Maxillary and Mandibular Split Crest Technique with Immediate Implant Placement: A 5-Year Cone Beam Retrospective Study

Roberto Crespi, MD, MSc, Prof1/ Paolo Toti, BSc, DDS, Prof1/Ugo Covani, MD, DDS, Prof1/Giovanni Crespi, DDS, Medical Student2/Giovanni-Battista Menchini-Fabris, DDS, Prof1

Purpose: This study aimed to test the effectiveness and reliability of the alveolar ridge-splitting technique in atrophic posterior arches, investigating the middle-term volumetric and clinical outcomes. Materials and Methods: Atrophic alveolar ridges in the maxillary and mandibular posterior areas were treated with the alveolar ridge-splitting/expansion technique (ARST), immediate implant placement, collagen sponges covering the defect, and healing by secondary intention. Areas were rehabilitated by fixed dental prostheses supported by dental implants. Changes in volume and width of the alveolar ridge were retrospectively calculated by comparing the x-ray tomography scans obtained before and 5 years after surgery. Report of failure in the case sheets was taken into account. Cross-sectional images were also used to assess the thickness of the labial alveolar plates at the implant shoulder. Nonparametric analyses of variance with post hoc and pair-comparison tests were performed with a level of significance of .05. Results: A total of 38 patients were retrospectively selected (23 women and 15 men). Six patients underwent ARST surgeries in both the maxilla and the mandible and were excluded from statistical analysis. Differences between 16 maxillae and 16 mandibles and between 12 single crowns and 20 fixed partial dentures (FPDs) were searched. Episodes of minor swelling occurred within the first 2 days after surgery. Neither mucositis nor flap dehiscence had been registered. The mean values of buccal cortical thickness were 2.46 ± 0.49 mm and 1.15 ± 0.33 mm, respectively, in the maxillary and mandibular areas. After 5 years of survey, maxillary increases in alveolar ridge width and volume were +4.4 ± 0.4 mm and +295 ± 45 mm³, respectively, whereas the same outcome variables (+3.5 ± 0.7 mm and +217 ± 53 mm³) measured in the mandible appeared to be significantly smaller than those in the maxilla (P < .0001). One maxillary single implant failed. Cumulative survival rates at 5 years were 100% for mandibles and 95.5% (95% CI: 86.8% to 100%) for maxillae. Conclusion: Posterior areas of the maxilla displayed a higher increase in alveolar width and volume than mandibular areas, and even if it would be premature to draw survival conclusions at this stage without any statistical support, a lower cumulative survival rate was reported for the maxillary single implants. Int J Oral Maxillofac Implants 2021;36:999–1007. doi: 10.11607/jomi.8572

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Several bone augmentation techniques, such as grafts with either cortical or particulate bone substitutes (xenogeneic, allogeneic, or synthetic scaffolds), and with or without membranes (resorbable, absorbable, or otherwise) could be used for correcting inadequate bone conditions due to very narrow alveolar ridges.1–3 Before dental implant placement, the recipient sites of the bone grafts had a variable healing time depending on the type of well-documented procedures that were employed; moreover, the use of bone substitute might enhance the risk for nonintegration and thus increase the rate of implant failure. As said, given the findings of the literature, the clinician could also decide not to use a bone substitute for bone augmentation, especially because in the case of autologous bone, a secondary surgical donor site was a necessary surgical step to increase the risk for postoperative complications and morbidities. In addition, it might be remembered that there was strong evidence that alveolar bone augmentation success rates had been hindered by partial bone loss resulting from negative remodeling phenomena.4,5

Guided bone regeneration and distraction osteogenesis were also used to increase the amount of

1Tuscan Dental Institute, Versilia Hospital, Lido di Camaiore, Italy; School of Dentistry, Saint Camillus International University of Health and Medical Sciences, Rome, Italy.
2Tuscan Dental Institute, Versilia Hospital, Lido di Camaiore, Italy.

