Ergonomic Prosthetic Ear Attachment

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Outline

- Motivation and need for a reliable prosthetic
- Market alternatives
- Design criteria
- Design alternatives
- Selection of final design
- Testing and obstacles to overcome
- Future outlook

The Motivation and Need for a Reliable Ear Prosthesis

- Motivation
  - Observable defects are a source of psychological trauma
- Need
  - Physical Trauma
  - Cancer
  - Microtia
    - Congenital deformity of outer ear occurring in every 1 of 10,000 births
  - Certain Syndromes
    - Malformed/absent outer ear, incomplete development of ear

Figure 1. Child with microtia.

Figure 2. Man with ear trauma.

Market Alternatives

- Slip-on prosthesis
  - Implant not used
  - Not secure
- Magnet-abutment cap techniques
  - Abutments implanted perpendicular to bone
  - Attachment not secure
- Bar-clip method
  - Difficult to clean under
  - Can become loose or get bent
  - No absolute measure of security

Figure 3. Slip-on prosthesis.

Figure 4. Magnet-abutment cap technique.

Figure 5. Bar-clip method.

Design Criteria

- Resists unintentional dislodgement
  - Withstands anterior and posterior forces
- Is low profile
- Contained within the prosthesis
- Integrates with titanium implants
- Requires minimal effort to remove and attach
- Fails before bone is damaged
- Applies to a variety of abutment orientations and head topographies

Vertical Track Design

- Three vertical track attachments in prosthesis
- Secured using:
  - Lips of the track
  - Gravity
  - Magnets
- Only works in ideal cases
- Attachment too strong

Figure 6. Ear with attachments.

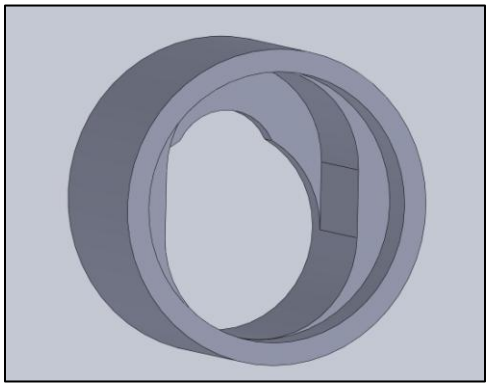


Figure 7. Attachment back.

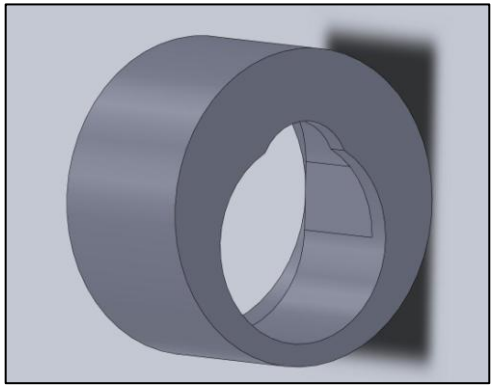
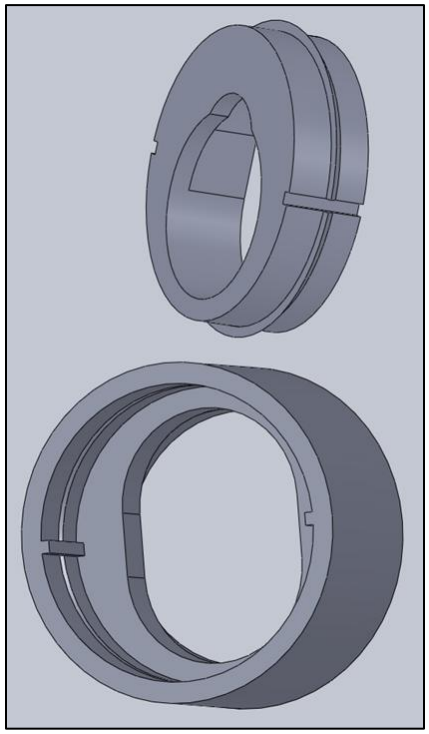
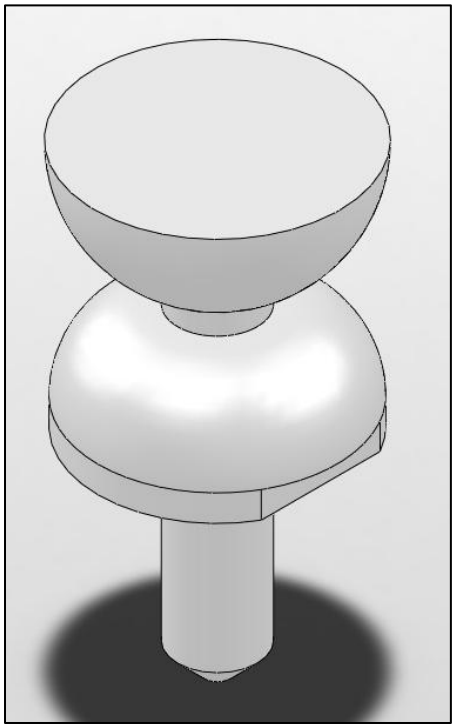
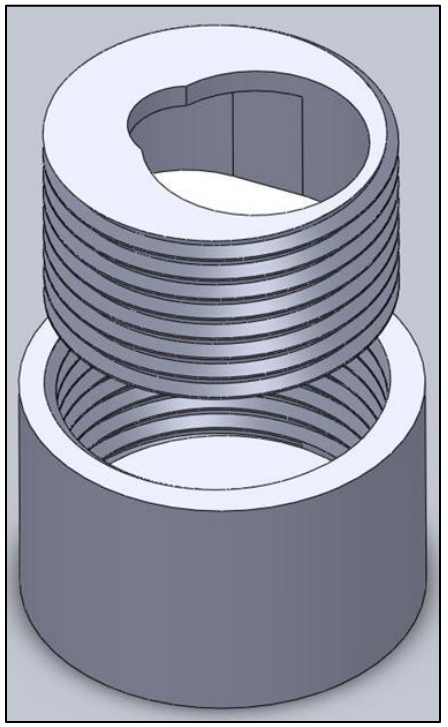


