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Bone changes in ridge split with immediate implant placement: A systematic review

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\textbf{Abstract}

Introduction: Alveolar width deficiency represents loss of buccal cortical or/and medullary bone. Deficiency of the buccal represents significant difficulty in implant reconstruction. A variety of implant-driven bone augmentation techniques for the deficient alveolar bone have been proposed. Alveolar ridge split is an excellent tool for regaining alveolar ridge width.

Material and method: Publications on the subject in English were searched to select articles up to June 2015. A systematic review was conducted searching an electronic database (MEDLINE, Pub- Med and Cochran) for articles in pre-reviewed journals concerning studies on humans. Two independent reviewers screened 815 papers.

Result: A consensus on the studies to be selected was reached after discussion; 804 articles were excluded on the basis of the title and abstract. Kappa score for the selection of the paper was 0.89. Full-text articles were obtained for the 11 selected publications. The 11 full texts were independently assessed by the two reviewers and 3 studies were found to qualify for inclusion.

Conclusion: Alveolar ridge splitting might be considered a predictable approach that demonstrates a high implant survival rate, adequate horizontal bone gain and minimal post-operative complications. Weak evidence showed the effect of flap design and immediate implantation on marginal bone loss and survival rate.

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1. Introduction

Atrophic maxilla or mandible can lead to lack of prosthesis retention because of an inadequate bearing area causing both functional and physiological problems for patient, these problems can be treated for patient satisfaction with an implant supported fixed or removable complete or partial denture. Atrophic edentulous jaws can represent a significant challenge to the successful use of endosseous implants for prosthetic reconstruction of the edentulous mandible [1,2].

An implant must be surrounded by at least 1 mm of cortical bone in buccal and lingual sides; if the alveolar ridge is narrower than 5 mm, it is difficult to insert an implant to replace posterior teeth [3,4].

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Alveolar ridge volume reduction is a direct consequence of\textsuperscript{5,6} tooth loss. This dimensional change occurs mainly at the expense of bone remodeling\textsuperscript{7,8}. The limited amount of remaining bone volume may compromise conventional implant placement and, subsequently, the functional and esthetic rehabilitation of the edentulous span.

Bone collapse after tooth loss in a horizontal and vertical direction, the horizontal deficiency or bone width loss develops in a larger extent\textsuperscript{9,10}. Alveolar width deficiency represents loss of buccal (labial) cortical or medullary bone, or both. Deficiency of the buccal cortex (cortical plate) after tooth extraction can present significant difficulty in implant reconstruction\textsuperscript{11,12}. The buccal cortical plate with a thickness < 2 mm next to an implant appears to have a higher risk of subsequent resorption\textsuperscript{13}.

A variety of implant-driven bone augmentation techniques for the deficient alveolar bone have been proposed\textsuperscript{14,15}. Four of these techniques are frequently performed: (1) guided bone regeneration (GBR)/particulate bone grafting;\textsuperscript{16,17} (2) onlay (veneer) block bone grafting with intraoral sources, such as chin, ramus, posterior mandible, zygomatic buttress, and maxillary tuberosity;\textsuperscript{18–20} (3) ridge split;\textsuperscript{21–23} and (4) alveolar distraction osteogenesis\textsuperscript{24}. These techniques are designed to improve horizontal bone loss before or simultaneously with dental implant placement.

Ridge splitting can be performed by splitting the cortical plate and further opening the space between the tables with Summers’s osteotomes\textsuperscript{25}. This creates room for implant placement with sufficient surrounding bone.

Splitting can be performed with chisels and hammers\textsuperscript{26} or with rotating\textsuperscript{27} or oscillating saws\textsuperscript{28}. The use of bone chisel can cause trauma and stress to the patient. Fine tuning of the splitting is difficult when the crest is dense, especially in the mandible\textsuperscript{29}. Ultrasonic bone surgery (USBS) represents a valid alternative to this procedure\textsuperscript{30}. The principle of USBS consists of inducing energetic micro-vibrations with an ultrasonic of 20–32 kHz frequency.

2. Material and method

Publications on the subject in English were searched to select articles up to June 2015. A systematic review was conducted searching an electronic database (MEDLINE, Pub-Med and Cochrane) for articles published in English in pre reviewed journals concerning studies on humans.

The key words used were [(Dental implant) OR (Dental implants) OR (Implant) OR (Implant placement) OR (Implantation) OR (Dental implantology AND Narrow ridges) OR (Thin ridge AND Horizontal Ridge augmentation) OR (Ridge alternation) OR (Ridge split) OR (ridge splitting) OR (Split crest techniques) OR (Alveolar ridge split) OR (Alveolar ridge splitting) OR (Ridge split techniques) OR (Ridge splitting) OR (Split crest) OR (Ridge splitting techniques) OR (Ridge splitting technique)].


