Int. J. Oral Maxillofac. Surg. 2011; 40: 57–64
doi:10.1016/j.ijom.2010.03.030, available online at http://www.sciencedirect.com

International Journal of
Oral & Maxillofacial Surgery

Clinical Paper
Pre-Implant Surgery

Alveolar split osteotomy for the treatment of the severe narrow ridge maxillary atrophy: a modified technique

R. González-García[1,2], F. Monje[1,2], C. Moreno[1,2]
[1]Department of Oral and Maxillofacial Surgery, University Hospital Infanta Cristina, Badajoz, Spain; [2]CICOM, Centro de Implantología y Cirugía Oral y Maxilofacial, Badajoz, Spain

R. González-García, F. Monje, C. Moreno: Alveolar split osteotomy for the treatment of the severe narrow ridge maxillary atrophy: a modified technique. Int. J. Oral Maxillofac. Surg. 2011; 40: 57–64.

Abstract. Alveolar bone splitting and immediate implant placement have been proposed for patients with severe atrophy of the maxilla in the horizontal dimension. A new modification of the classical alveolar bone splitting for the treatment of the narrow ridge in the maxilla is provided. Thirty-three dental implants in eight consecutive patients were evaluated retrospectively following the described modified split-crest osteotomy. Inclusion criteria were: inadequate maxillary buccolingual dimension, 3–4 mm of crestal width, and sufficient height from alveolar ridge tip to maxillary sinus floor. Primary stability was calculated using resonance frequency analysis (RFA). Alveolar bone height was measured in the panorex pre- and postoperatively. Histological bone examination was assessed following trephine bone harvesting during the second operation. Mean follow-up was 28.33 months. Bone regeneration of the inter-cortical gap occurred in 98% of implant sites (implant survival rate 100%). Mean implant stability quotient (ISQ) for the whole series of implants was 69.48. At the second operation, mean loss of the alveolar bone height was 0.542 mm. Predictable results are obtained using the modified split-crest osteotomy. This technique provides an acceptable inter-cortical gap, decreases the risk of necrosis of the outer cortex, and provides a firm-wall box for the placement of particulate bone grafting.

Key words: alveolar split osteotomy; narrow ridge; maxillary atrophy; endosseous dental implants.

Accepted for publication 16 March 2010
Available online 21 August 2010

Horizontal and vertical atrophy of the alveolar ridge are usually present in severe edentulism, corresponding to classes IV to VI according to Cawood & Howell[3]. In these cases, vertical and horizontal augmentation of the alveolar ridge is mandatory to allow adequate implant insertion. In the severely atrophied maxilla, alveolar ridge augmentation by means of bone grafting, guided bone regeneration or distraction osteogenesis is mandatory previous to the placement of endosseous implants. Specific disadvantages have been reported for each technique, such as: resorption, limited amount of bone, damage to the adjacent teeth and sensory nerve disruption, in bone grafting; tissue dehiscence, membrane displacement and membrane collapse, in guided bone regeneration; and inadequacy of the distraction vector, bone resorption, absence of bone formation and prolonged time for implant placement, in alveolar distraction.

Alveolar bone splitting and immediate implant placement have been proposed for patients with severe atrophy of the maxilla in the horizontal dimension. Osborn[10] described the 'extension plasty', a two-staged method for splitting and extending the alveolar crest and filling the expanded space with hydroxyapatite or autogenous bone, while insertion of the implant was performed 8–12 weeks later. NENTWIG & KNIHA[9] reported the bone splitting technique in 1986, as a one-staged method that allowed extension of the alveolar crest and insertion of the implant at the same time. These classical approaches for the splitting technique were generalized with the use of osteotomes. Since then, several modifications have been reported for the classical technique, such as the use of ultrasonic surgery[2] or the staged ridge splitting technique[6]. CHIAPASCO et al.[5] cited the technique of sagittal osteotomy of the anterior maxilla with preservation of the buccal cortex periosteum and vascularization with a half-thickness flap, stating that this technique results in a better outcome than other techniques.

Otherwise, it is thought that implant primary stability plays a major role in successful osseointegration. It depends on the quality and quantity of the bone, the implant geometry and the technique for preparation of the implant site[12]. Volume and quality of bone are important factors in determining the surgical process and the type of implant to be used, and are related to the success of implant surgery. The technique of resonance frequency analysis (RFA) measures the stability of the implant as a function of the rigidity of the complex bone/implant. The frequency of the resonance (in Hz) in a transducer is established by means of the implant stability quotient (ISQ), and typically ranges between 45 and 85. Although the use of RFA was primarily introduced to help in the decision of when to use implants with the immediate load technique, its use in other scenarios makes it possible to evaluate the primary stability of implants placed on atrophic crests undergoing previous augmentation procedures.