Figure 8. Attachment front.

Figure 9. Abutments in patient.

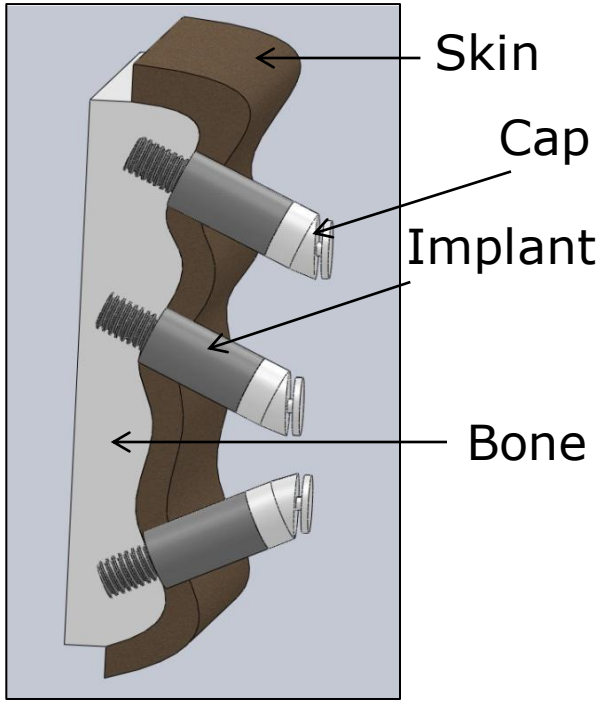
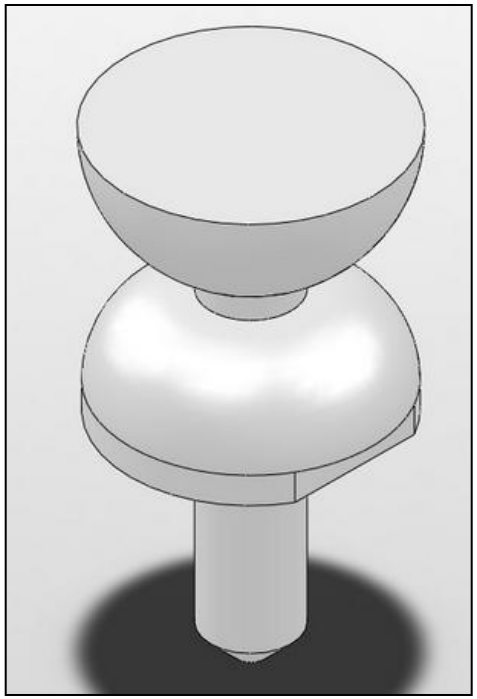
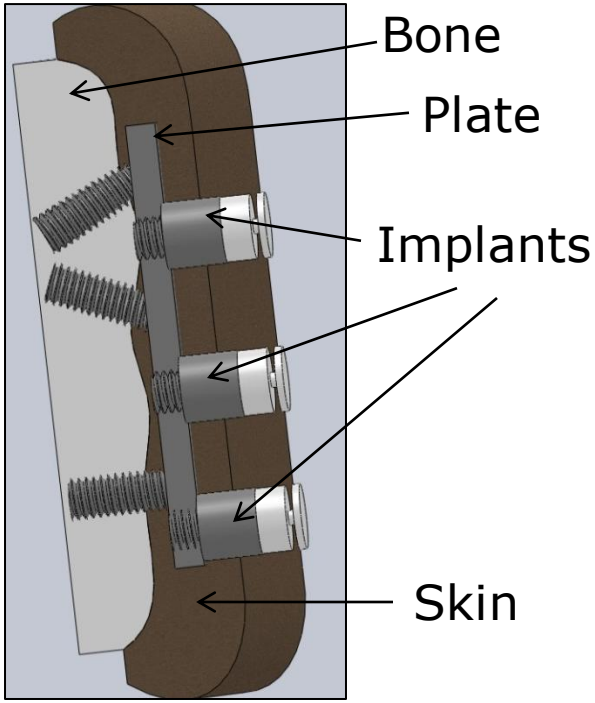
Break Away Options

