The Monocortical Window (MCW): A Modified Split-Crest Technique Adopting Ligature Osteosynthesis

Marcello Contessi, MD, DMD[1]

Split-crest procedures performed with ultrasonic devices have proven to be a viable and effective surgical treatment when the alveolar ridge shows forms of resorption in thickness while its height remains virtually unchanged. However, in the case of stiff, type 1, corticalized mandibular bone, it may be very difficult or even impossible to have any elasticity and lateral augmentation in between the split bone walls. Furthermore, a complete detachment of the outer lamellae may also occur during expansion maneuvers or during implant insertion. This study describes the use of a steel-wire ligature osteosynthesis technique to give primary stability both to the expanded cortical window and to the implants themselves when they have none at all. This osteosynthesis is simple, quick, safe, and bone-saving in force delivery. It is also extremely cheap as well as being effective in obtaining ridge expansion, bone regeneration, and implant positioning in an all-in-one procedure. This article describes the foundations in the literature as well as new elements in the technique. Three short case studies are used by way of example. (Int J Periodontics Restorative Dent 2013;33:e127–e139. doi: 10.11607/prd.1559)

[1]Private Practice, Trieste, Italy.

Correspondence to: Dr Marcello Contessi, via del Coroneo, 19- 34.100, Trieste, Italy; fax: 0039 040 3476308; email: contegiallots@hotmail.it

Implant therapy is particularly challenging in cases of severe bone atrophies. These are usually the result of jaw bone trauma, chronic periodontal disease, or endodontic or combined pathologies that take the edentulous crestal bone to variable forms of resorption, as classified clearly and simply by Seibert.[1] These atrophies have prevalence in the population according to their shape, as described by Abrams et al,[2] with the majority of cases (57.3%) having both atrophies in the width as well as in the height of the alveolar crest (the Seibert Class 3 defect). In this kind of bone deficiency, the onlay or "J" block grafts,[3–5] guided bone regeneration (GBR),[6,7] or osseodistraction[8] are indicated treatments, while all split-crest procedures are obviously unable to cope with the lack of bone height.

Furthermore, all of the former have their own specific disadvantages: *(a)* may require a second surgical site to gather either intra- or extraoral bone grafts (onlay grafts), with high invasivity as well as patient discomfort; *(b)* the grafted block presents fairly unpredictable resorption varying from around

30% to 35%, or more, in its volume, depending on whether there is efficient adaptation and rapid revascularization in the recipient site[3]; alternatively, *(c)* the grafted material might heavily resorb when the recovering site becomes prematurely exposed (onlays and GBR[4]); this means they are *(d)* highly technique-sensitive and, in any case, *(e)* implant positioning is delayed. Sometimes implants themselves may provide support to the regenerating site as "tent poles" in the vertical dimension.[11,12] These require a high degree of skill and are certainly riskier in cases of site dehiscence.

In a minority (32.8%) of cases,[2] alveolar ridge resorption has a total or subtotal width deficiency, while height is maintained (Seibert Class 1 defect). All of the previously mentioned techniques can generally be used in these patients, according to the surgeon's experience and preferences, but various kinds of split-crest procedures need also be considered as they are also effective.

In the late 1980s, Bruschi et al[13] created the split-crest technique. The authors later presented[14] a 5-year follow-up study on 170 patients with 329 inserted implants in width-deficient ridges. They had an overall success rate of 98.8% with no membrane setting over the sites. Simion et al[15] obtained a bone width gain of 1 to 4 mm, a major regeneration in the maxilla (between 3 and 4 mm), though less in the mandibular sites (between 1.0 and 1.5 mm) in a total of 10 treated implant sites in 5 patients. They also used chisels and hammers to sever the crest, thus obtaining "green stick fractures" of the narrow crests, and all implant sites were covered by an expanded polytetrafluoroethylene (e-PTFE) membrane.

In the late nineteenth century, the so-called Piezosurgery technique was presented[16–18] as a safe, new technique to selectively cut hard tissue such as teeth or bone without being a threat to soft tissues such as the gingiva, inner buccal mucosa, tongue, or lips. This was a pleasant alternative to the traditional tools used to cut bone, such as chisels, hammers, oscillating saws,[19,20] or rotating microsaws.[21,22] Those were probably faster, but more likely to cause some degree of overheating of the recipient bone. They were also likely to entangle vital blood vessels, nerves, or other soft tissue, incurring some damage to the patient.

Ultrasonic bone surgery (UBS) has been shown as safe and reliable in the sinus elevation procedure to open a bone window to begin the sinus membrane procedure with less trauma and a smaller percentage of membrane tearing.[23] Blus and Szmukler-Moncler[24] reported the experience of treating 172 sites with this technique in 2003 and again in 2006.[25] They reported a 3-year life table analysis of the split-crest technique obtained by UBS machines in 230 treated sites with narrow bone ridges. They brought the initial mean width of 3.2 mm (1.5 to 5 mm) to a final mean width of 6.0 mm (4.5 to 9.0 mm), treating 78 cases in the mandible and 152 in the maxilla. At stage-two surgery, 8 of 228 (3.5%) implants that could be inserted at stage one simultaneously with the ridge widening failed to integrate with the bone. The success rate of the placed implants was then 96.5%, while the cumulative survival rate of loaded implants was 100%, the oldest ones being 5 years old.

The same authors refer to this technique as the Rapid Horizontal Osseodistraction Technique (RHOD). To obtain good ridge augmentation in the narrow bone crest of the mandible, they recommend adding a "longitudinal discharge notch" at the base of the alveolar bone to the first cut along the cresttop and the other two, mesial and distal, releasing vertical cuts. This evidently is unnecessary for the maxilla as it is more elastic. In the same way as proposed by Bruschi et al,[13] they did not use any type of membrane on top of the enlarged crest to cover implant sites while performing a full-thickness flap bone denudement, as is normal for any regular augmentation procedure. This was evidently mandatory to gain access and control of the longitudinal discharging notch in the mandible.

The atrophic mandibular bone usually has a pyramidal shape in its sections (in type 1 defects), especially at its base. It is notoriously hard bone, mostly of the cortical type. No matter how experienced and careful the surgeon may be, four major events may occur after completing this longitudinal baseline osteotomy: *(1)* The alveolar mandibular bone does not have sufficient elasticity to allow any further expansion and, consequently, implant insertion. *(2)* As a direct consequence of this notch, excessive mobility or a complete detachment of the bone wall occurs. This becomes a real "monocortical window" (MCW) in the alveolar crest, completely splitting the rectangular piece of bone of the outer cortex from the underlying medullary part. *(3)* Primary implant stability cannot be obtained in any way, owing to the conditions obtained in point 2. *(4)* The implant insertion maneuver itself causes the release or the complete detachment of the vestibular lamellae of bone, pushing it outward so that both graft and fixture stability are missing.

