pole technique used in the anterior maxilla\textsuperscript{32} yielded bone formation, and later implant stability, in sites filled with xenografts. Another study\textsuperscript{33} reported on 31 implants placed in augmented sites in mandibular and maxillary areas using the tent pole technique, observing stability in the short term. In the present case series, no early dental implant failure was observed, which is consistent with other reports.\textsuperscript{34} In a systematic review, Sanz-Sánchez et al\textsuperscript{35} concluded that the stability of the peri-implant tissue is predictable with no relation to the technique used for reconstruction and could maintain osseointegration in the long term; bone augmentation is not a variable associated with potential failure.

**Conclusions**

It may be concluded that the tenting screw technique is predictable in achieving significant augmentations with low morbidity in the posterior mandible. It is possible to obtain implant stability and prosthetic rehabilitation with low morbidity using this method.

**Acknowledgments**

The authors declare no conflicts of interest.
References