The authors describe a modification of the classical alveolar bone splitting technique for the treatment of the narrow ridge in the maxilla, bearing in mind the degree of implant primary stability measured by RFA.

Patients and methods

33 dental implants in 8 consecutive patients (mean age 53 years; range 38–69 years) with severe atrophy of the alveolar maxillary ridge were evaluated in this retrospective study (Fig. 1). The study was carried out at the Centro de Implantología y Cirugía Oral y Maxilofacial CICOM, Badajoz, Spain. The study was approved by the Ethical Committee. All the patients underwent a modified split-crest technique with immediate implant insertion. Implant placement was conducted through a conventional two-step procedure, and a second stage surgical procedure to place the abutments was performed following the healing process 4 months later. Patients were selected using the following inclusion criteria: inadequate maxillary buccolingual dimension, 3–4 mm of crestal width; and sufficient height from the tip of the alveolar ridge to the floor of the maxillary sinus, to allow immediate implant placement without the need for an associated sinus lift procedure. Panoramic radiography and dental CT scans were used to assess the preoperative conditions. Implant stability was measured using the RFA with the Ostell™ Mentor (Integrations Diagnostics AB, Savedalen, Sweden) in ISQ units. The pre- and postoperative alveolar height measurements were made in relation to implant sites. Height of the maxillary bone was measured from the head of the implant (postoperatively) or from the tip of the alveolar ridge at implant site (preoperatively) to the cortical bone corresponding to the floor of the maxillary sinus or the nasal cavity. The loss or increase of alveolar height was expressed as the difference between pre- and post-operative heights.

Adequate bone formation was assessed by histological examination of specimens obtained with a trephine drill during the second operation. The biopsy was taken with a 2.0 mm diameter trephine introduced within the grafted bone in the vicinity of the implant. Special care was taken not to disturb the architecture of the bone around the implant. Specimens were washed and immediately fixed in 10% formalin following biopsy. Conventional histological examination with haematoxylin–eosin was performed once the bone was completely decalcified with a freshly prepared aqueous solution of CH_2O 4% and HCl 10%. A physical method (needle prick) was used to confirm adequate decalcification of the specimen, taking care to use it away from the site of interest to avoid artifacts. The specimens were rinsed to wash away the acid. The sections were processed and embedded in paraffin blocks.

All patients were clinically followed for at least 24 months postoperatively (Fig. 2), although mean postoperative follow-up for the whole series was 28.33 months. Panorex radiography was performed for each patient to assess postoperative alveolar bone height in the site of implant placement. Panorex radiography obtained at month 24 was compared with that for preoperative evaluation in terms of alveolar bone height at the implant site.

Fig. 1. Cone-beam CT showing severe horizontal resorption of the atrophic maxilla.

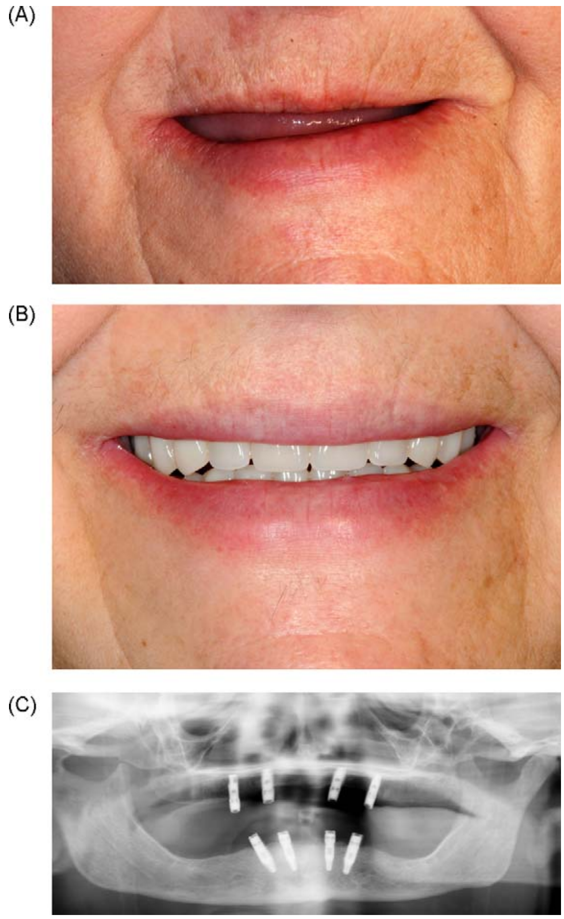

Fig. 2. Patient no. 1. (A) Preoperative clinical view. (B) Postoperative clinical view. (C) Panoramic radiography showing the placement of implants in the upper maxilla for prosthetic rehabilitation following the modified alveolar split osteotomy.

