Classification of the Alveolar Ridge Width: Implant-Driven Treatment Considerations for the Horizontally Deficient Alveolar Ridges

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Among many techniques advocated for the horizontally deficient alveolar ridges, ridge-split has many advantages. Here, treatment management strategies of the horizontally collapsed ridges, especially the ridge-split approach, are discussed and a clinically relevant implant-driven classification of the alveolar ridge width is proposed, with the goal to assist an operator in choosing the proper bone augmentation technique. Comparison and advantages of two commonly used techniques, ridge-split and block bone graft, are presented.

Key Words: ridge-split, block bone graft, alveolar ridge

INTRODUCTION

It has been shown that although bone collapse after tooth loss is usually three dimensional (3D), the horizontal deficiency or width loss develops to a larger extent. Alveolar width deficiency can represent 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. The buccal cortical plate with a thickness <2 mm next to an implant appears to have a higher risk of subsequent resorption.

A variety of implant-driven bone augmentation techniques for the deficient alveolar bone have been proposed. Four of these techniques are frequently performed: (1) guided bone regeneration (GBR)/particulate bone grafting; (2) onlay (veneer) block bone grafting with intraoral sources, such as chin, ramus, posterior mandible, zygomatic buttress, and maxillary tuberosity; (3) ridge-split/bone graft procedure; and (4) alveolar distraction osteogenesis. Most of these techniques are designed to improve horizontal bone loss before or simultaneously with dental implant placement.

DIAGNOSIS AND TREATMENT PLANNING

It is important to establish a proper diagnosis based on the alveolar ridge assessment before initiation of the treatment plan. Initial clinical evaluation supplemented by radiographic images helps in most cases to distinguish two-dimensional (2D) versus 3D alveolar bone deficiency. Although minimal bone loss and patient’s lack of desire to go through grafting surgical procedure(s) can be circumvented with restorative means, extensive bone atrophy usually requires surgical correction for a proper implant placement.

Alveolar bone should be initially assessed clinically (visually) for a rough width and height analysis and interarch-occlusal relationships. In some cases, although 7–8 mm of bone width is present, it could be lingually (palatally) positioned and therefore might require an additional buccal bone grafting for a proper restoratively driven implant insertion.

Alveolar width can be measured with different calipers on top of the thin mucosa or by ridge...
FIGURES 1 AND 2. **FIGURE 1.** Cone beam computerized tomography scan of the horizontally deficient edentulous maxillary alveolar ridge. Alveolar bone width and height, as well as thickness of the buccal and palatal cortical and medullary bone are demonstrated. This alveolar ridge is a class III ridge according to the classification presented in the article. **FIGURE 2.** Axial cone beam computerized tomography scan of the horizontally collapsed edentulous right maxillary alveolar ridge showing varied thickness of the alveolar ridge.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Classification of alveolar ridge width</th>
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<tbody>
<tr>
<td>Alveolar ridge width (mm), based on CBCT* scan</td>
<td>&gt;10</td>
</tr>
<tr>
<td>Alveolar ridge deficiency</td>
<td>No deficiency</td>
</tr>
<tr>
<td>Class</td>
<td>0</td>
</tr>
<tr>
<td>Schematic diagram</td>
<td><img src="image1.png" alt="Diagram" /></td>
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<tr>
<td>Comments</td>
<td></td>
</tr>
<tr>
<td>Indications for surgery</td>
<td>Hard tissue surgery is not indicated. Occasionally, alveolar width (buccal convexity) can be improved for esthetic reasons with a soft tissue graft.</td>
</tr>
<tr>
<td>Immediate insertion</td>
<td>Yes</td>
</tr>
<tr>
<td>Operator experience</td>
<td>Basic</td>
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*CBCT, cone beam computerized tomography. **GBR, guided bone regeneration.
mapping (with local anesthesia) through it. Panoramic and other 2D radiographic images are often sufficient in some implant cases, although an implant-driven bone analysis often implies need for a 3D or volumetric bone evaluation with cone beam computerized tomography (CBCT) scans. CBCT improves the ability for precise measurement of the ridge on all levels as well as evaluation of both cortical and medullary portion of the bone for primary implant stability (Figures 1 and 2).