In these conditions, as the osteotomized cortical wall is exactly like a graft taken from the chin or the ramus, a miniscrew fixation of the "graft-like" cortical wall is required.

Screw-fixing procedures are commonly used in implant dentistry for monocortical, bone-block (MCBB) fixation[25] to recover bone deficiencies by accurate graft to host adaptation and fixation. However, besides the aforementioned problems, they also present further drawbacks: *(1)* the diameter of the screw is normally 1.0 to 1.5 mm, which can be too big for thin lamellae of bone; *(2)* hole drilling through the bone graft is complicated and fracturing or even shattering of the graft may occur; *(3)* the screwing motion creates a spinning force in the graft that generates stress forces; and *(4)* the sizes and lengths of the necessary screws may vary, needing increased storage with a consequent rise in costs. Osteo-synthesis with steel wires is also commonly used by maxillofacial surgeons in trauma pathology[26] and other surgical fields. "Cerclage" osteosynthesis of the mandible was used in the past, only recently substituted by titanium "L" plates and screws.[27]

This article describes a technique for splitting and widening the atrophic alveolar crest when it has a narrow diameter (width atrophy), but when the original height is virtually maintained. The implants are positioned in one stage together with the expansion procedure, as in the previously mentioned clinical studies and in the RHOD technique. New elements include: *(1)* the full detachment of the vestibular cortical plate becomes a MCW, and this window is treated in the same way as an outer graft; *(2)* the MCW is fixed by means of an orthopedic type of osteosynthesis that makes a hoop of the two cortical plates, ie, a ligature osteosynthesis; and *(3)* the ligature itself can provide sufficient primary stability both to the cortical plate and the implants when it is missing.

The aim of this technique is to obtain simultaneously, in indicated ridge deformities, horizontal-ridge expansion, implant positioning, and regeneration of the bone.

Method and materials

A full-thickness flap is recommended to uncover the edentulous area. A midcrestal incision reaches the adjacent teeth and goes all the way around into their sulcus and up to one or two teeth beyond the augmentation site. Mesial and distal soft tissue discharges are made to obtain both more visibility and flap mobility. The denuded bone area is usually debrided with bone chisels, such as the 1/2 Kramer-Nevins or the 36/37 Rhodes back-action (Hu–Friedy) or sickle-scalers (Towner, Hu-Friedy) for regular GBR procedures, aiming at eliminating all connective tissue fibers left on bone surfaces. Root planing and degranulation of neighboring teeth are also advisable. A longitudinal midcrestal osteotomy is performed by a gentle, back and forth painting-like movement of the handpiece of the ultrasound unit of choice, either the UBS (ResistaOmegnaVB), which works in the 32 Hz range with a maximum ultrasound power of 90 W, or Piezosurgery (Mectron-Carasco, GE), which works in the 24 to 29 Hz range with 90 W.

The depth of this first cut is measured according to the planned implant's length and/or the imposed safety distance from the alveolar nerve (in the mandible). Then two vertical bone incisions are made, one mesial, the other distal, at least 3 mm from the adjacent roots, thus aiming to provide an internal bevel orientation to the cutting path whenever possible.

These two discharging osteotomies run throughout the medullary bone, as well as the lingual/palatal cortex. The surgeon will try to keep any vertical bone severing away from the planned implant position. However, in the case of tooth-to-implant proximity, some vertical cuts partially overlap the implant line as well. While the former are generally sufficient for obtaining a wide distraction between the two cortical plates in the maxilla, on the contrary, the stiffness of the alveolar ridge bone in the mandible, often supported by a pyramidal section shape at its base, causes considerable rigidity. To counter this, a supplementary longitudinal osteotomy, previously called a longitudinal notch, is added at the base of the crest, which does not so much intercross with the others but rather acts as a sort of hinge to increase mobility. When the four bone incisions are made, the osteodistraction starts.

Expansion pressure is provided in the majority of cases by the Ostwill system (Ostwill, Meta-Reggio Emilia), a set of increasing-diameter conical steel screws that work by means of a finger twisting movement to screw into the groove between the two split cortical plates of the crest. The screws begin with the number 1 and alternate each number with the preceding and the following ones in two different mesiodistal positions up to number 3 (∅ 4.5 mm) or 4 (∅ 5 mm). The screws are left in position while inserting a second screw into the next implant position. If stronger resistance is felt, drilling with a regular ∅ 2 to 2.2 mm implant drill is made to ease the Ostwill penetration. In many maxillary positions, Summers' osteotomes prove useful, having the same purpose and effect of the conical screws and, thus, were used as an alternative. In a few cases, other similar bone expander devices could be used. Whatever the means employed, the final diameter of the gained neo-alveolus is then measured with an implant analog that in the maxilla could be one diameter size lower.

Leaving the two final Ostwills in the bone, a horizontal tunnel (∅ 1.5 to 2 mm) is drilled with a long stem, round bur through the outer cortex. This is positioned approximately in the middle of the MCW, throughout the medullar space and the inner (lingual/palatal) cortex to create a passage for the steel ligature. Then a sterilized 12-inch orthodontic ligature (American Orthodontics) is slipped into the hole, held with pliers, and turned around the crest in a vertical loop to meet the entering wire on the vestibular wall, similarly to a regular, single suture.

The initial cortex wound and the cortex tunneling are completed with the two final expanders fixed into the bone, simulating implant positions and avoiding any setting of the ligature in conflict with the planned implants. Then the two ends are crossed and slightly twisted just to set the position and form a sort of a loose knot. Successively, the implants planned for those positions are set and their stability checked. Notice that in most cases, especially in the mandible when the vestibular wall has been detached or in the maxilla when the residual bone is extremely thin, the implant shows inadequate primary stability. The outer cortical wall is unstable as well.

The regenerating procedure starts thereafter by packing into the artificial groove a composite graft made of autologous bone, Bio-Oss (Geistlich Pharma), plasma rich in growth factors (PRGF) (autologous)[28] and rifamicine clorhidrate (Rifocin, Avenis, 250 mg/mL) with antibiotic applied (only one drop/mL), and the patient's blood. Any gap on top of the crest and along the vertical osteotomies is filled, taking care not to exert excessive pressure, or cause bleaching of the graft.

Only after this step is the first knot on the ligature wire tightened. At the surgeon's discretion, it should not be so tight as to break it, but it should be strong enough to allow the complete fixing of the implants and the bone wall. Any excess wire is cut off with an ortho cutter. The bending of this wire must be very accurate, flattening it onto the bone so as to avoid mucosal perforation in the healing period.

