Total flapless split-crest technique with tunnel connective graft using microspire conical connection implants: a 3-year retrospective study

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ABSTRACT

Introduction During fixed implant-prosthetic rehabilitation of the jaw there is often an alveolar bone volume that is not suitable for a correct and prosthetically guided insertion of the implant.
In horizontal bone defects, the split crest technique with concomitant insertion of the implant fixture has proved to be a valid solution for the management of atrophy in cases of bone thickness of 3 mm or more. The total-flapless technique, with the complete vascular preservation, seems to significantly reduce bone resorption following the split crest even in cases of a high degree of horizontal atrophy, between 1.5 and 3mm, in which more significant volumetric increases are required. In addition, the insertion of a switching-platform implant associated with a supracrestal soft tissue tickness greater than 2mm seems to ensure a lower risk of gingival recession and bone loss around implants in medium and long term.
Materials and Methods In the present study, 23 patients underwent a total flapless split crest surgery with contextual insertion of 37 implants sometimes associated with soft tissue augmentation procedure. All patients showed pre-operative horizontal dimension of the alveolar ridge in its most coronal portion between 1.5 mm and 3 mm. For each of the 37 implants included in this study, crestal bone thickness was assessed before surgery (T0), 6 months after surgery (T1) and 3 years later (T2) by CBCT.
Results Six months after surgery (T1) the horizontal bone volume increased and varied in a range between 3.5mm and 4mm, with an average value of 3.8mm (DS 0.20mm).
Three years after surgery (T2) was possible to observe a very low vertical bone loss around implants. Overall implant survival rate was 100% and no cortical fractures were detected during cortical expansion. The supracrestal soft tissue was stable and free from periodontal recessions.
Conclusions The use of a total flapless bone expansion technique allows to minimize the surgical trauma and to avoid the use of sutures . In addition, the blood circulation between the bone and the periosteum should be fully preserved with a decrease of post-surgical vertical bone resorption in the augmentation area. The simultaneous insertion of a platform switching implant with conical connection seems to improve the maintenance of bone peaks in the first 3 years after surgery if original trans-gingival path is of at least 2mm. The technique is characterized by reduced visibility. Therefore a correct pre-surgical digital planning and a long learning curve make this approach highly operator dependent.

KEYWORDS Dental implants, bone regeneration, minimally invasive surgery, total flapless split crest, flapless technique, connective tissue graft

INTRODUCTION

The loss or extraction of the dental elements leads to a natural reduction of the alveolar bone volume both in the coronal-apical and bucco-lingual direction. This event proceeds more rapidly in the months following the extraction, then slowing down over time(1). From a clinical point of view, this resorption leads to important structural changes in the jaws, making it necessary to carry out a careful anatomical evaluation before attempting an implant-prosthetic rehabilitation. There are many effective and predictable techniques to increase the horizontal bone volume in the case of atrophic alveolal crest. Among these we include the split crest technique described by Nentwig in 1986(2). Horizontal expansion of the bone crest is achieved by dividing and deforming the bone cortices and is a suitable surgical approach to restore adequate horizontal bone volume in order to allow concomitant implant placement.
The cortical separation and alveolar bone deformation techniques (split crest technique) allow to obtain an adequate volume for implant insertion but at the same time trigger bone remodeling phenomena that inevitably lead to a vertical reabsorption of the cortical bone and a consequent partial exposure of the implant surface, limiting the use of these techniques to atrophies with a bone thickness greater than 3mm. The split crest performed with the total-flapless technique seems to be able to significantly reduce vertical bone resorption even in cases of thinner horizontal bone thickness, attributable to class 4 of the Cawood-Howell classification(3), up to thicknesses of around 1,5 mm(4).
The transmucosal path through which the prosthetic connection is inserted on the implant represents a constant anatomical condition in an implant-prosthetic rehabilitation. Today we know that the implant

transmucosal path is colonized by various bacterial species both Gram + and Gram-, from a microbiological point of view like a periodontal pocket around a natural dental element(5). The transmucosal path will therefore be subjected to chronic inflammatory phenomena. The greater is the supracrestal soft tissue thickness, the more difficult it will be for bacterial proliferation to reach the bone at the level of the implant neck. Therefore, in cases of too thin gingival thickness (less than 2mm) this contamination will have a high probability of leading to a periodontal recession, both mucous and alveolar, around the implant neck(6).
Finally, the use of bone level implants with a "platform switching" type connection, would seem to reduce the proliferation and accumulation of bacteria at the level of the implant / abutment connection, reducing bacterial inflammatory phenomena that would lead to bone resorption around the implant. It seems that the displacement of the implant / abutmet junction involves an infiltration of inflammatory cells in the central axis of the implant and away from the adjacent crestal bone: this mechanism would limit bone resorption at the alveolar ridge(7).
Platform switching is therefore an important element for tissue stability. To achieve this stability, it must also be provided a stable connection refractory to bacterial penetration.
Lazzara and Porter(8) conducted a significant long-term study: from repeated radiological evaluations over time it was found that the insertion of a platform-switched implant causes minimal changes in crestal bone levels compared to what is seen with insertion of conventional implants, equipped with a shoulder with a diameter equal to that of the abutments.
Cappiello(9) also conducted a study to evaluate peri-implant bone loss using platform-switching connections. In his case-control study, 131 implants were placed in 45 patients. Of the 131 implants, 75 were equipped with a healing abutment 1 mm smaller than the implant platform, while the remaining 56 implants were connected with an abutment of the same size as the implant platform. All implants were placed at the level of the bone crest and clinical and radiographic examinations were performed for a follow-up of 12 months after loading. The data collected show that the vertical bone resorption was 0.95 ± 0.32 mm in correspondence with the test implants (platform-switching) and 1.67 ± 0.37 mm for the control ones.
The goal of this study is to verify the peri-implant vertical bone resorption in both the vestibular and lingual components 3 years after the use of a total flapless split crest technique. This procedure is associated with the insertion of a fixture with platform switching design and conometric connection in presence of an adequate supracrestal soft tissue tickness, with non-invasive augmentation techniques.