Film Canister	Circular Groove	Screw in Attachment
		
• Face of attachment snaps into main part • Can be replaced when it breaks	• Groove cut in body of abutment cap • Breaks above the threads so it can be unscrewed	• Attachment made of weaker material • Unscrew and replace when it breaks

Break Away Matrix

Criteria	Film Canister	Circular Groove	Screw in Attachment
Cost (10)	7	6	2
Feasibility (25)	11	20	8
Replaceability (25)	16	21	15
Effectiveness (40)	26	35	26
Total	60	82	51

Alignment Options

Angled Cylinders	Spherical Cap	Plate
		
• Caps correct for non-parallel abutments • Must be customized for each patient • Does not use commercially available caps	• Tolerates slightly non-parallel abutments • Does not use commercially available caps	• Potential to work for every case • Requires extra material in the head

Alignment Matrix

Criteria	Angled Cylinders	Spherical Cap	Plate
Cost (10)	5	7	2
Feasibility (25)	18	18	6
Effectiveness (25)	10	19	23
Compatibility (40)	36	33	10
Total	69	77	41

Testing of Device

- Large scale models
  - Determine range of applicable angles
  - Determine assembly fit/quality of fit
- SolidWorks Stress Analysis
  - Different materials
- Physical force testing on cap
- Physical testing on ear

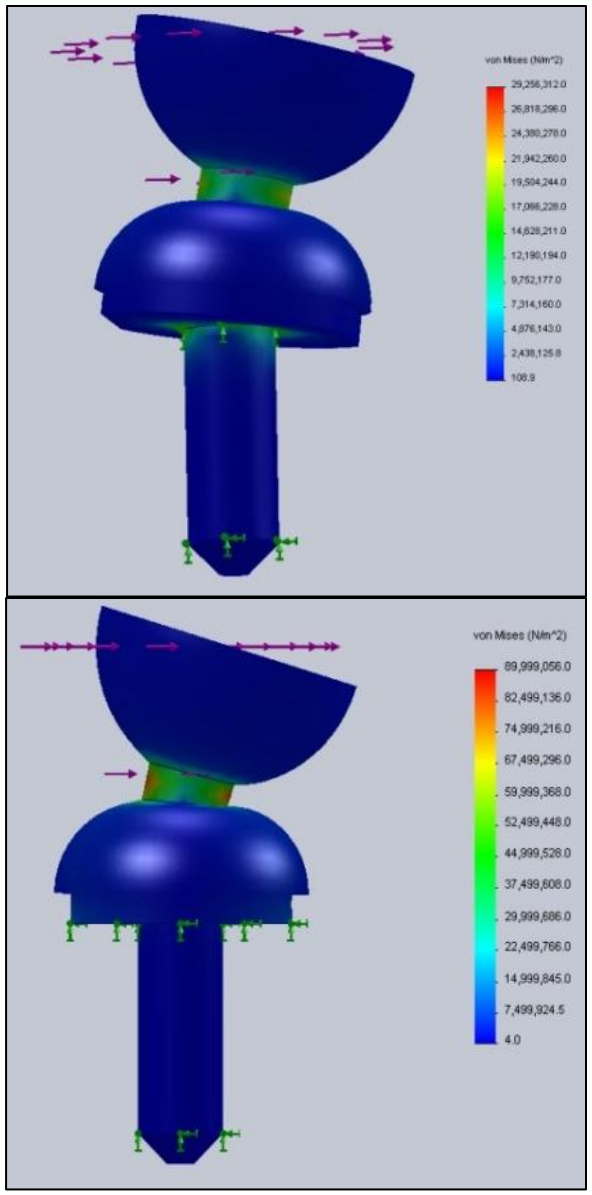


Figure 10. SolidWorks stress analysis.

Where will we go from here?

- Finalize cap dimensions and material
- 2nd meeting with WARF
- Fabrication
  - Injection Molding
- Alignment of attachment and caps in non-ideal cases
- Force testing
  - Safety breakage
  - Attachment quality
- Reduce attachment visibility
  - Conceal slot
  - Reduce size

Figure 11. Woman with ear prosthesis.

Questions?