The surgical site is then covered with a slow resorbable membrane, Biomend Extent (Zimmer Dental) or Osseoguard (Biomet 3i). Whenever possible, the membrane is pointed and secured with tacks or minipins (Geass). Should the membrane not be tacked on, a double layer covering with Osseo-Gide (Geistlich Pharma) is adopted.

All the flaps are then closed using regular double-layer suturing techniques with horizontal mattress sutures in the deep apical parts and single e-PTFE sutures on the top of the crest (De-Ore Biomat). To gain further flap mobility for coronal repositioning, releasing periostium incisions are used whenever necessary to obtain mandatory primary flap closure.

Patients are administered amoxicillin (875 mg), clavulanate (125 mg for 7 days), ibuprophen (600 mg for 3 days), and clorexidine (0.2% 3 times a day for 15 days). When the surgical site is set in between natural teeth supporting a fixed prosthesis, the provisional prosthesis is smoothed and polished to permit immediate bonding on day one. All the pontics are also ground to allow for easy cleaning and to counter typical postoperative swelling. These simple maneuvers are intended both to increase the patient's compliance and possibly to provide some shielding to the surgical site. Sutures are removed 15 to 21 days postsurgery.

Case report

Statistical data

Eight cases have been treated and fully documented with this technique so far, 3 in the mandible and 5 in the maxilla. All cases presented an atrophic alveolar ridge with predominant resorption in the width of the alveolar crest, but with its height mostly intact (Seibert Class 1 defects).

The scheduled treatment included implant therapy, but the initial mean ridge width was poor so that several dehiscences could be predicted as the immediate implant result. Alternatively, the case should have been treated with a two-stage approach, beginning with a ridge reconstruction and delaying the implant stage for a very long time. For this reason, MCW therapy was selected in an attempt to condense reconstruction and implant positioning into a single appointment.

The mean mandibular width at the first surgical stage was 4.5 mm (range, 2.0 to 8.0 mm); (2.66 mm in the narrowest sections); 2.55 mm for the maxilla (range, 1.0 to 5.0); (1.3 mm in the narrowest sections). Measuments were taken with a periodontal probe (CP-12, Hu-Friedy) placed in three different crestal positions on top of the narrow ridge in a mesiodistal direction, considering the area for the expansion.

At the end of stage-one surgery, after completing the ligature tightening to close and secure the bone window to the inserted implants, a second set of measurements was recorded while attempting to remain approximately at the previous sites. The mean widths of the enlarged crests were 8.42 mm for the mandible (a gain of 3.92 mm) and 7.70 for the maxilla (a gain of 5.20 mm).

Cumulatively, the ridge width was taken from 3.52 mm (mean) to 8.06 mm (mean).

Stage-two surgery was carried out after a 6- to 9-month healing period (mean, 7.5 months), resuming regular procedures. If the site had been treated with a slow resorbable membrane fixed with tacks, the tacks were removed, and the crestal width was recorded again.

The mean crestal width of the expanded crests was 7.08 mm for the mandible and 5.09 mm for the maxilla. Implant stability was evaluated either by conventional manual tools, including hammering high tone sounds with a regular mirror handle, or by using the Osstell-Mentor device (Osstell) so as to obtain their comparative implant stability quotient (ISQ) values.

Tables 1 and 2 briefly describe these data.

Patient no. 1

A 64-year-old woman needed implant therapy in her right mandible (Fig 1) for two molars that had long been missing and a degraded first premolar (Fig 1a). The crest width was inadequate for immediate regular-diameter implants, having a mean width of 3.0 to 4.5 mm. What is more, the bone crest seemed to be inadequate for the planned restorative intervention (Fig 1b). During RHOD, the jaw bone showed insufficient elasticity; thus, the MCW technique was applied. The outer cortical wall proved very mobile and unsteady before implant positioning, so the bone rectangle was secured with the first distal ligature (Fig 1c), the implants were screwed in, the first ligature tightened, and a second one added to gain stability for the implant in the first molar position. This was in fact a 4-mm-diameter root-form implant which could not be sunk any deeper owing to the proximity of the alveolar nerve, so it was a completely loose implant.

The implant in the second molar position was stable right from the beginning, the other one not so. After ligature tightening and fixation, both showed perfect

Table 1 Intrasurgery measurements of the ridge width for eight cases (mm)

Patient no.	Preoperative			Postoperative			Stage-two surgery			Vertical bone loss		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Mandible												
1	3.00	7.00	5.00	8.00	10.00	9.00	6.00	10.00	8.00	–1.00	–1.00	–1.00
2	2.00	4.00	3.00	6.50	11.00	8.75	5.00	8.00	6.50	–5.00	–3.00	–4.00
3	3.00	8.00	5.50	6.00	9.00	7.50	5.50	8.00	6.75	–2.00	0	–1.00
Mean			4.50			8.42			7.08			–2.00
Maxilla												
1	2.00	3.00	2.50	5.00	9.00	7.00	4.50	6.50	5.50	–3.00	–1.00	–2.00
2	2.00	5.00	3.50	8.00	10.00	9.00	6.00	7.00	6.50	–1.00	–1.00	–1.00
3	0.50	5.00	2.75	7.00	10.00	8.50	5.00	8.00	6.50	0	–2.00	–1.00
4	1.00	3.00	2.00	6.00	8.00	7.00	5.00	7.00	6.00	0	0	0
5	1.00	3.00	2.00	5.00	9.00	7.00	4.00	6.00	5.00	–4.00	–2.00	–3.00
Mean			2.55			7.70			5.90			–1.40

Min = minimum; max = maximum.

Table 2 Intrasurgery measurements of ridge width: summary

Patient no.	Preoperative (mm)	Postoperative (mm)	Stage-two surgery (mm)	Implants (n)	Implants lost (n)
Mandible					
1	5.0	9.0	8.0	2	0
2	3.0	8.8	6.5	3	0
3	5.5	7.5	6.8	2	0
Maxilla					
1	2.5	7.0	5.5	4	0
2	3.5	9.0	6.5	3	0
3	2.8	8.5	6.5	3	0
4	2.0	7.0	6.0	1	0
5	2.0	7.0	5.0	3	0

immediate stability. All gaps between the implants, the osteotomies, and the expanded cortical plates were filled with a composite graft (anorganic bovine bone mineral, autologous bone chips, patient blood, and PRGF) (Fig 1d).

Two resorbable membranes were trimmed and adapted to the surgical site (Bio-Gide), placing one upon the other so as to form a double layer and possibly delay resorption. They were then fixed with one tack lingually and two tacks on the vestibule (Fig 1e). Primary closure was obtained by splitting the vestibular flap and by applying two sets of sutures: a horizontal mattress suture in the deeper apical layers and single sutures on top of the crest. All sutures were e-PTFE sutures. Regular postoperative medications were prescribed.

