SOCKET PRESERVATION AND TECHNIQUES
– AN EVALUATION OF THE LITERATURE

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Goals and Outline

• Describe socket healing processes
• Define the difference between preservation and augmentation/reconstruction
• Explain the rationale for socket preservation
• Literature review on technique selection
• Evaluate the literature on efficacy of techniques
• Case Example
• Conclusions
Healing of Extraction Sockets
First 24-48 Hours

• The remaining empty socket consists of cortical bone covered by torn PDL with a rim of oral epithelium left at the coronal portion
• Extraction sockets heal by secondary intention
• Socket fills with blood and coagulates and seals the socket from the oral environment
• Organization of blood clot within 24-48 hrs
Healing of Extraction Sockets

Inflammatory Phase – 1st week

- Clot forms a scaffold upon which inflammatory cells migrate
- Epithelium at the wound periphery grows over the surface of the organizing clot
- Fibroplasia and angiogenesis begins
- Osteoclasts accumulate along the alveolar bone crest setting stage for active crestal resorption
Healing of Extraction Sockets
2nd week – Fibroplasia Continued

• Clot continues to organize through fibroplasia and new blood vessels that penetrate the center of the clot
• Osteoid deposition begins along alveolar bone lining the socket
Healing of Extraction Sockets
3\textsuperscript{rd} week – Epithelialization

- Extraction socket is filled with granulation tissue and poorly calcified bone at the wound perimeter
- Surface of wound is completely epithelialized
Healing of Extraction Sockets
4th Week onwards – Bone Remodeling

• Cortical bone continues to be resorbed from the crest and walls of the socket (full resorption in 4-6 months)
• New trabecular bone is laid (radiographic evidence at 6-8 weeks) and epithelium migrates towards the crest
• 4-6 months woven bone is replaced with lamellar bone
What happens to extraction sockets over time? Why are we concerned?
Alveolar Bone Loss

- Loss of alveolar bone could be due to periodontal disease, periapical pathology, trauma to teeth/bone, surgical technique for extraction
Patterns of Jaw Resorption Post-Extraction

- Loss of alveolar ridge is greater in the horizontal dimension compared to the vertical dimension (5-7mm during a 6-12 mo. period)
- Most of bone loss occurs in first 3-6 months
  - Greater resorption in the molar region
- Height of healed socket never reaches the coronal level of bone attached to the extracted tooth

<table>
<thead>
<tr>
<th>Study</th>
<th>Vertical Bone Loss</th>
<th>Horizontal Bone Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schropp et. al</td>
<td>0.7mm (after 12 mo.)</td>
<td>6.1mm (2/3 after 3 months)</td>
</tr>
<tr>
<td>Lekovik et al</td>
<td>1.5mm (after 6 mo.)</td>
<td>4.5mm (after 6 mo.)</td>
</tr>
<tr>
<td>Iasella et al</td>
<td>0.9mm (after 6 mo.)</td>
<td>3.6mm (after 6 mo.)</td>
</tr>
</tbody>
</table>
Patterns of Jaw Resorption Post-Extraction

• Role of the buccal plate
  - Araujo and Lindhe (2005): Crestal portion of buccal bone wall composed mainly of bundle bone (lingual wall composed of both lamellar and bundle bone)
  - *Alveolar Bone Dimensional Changes of Post Extraction Sockets in Humans: A Systematic Review*
    - Resorption: 2.59mm buccal, 2.03mm lingual
What is Socket Preservation?

“Any procedure undertaken at the time of or following an extraction that is designed to minimize external resorption of the ridge and maximize bone formation within the socket”

(Darby et al. 2008)

Socket preservation vs. augmentation vs reconstruction?
Goals of Socket Preservation

- To reduce loss of alveolar bone volume
- To enable installation and stability of a dental implant
- To reduce need for additional bone grafting procedures
- To improve the esthetic outcome of the final prosthesis
- To regenerate bone faster allowing earlier implantation and restoration
- To enable the generated tissues to provide implant osseointegration
Socket Preservation Principles and Techniques

- Minimally atraumatic tooth extraction with or without debridement/decorication of the socket
- Guided bone regeneration and tissue engineering
- Membranes only
- Bone substitutes only
- Bone grafts and membranes together
- Other space fillers
- Implants as ridge preservers
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Extraction Techniques

- Application of appropriate instruments with minimal force to limit damage to hard/soft tissue
- Debridement vs. decortication of the extraction socket
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Principles of Guided Bone Regeneration