Correspondence to: Prof Giovanni-Battista Menchini-Fabris, Department of Stomatology, Tuscan Stomatological Institute, c/o Versilia General Hospital, via Aurelia 335, 55049 Lido di Camaiore, Italy. Email: editorial.activities@istitutostomatologicotoscano.it

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bone volume and to improve prosthetic rehabilitation outcomes. However, both of these techniques might present potential disadvantages, such as tissue dehiscence, displacement or collapse of the membrane, inappropriate distraction, unpredictable amount of bone loss, and delay in implant placement.6

To find an alternative solution for increasing the bone volume before implant placement in case of an insufficient width of the alveolar ridge, a splitting/expansion technique was used to separate the buccal and the lingual/palatal cortical plates to increase the space from each other created by a greenstick fracture and to induce new bone formation in the inner cavity.

The ridge/expansion technique created a recipient bed without the use of bone grafts, providing successful outcomes with high predictability and low risk of complications compared with those of other techniques that make use of autologous donor sites.7

Horizontal alveolar expansion of the narrow edentulous ridges followed by placement of implants or “alveolar ridge-splitting/expansion technique” (ARST) was originally described by Simion and coworkers and later by Scipioni and colleagues.8,9

A few authors also mentioned some surgical variants of the standard ridge-split procedure, such as a “sandwich” technique, which attempted to address several of the methodologic difficulties and the major challenges still existing with hard tissue augmentation procedures.10–13

An outline and a rough description of the surgical technique was that the surgeon used to expand the narrow edentulous ridge by splitting the cortical plate, further opening the space between the two halves, and moving them away from each other; the space in the middle of them was occupied for the most part by an immediate endosseous dental implant.

The main advantages of ARST were that it was simple and quick, probably because of both the relatively atraumatic flapless procedure and the use of alternatives to bur preparation.14 Moreover, the way the residual alveolar ridge underwent an expansion in width appeared to also be highly predictable.15 As said in the literature, studies for assessing middle-term quantitative evaluation of bone volume change after ridge-splitting/expansion were not reported.

The aim of the present study was to test the effectiveness and reliability of ARST for fixed rehabilitation supported by osseointegrated implants in the atrophic posterior arches, investigating the middle-term linear and volumetric outcomes of patients who underwent splitting/expansion surgery, immediate dental implant placement, a simple collagen sponge covering of the wound, and healing by secondary intention.

The secondary aim was to reveal the clinical difference between the maxilla and mandible sites, and between two different rehabilitation strategies (single crown [SC] vs fixed partial denture [FPD]).

**MATERIALS AND METHODS**

**Patient Selection**

From a single cohort of consecutive patients treated between June 2012 and July 2014, by one oral surgeon and one prosthetic specialist at Tuscan Stomatological Institute, who underwent implant-supported fixed rehabilitation in the posterior areas, a subgroup was scheduled for the present retrospective study.

To be included in the analysis, patients had to match the following inclusion criteria:

- Split crest procedure with an immediate dental implant in a split alveolar ridge
- Report of long-standing edentulism in posterior sites (loss of tooth at least 2 years before implant placement)
- Clinical report of a thickness of the keratinized gingiva equal to or greater than 3 mm16,17
- Restored implant (SC or FPD)
- Implant axis perpendicular to the occlusal plane17
- 5-year follow-up from the first surgery

Patients were excluded from the present data analysis when in the medical record, it appeared that:

- They had undergone any surgical treatment different from that described earlier within or in an area close to the selected site (other tissues’ augmentation techniques, to be more precise).
- Absence of an antagonist tooth of any sort (natural teeth, composite-restored tooth, tooth-supported fixed prosthesis, or implant-supported fixed prosthesis).

Although this was a retrospective selection of previously treated patients, it was a common practice of the clinician to fulfill the following contraindication guidelines, even if a single-patient rehabilitation strategy was decided on a case-by-case basis.

Absolute contraindications included: chronic systemic disease (report of immunocompromised condition, uncompensated/uncontrolled diabetes, coagulation disorders); intravenous and/or oral bisphosphonate therapy, chemotherapy, or radiotherapy.

Relative contraindications included: heavy smoker habit (> 10 cigarettes per day), alcohol or drug abuse.

Patients had to sign a routine informed consent form regarding surgical treatment and additional informed consent for analysis of their data, as requested by the
ethical committee according to principles embodied in the Helsinki Declaration of 1975 and further revisions.

Surgery
One hour before surgery, the patients received 1 g amoxicillin (Zimox, Pfizer Italia) and 1 g twice a day for a week after the surgical procedure (or clindamycin if allergic to penicillin, 600 mg before surgery, then 600 mg 3 times daily for 7 days). Surgery was performed under local anesthesia (optocaine, 20 mg/mL with adrenaline 1:80,000, Molteni Dental, Scandicci).