After 6 months, the area was reopened (Fig 1f). The ligatures were cut and removed from their tunnel. This maneuver was extremely simple and no resistance was encountered.

Implant stability proved to be perfect. Any previous defect had apparently been filled by new cortical bone (Fig 1g). The case was then completed with one implant in the second premolar position (premolars extracted), and 3 months later the prosthetic phases could be completed.

Fig 1a *Preoperative view of the atrophic interdental crest.*

Fig 1b *The provisional partial denture highlights the discrepancy between the width of the resorbed alveolar crest and the position of the restoration-driven implant planning.*

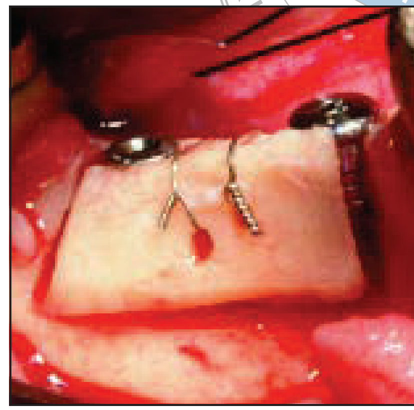


Fig 1c *A double ligature osteosynthesis is set to assure firm stability in the mono-cortical segment and in the mesial implant.*

Fig 1d *The first wide collagen membrane, fixed on the lingual side, is going to be closed to the vestibule after fixing procedures.*

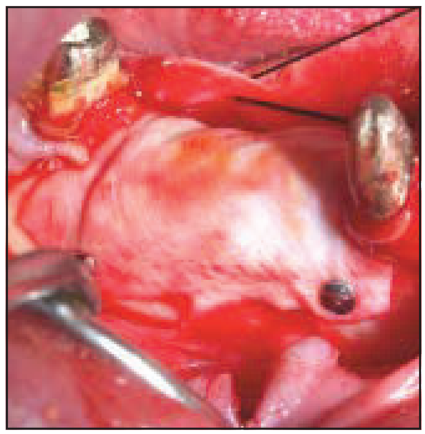


Fig 1e *A double layer of collagen membranes completes the regenerative procedure. The membranes are secured with metal tacks.*

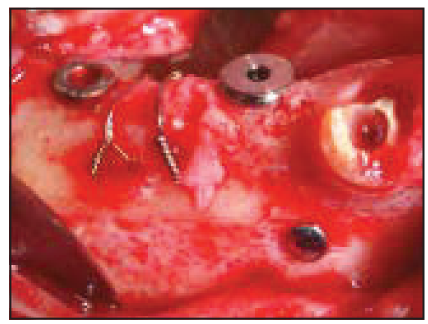


Fig 1f *Site reentry after 6 months. Note the looseness of the two ligatures meaning both the shrinkage of the underlying cortical plate and its good maturation.*

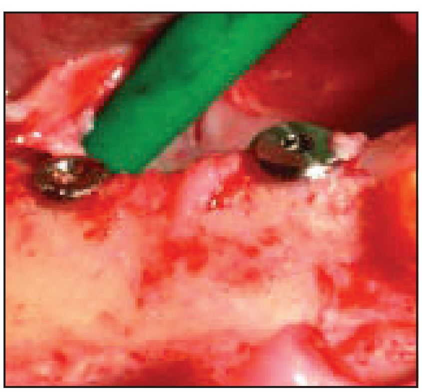


Fig 1g *Note the small size of the residual tunnel entry and the healthy appearance of the cortical window that has been moved to the side.*

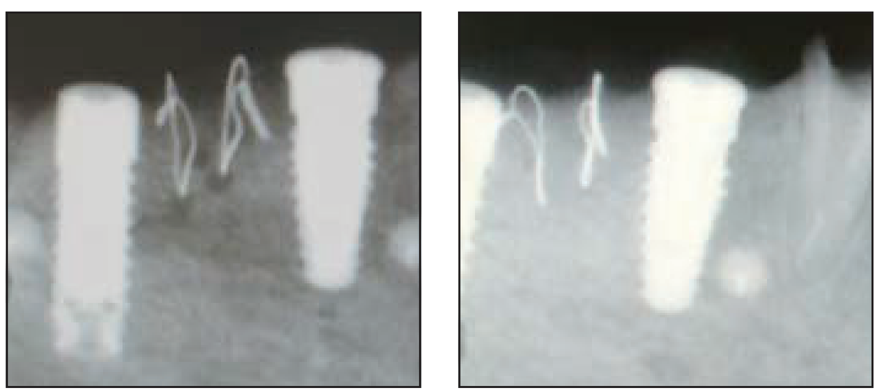


Fig 1h *Peri-apical radiographs at the time of first surgery* (left) *and at the uncovery stage, 6 months later* (right).

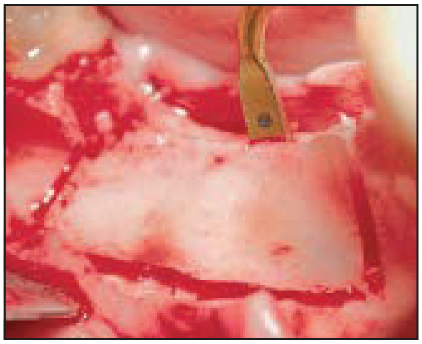


Fig 2a *Piezosurgical osteotomy is deepened into the crest; note the discharging notch at the alveolar base.*

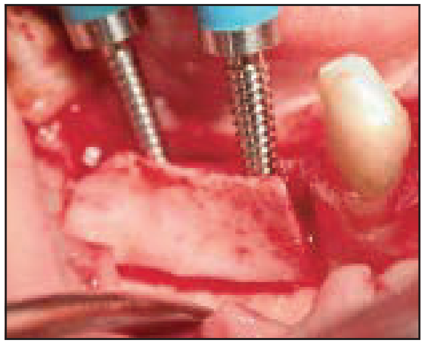


Fig 2b *Expansion sequence; note the rigidity shown at the base in spite of all four cuts having been completed.*

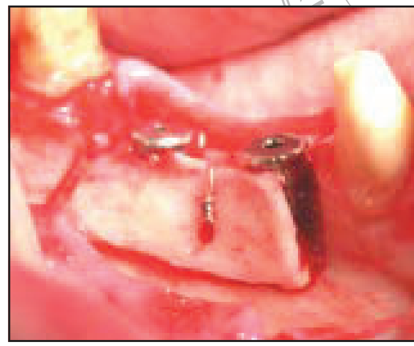


Fig 2c *The MCW is moved aside. Osteosynthesis ligature gives stability.*

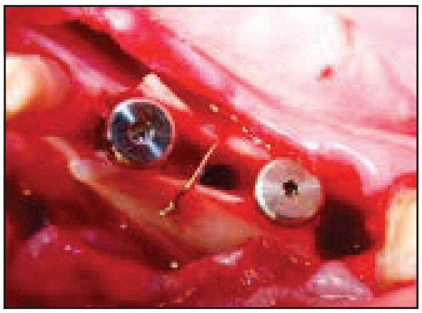


Fig 2d *The vertical discharging osteotomies are carried up through the lingual cortex; note the gap and the outward displacement of whole cortical plate.*