- Osteoconduction – graft acts a scaffold through which osteoblasts and fibroblasts and blood vessels can grow (FDBA, xenografts, synthetic alloplasts)
- Osteoinduction – graft acts to stimulate new bone formation through molecules contained in the graft, convert neighboring cells into osteoblasts (DFDBA)
- Osteogenesis – the cells within the graft actually initiate the production of new bone (autogenous marrow)
Principles of Guided Bone Regeneration – Active Tissue Engineering Approach
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Non-Resorbable Barrier Membranes

- **ePTFE** (Goretex)– porous, membrane exposure creates communication between oral environment and newly forming tissues increasing risk of infection
  - Lekovic et al (1997): 10 pts/2 sites, more infill of bone width and height than control group, but noted 30% exposure rate (with results similar to control group)
  - Machtei et al: Meta analysis: 0.56mm new bone formed when membrane exposed, 3.01 mm when covered
- **dPTFE** (Cytoplast): titanium reinforced non-porous, circumvents necessity to gain primary closure
  - Hoffman et al (2008): 276 patients with membrane exposed for 4 weeks, results show minimal changes in the alveolar process when a d-PTFE membrane was placed following an extraction
Resorbable Membranes

- Polyglycoside synthetic copolymers
  - Lekovic et al (1998): 16 pts, showed more internal socket fill and less horizontal resorption of the ridge, no exposures
- Collagen
  - Acts as hemostatic agent, assists in clot formation and stabilization
  - Acellular dermal matrix
    - Used for cases with thinner soft tissues, capable of barrier function and also tissue thickening
- Calcium sulfate
  - Questionable efficacy

Table 3: Comparison of mean difference in ridge height and width with collagen membrane vs calcium sulfate

<table>
<thead>
<tr>
<th></th>
<th>Collagen (n = 9)</th>
<th>Calcium sulfate (n = 9)</th>
<th>p†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height</td>
<td>1.06 ± 1.01</td>
<td>-0.14 ± 0.74</td>
<td>0.01</td>
</tr>
<tr>
<td>Width</td>
<td>0.19 ± 1.11</td>
<td>-0.19 ± 0.74</td>
<td>0.66</td>
</tr>
</tbody>
</table>

†Student's t-test
<table>
<thead>
<tr>
<th>Membrane category</th>
<th>Advantages</th>
<th>Disadvantages</th>
<th>Commercial examples</th>
</tr>
</thead>
</table>
| Nonresorbable     | - Numerous studies demonstrate their success  
- May be titanium reinforced  
- Remain intact until removal  
- Easily attached with titanium or resorbable tacks  
- Greater bone fill if membrane not exposed  
- Minimal tissue response if membrane not exposed | - Require a second surgery for removal  
- Increase patient morbidity  
- If exposed, must be removed  
- Can be technique sensitive | - ePTFE membranes, e.g., Gore-Tex (Gore Medical, Flagstaff, Ariz.)  
- Titanium-reinforced Gore-Tex |
| Resorbable        | - Numerous studies demonstrate their success  
- Does not require surgical removal  
- Decreased patient morbidity  
- Improved soft-tissue healing  
- Tissue-friendly reaction to membrane exposure  
- Cost effective; one surgery only  
- Does not have to be removed if exposed | - Uncertain duration of barrier membrane function  
- Difficult to tack down  
- Slightly less bone fill than nonresorbable membranes  
- Inflammatory response from tissues may interfere with healing and GBR  
- Can be technique sensitive | - Neomem (bovine collagen matrix; Citagenix Inc., Laval, Que.)  
- Bio-Gide (porcine collagen matrix; Geistlich AG, Wolhusen, Switzerland)  
- Ossix (cross-linked collagen barrier; Implant Innovations Inc., Palm Beach Gardens, Fla.) |
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Bone Substitutes Only

- Autografts (oral or extraoral)
  - Extra-oral grafts fallen out of favor due to necessity of harvesting from 2nd site/surgical morbidity
  - Source of intra-oral bone is important – when mostly cortical in nature has little osteogenic potential
Bone Substitutes Only

- **Allografts (human freeze dried bone)**
  - Advantage: lack of secondary surgical site, decreased host morbidity, can obtain unlimited quantities of graft material
- **DFDBA vs. FDBA**
  - Wood et al (2012): Histological and clinical evidence that greater new bone formation with DFDBA after tooth extraction (38.42% compared to 24.63%) with less residual bone particles
  - Hoang et al (2012): DFDBA with bone putty of different size particles, at 20 weeks showed 49-53% vital bone
  - Eskow et al (2013): Cortical vs cancellous FDBA comparison showed 13-16% vital bone at 18 weeks
Bone Substitutes Only

- **Xenograft (bovine/porcine)**
  - Artzi et al (2000): Deproteinized bovine bone material (Bioss) in 15 sockets evaluated at 9 months, found bone tissue 15.9%-63.9% from coronal to apical, 30% residual graft