MATERIALS AND METHODS

Inclusion criteria

In this study, 23 patients were recruited and 37 implants were inserted respecting the protocol reported by the total flapless split crest technique(4).
All the patients recruited in this study presented a need of an implant-prosthetic rehabilitation of one or more dental elements in both maxillary jaws. The cases were all characterized by partial edentulism with horizontal atrophy of the alveolar process attributable to class IV according to the Cawood-Howell classification, in the absence of significant vertical bone loss.
Before surgery, a measurement of the thickness of the mucosa was also performed in correspondence of the implant insertion area and in eighteen sites less than 2 mm was detected. In these cases an atraumatic soft tissue augmentation technique was planned, in the same session of the implant surgery.
Patients with systemic pathologies or presence of compensated systemic pathologies (diabetes, heart failure, hypertension, renal insufficiency, hepatic insufficiency, respiratory insufficiency, other endocrine / metabolic diseases or coagulation disorders) were excluded.
Patients lacking of an adequate level of compliance (like psychiatric pathologies etc.), severe congenital/acquired malformations, severe disabilities, were excluded.
Patients with oral mucosal diseases such as lichen planus in the area to be treated and cases with severe active periodontal disease were excluded. Patients on anticancer therapy or with a history of radiotherapy in the head and neck area were also excluded.
Through the radiographic analysis with CBCT, the implant positioning in correspondence with the edentulous site was planned on 3D software (Romexis - Planmeca, Helsinki, Finland). The bone thickness of the alveolar ridge was measured in the 3D scan passing through the virtual center of the implant inserted in the three-dimensional project.
The measurement was carried out in the most coronal portion of the alveolar process and have been selected the cases in which the thickness was between 1.5 and 3 mm. The goal was to obtain an increase in crestal thickness between 3 and 4 mm.
All patients underwent a professional hygiene session within 2 weeks before the surgery and an antibiotic therapy based on 1g of amoxicillin + clavulanic acid was administered every 12 hours for 6 days from the day before surgery.
If necessary, a 7.5 mg Midazolam tablet was given 20 minutes before surgery to help the patient relax and cooperate.
In case of post-operative pain, Ibuprofen (600mg every 8 hours) was prescribed to the patient. If severe and persistent pain occurs, the patient was invited to contact our dental clinic for a consultation.

Implants

In all cases implants with a diameter of 3.5 mm and length between 10 and 11,5 mm were placed in mandible and maxilla, simultaneously with the bone expansion procedure. The implants used are characterized by a platform switching conometric connection, with an interfacial gap of the connections between 0.5 and 1 micron in size. The microspires in the crestal portion of the implants allow an increased stability at the cortical level, as well as allowing an optimal osseointegration area. The implant surface is characterized by sandblasting treatment and double acidification.

Surgical procedure

All cases in this study were treated with the total-flapless split crest technique after a precise measurement of the width of the alveolar process, detected in its most coronal portion.

Before surgery, the patient rinsed with Chlorhexidine digluconate 0.20% for 1 minute. The lips and perioral tissues were disinfected with Betadine® antiseptic solution.

The surgical procedure provides, after loco-regional anesthesia (Articaine 40mg / ml + adrenaline 0.01mg / ml), the measurement of the mucous thickness and the identification of the bone crest by probing with a periodontal probe (figure 1). A single full-thickness incision of approximately 3 mm is made in the mesio-distal direction of the residual bone crest.

Through this incision, a thin Ot2 piezoelectric osteotomy insert (Mectron©, Carasco, Italy) or a Swann Morton model SM64 blade activated by magnetic dynamic instrumentation (Osseotouch, Gallarate VA, Italy) is inserted, performing a sagittal cut of the cortex, corresponding to the mucosal incision line.

This osteotomy is about 1mm deep and it extends 1mm mesially and distally under the mucosa in addition to the cutting line, reaching an overall extension of about 5mm for each implant placement site. The incision must not be extended to involve any adjacent natural element.

Subsequently, the osteotomy line is deepened through the use of osteotomes with blade tip activated through magnetic dynamic instrumentation used in sequence with increasing thicknesses: MM-F-CUTD (blade instrument), MM-F-EXP1D (instrument with chisel with maximum thickness 2 mm) and MM-F-EXP2D (chisel tool with maximum thickness 3.5 mm) (Osseotouch, Gallarate VA, Italy). The blade and chisel expansion is carried out until a sagittal separation of the two cortices is obtained at an average depth of 7-8mm such as to obtain a first horizontal increase between 1.5 and 2mm (Figure 3).