Surgical technique

A buccal mucoperiosteal flap was elevated following mid-crestal and intracrevicular incisions. No palatal flap was harvested in order to maintain adequate irrigation of the alveolar ridge. First, a mid-crestal osteotomy with a reciprocating saw or a diamond disc was performed into the alveolar ridge (Fig. 3A). This osteotomy was extended as far as the narrow alveolar crest was present. Two vertical cuts were then performed on the proximal and distal ends of the mid-crestal osteotomy (Fig. 4). The cephalad ends of the vertical cuts were connected with a horizontal corticotomy by means of a piezosurgical device (Fig. 5). Vertical osteotomies were deepened 3 mm through the cortical bone, with preservation of intact cancellous bone. The authors only used the piezosurgical device to make the corticotomy that connected both vertical osteotomies. This was because a careful cut to cortical bone was selectively required at this point, in order to create a green-stick fracture and avoid a complete fracture of the buccal plate. The other osteotomies required deeper cuts, and a diamond disc (Fig. 3A) or a reciprocating saw was used.

A green-stick fracture of the cephalad horizontal corticotomy was performed carefully with the introduction of a thin chisel (Fig. 4). Following this manoeuvre, progressive introduction of thin osteotomes between buccal and palatal cortical plates was performed in order to obtain the desired widening of the inter-cortical gap (Figs 3B,4 and 5). The sequential introduction of the osteotomes from a minor to a major diameter allowed safer and more controlled splitting. Following splitting of the outer cortex, implants were placed in the cancellous bone without saline irrigation (Figs 6 and 7A). Primary implant stabilization was assessed with the ISQ values. Subsequent filling of the gap with particulated bone graft was carried out (Figs 3C and 7B). It was composed of a mixture of autogenous bone graft obtained from the vicinity with a bone scraper and the allogenic bovine particulated bone graft Laddec® (Transphyto, France). A re-absorbable membrane Gore Resolute® (W.L. Gore & Associates, Inc, Newark, Delaware, USA) was used to cover the graft. Finally, the mucoperiosteal flap was repositioned and fixed with a 4/0 Gore-tex® suture (W. L. Gore & Associates, Inc, Newark, Delaware, USA) (Figs 3D and 7C). The degree of ossification in the inter-cortical gap was assessed by histological analysis of bone biopsies adjacent to implants obtained during the second operation (Fig. 8).

Results

The postoperative period was uneventful. The mean follow-up for the whole series was 28.33 months. Thirty-three endosseous implants were placed following the modified split-crest osteotomy. Twenty implants were placed in the anterior maxilla (intersinus), and 11 in the posterior maxilla. The implant diameters were: 3.3 mm (9%); 3.75 mm (31%); and 4 mm (60%). Bone regeneration of the inter-cortical gap occurred in 98% of the implant sites, with an implant survival rate of 100%. Mean ISQ for the whole series was 69.48. At the end of the follow-up period, mean loss of the alveolar bone height was 0.542 mm. Twenty-two implants underwent bone resorption ranging from 0.1 mm to 2.8 mm, while nine implants underwent increases of alveolar bone height from 0.1 mm to 1.1 mm (Table 1). Two other cases did not experienced any change in alveolar bone height pre- and postoperatively. Neither dehiscence of the suture nor wound infection was observed in any of the patients. No total fracture of the buccal plate was observed, probably due to the careful insertion of the osteotomes within the bone cut followed by the green-stick fracture of the horizontal cephalad osteotomy. For eventual cases with total fracture of the buccal bone segment, the authors believe that careful fixation of the buccal cortex to the underlying palatal bone cortex with two bicortical microscrews may be enough to stabilize the bone segment, while allowing the preservation of a neo-gap that should be filled with autogenous or allogenic bone graft. The histological specimens showed a mixture of autogenous bone graft and allogenic bovine particulated bone graft, together with de novo formation of mature bone connecting previous isolated bone islands between the allogenic material (Fig.8).

