Wrist Implants

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What is Arthritis?

- Occurs at tissues within joints
- Decrease protective layer between bones
- Extremely painful
  - Reduced mobility
  - Deformity of joints
  - Loss of function
Arthritis in Wrists

Most common types:

- Osteoarthritis (OA)
- Rheumatoid arthritis (RA)
- Posttraumatic Arthritis
Why does it matter?

- Affects 3 million US citizens per year
Current Treatments

1. Non-surgical
   - Exercise
   - Steroid Injections
   - Medications

2. Surgical
   - Proximal Row Carpectomy
   - Wrist Fusion
   - Total Wrist Replacement
Current Surgical Treatments

1. Wrist Arthrodesis (Fusion)
   - Immobilize the bones to eliminate pain caused by motion.
   - More favorable than arthroplasty
     - Lower complication rate
   - Less range of motion
     - Due to fusion of bones
Current Surgical Treatments

2. Total Wrist Replacement (Wrist Arthroplasty)

- Replacing damaged joint with a prosthetic one.
- Long-term pain relief
- Improves overall function
- Higher complication rate than wrist fusion
Issues with Total Wrist Implants

- Dislocation
- Loosening
- Stiffness
- Limited range of motion
- High pressure & stress at certain locations
Simulating Bone Growth with HA and BMP

- Titanium alloy coated with porous Hydroxyapatite (HA) and Bone Morphogenetic Protein (BMP) to decrease loosening and promote bone growth
- Titanium oxide coating through plasma spray process to prevent corrosion
- Surface roughness will be increased
- HA and BMP coating will be applied (BMP dosage range from 20 to 100 µg/g of coating)
- Pores (ranging from 100 µm to 600 µm) will be incorporated

Bone growth assessment techniques include:

- Dual energy x-ray absorptiometry-bone mineral densitometry
- Bone histomorphometry.
**Synthetic Cartilage**

- High stress occurs due to lack of cartilage & bone erosion
- **Stress = Force / Area**
  - Force is constant
  - Increase area $\longrightarrow$ decrease stress
- Increasing area would be achieved by:
  - Enhancing bone growth (ex. HA & BMP)
  - Replacing cartilage (ex. Hydrogels)
PVA Hydrogels

- Similar properties to real cartilage
  - Rubber elastic
  - Biocompatible
  - High water content

- Can be manufactured to have specific tensile and compressive properties
  - Repeated freezing-thawing
  - Dehydrating the hydrogel in vacuum
  - Cross-linking through irradiation
PVA Manufacturing & Testing

- 1799-PVA initially dissolved in 90 degrees and mixed for ~6 hours
- Results in 14-20% aqueous PVA
- Repeated freezing (-26 degrees) and thawing (room-temp)
  - Freezing 6-12 hours
  - Thawing 1-2 hours
  - Repeat cycle 1-3 times
- Dehydrate in vacuum 8-10 hours
- Cross-link by irradiation (16Mrad)
- This process would be adjusted based on the resulted mechanical properties
- A long-focal-microscopy-based microindentation system would be used for testing
References

- https://journals.lww.com/c-orthopaedicpractice/Citation/2015/05000/Past,_Present,_and_Future_in_Total_Wrist.21.aspx
Questions?