Bone Wound Healing and Osseointegration

OMS Society General Pathology Academic Elevator
Case

• A 25 year-old male was playing basketball with his friends when he took an elbow to his mouth and tooth #8 was avulsed from its socket. It has been 6 hours since the tooth was avulsed and he has come to you for help.
Question

• Which of the following should you try to preserve in order to aid in the bone wound healing process of your patient’s socket?
  – A. Granulomatous tissue
  – B. Blood clot
  – C. Fibrous tissue
  – D. Periodontal ligament
Answer

• Which of the following should you try to preserve in order to aid in the bone wound healing process of your patient’s socket?
  – A. Granulomatous tissue
  – B. Blood clot (the blood clot is important for formation of granulation tissue and care should be taken in order to make sure it doesn’t get dislodged from the socket)
  – C. Fibrous tissue
  – D. Periodontal ligament
Question

• This patient is most likely in which phase of wound healing and bone repair?
  – A. Proliferative phase
  – B. Remodeling phase
  – C. Inflammatory phase
  – D. Granulomatous phase
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  – C. Inflammatory phase
  – D. Granulomatous phase
Wound Healing: Inflammatory Phase (days to weeks)

- Tissue damage leads to **blood clot formation**.
- Fibrin clot contains **serum, PMNs, macrophages, fibroblasts, platelets, and others**.
- Macrophages begin wound debridement and activation results in **cytokine (IL-1, TNFα)** production and growth factor production. PMNs eliminate bacteria.
- **PDGF** (platelet derived growth factor), **VEGF** (vascular endothelial growth factor), **FGF** (fibroblast growth factor), **TGF-beta** (transforming growth factor beta) begin to recruit cells and stimulate proliferation.
Question

Which cells most likely arrived to the wound site first?

- A. Fibroblasts
- B. Osteoblasts
- C. Erythrocytes
- D. Neutrophils
Answer

• Which cells most likely arrived to the wound site first?
  – A. Fibroblasts
  – B. Osteoblasts
  – C. Erythrocytes
  – D. Neutrophils
Who wins the cell race to the wound site?

- 1st Place — Neutrophils (by a mile!)
- 2nd Place — Fibroblasts — Part of granulation tissue
- 3rd Place — Osteoblasts — Interaction with the surface is a late event, and occurs during primary bone formation
Question

- The patient threw the tooth away. You decide that the best option is to wait for the socket to heal so that you can place an implant later. Which technique may be useful in order to prevent excessive loss of ridge height and ensure there is an adequate amount of bone when you place the implant?
  - A. Socket preservation
  - B. Crown lengthening
  - C. Osseointegration
  - D. Soft tissue grafting
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- A. Socket preservation (a technique that usually involves filling the socket with a bone grafting material in order to prevent excess alveolar ridge resorption)
- B. Crown lengthening
- C. Osseointegration
- D. Soft tissue grafting
Case

• A 59-year old female patient of yours is inquiring about implants as she is not ready for a removable partial denture. She has a history of depression and is currently taking Denosumab for her rheumatoid arthritis.
Question

• What concerns should you share with this patient while having the discussion about implants?
Answer

• What concerns should you share with this patient while having the discussion about implants?
  – This patient is taking a RANKL inhibitor in order to manage her rheumatoid arthritis. Denosumab can result in IMPAIRED BONE WOUND HEALING.
Case

• You have just used non-cruel methods to place an implant in a dog who desperately needed it.
Question

• Using the Berglundh study as a guide, when can you expect immature bone formation around the implant?
  – A. 1 week
  – B. 1 month
  – C. 6 months
  – D. 1 year
Answer

• Using the Berglundh study as a guide, when can you expect immature bone formation around the implant?
  – A. 1 week (takes about 1 week in dogs)
  – B. 1 month
  – C. 6 months
  – D. 1 year
Question

• If it were a human, when would you expect immature bone formation?
  – A. 1-1.5 weeks
  – B. 2-2.5 weeks
  – C. 1-1.5 months
  – D. 2-2.5 months
Answer