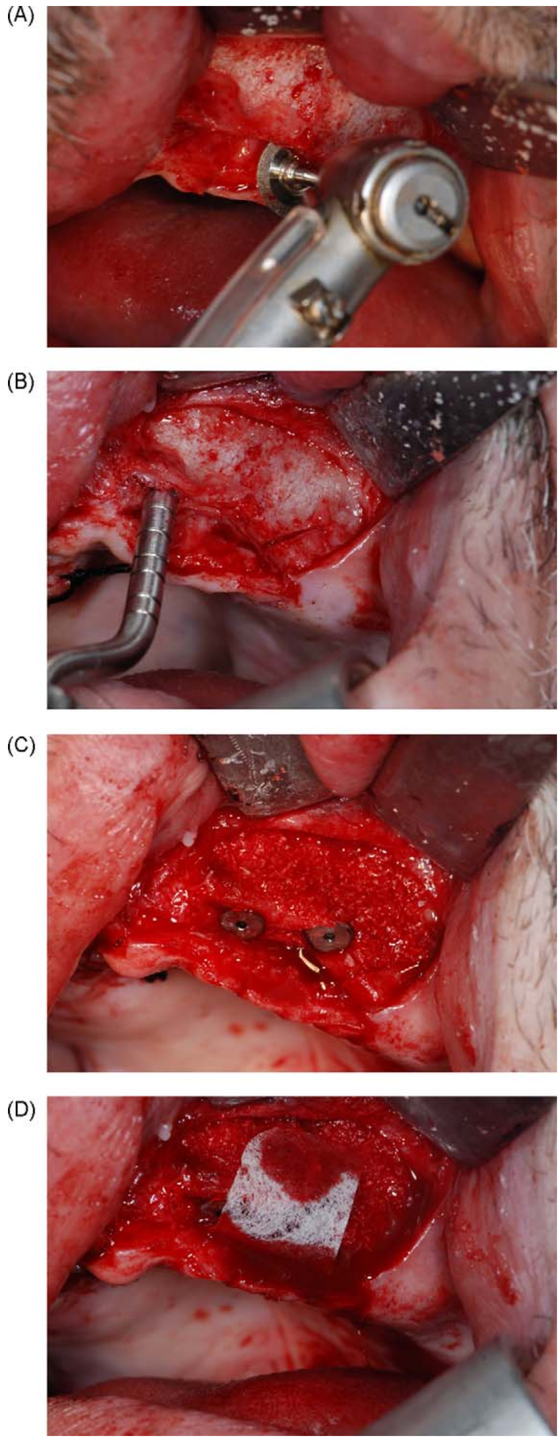

Fig. 3. Patient no. 2. Split osteotomy on the anterior maxillary bone. (A) Use of a diamond disc to perform a longitudinal mid-crestal osteotomy. (B) Use of an osteotome to expand the outer cortex. (C) Placement of two implants and particulated demineralized bovine bone graft. (D) Placement of allogenic membrane over the particulated bone graft.

Discussion

In relation to the atrophic maxilla, most authors recommend some type of bone augmentation procedure for anterior and posterior Class IV and V cases. Owing to potential complications at the donor site and difficulty with the harvesting procedure, selected cases with maxilla Class IV may benefit from the modified split osteotomy for the immediate insertion of endosseous implants[4].

Predictable results are obtained using particulated cancellous bone within the gap following the split osteotomy, as proved with alveolar palatal cleft grafting, sinus floor augmentation and interpositional bone grafts in the maxilla. Cortico-cancellous block grafts as 'onlay' grafts are used to augment areas where an important horizontal decrease of the alveolar process is present. Using the technique described, the use of barrier membranes to contain the particulated graft is unnecessary. Simion et al.[14] and Scipioni et al.[11] first described the split-crest technique. The obvious advantage of this technique is the absence of donor site morbidity associated to autologous bone harvesting. This condition is usually observed when harvesting bone from the hip, maxillary tuberosity, chin or mandibular ramus for onlay grafting. Another advantage is the possibility of immediate implant insertion without the need for a second surgical procedure. This is especially true with lateral augmentation grafting, in which a healing phase before implant placement is usually required.

The degree of lateral onlay bone graft resorption varies between 20% and 50% in the reported series[6,8]. The authors have not observed any degree of bone resorption following the modified split-crest technique. This condition is extremely important when severe limitation of the alveolar width is present. Several authors have reported an implant 5-year cumulative success rate between 86% and 99% for maxillary interpositional augmentation[7,13]. The main limitation of the present study was the relatively short follow-up period in comparison with other previous studies[2,14]. No implant failure was observed for more than 24 months for the whole series, and maintained adequate bone expansion was assessed by means of postoperative CT scans during the 28.33-month mean follow-up period. These results are probably not extendable to the mandible, since attempts to use interpositional augmentation in this bone have shown less predictable results[15]. Care must be taken in extrapolating these data to the mandible, since they have been exclusively obtained from the maxilla.

Despite the need for a buccal subperiosteal flap elevation, the authors did not observe any alteration to the general bone perfusion. This may be attributable to the preservation of a complete intact palatal periostium and the design of the greenstick fracture of the basal horizontal corticotomy. The development of a greenstick osteotomy avoids the presence of a full free cortical bone block, which is more prone to show any perfusion problem. The authors strongly recommend the use of a

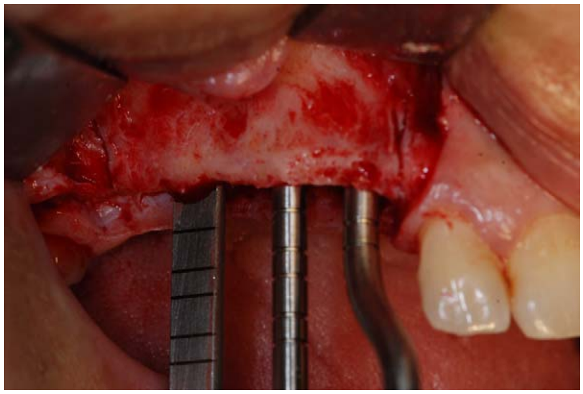

Fig. 4. Patient no. 4. Right upper maxilla. Use of a chisel and progressive osteotomes for gradual expansion of the outer cortex in maxillary bone. Note both vertical osteotomies performed with a reciprocating saw or a diamond disc in a previous step.

