Metal Implants

Common Types
- Stainless Steel
  - American Society of Testing and Materials recommends type 316L for orthopedic surgery due to improved corrosion resistance, fatigue resistance and wear.
    - “L” stands for low carbon.
  - Composition – 17-20% Chromium, 12-14% Nickel, 2-4% Molybdenum, 2% Manganese, 0.75% Silicon, 0.03% Carbon, phosphorous and sulfur.
  - Not magnetic.
- Titanium
  - Four grades based on amounts of oxygen, iron and nitrogen, and alloys commonly made to broaden mechanical properties.
    - Most common alloy is Ti6Al4V, and most common alloying agents are aluminum and vanadium.
  - Has the lowest specific gravity and is the lightest weight (4.5g/cm) compared to 316L stainless steel (7.9g/cm).
  - Greatest specific strength (strength per density), but poor shear strength, so it is less desirable for bone plates and screws than stainless steel.
- Cobalt-Chromium Alloy
  - Mainly in artificial joints, and often coated with titanium for better bone integration.

Corrosion and Other Undesirable Effects
- Corrosion is divided in to three interactions
  - Galvanic Corrosion – occurs with two dissimilar metals in the same environment.
    - The most rapid type of corrosion.
    - More negative material becomes an anode, try to avoid using different metals in same area.
  - Fretting (Crevice) Corrosion - caused by the mechanical rubbing of one part on another.
    - Ex: a screw on a plate leads to a localized pitting corrosion.
    - Mechanical stress accelerates process.
  - Frictional Corrosion - caused by debris created from contact and micromotion between bone and the implant.
- Metallosis – release of corrosion debris into the surrounding soft tissue.
  - Stainless steel is incorporated into macrophages and giant cells, while titanium is not.
  - Titanium has low tissue toxicity compared to stainless steel.
- Other Complications – fracture or loosening of hardware, fracture in surrounding bone, lymphocytic reaction.

Imaging with Metal Implants
- Most modern, commercial materials do not contain ferromagnetic metal, are safe for MRI at 1.5T and 3.0T.
- Metal related artifacts affect the image quality of CT and MRI.
  - CT – seen as bold and starburst streaks.
  - MRI – seen as dark or bright blotches.
- Size of artifact depends on size, shape, composition and position of the implant.
  - Stainless steel produces a bigger artifact than titanium alloy
  - Canulated screws produce a smaller artifact.
- Radzi et al. – screws need to be 3mm away from joint in order to properly assess the articular surface with an MRI.

"Will I be able to get through airport security?"
- Studies done before 9/11:
  - 1992, Pearson et al. – most orthopedic implants not identified by metal detectors.
  - 1994, van Rhijn et al. – airport detectors, as a rule, did not detect metal implants.
- Since 9/11, airport metal detectors operate at a higher sensitivity, in a constant state of high security.
- 2007, Ramirez et al. – type of implant, material and body location all independent predictors of detection.
  - Detection Rate – arthroplasties 90%, plates 30%, screws 20%, K-wires and nails 0%.
  - Titanium 5x more likely to be detected than stainless steel, Cobalt-Chromium 73x more likely.
  - Implants in lower extremity 10x more likely to be detected than upper extremity.
- No correlation between BMI and likelihood of detection.
- TSA – individuals with metal implants that set off detector will be patted down as an extra screening procedure.
  Those who carry a card signed by a physician can bypass the metal detector and receive a brief personal screening.

References