Subsequently, a second circular expansion at the center

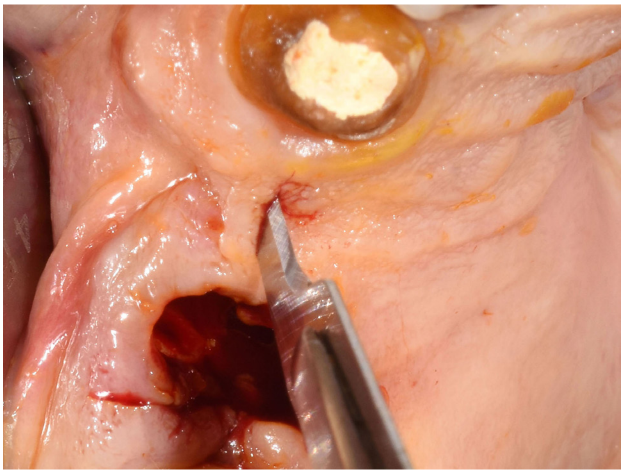

FIG. 1 A single full-thickness incision of approximately 3 mm is made in the mesio-distal direction of the residual bone crest

of the ridge splitting site was carried out. It was obtained through a sequence of osteotomes with a conical section, also activated through magnetic dynamic instrumentation. The instruments are MM-F-100D (pointed instrument, tip diameter of 1.4mm up to a maximum of 3.3mm) and MM-F-200D (truncated cone instrument, smaller diameter 1.6 mm and greater diameter of 4.0 mm) (Osseotouch, Gallarate VA, Italy) (figure 4).

Once the thickness of the preparation equivalent to the diameter of the implant neck to be inserted has been reached, it was possible to proceed, if necessary, by finishing the preparation of the most apical portion of the implant site with the implant kit drills (Figure 5).

Then we proceeded with the bone level insertion of the implant fixture BNX Evo, with a diameter of 3.5 mm (Ghimas©, Casalecchio di Reno BO, Italy) (Figure 6).

Once the bone expansion procedure was completed, the supracrestal soft tissue thickness was measured in correspondence of the gum over the implant (Figure 7). In cases where a mucous thickness less than 2mm was detected, a connective graft through a tunnel technique was carried out.

This technique involves, after local anesthesia, the remov-

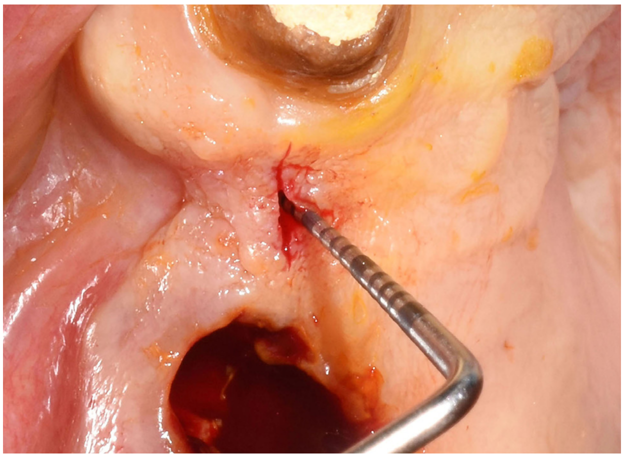

FIG. 2 Measurement of the mucous thickness with a periodontal probe

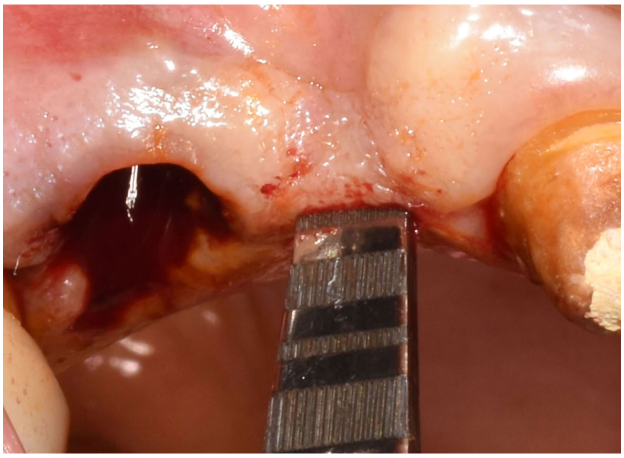

FIG. 3 Use of osteotomes with a blade tip

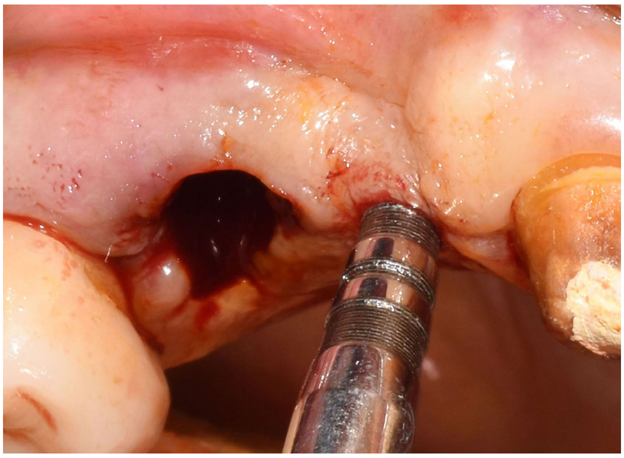
FIG. 4 Use of osteotomes with a conical section