In the edentulous alveolar ridge, a palatal or lingual incision in the crestal direction was performed, followed by transperiosteal incisions made perpendicular to the initial one on each side, allowing the raising of a partial-thickness flap (Figs 1a to 1c). After the flap reflection, two vertical grooves were made by the penetration of the vestibular cortical bone plate on the mesial aspect and one on the distal aspect of the flap edges of the buccal site by keeping a safe distance of 1 mm from the adjacent teeth. In the absence of teeth, the discharges were performed 3 to 5 mm away from the closest implant planned site. The crestal incision was continued into the bone to perform an intraosseous groove (Fig 1d) with a blade directly attached and pushed by an electromagnetic device (Magnetic Mallet, www.osseotouch.com, Meta-Ergonomica, Turbigo). The device was set to apply different forces from 85 to 260 DekaNewton with a duration of 120 microseconds according to the different bone densities. The clinician was cautious and prudent during bone penetration and enlargement to prepare the alveolus for subsequent handling of a proper implant bed preparation: In particular, it was appropriate that the blade might penetrate down into the alveolar ridge no less than 7 mm and no more than 11 mm.

Subsequently, in the maxillary site, specific tool sequences of bone expanders were loaded on the handpiece of an electromagnetic device to create a site to allocate the implant by expanding the bone tissue in both the lateral, against the preexisting bone walls, and the apical directions, by moving it up and compressing the residual bone on the surfaces inside the newly created space. In mandibles, different tools of blades with an increasing thickness were used for ridge splitting so that the buccal plate was slowly dislocated in the lateral direction with care to maintain a zone of spongiosa beneath the cortical plate with a minimum thickness of 1.5 mm. Moreover, the final sequence of burs was used to underprepare the implant host site up to 1.2 mm less than the nominal implant diameter, although the value of the threshold appeared to be reduced depending on the local bone density. Rough plasma-spray–surface, 2-mm machined-neck, progressive-thread-design external-hexagon osseointegrated dental implants (Out-Link, Sweden & Martina) were placed completely subcrestal within the boundaries of the newly augmented volume (Fig 1e).

The buccal flap was apically repositioned and sutured to the margin of the palatal/lingual flap, and anchored with a loose loop to the periosteum at the level of the alveolar mucosa. The surgical field was covered by collagen (Gingistat, Acteon Pharma) that was inserted under the undermined keratinized mucosa that lined the flap edges. The collagen ensured that the bleeding stopped and intended to stabilize the blood clot.

Prosthetic Procedure
The submerged dental implant was loaded (Fig 1f) after 2 months with a healing abutment and a temporary cement-retained restoration (TempBond, Kerr Italia) with custom-shaped acrylic resin to maintain a relationship with the mucosal margins. The registration of the emergence profile was performed by impression compound with the addition of silicone of two different consistencies (polyvinyl siloxane impression material, Flexitime Heavy + Flow, Heraeus/Kulzer) in an individual acrylic impression tray. An ideally constructed definitive abutment was fabricated, and then, a ceramic-fused-to-metal definitive fixed prosthesis was cemented (TempBond) 4 months after implant placement. Each patient received a single implant crown or an implant-fixed partial denture supported by two or three implants.

Primary Predictors
The primary predictors were: group A—maxillary implants and group B—mandibular implants.

Secondary Predictors
The secondary predictors were: type of prosthesis (single-implant crown vs implant-supported FPD), type of opposing tooth (porcelain vs enamel/restorative material), patient sex (male vs female).

Radiographic Examination and Outcome Variables
Planning and follow-up examinations were assessed radiographically using a CBCT scanner (Gendex GXCB-500, Gendex Dental Systems) with the following setting: 120 kV, 30.89 mAs, isotropic voxel size of 200 mm, and 8.72-cm-diameter field of view (FOV).

Preoperative and postoperative CBCT scans were superimposed according to Crespi and coworkers. Then, superimposed data were saved (in .DICOM [Digital Imaging and Communications in Medicine]).

All CBCT scans were then sent to a single, blinded examiner (T.P.), who performed all the measurements.