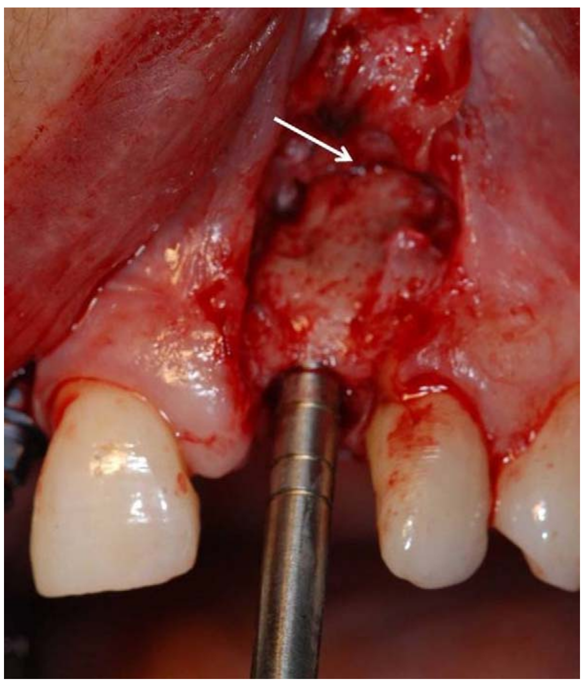

Fig. 5. Patient no. 4. Left upper maxilla. The cephalad ends of the vertical cuts were connected with a horizontal corticotomy (white arrow) by means of a piezosurgical device.

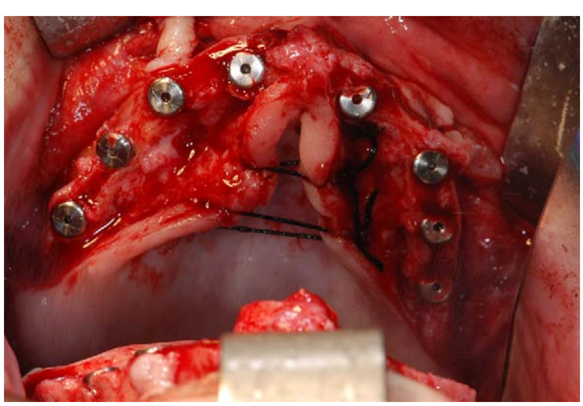

Fig. 6. Patient no. 5. Longitudinal mid-crestal osteotomy involving the entire upper maxilla. Immediate implant placement.

series of consecutive thin osteotomes between the buccal and palatal cortical plates, in order to avoid undesired lines of fracture.

The assessment of alveolar height by panorex pre- and postoperatively at month 24 led to the conclusion that a mean loss of 0.542 mm was present for the whole series at the second stage surgical procedure, following insertion of implants. Although almost one-third of the implants underwent a process of alveolar height increase of 0.6 mm (range: 0.1–1.1 mm) at the second stage surgical procedure, the other two-thirds underwent resorption of the alveolar bone height of 1.06 mm (range: 0.1–2.8 mm). These results show that despite the aggressive approach to the alveolar bone, the cortical bone is adequately perfused following vertical osteotomies and horizontal corticotomies. The mainstay of width preservation together with a very slight loss of alveolar bone height makes this technique predictable, although controlled studies with dental CT scans or cone-beam CT pre- and postoperatively may be necessary to further assess these observations, more specifically in terms of alveolar width dimensions.

In relation to the osteotomy design, Enislidis et al.[8] have described a staged ridge splitting technique that may alleviate the poor success rate of the splitting technique. It consists of dividing the surgery in two steps: the first to mark the corticotomy sites via the buccal flap without mobilizing the bone segment; the second to complete the osteotomies apically leaving the periosteum attached to the buccal surface of the bone segment, and generating a green-stick fracture. This technique reduces overall treatment time in comparison with onlay grafting procedures and avoids the need for a donor site. The technique requires a longer treatment period in relation to the above single-step technique. The presence of a better vascularized bone makes the modified split-crest technique a predictable method for the maxilla. For these cases, the authors believe that the staged ridge splitting technique is unnecessary.