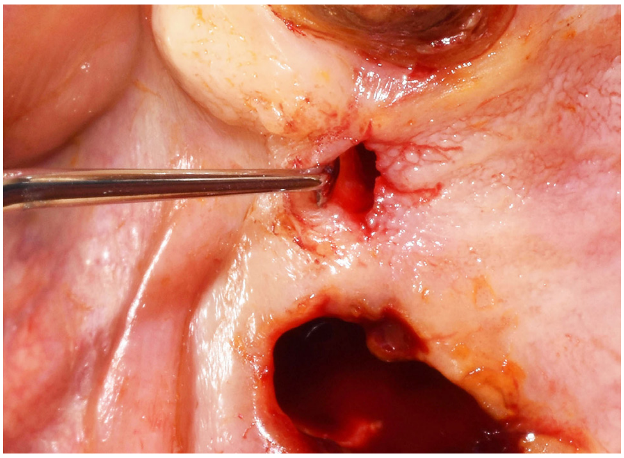
FIG. 5 Implants bed preparation

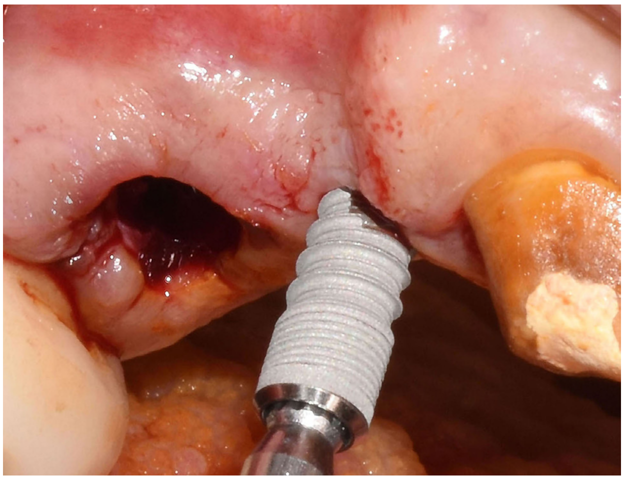
FIG. 6 Implants insertion

al of an epithelial-connective portion of mucous tissue from the palatine area of the 6th-7th upper dental element. The goal was to obtain an implant supracrestal soft tissue with a thickness of more than 2mm. The extension of the graft is evaluated according to the initial gingival thickness: areas with insufficient supracrestal soft tissue will be involved, for at least 3mm in the buccal, lingual, mesial and distal directions with respect to the emergence of the implant site.
Before proceeding with the sampling from the palate, a transgingival healing screw with a height of 4mm and diameter 4.5mm with a conical connection was screwed onto the implant to obtain an initial conditioning of the soft tissue during the palatine sampling procedures (Figure 8).
The epithelial-connective tissue from the palatine area was subsequently de-epithelialized and cleaned of any glandular and adipose residues. The remaining connective layer showed a high consistency and a homogeneous color, with a thickness ranging between 1 and 1.5mm.
The connective layer was kept hydrated with sterile physiological solution and subsequently sectioned according to the areas of the defect to be increased with the following criterion:

- vestibular area of the implant: 1 or 2 portions
- lingual area of the implant: 1 or 2 portions
- mesial area of the implant: 1 portion
- distal area to the implant: 1 portion

Subsequently, the healing screw was removed and a partial thickness incision of the gingiva with a Spoon Blade for tunneling (MJK Instruments, Marseille, France) was performed through the transgingival area of the implant path.
With #2 Giles de Quincey tunneling tools (Hu-Friedy Mfg. Co.©, Tuttlingen, Germany), a pocket was obtained for each area where soft tissue augmentation was required, with an extension of at least 3mm and the necessary width. The connective graft previously prepared was then inserted into the mucous pocket through the partial thickness incision performed through the transgingival pathway of implant insertion.
Once the positioning of the connective tissue portions was completed, the graft was stabilized in the desired position by reinserting the transgingival screw. This tunneling technique was performed totally without stitches.

Prosthetics

Six months after surgery, the prosthetic phase was carried out using a digital workflow. We proceeded taking digital impression by scanning with Cerec MC XL system (Dentsply Sirona, North Carolina, USA), followed by the modeling and milling phase of the prosthetic crown. The screw-retained prosthetic crowns were made of lithium disilicate.
The chairside digital workflow allows the clinician to deliver crowns in a short time and allows to obtain a high degree of precision of the products, eliminating the need for occlusal retouching after delivery of the prosthetic crown, thanks to the high degree of precision with the system impression and milling.
The data reported in the scientific literature for prosthetic restorations performed with the CEREC system are very positive(10). Furthermore the digital impression and the possibility of shortening the delivery time of the prosthetic products

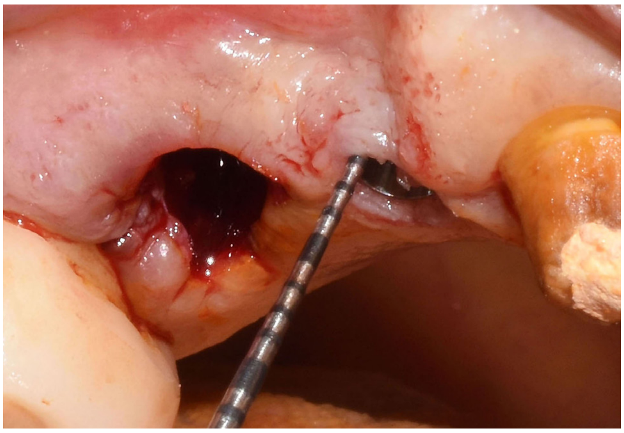

FIG. 7 Probing the bone level and gingival thickness in correspondence with the transgingival path of the implant with a periodontal probe.

FIG. 8 Insertion of a transgingival healing screw

compared to traditional methods, allows to obtain a better satisfaction for operator and patient(11).