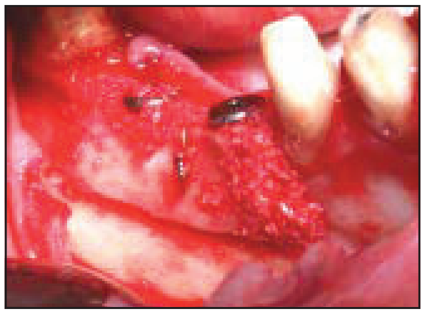


Fig 2e *The particulated graft.*

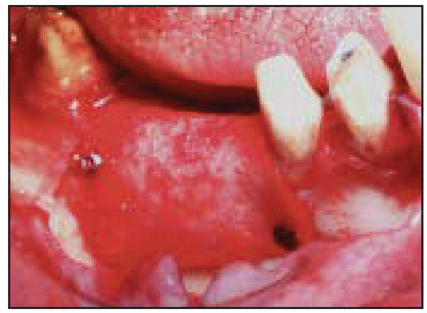


Fig 2f *A bovine tendon long-term resorbable membrane has been trimmed and secured on the site.*

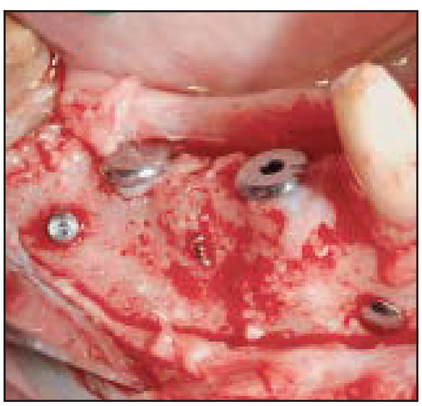
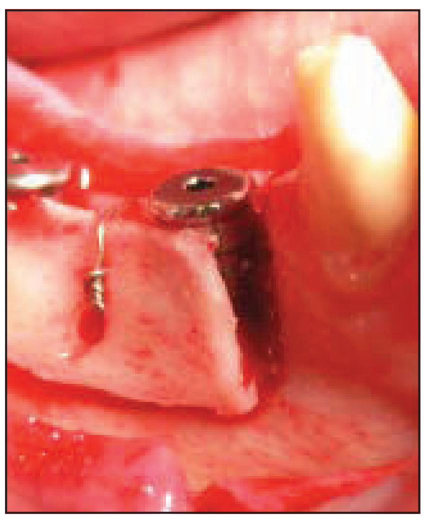
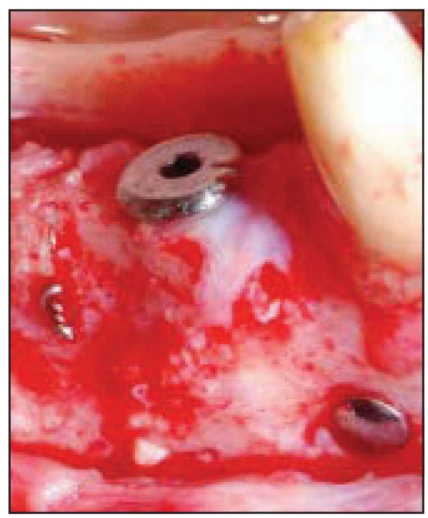


Fig 2g *Reentry after 6 months.*





Figs 2h and 2i *Before* (h) *and after* (i) *comparison of the mesial vertical osteotomy zone now fully welded by new cortical bone.*

Patient no. 2

A 54-year-old woman presented with a narrow interdental crest in her right mandible needing implant therapy. Piezosurgery expansion was performed starting from a 3.5 to 4.0 mm crestal width (Fig 2a). Once all three of the bone cuts were made, progressive expansion was carried out with screw-shaped bone expanders (Fig 2b). Then two

4.0-mm-diameter implants were inserted (Fig 2c).

At the time of insertion, stability was totally absent and there was a wide gap between the expanded cortical plate of bone and its original native position (Fig 2d). The steel wire loop of the ortho 0.12-ligature was then tightened, cut, and bent upon the bone. All spaces were accurately filled with the previously described composite graft (Fig 2e). Then the regenerative site was covered with a slowly resorbable membrane (Biomend Extent, Sulzer), which was secured by means of tacks and/or mini-screws, with only one tack on the lingual side (Fig 2f).

After 6 months of an eventless healing period, the site was reopened, showing new bone filling everywhere (Fig 2g). The ligature was gently bent upwards, severed with an ortho cutter, and pulled through the original hole that was now barely perceptible. Case prosthetic therapy was applied thereafter.

In particular, the mesial vertical osteotomy had been perfectly soldered with new cortical-like bone (Figs 2h and 2i). The implants had perfect stability with ISQ values largely above 60. No inflammatory tissue was present on the cortical line, nor around the fixation tacks that were removed.

Patient no. 3

An overdenture prosthesis was planned for this 73-year-old woman, who asked for a removable denture without palatal support (Fig 3). She had a heavy bone atrophy in the maxilla (Fig 3a). The MCW procedure was performed to accomplish the crest widening, implant positioning, and GBR all in one stage, for the ridge had maintained a certain height available in spite of the severe resorption in thickness. In this particular case, the implant inserted in the right central incisor position had absolutely no stability at the beginning, owing to the full detachment of the buccal bone lamellae after the expansion maneuvers shown in Figs 3b and 3c. Only by tightening the ligature was primary stability rendered both to the bone plate and to the implants (Fig 3d). After 4.5 months, the site was reopened to allow attachment connection and soft tissue enhancement procedures (Figs 3e and 3f). The implants were very well integrated, and the cutting lines of the previous surgery appeared completely healed by new bone (Fig 3e).

Discussion

In the literature, split-crest procedures have generally led to good results in developing narrow bone crests, especially in the maxilla, where the cortical plate is thinner and surgeons have to cope with a more elastic quality of bone. Mandibular atrophic ridges cannot be treated with the same confidence because the cortical plates are thicker, the overall mineralization of the bone is higher, and the cross sections of the alveolar bone when the resorption is advanced tend to maintain a pyramidal shape at the base.