2.1. Inclusion criteria

- Randomized Control Trials (RCT) or retrospective studies on ridge splitting

![Prisma chart of exclusion criteria](https://digitalcommons.aaru.edu.jo/fdj/vol1/iss1/2)
• immediate implant insertion,
• human study
• The primary outcomes were bone resorption
• Secondary outcomes failure and survival of implant

2.2. Exclusion criteria
• Invitro studies,
• systematic reviews,
• case series,
• ridge splitting in lower arch only (without maxilla),
• two staged ridge splitting,
• ridge splitting without immediate implantation.

2.3. Screening process showed in prisma chart
Two independent reviewers screened 815 papers retrieved from the electronic and hand search for possible inclusions in the review. A consensus on the studies to be selected was reached after discussion; 804 articles were excluded on the basis of the title and abstract. Kappa score for the selection of the paper was 0.89.

Full-text articles were obtained for the 11 selected publications. The 11 full texts were independently assessed by the two reviewers. 3 studies were found to qualify for inclusion, whereas 8 studies had to be excluded (Fig. 1). Any disagreement was resolved by discussion and third reviewer.

2.3.1. Excluded studies
The reasons for excluding the papers were that six was found to be case series one was case report and one narrative review (Table 1).

2.4. Risk of bias
Two review authors independently undertook the risk of bias assessment of the included trials in duplicate as part of the data extraction process. In the case that the paper to be assessed had one or more review authors in the authors list, only those review authors not involved in the trial evaluated it.

We used the recommended approach for assessing risk of bias in studies included in Cochrane reviews [31]. It is a two part tool, addressing the six specific domains (namely, sequence generation, allocation concealment, blinding of the outcome assessor, incomplete outcome data, and selective outcome reporting and other bias). Each domain includes one specific entry in a ‘Risk of bias’ table within each entry.

2.5. Assessment of heterogeneity
The authors would have assessed the significance of any discrepancies in the estimates of the treatment effects from the different trials by means of Cochran’s test for heterogeneity and heterogeneity would have been considered significant if p value < 0.1.

The authors would have used the I2 statistic, which describes the percentage total variation across studies that is due to heterogeneity rather than chance, to quantify heterogeneity with an I2 statistic over 50% being considered substantial heterogeneity due to this heterogeneity in articles we couldn’t do meta-analysis.

2.6. Assessment of reporting biases
If there had been sufficient numbers of trials (more than 10) in any meta-analysis, we would have assessed publication bias according to the recommendations on testing for funnel plot asymmetry [32] as described in the Cochrane Handbook for Systematic Reviews of Interventions [31]. If we had identified asymmetry, we would have examined possible causes.

(As we have 3 article so publication bias could not done).

2.7. Measure of treatment effect
For dichotomous outcomes, we expressed the estimate of effect of an intervention as risk ratios (RR) together with 95% confidence intervals (CIs). For continuous outcomes, we used mean differences (MD) and standard deviations to summarize the data for each group and express it as MD and 95% CIs.

<table>
<thead>
<tr>
<th>Table 1 – Showing excluded articles.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Authors and date</td>
</tr>
<tr>
<td>-------------------</td>
</tr>
<tr>
<td>Oikarinen KS, 2002</td>
</tr>
<tr>
<td>Massiom simon, 1992</td>
</tr>
<tr>
<td>Cornelio Blus, 2015</td>
</tr>
<tr>
<td>Angio stone, 2005</td>
</tr>
<tr>
<td>Cornelio Blus et al., 2010</td>
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<tr>
<td>Gonzelaaz gracile et al., 2010</td>
</tr>
<tr>
<td>G. Sammartino, 2014</td>
</tr>
<tr>
<td>J. Garcez-Filho, 2013</td>
</tr>
</tbody>
</table>
3. Result

3.1. Included studies and data extraction

3.1.1. Data extraction and management

At least two review authors independently extracted data using specially designed data extraction forms. We had piloted the data extraction forms on several papers and modified them as required before use. We resolved any disagreements by discussion and consulted a third review author where necessary. We contacted authors for clarification or missing information.

For each trial, this study recorded the following data:

- Year of publication, country of origin and source of study funding;
- Details of the participants including demographic characteristics, source of recruitment and criteria for inclusion;
- Details of the type of intervention;
- Details of the outcomes reported, including method of assessment, and time intervals.

All papers included were searched for information regarding bone resorption, survival and failure.

The included papers were 3 articles mentioned in Table 2. The included papers were two RCT “Mounir et al., 2014 and Jensen et al., 2009”. And one retrospective paper Matteo et al., 2015.