- **Alloplasts (hydroxyapatite, tricalcium phosphate, bioactive glass)**
  - Nemcovsky et al: 23 cases of hydroxyapatite in extraction sockets with primary closure, show minimal ridge deformation (1.4mm vertically and 0.6mm horizontally), sufficient volume for implant
    - Half patients experienced exfoliation of particles
  - Froum et al: Compared bioactive glass, DFDBA, and control with primary closure over 6-8 month period, showed 60% bone fill for bioactive glass, 33% for DFDBA and control
    - Success rate of implant placement not affected in all 3 groups
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Bone Grafts and Membranes Together

- Iasella et al: FDBA + collagen resorbable membrane (test) vs. extraction alone (control)
  - 24 patients randomized control study
  - Width of control group decreased from 9.1mm to 6.4mm, vertical gain 1.3mm
  - Width of test group decreased from 9.2mm to 8mm, vertical loss 0.9mm
  - Test group with 28% vital bone and 37% non-vital FDBA
  - Control group with 54% vital bone
  - Conclusions: ridge preservation maintained ridge height and width when compared to extraction alone
    - All sites were still able to receive implants

- Vittorini et al. Surgical Technique for Alveolar Socket Preservation: A Systematic Review:

<table>
<thead>
<tr>
<th>Study</th>
<th>Graph of values</th>
<th>Mean difference (mm)</th>
<th>95% CI (mm)</th>
<th>Test patients</th>
<th>Control patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barone et al</td>
<td><img src="image" alt="Graph" /></td>
<td>2.00</td>
<td>1.368 to 2.362</td>
<td>20</td>
<td>20</td>
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<tr>
<td>Iasella et al</td>
<td><img src="image" alt="Graph" /></td>
<td>1.40</td>
<td>0.002 to 2.797</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Camargo et al</td>
<td><img src="image" alt="Graph" /></td>
<td>-0.42</td>
<td>-2.186 to 1.346</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>Pooled*</td>
<td><img src="image" alt="Graph" /></td>
<td>1.999</td>
<td>0.086 to 2.485</td>
<td>48</td>
<td>48</td>
</tr>
</tbody>
</table>

Homogeneity test: Cochran Q = 6.570, P > .001.
*Random effects weighted mean difference.
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Other Space Fillers

- Sponges made of collagen or polyactic/polyglycolic acid
  - Fiorellini et al (2005): RCT with 80 pts in 3 groups (rh-BMP-2 + ACS, ACS, no treatment (blood clot)). Adequacy of bone for implant in rhBMP2 and ACS twice as great as controls
Literature Review on the Outcomes

• Darby et al. Ridge preservation techniques for implant therapy
  • No evidence to support the superiority of one technique over another, all effective in limiting horizontal/vertical ridge alterations

• Horvath et al. Alveolar ridge preservation: a systematic review
  • Magnitude of ridge resorption more pronounced in horizontal dimension
  • Presence of intact socket walls and primary flap closure associated with favorable results
  • Conflicting evidence on benefits of ridge preservation

• Morjaria et al 2012. Bone healing after tooth extraction with or without an intervention: systematic review of RCT's.
  • 9 studies included (out of 2861), found loss of ridge width 2.46mm-4.56mm for control compared to 1.14-2.5mm for test sites, radiographic change in height between 0.51mm-1.17mm compared to 0.02mm-1mm in test sites
  • Large proportion of ridge preservation in test sites due to un-resorbed graft material

• Vignoletti et al. Surgical protocols for ridge preservation after tooth extraction: a systematic review
  • Meta analysis on 6 studies: More favorable outcomes with use of barrier membranes, flapped procedures, and primary closure of flaps

• Vittorini et al. Surgical techniques for alveolar socket preservation: a systematic review
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Systematic Reviews: Treatment Modalities and Expected Dimensional Changes

Table 1. Treatment modalities and expected dimensional changes.