For these reasons, Blus and Szmukler[24] applied a longitudinal notch at the base of the alveolar crest of the mandibular bone to create a hinge effect during the crest-splitting procedure. They did not report any cases of fracture in their work. Nevertheless, when operating in the mandible, the surgeon may encounter great difficulty in having an elastic expansion of the outer cortical bone, even when adopting a correct technique. No matter how experienced and how careful he may be, four major events may occur after completing this longitudinal baseline osteotomy, as previously mentioned.

A common consequence of these situations was to abort the intervention, much to the operator's frustration and with great patient discomfort. There is a chance to save the procedure by placing it back with mini-screws, as widely illustrated in the literature, for bone block procedures.[25] Not least, it occurs, when using this particular technique, that screws need to be placed between the implants and the graft material, which makes the process even more complicated.

In a similar clinical field, osteosynthesis with steel wires is commonly used by maxillofacial surgeons in trauma pathology and in other surgical fields. The premise of the author was to try to simplify this fixation maneuver by binding it with a regular orthodontic ligature. This is sterilized beforehand and simply passed through and around

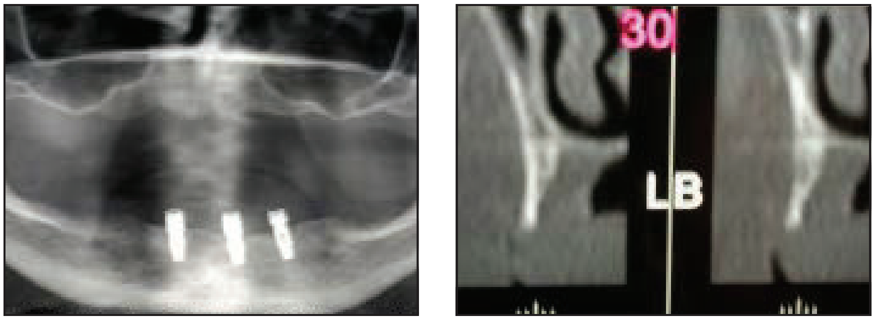
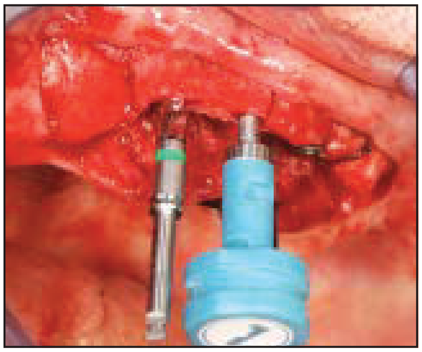


Fig 3a *Preoperative panorex* (left) *and computed tomography* (right).



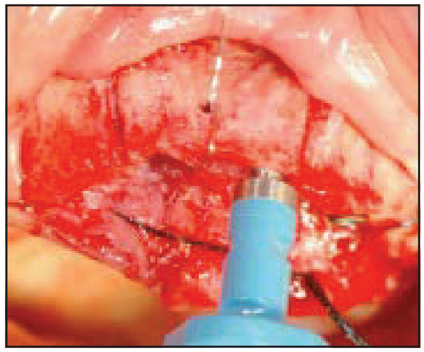


Fig 3b (left) *Crest expansion sequences: expanders and drill.*

Fig 3c (right) *Crest expansion sequences: the steel wire ligature is loosely twisted while the last expander is kept in place.*

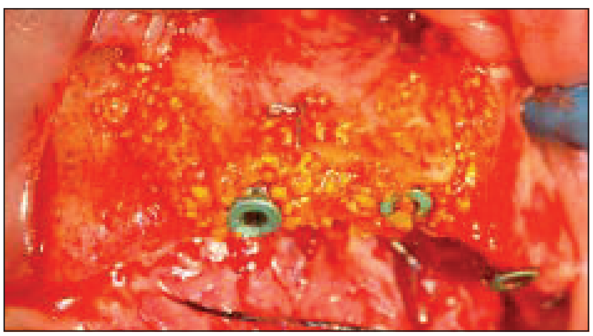


Fig 3d *The ligature braid has been cut and bent onto the bone plate. Osteotomies filled with the graft material.*

the outer mobile/detached cortical wall. The entry and the piercing tunnel were made with a long-shaft round burr mounted on a regular water-cooled handpiece. This is quite familiar to any clinician, and the final tightening of the ligature itself, performed only after any desired grafting procedure, is simply accomplished by twisting the wire on itself until a solid braid is created. This steel braid is then cut and bent up to the bone plate to avoid cutting the mucosa.

The procedure, as described here, proved to be extremely fast, simple, replicable, and highly effective. Most of all, in many cases the ligation was effective not only to secure the MCW of bone, but also provided sufficient primary stability to the implants, even when they had none before.

The mean mandibular width increased from 4.50 to 8.42 mm (a gain of 3.92 mm) during stage-one surgery. The maxilla increased from 2.50 to 7.70 mm (a gain of 5.20 mm) at the same stage (Fig 4). A greater widening capacity is naturally to be expected in the maxilla due to its elasticity. However, a steady decline in the volume of the gained bone width was noticed at stage-two surgery (Fig 4). The mandible mean decreased from 8.42 to 7.08 mm (a loss of 1.34 mm), and the maxilla decreased from 7.70 to 5.90 mm (a loss of 1.80 mm). This greater dynamic remodeling in the maxillary bone is in line with the histologic features of this bone, while

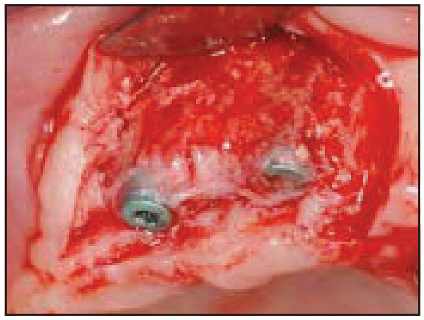


Fig 3e Reentry after 6 months. Some shrinkage is evident in the bone volume, but no gaps are visible along the cutting lines.

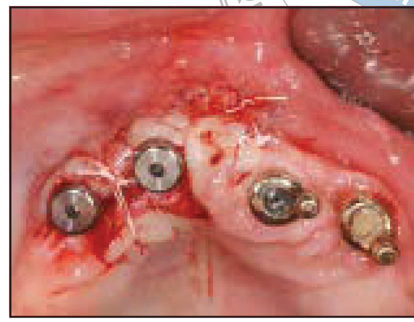


Fig 3f A pedicle graft rotated from the palate completes the reentry surgery.