3.1.2. Characteristics of trial setting and investigators

- Of the 3 included trials, one was conducted in Egypt (M. Mounir, 2014), one in Ohio Staten (Ole T. Jensen, 2009) and one in Italy (Matteo Danza, MD, 2015). Three trials had a parallel group study design two trials were conducted at university dental clinics or Hospitals (M. Mounir, 2014, Matteo Danza, MD, 2015) one was in private clinic (Ole T. Jensen, 2009). All studies included adults only.

First article (Mounir et al., 2014): a randomized clinical trial was done as 43 implant was installed in maxilla in 22 patient, 9 female and 13 male with mean age 38 with bone graft divided in two parallel groups one with split thickness flap and one with complete reflection flap followed up for 6 months.

Second article Jensen et al., 2009: a randomized clinical trial was done as 81 implant where installed in maxilla and mandible of 40 patients with bone graft in three groups split thickness flap versus full thickness flap versus minimum flap reflection followed for 1 year.

Third article Matteo Danza, MD, 2015: a retrospective study was done as 234 implant was installed in maxilla and mandible of 86 patient (55female and 31male) comparing ridge split with non-splitted ridge with 13 months follow up period (Table 3).

3.1.3. Risk of bias

- **Sequence generation**

  One of the articles follow randomization with computer software (Mounir et al., 2014).

- **Allocation concealment**

  One of the articles follows allocation concealment with closed envelope technique (Mounir et al., 2014).

- **Blinding**

  One article does double blinded patient and assessor (Mounir et al., 2014).

- **Incomplete data**

  All articles did not mention how to deal with incomplete data.

- **Reporting bias**

  There is no reporting bias in all articles (Table 4).

3.1.4. Primary outcome

**Mounir et al, 2014** All patients were included in the statistical analyses. There was no significant difference between the two studied groups regarding the distribution of patient age or gender. There was also no significant difference between the two groups regarding the immediate postoperative bone height. On the other hand, there was a significant decrease in bone height at 6 months postoperative when compared to the immediate postoperative height in both groups in this study, the mean MBL of the labial plate in the control group was found to be 2.29 mm (15.36%), while in the study group it was found to be 0.71 mm (5.89%). The mean palatal MBL in the control group was 2.48 mm (16.84%) and that in the study group was 1.14 mm (8.99%). mesiodistal MBL in the control

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**Table 2 – Showing the included articles.**

<table>
<thead>
<tr>
<th>Authors and date</th>
<th>Title</th>
<th>Type of study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mounir et al., 2014</td>
<td>Assessment of marginal bone loss using full thickness versus partial thickness flaps for alveolar ridge splitting and immediate implant placement in the anterior maxilla&lt;sup&gt;1&lt;/sup&gt;</td>
<td>RCT</td>
</tr>
<tr>
<td>Jensen et al., 2009</td>
<td>Marginal Bone Stability Using 3 Different Flap Approaches for Alveolar Split Expansion for Dental Implants—A 1-Year Clinical Study</td>
<td>RCT</td>
</tr>
<tr>
<td>Matteo Danza, MD, 2015</td>
<td>Comparison Between Implants Inserted Into Piezo Split and Unsplit Alveolar Grafts</td>
<td>Retrospective study</td>
</tr>
</tbody>
</table>
group to be 1.83 mm (12.21%), while that in the study group was 1.15 mm (8.77%). The percentage MBL in the study group was significantly less than that of the control group for the three surfaces. The partial thickness flap used in the study group decreased the percentage of bone loss by 9.5% for the labial bone plate, 7.9% for the palatal bone plate, and 3.5% for the mesiodistal bone plate.

Jensen et al., 2009 stated that Nine implants were lost (i.e. survival rate 96.2%, 5 in postoperative period, i.e., within 1 month) and this parameter (implant lost_survival rate) was not statistically significant. Only 1 implant inserted in a split crest failed.

Of the remaining 225, 5 were not received prostheses at the end of the observation period and were considered missing values: all belonged to the group of fixtures inserted in the non-split crest.

Matteo Danza, MD, 2015 statistically analyzed retrospectively for buccal bone augmentation presence and implant restorability after 1 year of healing. Facial bone loss of 2 mm or more was seen in 11 sites, 10 of which were full flap reflections and 1 an osteoperiosteal flap site Implant osseointegration was 92.5% for the osteoperiosteal flaps, 93.3% for the partial-thickness flaps, and 94.4% for the full-thickness flaps.