• If it were a human, when would you expect immature bone formation?
  – A. 1-1.5 weeks
  – B. 2-2.5 weeks (takes 2-2.5x more time in humans)
  – C. 1-1.5 months
  – D. 2-2.5 months
Question

• The dental implant that you used has a roughened surface that will most likely osseointegrate via which of the following mechanisms?
  – A. Aiding in the differentiation of osteoblasts
  – B. Stimulation of fibrous tissue proliferation
  – C. Inhibition of fibrous tissue proliferation
  – D. A & B
  – E. A & C
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- C. Inhibition of fibrous tissue proliferation
- D. A & B
- E. A & C
How Does Implant Surface Microtexture Influence the Hard Tissue Interface

• Current surface microtextures enhance osseointegration through suppression of early fibrous capsule formation and enhancement of bone cell differentiation
• We have empirically arrived at a set of surfaces that osseointegrate reasonably well, even though these are mixed topography surfaces
• We can get more consistent bone integration by using controlled topographies
Question (Miscellaneous)

• During the early stages of bone wound healing in a tooth socket, there is a competition between bone formation and ______?
  – A. Granuloma formation
  – B. Soft tissue formation
  – C. Cartilage formation
  – D. Pumpkin formation
Answer (Miscellaneous)

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Question (Miscellaneous)

• What type of bone is first to form during wound healing?
  – A. Lamellar bone
  – B. Cortical bone
  – C. Cancellous bone
  – D. Woven bone
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Question (Miscellaneous)

• What is the difference between bone repair and bone regeneration?
• What is the difference between bone repair and bone regeneration?
  – Repair: direct formation of new tissue through activation of existing differentiated cell populations to form repair tissue (secondary union)
  – Regeneration: activation and differentiation of stem cells to regenerate tissue as it forms in embryology (endochondral bone repair and osseoinduction)
Question (Miscellaneous)

- During BONE wound healing, what type of union takes place?
  - A. Primary
  - B. Secondary
  - C. Tertiary
  - D. Quaternary
Question (Miscellaneous)

• During BONE wound healing in a tooth socket, what type of union takes place?
  – A. Primary
  – B. Secondary (due to the relative rigidity of bone in a tooth socket, primary union does not take place. Instead, healing is by secondary union)
  – C. Tertiary
  – D. Quaternary
Question (Miscellaneous)

• Conversion of the blood clot to granulation tissue occurs during which phase of bone wound healing?
  – A. Inflammatory
  – B. Proliferative
  – C. Remodeling
Answer (Miscellaneous)

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Wound Healing: Proliferative Phase (days to months)

- Cellular proliferation and activation lead to new blood vessel formation.
- **Conversion of clot to granulation tissue** (immature connective tissue).
- Some growth factors and cytokines continue to be expressed.
- **Primary bone formation begins**.
Question (Miscellaneous)

• How do you optimize bone formation, limit soft tissue formation, and limit bone resorption?
Answer (Miscellaneous)

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- **Protect the clot.** A stable clot is a matrix for bone repair.
- **Limit tissue damage from heating of bone.**
- **Limit soft tissue ingrowth.** See the Guided Tissue Regeneration (GTR) concept.
- **Use implant surfaces that attach bone and soft tissue.** This uses soft tissue to seal the bone from the oral environment and maintains bone height.
- **Limit inflammation from debris and infection.** Inflammation causes bone resorption.
Question (Miscellaneous)

• What is the most common type of implant surface?
  – Subtractive surface
  – Additive surface
  – Special surface
  – Passivation
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Random Facts

• 1-3 μm features superimposed on 6-10 μm “waviness is the ideal mixed textured surface topography for dental implants
• Granulation tissue is not replaced by bone, but is rather used as a matrix/template to produce and direct new bone formation
• Pre-osteoblasts pave the way and release matrix proteins that stimulate bone formation (osteopontin, bone sialoprotein, osteocalcin)
• Recent evidence suggests macrophages produce BMPs and osteopontin which mark the matrix for bone deposition