Some authors[1] have analysed the outcome of implants placed in a gap generated between a completely separated osteotomized bony window and the inner mandibular cortex. The inter-cortical space was filled with platelet rich plasma (PRP) and β-tricalcium phosphate (β-TCP) allograft, and the separated bony fragment was stabilized with bicortical bone screws, which allowed a tight adaptation for adequate pressure on the

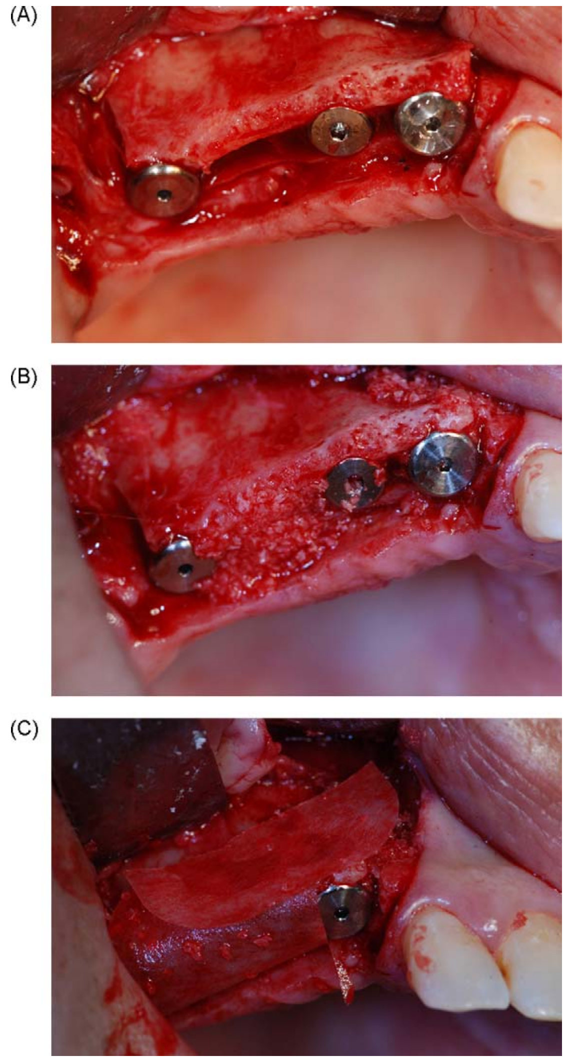

Fig. 7. Patient no. 7. (A) Gap following osteotomy and expansion of the maxillary outer cortex. (B) Filling the gap with particulated demineralized bovine bone graft. (C) Placement of a membrane covering the reconstructed narrow alveolar ridge.

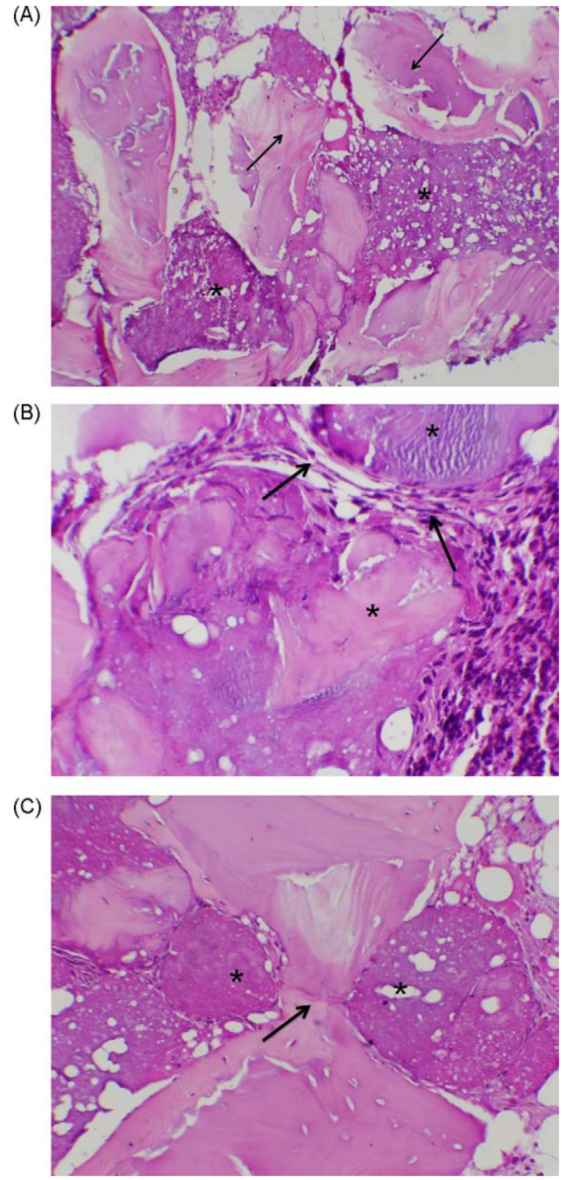

Fig. 8. Histological examination (haematoxylin–eosin) of the specimen. (A) Mixture of autogenous bone graft (arrows) and allogenic bovine particulated bone graft (asterisks) (20×). (B) Note the new bone formation as a bridge (arrows) between the interpositioned material (asterisks) (40×). (asterisk, new bone). (C) De novo formation of mature bone (arrow) connecting previous isolated bone islands between the allogenic material (20×) (asterisks).