A CBCT cross-sectional image was extrapolated perpendicular to the implant direction and alveolar crest width (ACW); that is, the distance between the most
prominent points on the palatal and buccal aspect, and
the buccal bone wall thickness (CT), were measured at
1 mm apical to the most coronal point (Fig 2).

Change in the width of the alveolar ridge (ΔACW)
was the difference between the preoperative (at least
2 years after tooth extraction) and postoperative mea-
surement (5 years after implant placement) following
equation 1:

\[ \Delta ACW_{\text{baseline} \rightarrow \text{postoperative}} = ACW_{\text{postoperative}} - ACW_{\text{baseline}} \]  
(equation 1)

At the end of linear analysis, for each patient, vol-
umes were measured as per Crespi and coworkers\(^{21}\)
within a standardized volume of interest (VOI), that is,
the volume contained within the following boundaries:
5 mm mesially and 5 mm distally to the center of the
implant shoulder, and extending 10 mm apical to the
most coronal level of the implant-abutment interface,
obtaining an increase at alveolar crest volume (ACV) as
per equation 2 (Fig 2):

\[ \Delta ACV_{\text{baseline} \rightarrow \text{postoperative}} = ACV_{\text{postoperative}} - ACV_{\text{baseline}} \]  
(equation 2)

in which ACV was the bone volume in the VOI.

Clinical Outcomes
The following clinical parameters had been gathered
from patients’ case sheets: report of pain, surgical com-
plication, and prosthesis mobility. The following had
been considered as dental implant failing criteria: the
presence of implant mobility, a radiolucent area close
to the implant surface, suppurative mucosa, associat-
ed pain, either spontaneous or due to the application
of external strength. Survival rates were calculated as
per Eckert et al.\(^{24}\)

Statistical Analysis
All statistical analyses had been performed using a sta-
tistical tool package (Statistics Toolbox, MatLab 7.11,
The MathWorks). In the case of a patient who under-
went a split crest procedure in both the maxilla and
the mandible, the subject was excluded from further
statistical analysis. Thus, exclusion had ensured that
all groups and subgroups were independent, with just
one enrolled site per patient. The Brown-Forsythe test
of homogeneity was used to test if variance among
all the subgroups was or was not the same; normality
of data was tested by the Shapiro-Wilk test. The data
passed all the following assumptions: data are con-
tinuous; data comes from a single group, measured
on different occasions; blocks are mutually indepen-
dent (ie, exclusion of the six patients treated both in
the maxilla and mandible); observations are ranked
within blocks with no ties (arches and prostheses are mutually exclusive). The effects on volume and alveolar width were evaluated with a nonparametric two-way repeated-measures test (Friedman). Differences between groups were searched by the unpaired two-sample Wilcoxon rank-sum test for independent groups and by the Wilcoxon signed-rank for matched data. In the text and tables, data were described as mean ± standard deviation (SD) and rounded to the nearest decimal. A $P$ value < .05 was the threshold for statistical significance.

**RESULTS**

Forty-three patients were retrospectively selected for the present study; five were excluded because the patients underwent additional surgeries that might affect the present outcomes. Out of the remaining 38 patients, 6 were excluded to make adequate statistical calculations. The patients, 23 women and 15 men with a mean age of 59.8 ± 5.2 years (ranging from 49.3 to 72.9 years), underwent the placement of 72 dental implants: 33 in mandibles with the diameters ranging from 3.75 to 5 mm and 39 in maxillae with the diameters ranging from 4.2 to 5 mm. Each patient received a single implant crown or an implant-fixed dental prosthesis supported by two or three implants. The distribution of patients according to sex (male vs female), treated site (maxilla vs mandible), and type of prosthesis (SC vs FPD) is shown in Table 1. The descriptions, dispersions, and statistics of all the data are reported in Table 2.