<table>
<thead>
<tr>
<th></th>
<th>Control Sites (No Treatment)</th>
<th>Bone Graft Only</th>
<th>Membrane Only</th>
<th>Combined Bone Graft + Membrane</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Horizontal bone changes</strong></td>
<td>-2.51 mm</td>
<td>-1.18 mm</td>
<td>-0.08 mm</td>
<td>+0.47 mm (gain)</td>
</tr>
<tr>
<td></td>
<td>Range: 0.16 – 4.5 mm (loss)</td>
<td>Range: 0.75 – 2.0 mm (loss)</td>
<td>Range: 0.1 (loss) – 2.90 mm (gain)</td>
<td>Range: 3.48 (loss) – 3.27 mm (gain)</td>
</tr>
<tr>
<td><strong>Vertical bone changes</strong></td>
<td>-2.07 mm</td>
<td>-1.31 mm</td>
<td>+0.14 mm (gain)</td>
<td>-0.15 mm</td>
</tr>
<tr>
<td></td>
<td>Range: 0.8 – 5.24 mm (loss)</td>
<td>Range: 0.48 – 2.48 mm (loss)</td>
<td>Range: 0.38 (loss) – 1.30 mm (gain)</td>
<td>Range: 0.02 (loss) – 1.3 mm (gain)</td>
</tr>
<tr>
<td><strong>Percentage of vital bone</strong></td>
<td>42.4%</td>
<td>46.2%</td>
<td>N.A.</td>
<td>31.7%</td>
</tr>
<tr>
<td></td>
<td>Range: 25.7 – 54.0%</td>
<td>Range: 32.4 – 59.5%</td>
<td></td>
<td>Range: 28 – 35.5%</td>
</tr>
</tbody>
</table>

Results are averages found from multiple studies using several different materials with follow-up of 4 – 6 months healing. N.A. = no studies available. Control sites are all extraction without augmentation (Data compiled from 14 studies in systematic reviews)
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Implants as Ridge Preservers

- Clementini et al 2015: Systematic review/meta analysis on dimensional changes after immediate implant placement with/without simultaneous regenerative procedures
  - Concluded: no conclusive evidence regarding efficacy of concomitant regenerative technique on preventing alveolar reduction

- Van Kersteren et al. 2011. RCT to compare the efficacy of immediate implant with ridge preservation with delayed implant.
  - Immediate implant sites received bone graft for defects >2mm.
  - Minimal mid-buccal soft tissue recession (mean 0.17mm), interproximal tissue height decreased (mean 1.48mm)
  - Concluded that no difference in between both groups, but greater decreases in width observed in sites lacking bone grafting
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Evaluation of Bone-to-Implant Contact in Grafted Sockets

• Becker et al. 1998: Minimal BIC with xenografts and DFDBA in histologic cores in 3-6 months
• Norton et al. 2002: Long healing time required to achieve a small amount of new bone incorporation into the graft with bioactive glass
• Zitzmann NU et al. 2001: Bovine bone material contained 30% particles at 6 months at time of implant placement
Evaluation of the Literature – How reliable are these studies?

• Most studies have a significant amount of bias and lack of consistency
  • Patient factors
  • Different reasons for tooth extractions
  • Sockets (single vs. multiple, anterior vs. posterior)
  • Number of residual bony walls
  • Different biomaterials and surgical techniques
  • Preservation vs Augmentation/Reconstruction
Proposed Treatment Algorithm

Is implant placement being considered within the next 6 to 8 weeks?

NO.... there is significant damage to the socket walls, primary implant stability cannot be assured or implant placement has to be delayed due to scheduling problems
Select a material that has a slow rate of resorption and which will eventually form new bone
- anorganic bovine bone
- bioactive glass
- biphasic calcium phosphate
Delay implant placement for 4 to 6 months

YES.... is a graft required?

NO.... the socket walls are intact and significant resorption is not anticipated in the following 6 to 8 weeks
- no graft required

YES.... One or more of the socket walls have been lost, and collapse of the ridge needs to be minimized.
Select a material that will rapidly resorb
- collagen plug
- calcium sulfate
Case Example

Pictures courtesy of Dr. Bedrossian
Managing the defect between the implant and the tooth socket
Managing the defect between the implant and the tooth socket

- Akimoto et al. 1997: percentage of bone to implant diminishes as the gap distance increases – histological examination revealed the presence of connective tissue between the implant and the newly formed bone.
Take Away Points

• Subsequent to extraction of a tooth, the alveolus loses both bone volume and height within first 6 months (horizontal > vertical, buccoal > palatal)

• Research demonstrates that socket grafting can preserve the structural integrity and volume of the alveolar ridge by slowing the resorption process

• An ideal graft material/technique should be one that is easy to use, minimally invasive, leave no residual foreign body particles with 100% turnover to native bone, involve no “floppy” membranes likely to collapse into the socket
  • No material or technique fully meets these criteria
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Take Away Points

• Potential benefits of the different materials and techniques used for socket preservation are still debatable

• No correlation that socket grafting materials improves or increases the longevity of implant placement, bone quality studies are not well documented (bone grafted vs natural healing)
  • Apical third of implants usually placed in native bone
  • Bone quality, quantity, and composition are important factors that influence implant longevity

• Understanding of the physical and biological properties of the materials will guide treatment planning in each patient specific case
  • Need to understand graft composition and turnover rate
  • Need to establish the restoration as the end goal in mind!
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References

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