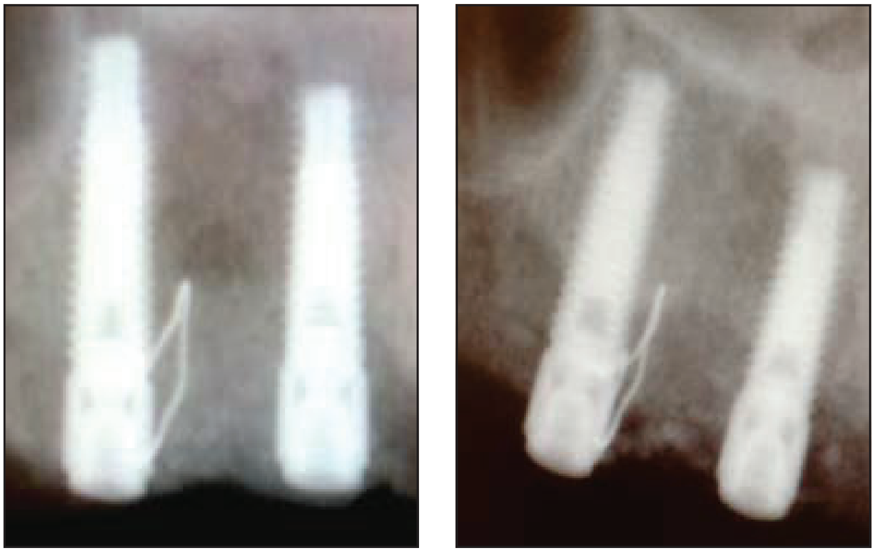


Fig 3g *First-* (left) *and second-stage* (right) *surgery controls.*

Fig 3h *Complete soft tissue healing of the expanded site.*

the larger representation of cortical segments in the mandible may explain its greater resistance both to the surgical wound and to the biologic remodeling during the healing period before nutrition can be provided by bone marrow revascularization, thus maintaining a wider diameter after this period. After all, from a histologic standpoint, this is the bone-envelope concept, primarily described by Wang et al.[29]

The use of autologous derivatives, such as the PRGF according to the protocol of Anitua,[28] hasn't yet fully demonstrate its inductive properties in the literature,

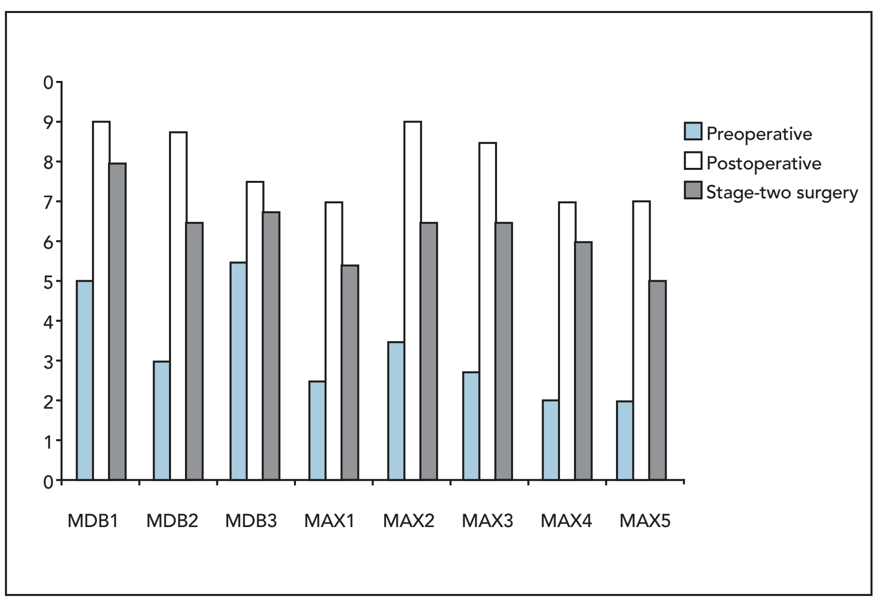


Fig 4 *Mean crestal bone width.*

but many clinicians do know its effectiveness in keeping the graft materials together while operating, and these adhesive properties are appreciated, particularly in the maxilla.

Moreover, the autologous fibrin membrane, obtained by the poor plasma (poor in growth factors) by the same protocol, seems to consistently prompt the healing velocity to the sutured soft tissues, and this is a common observation.

Except in one case of premature cover screw exposure, no complications have occurred in the cases reported in this article so far, and they were all loaded with regular fixed prostheses. Some resorption was observed in between the positioned implants at reentry time, but the statistics are heavily affected by the one mandibular case that received premature exposure. Blus and Szmukler-Moncler[18] referred to it as saucerization, a vertical depression between the implants, meaning a certain minimal loss of bone. They did not use any kind of membrane on the expanded sites, which the current study did. Moreover, the author believes that a certain amount of GBR on top of the crest helps in preserving the medullary part of the expanded bone between the two cortical plates.

The use of an antibiotic solution on the particulated graft has no scientific evidence. The author believes that it could prevent bacterial proliferation in the very first wound healing phases, without interfering too much with the chemotactic and proliferative factors in the area, since it is rapidly absorbed by macrophages.

What is more, no synthetic molecular enhancer was used, for example recombinant human platelet-derived growth factor BB (rhPDGF-BB) or other chemical growth factors, as this could have negative effects in association with barrier membranes. This has been suggested by Simion et al[30] using an equine block infused with rhPDGF-BB in a canine model study and recently confirmed by Nevins et al,[31] mixing the same synthetic molecule to a mineral collagen bone substitute as a scaffold.

However, one has to consider the fact that those studies respectively treated vertical deformity reconstructions and cases of deficient vestibular plate of bone, which by definition do not have a cortical plate capable of expansion and which are more demanding from a biologic standpoint.

Conclusions

This article deals with the MCW technique: a graft is taken exactly where it is required to be repositioned, which means a maximum dimensional fit and possibly a perfect biologic match with the recipient site. This also means there is no need to have a second surgical site in the patient's mouth or in a distant donor site, which entails evident advantages in terms of reduced morbidity.

The novelty is mainly in the way the monocortical plate of bone is fixed to the palatal/lingual bone. It is a common steel ligature, twisted and properly tightened around the graft and the native bone to obtain the desired stability. This method of bone fixation has proved to be quick, simple, easy, and effective not only for graft stabilization but also in giving primary stability to the implants themselves. This aspect deserves to be taken into consideration because it could represent an additional tool in the surgeon's hands to improve success rates. All implants inserted in the present study showed strong stability at stage-two surgery, while all gaps in the surrounding bone had been filled with apparently mature, sound new bone.

No histologic specimens were taken in this study, which doubtless is a limitation in assessing the quality of bone in the augmented sites. Nor can the success rate obtained be ascribed with absolute certainty to either the GBR, split-crest technique, or a combination of both. This is simply because they were always used simultaneously, although it is maintained that the solid fixation provided by the introduced ligature is a consistent and positive factor. Also, a great deal of attention was paid to achieving primary flap closure, as with all augmentation procedures.