Follow-up and analysis of vertical bone loss

For each of the 37 implants included in the present study, the crestal bone thickness was therefore evaluated before surgery (T0).
During the prosthetic phase (T1) a second CBTC was made through which the heights of the bone in the vestibular and in the lingual/palatine portion were measured with respect to the emergence of the implant neck. This measurement was calculated in the scan corresponding to the vertical axis passing through the center of the implant.
Following predictive criteria for implant success, great care was taken to oral hygiene, temporary prosthesis stability and trimming, to avoid inappropriate early clinical loading of the inserted implants and expanded bone by the surgical splitting technique.
In the first 3 years after surgery, parameters such as the number of surgical troubles, implant survivals, post-surgical complications, height of the lingual and buccal bone portions in correspondence of the implant axis were recorded.
Three years after the prosthesis (T2) the patients were recalled for control and subjected to a new CBCT. The height of the bone in the buccal and lingual side was again measured in a scan through the center of the implant axis. The same measurement was so taken in the same position as the previous one and compared.
The vertical bone loss (VBL) was obtained through the use of cone-beam CT and it is divided into vestibular and lingual at T1 (6 months) and T2 (3 years). Each of these values was inserted into one of the 3 groups in relation to the mm of implant surface with loss of bone support (Figure 9).

RESULTS

A group of 23 patients aged between 34 and 69 years was recruited for this study and a total number of 37 bone level implants with conical connection and platform switch were placed over a 15 months period with the total flapless horizontal expansion technique.
For each of the 37 implants included in the present study, the crestal bone thickness was evaluated before surgery (T0). At 6 months after surgery (T1), the horizontal increase obtained and the vertical bone loss were measured. After a further 3 years (T2), a new CBCT allows to evaluate vertical bone loss 3 years after surgery (Table 1).
The low dose CBCT performed 6 months after surgery (T1) demonstrates a significant horizontal increase in bone thickness.

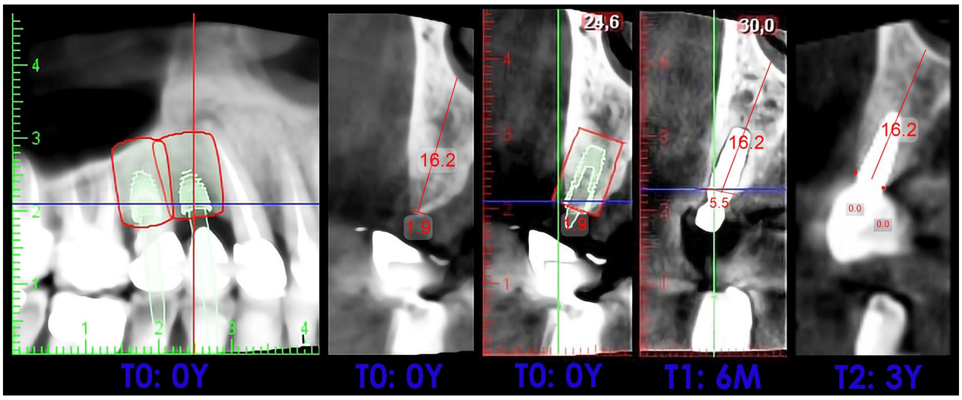

FIG. 9 Radiographic evaluation by CBCT at T0, T1 (6 months) and T2 (3 years)

Case	Initial bone thickness (T0)	6 months bone thickness (T1)	3 years bone thickness (T2)	3 years vestibular vertical bone loss (T2)	3 years lingual/palatal vertical bone loss(T2)
1	1,7mm	5,4mm	5,3mm	0,0mm	0,2mm
2	2,2mm	6,0mm	6,0mm	0,3mm	0,1mm
3	2,4mm	6,3mm	6,4mm	0,0mm	0,0mm
4	1,5mm	5,4mm	4,8mm	1,6mm	1,3mm
5	1,9mm	5,5mm	5,5mm	0,5mm	0,2mm
6	2,7mm	6,7mm	6,9mm	0,0mm	0,0mm
7	1,7mm	5,2mm	5,2mm	1,3mm	0,7mm
8	2,6mm	6,5mm	6,5mm	0,4mm	0,0mm
9	3,0mm	6,8mm	7,0mm	0,0mm	0,0mm
10	2,4mm	5,9mm	5,8mm	0,3mm	0,1mm
11	1,8mm	5,5mm	5,1mm	0,6mm	0,9mm
12	2,9mm	6,0mm	6,0mm	0,0mm	0,0mm
13	2,4mm	6,5mm	6,5mm	0,0mm	0,0mm
14	2,1mm	5,9mm	6,0mm	0,0mm	0,4mm
15	1,8mm	5,4mm	5,5mm	1,6mm	0,5mm
16	2,9mm	6,4mm	6,5mm	0,0mm	0,0mm
17	2,3mm	6,2mm	6,3mm	0,0mm	0,6mm
18	1,9mm	5,7mm	5,7mm	0,4mm	0,4mm
19	2,7mm	6,8mm	6,8mm	0,0mm	0,1mm
20	2,0mm	5,7mm	5,7mm	1,0mm	0,6mm
21	1,6mm	5,2mm	5,4mm	2,2mm	1,6mm
22	2,2mm	6,4mm	6,4mm	0,8mm	0,3mm
23	2,9mm	6,6mm	6,6mm	0,1mm	0,5mm
24	1,5mm	5,3mm	5,2mm	2,0mm	1,5mm
25	2,7mm	6,7mm	6,7mm	0,0mm	0,0mm
26	3,0mm	6,9mm	7,1mm	0,3mm	0,3mm
27	2,2mm	6,4mm	6,2mm	0,7mm	0,7mm
28	1,5mm	5,1mm	5,4mm	1,4mm	0,4mm
29	2,9mm	6,5mm	6,5mm	0,5mm	0,0mm
30	2,7mm	6,5mm	6,7mm	0,0mm	0,0mm
31	2,7mm	6,7mm	6,5mm	0,3mm	0,0mm
32	1,8mm	5,5mm	5,5mm	1,1mm	0,1mm
33	2,3mm	6,5mm	6,4mm	0,8mm	0,7mm
34	1,6mm	5,1mm	4,8mm	1,4mm	0,8mm
35	2,8mm	6,6mm	6,6mm	0,2mm	0,3mm
36	2,4mm	6,3mm	6,3mm	0,1mm	0,3mm
37	1,9mm	5,5mm	5,6mm	0,0mm	0,0mm