<table>
<thead>
<tr>
<th>Ridge Split or Block Bone Graft</th>
<th>Large Extraoral Block Graft is a Preferable Surgical Choice. Alternative is Multiple and Sequential Augmentation Procedures.</th>
<th>GBR at the Mid Ridge Level Can Be Done</th>
<th>Ridge Reshaping or GBR at the Top of the Ridge Can Be Done</th>
</tr>
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<tbody>
<tr>
<td>Not Recommended</td>
<td>No</td>
<td>Yes/No, Depends on the Severity of the Undercut</td>
<td>Usually Yes, Can Depend on the Morphology of the Top Portion of the Ridge</td>
</tr>
<tr>
<td>Advanced</td>
<td>Advanced</td>
<td>Basic</td>
<td>Basic</td>
</tr>
</tbody>
</table>

Table 1

Extended

**Figures 3 and 4.** Figure 3. Intraoperative photograph of the ridge-split procedure demonstrating the mobilization and repositioning of the buccal muco-osteo-periosteal flap. Figure 4. Intraoperative photograph of the ridge-split procedure that is done simultaneously with the implant insertion.
In 1988, Cawood and Howell\textsuperscript{20} suggested an anatomic classification of the edentulous jaws for the preprosthetic surgery. It proposed six classes and detailed the changes that the edentulous alveolar process in anterior and posterior maxilla and mandible undergo after teeth extraction (the pattern of resorption). In 1989, Jensen\textsuperscript{21} proposed an implant-driven site classification by bone quality and quantity and proximity to vital structures. In 2002, Wang and Al-Shammari\textsuperscript{22} described a practical (therapeutically oriented) classification of alveolar ridge defects, that is, horizontal, vertical, and combination defects, proposing the edentulous ridge expansion approach (ridge-split) for the horizontal and combination defects of the alveolar ridge.

### Table 2

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Monocortical Block Grafting (Intraoral)</th>
<th>Ridge-split Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1</strong> Type of grafting</td>
<td>Onlay: external, “cortex to cortex”; donor cortical graft is added to the collapsed recipient buccal cortical bone, resulting in the grafted bone that has cortical environment on one side and periosteum on the other side</td>
<td>Inlay: internal (like an “open book”); cortical envelope is preserved and expanded and a particulate grafting is done “from within,” resulting in a bilateral proximity of the grafted bone to both cortices (similar to a 4-wall defect of extraction socket)</td>
</tr>
<tr>
<td><strong>2</strong> Graft resorption</td>
<td>Free (devascularized) graft; the grafted bone may contain a substantial amount of nonvital bone that did not survive detachment, devascularization, and transportation; an increased risk of postoperative graft resorption\textsuperscript{27}; slow and incomplete neovascularization rate\textsuperscript{28}</td>
<td>Vascular bone flap (muco-osteoperiosteal flap) (see Figure 3), vascularization is preserved at all times; cancellous bone grafts are more rapidly and completely revascularize than cortical grafts\textsuperscript{29} Decreased risk of postoperative graft resorption\textsuperscript{16}</td>
</tr>
<tr>
<td><strong>3</strong> Donor site morbidity</td>
<td>Yes: pain, swelling, IAN\textsuperscript{*} injury (posterior mandible, ramus), “wooden teeth sensation” (chin), sinus perforation (zygomatic buttress), others</td>
<td>No</td>
</tr>
<tr>
<td><strong>4</strong> Recipient site morbidity</td>
<td>Soft tissue dehiscence and graft exposure, loose fixation screws and graft mobility; graft loss</td>
<td>Soft tissue dehiscence and graft exposure, buccal plate malfracture; inadequate split</td>
</tr>
<tr>
<td><strong>5</strong> Wound closure</td>
<td>Primary wound closure is mandatory</td>
<td>Closure by secondary intention is preferred</td>
</tr>
<tr>
<td><strong>6</strong> Buccal soft tissue flap</td>
<td>Buccal flap is lifted and often stretched; tension-free primary closure is important, but can be challenging</td>
<td>Buccal flap is not compromised; it is not lifted and left attached to the buccal periosteum</td>
</tr>
<tr>
<td><strong>7</strong> Wound healing</td>
<td>By plasmatic imbibition from the host (recipient) tissue</td>
<td>Internal “coagulum” is easily converted in the woven bone due to protection and excellent vascularization from both cortices throughout the whole process</td>
</tr>
<tr>
<td><strong>8</strong> Immediate implant insertion</td>
<td>Traditionally not done</td>
<td>Can be done in some cases (see Figure 4)</td>
</tr>
<tr>
<td><strong>9</strong> Delayed implant insertion</td>
<td>Implants are placed into the cortical bone interface 4 to 6 months later</td>
<td>Implants are placed into the cancellous bone interface 4 to 6 months later</td>
</tr>
<tr>
<td><strong>10</strong> Environmental factors and long-term stability of a graft</td>
<td>More subject to a postoperative injury (“external” grafting); less long-term stability and more long-term resorption\textsuperscript{28}</td>
<td>Less subject to a postoperative injury during mastication; it is more protected (“internal” or interpositional grafting); less long-term resorption and more long-term stability\textsuperscript{30,31}</td>
</tr>
</tbody>
</table>