### Table 3: Showing included article characteristics.

<table>
<thead>
<tr>
<th>Article</th>
<th>Study design</th>
<th>Number of patient</th>
<th>Mean age</th>
<th>Number of implant</th>
<th>Site</th>
<th>Bone graft</th>
<th>Funding</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mounir et al., 2014</td>
<td>RCT</td>
<td>22 F 9 M 13 M</td>
<td>38</td>
<td>43</td>
<td>Maxilla</td>
<td>Yes</td>
<td>Self funding</td>
</tr>
<tr>
<td>Jensen et al., 2009</td>
<td>RCT</td>
<td>40 NO</td>
<td>81 NO 53</td>
<td>Maxilla &amp; mandible</td>
<td>Yes</td>
<td>No</td>
<td>Not mentioned</td>
</tr>
<tr>
<td>Matteo Danza, MD, 2015</td>
<td>Retrospective design</td>
<td>86 55 F 31 M</td>
<td>234</td>
<td>Maxilla &amp; mandible</td>
<td>Yes</td>
<td>No</td>
<td>Not mentioned</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Article</th>
<th>Type of comparators</th>
<th>Type of intervention</th>
<th>Outcome</th>
<th>Follow up</th>
</tr>
</thead>
<tbody>
<tr>
<td>b</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mounir et al., 2014</td>
<td>Split thickness flap full thickness flap</td>
<td>Marginal bone loss</td>
<td>6 month</td>
<td></td>
</tr>
<tr>
<td>Jensen et al., 2009</td>
<td>Split thickness flap Full thickness flap versus minimum flap reflection</td>
<td>Marginal bone stability &amp; Survival rate</td>
<td>1 year</td>
<td></td>
</tr>
<tr>
<td>Matteo Danza, MD, 2015</td>
<td>Split using piezo Unsplit alveolar crest</td>
<td>Marginal bone loss &amp; Survival rate</td>
<td>Mean 13 month</td>
<td></td>
</tr>
</tbody>
</table>

### Table 4: Showing risk of bias.

<table>
<thead>
<tr>
<th>Article</th>
<th>Bias</th>
<th>Sequence generation (randomization)</th>
<th>Allocation concealment</th>
<th>Blinding</th>
<th>Reporting bias</th>
<th>Incomplete outcome data</th>
<th>Risk of bias</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mounir et al., 2014</td>
<td>Yes</td>
<td>Yes</td>
<td>Double blinded</td>
<td>no</td>
<td>No</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>Jensen et al., 2009</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>no</td>
<td>No</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Matteo Danza, MD, 2015</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>no</td>
<td>No</td>
<td>High</td>
<td></td>
</tr>
</tbody>
</table>

A better outcome for implants inserted into split crest bone, although no statistically significant difference was detected (Kaplan–Meier algorithm, log-rank _ 0.95, df _ 1, P _ .3295).

### 4. Discussion

Alveolar split expansion is an excellent tool for regaining alveolar ridge width but the procedure should avoid bone fragment dislodgment or flap detachment of the out-fractured plate, which leads to bone devitalization and subsequent remodeling resorption. When implants are placed simultaneously, primary fixation of the implant must be obtained apically other else osseointegration will be jeopardize. The partial-thickness flap reflection and/or osteoperiosteal flap with minimal flap reflection at the crest is most likely to maintain bone vitality, as well as alveolar width stability. Splitting of a thin buccal plate fragment from a crest width of 3 mm or less that becomes separated from both the buccal and the endosteal blood supply will lead to complete buccal bone resorption even if bone is grafted.

The development of osseointegration is not a valid measure for judging split bone graft technique success because osseointegration is not differentially influenced by the flap or grafting approach as long as apical implant fixation occurs. Therefore, the method to ascertain alveolar width expansion success is not by implant success, but by marginal bone dimensional stability.

Scipioni et al. [21] and Chiapasco et al. [34] recommended that the periosteum should not be stripped off the labial plate in order not to affect the blood supply and to allow rapid...
revascularization of the expanded plate of bone. The periostium has another function in treating the mal-fractures that might occur during the splitting procedure in which it prevents any cracked segment from dislodging and maintains the blood supply.

Sub-periosteal reflection at the future sites of the bony cuts (tunneling), is a modification of the split thickness flap reflection, leaving the periostium intact in the remainder of the bone plate. Some clinicians who perform the splitting technique with delayed implant placement prefer to do a full thickness flap prior to making the corticotomies (at the first surgery) and then perform a partial thickness flap during the second surgery for implant placement in order to reduce the bone resorption [35,36].

5. Conclusion

5.1. Implications for practice

In selected scenarios, alveolar ridge splitting might be considered a predictable approach that demonstrates a high implant survival rate, adequate horizontal bone gain, and minimal intra and postoperative complications.

Based on the results of the included articles, there was a weak evidence (only two RCT and one retrospective study risk of bias) showing effect of flap design and immediate implantation on marginal bone loss and survival rate.

5.2. Implications for research

More well-designed, long-term randomized control trials are required to understand the effect of flap design and immediate implantation on marginal bone loss and survival rate.

REFERENCES