TABLE 1

All patients underwent periodontal causal therapy before surgery and for the duration of the study. The 37 implants were placed in absence of complications or adverse events.
Initial horizontal bone thicknesses before surgery (T0) ranged from 1.5 mm to 3.0 mm (mean 2.2 mm).
Post-surgical horizontal bone thicknesses measured at T1 vary between 5.1 mm and 6.9 mm (mean 6.0 mm). This results in horizontal increments that vary in a range between 3.5 mm and 4.0 mm with an average value of 3.8mm (SD 0.2 mm).
The measurement of vertical bone loss (VBL) is divided into vestibular and lingual at T1 (6 months) and vestibular and lingual at T2 (3 years) with 75% of cases of vestibular and lingual resorption less than 1 mm at 3 years (table 2).

VBL	T1 vestibular	T1 lingual	T2 vestibular	T2 lingual
Between 0 and 1mm	33	35	28	34
Between 1 and 2mm	4	2	7	3
More than 2mm	0	0	2	0

TABLE 2

DISCUSSION

Various studies in literature have evaluated the structural modifications of the alveolar process that are triggered as a result of the loss of an element. These modifications lead to a reduction of bone volume in the apical and lingual direction, reducing the crestal bone width of the alveolus up to 50% after one year, with an horizontal bone loss that can vary between 29% and 63% afterwards extraction, as reported in a systematic review of the literature(12).
In addition, various causes that may have led to the loss of the dental element (periodontal disease, mechanical trauma, infectious lesion, iatrogenic damage, etc.) can increase the reduction of the residual alveolar bone support after the extraction.
This fact often makes necessary in clinical practice to evaluate bone regeneration procedures before or at the same time of the implant placement. Many surgical techniques are reliable to restore the correct bone volume such as GBR, sinus lift or SCT (split crest technique), analyzed in this article.
SCT is indicated for treating even significant horizontal defects in sites where vertical regeneration is not necessary (Cawood and Howell class IV atrophy). The rationale behind the choice of a SCT is to obtain an horizontal bone expansion through deformation, avoiding macro-fractures of the buccal and lingual bone cortices. This expansion needs to make stable through the grafting of bone substitutes, the insertion of the implants or both procedures, allowing in these cases the execution of a one-stage procedure, with a faster timing and the consequent reduction of the number of interventions for the patient.
The guidelines in the traditional use of SCT need a minimum