implants and the grafted material. By means of the split-crest technique predictable results in terms of bone regeneration of the osteotomy lines and implant overall survival were obtained. Other authors[2] have reported expanding edentulous ridges without filling bone gaps, and described the inter-cortical bony gap as an extraction site that should be left at rest without bone grafting. In the present study, the use of a mixture of autogenous bone graft and allogenic bovine particulated bone graft showed predictable results in terms of generation of new bone within the inter-cortical space.

By means of the green-stick fracture no additional fixation procedures such as bicortical screws were necessary for adequate implant stabilization. This was also demonstrated by the high ISQ values for the primary implant stabilization in the authors' series. The absence of any fixation hardware also reduces the incidence of suture dehiscence or wound infection and may lead to a better outcome in terms of implant survival. In the authors' opinion, the green-stick fracture provides a firm self-space-making structure that may be able to keep the bone graft following the osteotomy. Other authors also consider that the split-crest technique creates a self-space-making structure. This seems to be important for the retention of the heterologous bone graft. In relation to the so-called 'guided bone regeneration', the use of barrier membranes has been reported to cover implants following a split-crest technique[11]. PRP and membranes were used for selected cases in order to stabilize the particulated bone graft and to avoid the internalization of soft tissue fibers from the vicinity. The PRP seems to be especially effective as a carrier for the particulated bone graft.

Table 1. Surgical data. ISQ, implant stability quotient. AH, alveolar bone height.

	Patient	Implant position	Implant width	Implant length	ISQ	Preop AH	Postop AH	AH difference
1.	1	22	4 mm	10 mm	67	10.4 mm	11.2 mm	0.8 mm
2.	1	24	4 mm	10 mm	68	11.2 mm	12.0 mm	0.8 mm
3.	2	12	4 mm	8.5 mm	70	7.7 mm	7.8 mm	0.1 mm
4.	2	14	4 mm	8.5 mm	75	6.5 mm	5.6 mm	−0.9 mm
5.	2	22	4 mm	8.5 mm	69	7.7 mm	7.8 mm	0.1 mm
6.	2	24	4 mm	8.5 mm	57	6.5 mm	6.4 mm	−0.1 mm
7.	3	15	4 mm	10 mm	–	25.0 mm	23.5 mm	−1.5 mm
8.	3	16	4 mm	10 mm	–	22.1 mm	21.4 mm	−0.7 mm
9.	4	12	3.3 mm	13 mm	83	15.7 mm	13.7 mm	−2.0 mm
10.	4	13	3.75 mm	13 mm	78	16.4 mm	15.7 mm	−0.7 mm
11.	4	21	3.75 mm	13 mm	73	17.1 mm	15.7 mm	−1.4 mm
12.	4	26	4 mm	10 mm	85	9.5 mm	9.5 mm	0.0 mm
13.	4	15	3.75 mm	13 mm	77	26.7 mm	26.0 mm	−0.7 mm
14.	4	16	4 mm	8.5 mm	68	21.2 mm	18.4 mm	−2.8 mm
15.	5	11	4 mm	13 mm	72	19.5 mm	18.7 mm	−0.8 mm
16.	5	13	4 mm	13 mm	65	18.7 mm	17.3 mm	−1.4 mm
17.	5	14	4 mm	13 mm	70	15.8 mm	14.4 mm	−1.4 mm
18.	5	16	4 mm	13 mm	75	10.1 mm	10.8 mm	0.7 mm
19.	5	21	4 mm	13 mm	78	18.7 mm	18.1 mm	−0.6 mm
20.	5	23	4 mm	13 mm	66	19.5 mm	18.1 mm	−1.4 mm
21.	5	25	4 mm	13 mm	77	15.1 mm	14.4 mm	−0.7 mm
22.	5	27	4 mm	11.5 mm	49	10.1 mm	10.1 mm	0.0 mm
23.	6	12	4 mm	8.5 mm	76	11.0 mm	9.8 mm	−1.2 mm
24.	6	14	4 mm	8.5 mm	79	6.1 mm	7.2 mm	1.1 mm
25.	6	22	4 mm	8.5 mm	77	11.6 mm	12.4 mm	0.8 mm
26.	6	24	3.3 mm	13 mm	83	11.0 mm	11.7 mm	0.7 mm
27.	7	13	4 mm	13 mm	81	17.3 mm	15.9 mm	−1.4 mm
28.	7	14	4 mm	13 mm	77	18.0 mm	15.9 mm	−2.1 mm
29.	7	16	4 mm	13 mm	80	15.1 mm	14.4 mm	−0.7 mm
30.	8	14	4 mm	10 mm	82	8.2 mm	8.0 mm	−0.2 mm
31.	8	16	4 mm	11.5 mm	77	10.4 mm	10.0 mm	−0.4 mm
32.	8	24	3.3 mm	13 mm	77	8.8 mm	8.6 mm	−0.2 mm
33.	8	25	3.75 mm	11.5 mm	82	7.0 mm	7.3 mm	0.3 mm