\textsuperscript{*IAN, inferior alveolar nerve.}
Here, a clinically relevant implant-driven classification of the alveolar ridge width based on precise measurement of the alveolar width with computerized tomography/CBCT scans is recommended; it is presented in the Table 1. The classification attempts to match the specific ridge (its width and topography) with the appropriate surgical technique (GBR, ridge-split, or block graft) that can be used in the particular case of horizontal bone atrophy. Although each operator’s experience ultimately determines the chosen surgical technique, it is important to compare benefits and drawbacks of different surgical procedures for certain ridges to improve the selection process.

**Comparison of the Ridge-split and Block Bone Grafting Techniques**

A literature review showed few similarities and many differences between autogenous intraoral monocortical (veneer) block graft and ridge-split/bone graft techniques. Both procedures require a skilled surgical practitioner equipped with knowledge of regional anatomy and vascularization and prepared for risks and complications of the procedure. Both the ridge-split and block grafting techniques are used mainly for a 2D horizontal alveolar ridge augmentation (alveolar bone widening; some height gain can also be achieved with both techniques).

Autogenous block bone grafting demonstrates high osteogenic potential and effective in severe anterior alveolar atrophy in maxilla and mandible.\(^1\)\(^2\)\(^3\)\(^4\)\(^5\)\(^6\)\(^7\)\(^8\)\(^9\)\(^10\) Two main disadvantages of monocortical block grafts are donor site morbidity and late-term graft resorption.\(^11\)\(^12\) The monocortical block bone resorption has been reported to have up to 5% early bone loss and up to 40% late bone loss of the entire graft volume due to remodeling and inadequate consolidation.\(^13\)

Table 2 shows differences (10-point comparison) between the ridge-split procedure and autogenous intraoral monocortical block bone grafting. Factors that are presented include donor- and recipient site morbidity, type of wound closure, buccal flap integrity and vascularity, specifics of wound healing, type of bone interface, and possibility of an immediate implant placement.

**Conclusion**

Knowledge of 3D bone anatomy with CBCT scan helps to establish a proper ridge diagnosis before initiation of implant treatment. The recommended ridge width classification for the horizontally deficient alveolar ridges is designed to be a clinically relevant implant-driven anatomic guide for choosing an appropriate surgical modality for the specific collapsed alveolar ridge. Operator experience and surgical comfort ultimately determines the choice of the technique. The ridge-split approach tends to have many advantages, including lack of donor site morbidity and a graft stability over time.

**Abbreviations**

CBCT: cone beam computerized tomography

GBR: guided bone regeneration

**References**