bone thickness of 1-1.5 mm per side around the implant after placement in order to reduce the risk of fracture and vertical resorbtion, particularly high in cases where there is no presence of cancellous bone between the cortical plates. Furthermore, the sagittal short incision of the soft tissue and the use of a combined osteotomy technique, first with sharpen section and subsequently rounded, seems to significantly reduce the risk of macro-fractures, particularly affecting the buccal bone wall(13).
In a systematic review by Waechter et al.(2017)(14) 27 studies were analyzed with a total of 1732 patients and 4115 implants inserted following split crest. The implant survival rate was 97%, the average horizontal gain between 3.61 and 3.69 mm although there was no scientific evidence that a technique or a selected instrument provides better clinical predictability.
Different approaches have been analyzed in the literature to perform sagittal osteotomy and cortical deformation in order to ensure adequate horizontal bone expansion and concomitant augmentation in split crest techniques (Piezoelectric cut, surgical drills, Magnetic Mallet, Osteotomies). Among these, it does not seem to be any relevant differences in the amount of increasing bone obtainable in volumetric terms. However, the use of piezoelectric surgery with very thin blade inserts seems to reduce trauma and at the same time increase osteotomic precision in the execution of the first crestal bone incision compared to the use of manual blades or scalpel inserts installed on osteotomes(15). Therefore, a more precise and less invasive surgical approach probably involves less trauma for the patient and a more accurate surgical procedure. This becomes even more relevant in the situations of minimum visibility as the total-flapless technique, further optimizing the preservation of the crestal bone tissue and the preservation of the supracrestal soft tissue corresponding to the incision site.
Starch-Jensen(16), on the other hand, analyzed the clinical results obtained with SCT compared to autologous bone grafts in blocks, showing similar results both in terms of horizontal bone gain and in terms of VBL (Vertical Bone Loss), suggesting that the choice between these 2 techniques could be case-specific.
The grafting technique with autologous bone block, however, provides for a donor site and a second deferred surgical re-entry for implant placement, thus resulting more invasive and with a longer case management time. Furthermore the graft of autologous bone block, when compared with a total-flapless SCT, presents significantly greater risks of post-surgical complications, discomfort and compliance by the patient.
The rationale behind the execution of a full thickness flap in the SCT is to improve the operator's vision during expansion of the cortical plates and to verify the absence of macro-fractures in the cortical bone. In addition, a large exposure of the bone defect allows the concomitant placement of bio-graft materials and the use of membranes to associate a GBR technique with the split crest in order to reduce post-surgical vertical bone resorption(17).
From a recent literature analysis from Cortese and coll (2016)(18), 2 rules are mandatory in implant surgery associated with alveolar bone augmentation for long-term results: alveolar cortical bone preservation (2 mm for each side) and bone vascular preservation. To achieve these 2 goals a new split crest flapless technique was performed obtaining adequate buccal and lingual cortical thickness preserving blood circulation in the area.
Also Schwartz-Arad and coll.(19) suggest that it is essential to leave unchanged the vascularity of the site in order to prevent vertical bone resorbtion in time.
Subsequent studies seem to demonstrate a reduction in vertical bone reshaping and resorption resulting from the split crest technique avoiding vertical bone release cuts and maintaining the cortical blood supply and subperiosteal blood (20,21). In order to avoid blood supply reduction, was introduced the use of a flapless concept adapted to the split crest technique(22).
A minimally invasive approach allows to reduce the surgical trauma and postsurgical discomfort. The complete vascular supply is maintained, the bone resorption is reduced, and soft tissue does not undergo post surgical retraction, achieving the full maintenance of the residual keratinized gingiva(4).
Preservation, conditioning, and eventually increasing the peri-implant soft tissue through connective tissue grafting techniques further improve prognosis and preservation of alveolar bone support following bone expansion techniques(23). Because the conditioning of the postoperative mucous tissue plays an important role in cases of major atrophy, especially in the VBL, the reduction in mucosal access allowed optimal preservation of the residual keratinized tissue.
When the thickness of the residual keratinized tissue was considered to be less than 2mm, a connective tissue graft, harvested from the palate, was fixed in the area with a tunneling technique without the use of sutures. In this way, the peri-implant mucous thickness showed bacterial penetration improvement and better hygiene of the surgical wound at the same time (plaque accumulation risk or food residues were reduced in the absence of sutures).
The choice of the epithelial/connective palatal graft, in line with our minimal-invasive surgical procedure, lies in the fact of guaranteeing a more superficial and therefore better quality connective tissue with less post-surgical discomfort for the patient compared to deeper, connective-only, tissue graft. The palatine area from which the graft is performed, in fact, has high average thicknesses, usually greater than 5mm, with the main nervous and vascular components located in the deeper layers. A more superficial tissue graft therefore involves less bleeding, less pain, fewer complications and less discomfort for the patient than a deeper connective tissue graft performed with envelope flap or trapdoor techniques. Furthermore, in deep withdrawals, a thin or inadequate thickness of the superficial component of the flap entails risks of wound necrosis and post-surgical dehiscence(24). In the present study, the palatine suture is also

removed on average after only 4 or 5 days after surgery.
In the traditional split crest technique the sectioned cortical walls are subjected to periosteal detachment and will undergo resorption because of lack of nourishment, particularly for the thin buccal cortex, followed by implant thread exposure. The advantages of a minimally invasive flapless technique in split crest consist of: preservation of cortical wall without vertical cortical cuts or fractures and preservation of the mucous tissues around implants without periosteal elevation in order to reduce the amount of VBL in time. The results showed an average bone gain of 3,8 mm, absolutely comparable with the literature, as shown in a systematic review by Waechter and coll.(14), even if the initial thickness was quite narrow (1,5-3mm) compared to other studies.
However the most significant result, besides the implant survival rate of 100%, is the VBL at T2 (3 years) which is referred to be at least for the 75% of the implant inserted < 1mm.
Longoni et al.(13) analyzed the marginal bone loss of 88 implant placed with SCT with 2D radiographic evaluation obtaining a mean value out of the mesial and distal bone loss. The observation period for all patients treated with split crest technique varied between 4 and 8 years (mean 6.2 years). Bone resorption ranged between 2.3 mm and 2.7 mm.
Troedhan et al.(25) analyzed the use of flapless SCT with piezoelectric surgical devices and after three years observed a significant difference (p = 0.24) of VBL between the group with less than 2 mm initial crest-width compared with the group with more than 2 mm crest-width but was still significant lower when compared with the results of similar studies published with a mucoperiostal-flap approach and baseline bone-cut. Therefore they suggest to insert implants sub-crestally in very thin residual crests, in order to avoid a substantial VBL.

CONCLUSIONS

The use of a total-flapless split crest technique allows to minimize the traumatic nature of surgery.
A minimally invasive techniques allows to reduce the patient's post-operative discomfort, the risk of post-operative complications and make the surgery more suitable even for less cooperative patients.
Through this approach it is possible to avoid the use of sutures even in cases of severe horizontal atrophy (1.5-3mm). In addition, the blood circulation between the bone and the periosteum should be fully preserved, with a lower post-surgical vertical bone resorption in the augmentation area.
The insertion of a platform switch implant with conical connection and microspire seems to improve the maintenance of the bone in the first 3 years after surgery if there is a transmucosal path with a thickness of at least 2mm.
Although the total flapless bone expansion technique has numerous advantages, it should be emphasized that this surgical procedure takes place with reduced visibility. This approach is therefore characterized by a high operator-dependence, requiring a correct and accurate pre-surgical digital planning, but if the surgical protocol is correctly followed the total flapless split-crest technique should be considered predictable.