The osteosynthesis ligature deserves to be kept on hand in the operative protocols for advanced bone reconstructions because it is a safe, easy, and inexpensive tool. Although all cases showed positive outcomes, the procedure needs to be replicated with larger numbers to definitively determine its validity.

Acknowledgment

The author reported no conflicts of interest related to this study.

References

1. Seibert J. Reconstruction of deformed partially edentulous ridges using full thickness onlay grafts. Part 1. Technique and wound healing. Compend Contin Educ Dent 1983;4:437–445.
2. Abrams H, Kopczyk R, Kaplan A. Incidence of anterior ridge deformities in partially edentulous patients. J Prosthet Dent 1987;57:191–194.
3. Nystrom E, Ahlqvist J, Kahnberg KE, Rosenquist JB. Autogenous onlay bone grafts fixed with screw implants for the treatment of severely resorbed maxillae. XR evaluation of pre-operative bone dimension and post-operative bone loss and changes in soft tissue profiles. Int J Maxillofac Surg 1996;25:351–359.
4. Schwartz A, Arad D, Levin L. Intraoral autogenous block onlay bone grafting for extensive reconstruction of atropic maxillary alveolar ridges. J Periodontol 2005; 76:636–641.
5. Chiapasco M, Gatti C, Gatti F. Immediate loading of dental implants placed in severely resorbed edentulous mandible reconstructed with autogenous calvarial grafts. Clin Oral Implants Res 2007; 18:13–20.
6. Simion M, Trisi P, Piattelli A. Vertical ridge augmentation using a membrane technique associated with osteo-integrated implants. Int J Periodontics Restorative Dent 1994;14:496–511.
7. Hammerle CH, Jung RE, Teloutzis A. A systematic review of the survival of implants in bone sites augmented with barrier membranes (guided bone regeneration) in partially edentulous patients. J Clin Periodontol 2002;29(suppl 3):226–231.
8. Jensen OT, Laster Z. Preventing complications arising in alveolar distraction osteogenesis. J Oral Maxillofac Surg 2002; 60:1217–1218.
9. Chiapasco M, Abati S, Romeo E, Vogel G. Clinical outcome of autogenous bone block or guided bone regeneration with e-ptfe membranes for the reconstruction of narrow edentulous ridges. Clin Oral Implants Res 1999;10:278–288.
10. Machtei EE. The effect of membrane exposure on the outcome of regenerative procedure in humans: A meta-analysis. J Periodontol 2001;72:512–516.
11. Simion M, Trisi P, Piattelli A. Vertical ridge augmentation using a membrane technique associated with osseo-integrated implants. Int J Periodontics Restorative Dent 1994;14:497–511.
12. Tinti C, Parma Benfenati S, Polizzi G. Vertical ridge augmentation. What is the limit? Int J Periodontics Restorative Dent 1996;16:221–229.
13. Bruschi GB, Scipioni A, Calesini G. The edentulous ridge expansion technique: A five-year study. Int J Periodontics Restorative Dent 1994;14:451–459.
14. Bruschi GB, Scipioni A, Calesini G. Bone regeneration in the edentulous ridge expansion technique: Histologic and ultrastructural study of 20 clinical cases. Int J Periodontics Restorative Dent 1999; 19:269–277.
15. Simion M, Baldoni M, Zaffe D. Alveolar ridges augmentation by means of immediate implant placement associated with "green stick fracture" of the ridge crest and guided tissue regeneration. Int J Periodontics Restorative Dent 1992; 12:463–473.
16. Torella F, Pitarch J, Cabanes G, Anitua E. Ultrasonic osteoctomy for the surgical approach of the maxillary sinus: A technical note. Int J Oral Maxillofac Implants 1998;13:697–700.
17. Vercellotti T. Piezoelectric surgery in implantology: A case report of a new piezoelectric ridge expansion technique. Int J Periodontics Restorative Dent 2000;20: 359–365.
18. Blus C, Szmukler-Moncler S. The split–crest procedure with ultra-sonic bone surgery. Results of a 3-year experience with 172 treated sites. Clin Oral Implants Res 2004;14:36–37.
19. Khoury F, Happe A, Hoppe A. Soft tissue management in oral implantology: A review of surgical techniques for shaping an esthetic and functional peri-implant soft tissue structure. Quintessence Int 2000;31:483–499.
20. Zjiderveld SA, Bruggenkate CM, van Den Bergh JP. Fractures of the iliac crest of the literature. Int J Oral Maxillofac Surg 2004;62:781–786.
21. Coatam GW, Mariotti A. The segmental ridge-split procedure. J Periodontol 2003;74:278–288.
22. 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.
23. Wallace SS, Mazor Z, Froum SJ, Cho SC, Tarnow DP. Schneiderian membrane perforation rate during sinus elevation using piezosurgery: Clinical results of 100 consecutive cases. Int J Periodontics Restorative Dent 2007;27:413–419.
24. 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 Implants Res 2006;17:700–707.
25. Buser D, Von Arx T. Horizontal ridge augmentation using autogenous block grafts and the guided bone regeneration technique with collagen membranes: A clinical study with 42 patients. Clin Oral Implants Res 2006;17:359–366.
26. Gandi LN, Kattimani VS, Gupta AV, Valliripalli SC. Prospective blind comparative clinical study of two points fixation of zygomatyc complex fractures using wire and mini-plates. Head Face Med 2012;8:7.
27. Goyal M, Marya K, Chawla S, Pandey R. Mandibular osteosynthesis: A comparative evaluation of two different fixation systems using two mm titanium miniplates and 3D locking plates. J Maxillofac Oral Surg 2011;10:32–35.
28. Anitua E. Expansion de cresta con osteotomos estado actual. Utilizacion del plasma rico en factores decresimiento (PRGF). Revista Espanola de Cirugia Oral y Maxilofacial 2001;23:1–5.
29. Wang HL, Mish CM, Neiva RF. Sandwich bone augmentation technique: Rationale and report of pilot cases. Int J Periodontics Restorative Dent 2004;24:232–245.
30. Simion M, Nevins M, Rocchietta I, et al. Vertical ridge augmentation using an equine block infused with recombinant human platelet-derived growth factor-BB: A histiologic study in a canine model. Int J Periodontics Restorative Dent 2009; 29:245–255.
31. Nevins ML, Camelo M, Shupbach P, Nevins M, Kim SW, Kim DM. Human buccal plate extraction socket regeneration with recombinant human platelet–derived growth factor BB or enamel matrix derivative. Int J Periodontics Restorative Dent 2011;31:481–492.