Changes in volume and width of the alveolar ridge were measured by a comparison of cone beam computed tomography scans acquired before and after surgery. Moreover, the cross-sectional images were used

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**Table 1** Demographic Data Description for the Sample

<table>
<thead>
<tr>
<th>Variable describing sample</th>
<th>Selected sample</th>
<th>Enrolled for statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Patient no. (with failure)</td>
<td>Percent</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>15 (1)</td>
<td>39.5</td>
</tr>
<tr>
<td>Female</td>
<td>23</td>
<td>60.5</td>
</tr>
<tr>
<td>All</td>
<td>38</td>
<td>32</td>
</tr>
<tr>
<td>Site no. (with failure)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arch and prosthesis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maxilla SC</td>
<td>10 (1)</td>
<td>22.7</td>
</tr>
<tr>
<td>Maxilla FPD</td>
<td>12</td>
<td>27.3</td>
</tr>
<tr>
<td>Mandible SC</td>
<td>13</td>
<td>29.5</td>
</tr>
<tr>
<td>Mandible FPD</td>
<td>9</td>
<td>20.5</td>
</tr>
<tr>
<td>All</td>
<td>44 (1)</td>
<td>32</td>
</tr>
</tbody>
</table>

SC = single-crown; FPD = fixed partial denture.
to examine the thickness of the labial plates at the level of the implant shoulder.

All the linear and volumetric outcomes are shown in Table 2. Values of buccal cortical bone thickness (CT) were $2.46 \pm 0.49 \text{ mm}$ and $1.15 \pm 0.33 \text{ mm}$, respectively, in the maxilla and mandible. After 5 years of survey, the preserved augmentation in length ($\Delta ACW$ in mm) and volume ($\Delta ACV$ in mm$^3$) were $+4.4 \pm 0.4 \text{ mm}$ and $+295 \pm 45 \text{ mm}^3$ in the maxillary bone, and $+3.5 \pm 0.7 \text{ mm}$ and $+217 \pm 53 \text{ mm}^3$ in the mandible. The changes in the mandibular bone appeared to be significantly smaller than the maxillary changes with $P$ values < .0005.

The results of the Friedman test (Table 2) seemed to suggest a significantly different volumetric behavior between the prosthetic treatments, such as single implant-supported crowns in single edentulous sites vs patients treated with two/three implants supporting an FPD, but just for linear outcomes; in fact, a significant difference was encountered when the change in alveolar width ($\Delta AW$) had been compared between the two prosthetic groups ($P = .0166$).

The results confirmed the statistical validity of the present finding when outcomes of the maxilla and mandible were compared. In the group analysis, the

<p>| Table 2: Mean and SD of Alveolar Crest Width (AW) and Volume (ACV) in the Volume of Interest, Measured at Preoperative, Preop (or $AW_0$ and $ACV_0$), at 5-year survey, 5 y (or $AW_1$ and $ACV_1$), and from Preoperative to 5-year survey, preop-5 y ($\Delta AW$ and $\Delta ACV$) |
|-----------------------------------------------|------------------|-----------------|------------------|-------------------|------------------|</p>
<table>
<thead>
<tr>
<th>Volume analysis</th>
<th>Sample size</th>
<th>$ACV_0$ (preop)</th>
<th>$ACV_1$ (5 y)</th>
<th>$ACV_0 - ACV_1$ (preop vs 5 y)</th>
<th>$\Delta ACV$ (preop-5 y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample size</td>
<td>Variable (cc)</td>
<td>Normality test</td>
<td>Variable (cc)</td>
<td>Normality test</td>
<td>Variable (cc)</td>
</tr>
<tr>
<td>Brown-Forsythe (homogeneity of variance): arch</td>
<td>$F = 2.3324$, df1 = 5, df2 = 90, $P = .0486^a$</td>
<td>Friedman: arch SS = 582.01, df = 1, $\chi^2 = 6.61$, $P = .001^a$</td>
<td>Maxilla 16</td>
<td>$714 \pm 84$</td>
<td>$.9561^a$</td>
</tr>
<tr>
<td>Mandible 16</td>
<td>$687 \pm 70$</td>
<td>$.7236^a$</td>
<td>$904 \pm 79$</td>
<td>$.3749^a$</td>
<td>$.0004^a$</td>
</tr>
<tr>
<td>Wilcoxon: (maxilla vs mandible)</td>
<td>.4286$^a$</td>
<td>.0050$^a$</td>
<td>Brown-Forsythe (homogeneity of variance): prosthesis</td>
<td>$F = 77.14$, df1 = 5, df2 = 90, $P = .1267^a$</td>
<td>Friedman: prosthesis SS = 70.08, df = 1, $\chi^2 = 1.40$, $P = .2363^a$</td>
</tr>
<tr>
<td>FPD 20</td>
<td>$676 \pm 61$</td>
<td>$.7654^a$</td>
<td>$938 \pm 103$</td>
<td>$.4650^a$</td>
<td>$&lt; .0001^a$</td>
</tr>
<tr>
<td>Wilcoxon: (SC vs FPD)</td>
<td>.0307$^a$</td>
<td>.1793$^a$</td>
<td>Brown-Forsythe (homogeneity of variance): arch</td>
<td>$F = 1.8187$, df1 = 5, df2 = 90, $P = .1171^a$</td>
<td>Friedman: arch SS = 506.25, df = 1, $\chi^2 = 5.77$, $P = .0163^a$</td>
</tr>
<tr>
<td>Mandible 16</td>
<td>$3.7 \pm 1.0$</td>
<td>$.3458^a$</td>
<td>$7.2 \pm 0.7$</td>
<td>$.1148^a$</td>
<td>$.0004^a$</td>
</tr>
<tr>
<td>Wilcoxon: (maxilla vs mandible)</td>
<td>.8209$^a$</td>
<td>.0017$^a$</td>
<td>$AW =$ alveolar crest width; $ACV =$ volume; preop-5 y = preoperative to 5-year survey; SC = single crown; FPD = fixed partial denture. Homogeneity of variance: §Brown-Forsythe test, and + Friedman analysis test (for arch, maxilla/mandible, and prosthesis, SC / FPD); normal distribution test: ^Shapiro-Wilk test; statistical comparisons: *Wilcoxon signed-rank test assessing changes in time from preoperative to 5-year follow-up; °Wilcoxon rank-sum test assessing changes between groups.</td>
<td></td>
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</tr>
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</table>
increase in bone width and volume appeared to be significant with $P \leq .0005$ (Table 2). The results of the Friedman tests indicated that both effects of sex and type of opposing tooth (with 10 opposed by porcelain surfaces and 34 naturally/restore opponent teeth) were not significant.