Pre- and postoperative ISQ values in relation to implant width and length. Pre- and postoperative alveolar height measurements in relation to implant sites. Height in maxillary bone was measured from the head of the implant (postoperatively) or from the tip of the alveolar ridge at the implant site to the cortical bone corresponding to the floor of the maxillary sinus or the nasal cavity. Loss or augmentation of alveolar height was expressed as the difference between pre- and post-operative heights.

The modified split-crest osteotomy for the maxillary narrow alveolar ridge provides predictable results in relation to primary stability and implant surveillance. This technique avoids morbidity related to the harvesting of autologous bone graft and provides a stable widening of the alveolar crest. The modification of the classical technique presented here provides an acceptable inter-cortical gap, while avoiding excessive loss of alveolar bone height. It also decreases the risk of necrosis of the outer cortex and provides a firm-wall box for the placement of particulate bone grafting.

Competing interests

None declared.

Funding

None.

Ethical approval

Not required.

References

1. Basa S, Varol A, Turker N. Alternative bone expansion technique for immediate placement of implants in the edentulous posterior mandibular ridge: a clinical report. Int J Oral Maxillofac Implants 2004: **19**: 554–558.
2. Blus C, Szmukler-Moncler S. Split-crest and immediate implant placement with ultra-sonic bone surgery: a 3 year life.table analysis with 230 treated sites. Clin Oral Impl Res 2006: **17**: 700–707.
3. Cawood JI, Howell RA. A classification for the edentulous jaws. Int J Oral Maxillofac Surg 1988: **17**: 232–236.
4. Cawood JI, Stoelinga PWJ, Blackburn TK. The evolution of preimplant surgery from preprosthetic surgery. Int J Oral Maxillofac Surg 2007: **36**: 377–385.
5. Chiapasco M, Romeo E, Vogel G. Tridimensional reconstruction of knife-edge edentulous maxillae by sinus elevation, onlay grafts, and sagital osteotomy of the anterior maxilla: preliminary surgical and prosthetic results. Int J Oral Maxillofac Implants 1998: **13**: 394–399.
6. Cordaro L, Amade DS, Cordaro M. Clinical results of alveolar ridge augmentation with mandibular block bone grafts in partially edentulous patients prior to implant placement. Clin Oral Implant Res 2002: **13**: 103–111.
7. Engelke WG, Diederichs CG, Jacobs HG, Deckwer I. Alveolar reconstruction with splitting osteotomy and microfixation of implants. Int J Oral Maxillofac Implants 1997: **12**: 310–318.
8. Enislidis G, Wittwer G, Ewers R. Preliminary report on a staged ridge splitting technique for implant placement in the mandible: a technical note. Int J Oral Maxillofac Implants 2006: **21**: 445–449.
9. Nentwig GH, Kniha H. Die rekonstruktion lokaler alveolar-fortsatzrezessionen im forntzahnbereich mit kalziumphosphat-keramic. Z Zahnärztl Implantol 1986: **2**: 80–85.
10. Osborn JF. Die alveolar-expansionsplastik. Quintessenz 1985: **39**: 9–14.

11. Scipioni A, Bruschi GB, Calesini G. The edentulous ridge expansion technique: histologic and ultrastructural study of 20 clinical cases. Int J Period Rest Dent 1994: **14**: 451–459.
12. Sennerby L, Roos J. Surgical determinants of clinical success of osseointegrated oral implants: a review of the literature. Int J Prosthodontics 1998: **11**: 408–422.
13. Sethi A, Kaus T. Maxillary ridge expansion with simultaneous implant placement: 5-year results of an ongoing clinical study. Int J Oral Maxillofac Implants 2000: **15**: 491–499.
14. Simion M, Baldoni M, Zaffe D. Jawbone enlargement using immediate implant placement associated with a split-crest technique and guided tissue regeneration. Int J Period Rest Dent 1992: **12**: 462–473.
15. Stoelinga PJW, Tidemann JS, Berger H, de Koonen A. Interpositional bone graft augmentation of the atrophic mandible. J Oral Surg 1978: **36**: 30–32.

Address:
Raúl González-García
c/ Los Yébenes 35
8C. 28047
Madrid
Spain
Tel: +34 639 129 396
E-mail: raulmaxilo@gmail.com