REFERENCES

1. Araùjo M., Lindhe J.: Dimensional Ridge alteration following tooth extraction. An experimental study in dogs. J Clin Periodontol 2005; 32:212-8
2. Nentwig GH. Technic of bone splitting for alveolar recession in anterior maxillary region. Quintessenz 1986;37:1825–34.
3. Cawood JI, Howell RA. A classification of the edentulous jaws.; Int J Oral Maxillofac Surg. 1988 Aug; 17(4):232-6.
4. Scavia S.,Roncucci R.,Bianco E., Maddalone M.: Minimal Invasive Flapless Piezotome Alveolar Crest Horizontal Split Technique: Preliminary Results; The Journal of Contemporary Dental Practice. 2020 January; (8):28 – 35.
5. T. Berglundh, J. Lindhe, C. Marinell, I.Ericsson, B. Liljenberg. Soft tissue reaction to de novo plaque formation on implants and teeth. An experimental study in the dog. Clin Oral Implants Res. 1992 Mar;3(1):1-8.
6. Suàrez-Lòpez del Amo F., Lin G-H, Monje A., Galindo-Moreno P., Wang H-L. Influence of Soft Tissue Thickness on Peri-Implant Marginal Bone Loss: A Systematic Review and Meta-Analysis. J Periodontol. 2016 Jun;87(6):690-9.
7. Prasad DK, Shetty M, Bansal N, Hegde C. Platform switching: An answer to crestal bone loss. J Dent Implants. 2011;1:13–7.
8. Lazzara RJ, Porter SS: Platform-switching: a new concept in implant dentistry for controlling post-operative crestal bone levels. INT J PERIOD RESTO DENT 2006; 26: 9– 17.
9. Cappiello M, Luongo R, Di IOrio D, Bugea C; Cocchetto R, Celletti R Evaluation of peri-implant bone loss around platform-switched implants INT J PERIOD RESTORAT DENT. 2008 Aug; 28(4): 347-55.
10. Nejatidanesh F, Shakibamehr AH, Savabi O., Comparison of Marginal and Internal Adaptation of CAD/CAM and Conventional Cement Retained Implant-Supported Single Crowns.. Implant Dent. 2016 Feb;25(1):103-8.
11. Schepke U, Meijer HJ, Kerdijk W, Cune MS. Digital versus analog complete-arch impressions for single-unit premolar implant crowns: Operating time and patient preference. J Prosthet Dent. 2015 Sep;114(3):403-6.e1. doi: 10.1016/j.prosdent.2015.04.003.
12. Tan WL, Wong TL, Wong MC, Lang NP. A systematic review of post-extractional alveolar hard and soft tissue dimensional changes in humans. Clin Oral Implants Res. 2012 Feb;23 Suppl 5:1-21.
13. Longoni S, Maroni I, Baldini A, Sartori M. Retrospective radiographic study of marginal bone changes of 88 implants placed with split crest technique in the maxillary latero-posterior area. J Osseointegr 2016;8(1):8-13.
14. J. Waechter, F.R. Leite, G.G. Nascimento, L.C. Carmo-Filho, F. Faot, The split crest technique and dental implants: a systematic review and meta-analysis, Int. J. Oral Maxillofac Surg. 2017; 46: 116-128.
15. Vercellotti T. Piezoelectric surgery in implantology: a case report – a new piezoelectric ridge expansion technique. Int J Periodontics Restorative Dent; 2000; 20(4):358-365.
16. Starch-Jensen T, Becktor JP. Maxillary Alveolar Ridge Expansion with Split-Crest Technique Compared with Lateral Ridge Augmentation with Autogenous Bone Block Graft: a Systematic Review J Oral Maxillofac Res 2019;10(4).
17. Simion M, Baldoni M, Zaffe D. Jawbone enlargement using immediate implant placement associated with a split-crest technique and guided tissue regeneration. Int J Periodont Res Dent, 1992; 12: 463-471.
18. Cortese A., Pantaleo G., Amato M, Claudio P.P., Ridge Expansion by Flapless Split Crest and immediate implant placement: Evolution of the technique. The Journal of Craniofacial Surgery, Vol. 27, nr. 2 March 2016.
19. Schwartz-Arad D, Levin L, Sigal L. Surgical success of intraoral autogenous block onlay bone grafting for alveolar ridge augmentation. Implant Dent 2005;14:131–138.
20. Scipioni A, Bruschi GB, Calesini G. The edentulous ridge expansion technique: a five-year study. Int J Periodontics Restorative Dent 19943; 14 (5): 451– 459.
21. Scipioni A, Bruschi GB, Calesini G, et al. Bone regeneration in the edentulous ridge expansion technique: histologic and ultrastructural study of 20 clinical cases. Int J Periodontics Restorative Dent 1999; 19 (3): 269–277.
22. Brugnami F, Caiazzo A, Mera P. Piezosurgery-assisted, flapless split crest surgery for implant site preparation. J Maxillofac Oral Surg 2014; 13 (1): 67–72.
23. Studer S, Naef R, Scharer P. Adjustment of localized alveolar ridge defects by soft tissue transplantation to improve mucogingival esthetics: a proposal for clinical classification and an evaluation of procedures. Quintessence Int 1997; 28 (12): 785–805.
24. Zucchelli G, Tavelli L, McGuire MK, et al. Autogenous soft tissue grafting for periodontal and peri-implant plastic surgical reconstruction. J Periodontol . 2020;91:9–16.
25. Troedhan, A., Kurrek, A., Wainwright, M. and Schlichting, I. (2015) Flapless Piezotome-Enhanced Vertical Alveolar Crest-Split and Horizontal Distraction of Alveolar Crests (FPeCSWT) of Less than 2 mm Width: Results of a Prospective Comparative 3-Year Clinical Multicenter-Study with 239 Patients, 261 Crest-Split Sites and 488 Inserted Dental Implants. Open Journal of Stomatology, 5, 157-178