No patient showed either signs or symptoms of benign paroxysmal positional vertigo.

The majority of the episodes of minor swelling had been reported as being encountered in the healing gingival mucosa within the first 2 days after surgical procedures. Through the time that the mucosal healing was achieved, surgical sites showed evidence of neither mucositis nor flap dehiscence. The case sheets did not report an unsuitable wound healing around temporary abutments or crowns.

After a follow-up period of 5 years, one maxillary implant failed in a patient treated with a single implant-supported crown, so cumulative survival rates were 90% (95% CI: 71.4% to 100%) for the maxillary single-crown group and 100% for all the other sites.

**DISCUSSION**

Comparing the surgical outcomes of both guided bone regeneration and the use of bone grafts vs the ARST, the use of the latter allowed clinicians to perform one-step surgical procedures, to effectively place dental implants, to eliminate the need for bone grafting, to reduce the risk of membrane exposure contributing to minimizing complications and morbidities, and finally to shorten the overall treatment time.25,26

The present ARST requiring a minimum bone width of 3 mm and at least 1 mm of cancellous bone sandwiched between the cortical plates could be successfully used for the treatment of horizontal alveolar deficiencies.27

Despite the limitations of the present study, the radiographic analysis was able to detect different behaviors between the maxillary and mandibular sites concerning all the variables designed to measure any increase in the horizontal bone width.

Concerning the measurement of the horizontal dimension of the alveolar process, the maxillary expansion of the bone crest appeared significantly higher than in the mandibles (+4.4 mm vs +3.5 mm). In line with this trend, the paper also demonstrated a statistically significant increase in the maxillary volume of the alveolar crest after a ridge split procedure (+0.295 cc) than that in the mandible (+0.217 cc). Perhaps, the authors of the present article could find a possible explanation about differences between the maxillary and mandibular sites through the following speculative consideration. As a result of the alveolar ridge-splitting/expansion procedure, it could be supposed that mandibular areas were associated with the smaller increase in width because mandibles had a mean buccal bone wall thickness (1.15 mm) less than half the maxillary thickness (2.46 mm). Moreover, the different behavior and significant gain in bone volume throughout the healing period obtained when the outcome of maxillary and mandibular areas had been compared for ridge width outcomes might depend on features of the bone, that is, a variable degree of its structure/density and elasticity in the two anatomical sites. In the maxillary area, the buccal bone was well-known to be highly viscoelastic and flexible so that, during the surgical procedure, the bone expander was able to minimize the amount of trauma to the bone and to avoid distress to the patient. The interpretation of the present results in terms of survival rates and increase in width of the alveolar bone suggested that they appeared to be very similar to those reported by few systematic reviews and meta-analyses. Irrespective of the surgical devices used (conventional or ultrasound), studies by Waechter et al and Elnayef et al reported horizontal gains in bone ranging from 2.00 to 5.17 mm, with a weighted mean of 3.6 mm.6,28

In the present study, the overall survival rate for implants (considering the patient as the unit of analysis) was 97.4% (95% CI: 92.3% to 100%); other studies advocating the use of a partial-thickness flap obtained a very similar result, with a mean implant survival rate of 96.7% and a range between 91.9% and 97.7%.28 Moreover, ARSTs, without bone grafts, on average, showed a survival rate ranging from 96% to 97.3%, with a mean follow-up from 2 to 3 years.15

An ARST with simultaneous implant placement could be used to treat atrophic arches only in the case where the primary stability could be achieved at least at the apex level of the placed implant. One of the additional advantages of placing immediate implants was that the patients underwent a single surgical procedure; thus, the time of treatment and care (from surgery to prosthesis-wearing) and their physical discomfort were significantly reduced.

In the atrophic regions of the mandible, the thickness of the buccal bone plate appeared to be greatly reduced, but the residual bone was replaced by deposition of more resilient lamellar bone; final implant bed preparation was generally achieved by increasing the size of drills and burs after the split stage of the ridge splitting/expansion procedure. The aforementioned surgical steps seemed to be essential for the success of the rehabilitation but also appeared to produce bony wall damage to such a degree that high bone resorption might occur during the healing phase following surgery.

Some researchers reached the same conclusions of this study, stating that the ridge-splitting technique...
and simultaneous implantation appeared to be less complex and demanding, and easier than in the mandibles; it probably depended on the malleable nature of the maxillary bone (from type III to IV) and its high degree of vascularization.27,29

Bone density appeared to be significantly higher in the mandible than in the maxilla; therefore, different approaches of ridge-splitting/expansion might be required. Moreover, a horizontal ridge augmentation of the atrophic posterior mandible with ridge splitting and expansion showed an increased risk of bone fracture during the mobilization of the vestibular flap; it was technically a more demanding surgery, making an early dental implant positioning quite difficult. This was the reason the ridge-splitting/expansion technique with immediate implant placement in the very narrow alveolar bone should be contraindicated in the mandibular areas in which an inadequate volume of cancellous bone did not guarantee a sufficient degree of flexibility.29,30

Based on the results of a clinical trial, clinicians recommended that the mandibles be treated by a two-stage technique and a conventional implant loading, as this could prevent thin buccal bony plates from being accidentally fractured, and reduce complications and barriers to treatment.31

If clinicians needed to plan immediate implant placement in the posterior mandibular region using a ridge-splitting procedure, the following general considerations should be taken into account:

- Bone density and two-stage surgery: Maxillary alveolar ridges were usually less dense than the mandibular ridges, and that was more manageable for surgeons to perform a single-stage procedure.
- Blood supply and periosteal vascularization: During the ridge-split procedure, the periosteum should be handled with extreme care to protect its role in the vascularization.29
- Healing by secondary intention: In most cases, a primary closure could not be achieved, because the soft tissue architecture was essentially unchanged.

Clinical and radiologic outcomes presented in this study showed that the present technique was reliable and also showed an effective bone gain and conservation around dental implants at a 5-year survey in patients who underwent the alveolar ridge-split procedure with an immediate implant, when the bone defect had been covered with collagen sponges alone and the wound was healed by secondary intention. The results attested that maxillary posterior sites had a higher chance to increase the alveolar ridge in width and volume, as it appeared for a 5-year period, than the mandibular sites.

The cumulative survival rate of a single implant placed in maxillary posterior areas seemed to be lower than the mandible and the group of implant-supported FPDs.

CONCLUSIONS

Posterior areas of the maxilla displayed a higher increase in alveolar width and volume than mandibular areas, and even if it would be premature to draw survival conclusions at this stage without any statistical support, a lower cumulative survival rate was reported for the maxillary single implants.

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