Ergonomic Prosthetic Ear Attachment

Client:

Greg G. Gion, MMS, CCA

Medical Art Prosthetics

Advisor:

Thomas Yen, PhD

Team:

Eamon Bernardoni - BSAC

Jim Mott – Team Leader

Brooke Sampone – Communicator

Michelle Tutkowski - BWIG

THE UNIVERSITY of WISCONSIN MADISON

Medical Art Prosthetics

Figure 1. Greg Gion, MMS, CCA

Figure 2. Dallas, TX Clinic

Figure 3. Madison, WI Clinic

Outline

- Motivation and need for a reliable prosthetic
- Market alternatives
- Design criteria
- Final design
- Fabrication
- Testing
- Future work

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 4. Child with microtia.

Figure 5. 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 6. Slip-on prosthesis.

Figure 7. Magnet-abutment cap technique.

Figure 8. 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 9. Ear with attachments.

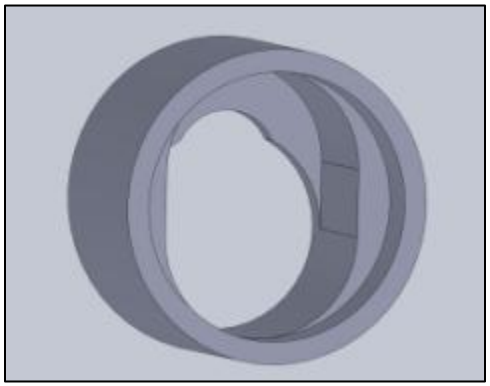


Figure 10. Attachment back.

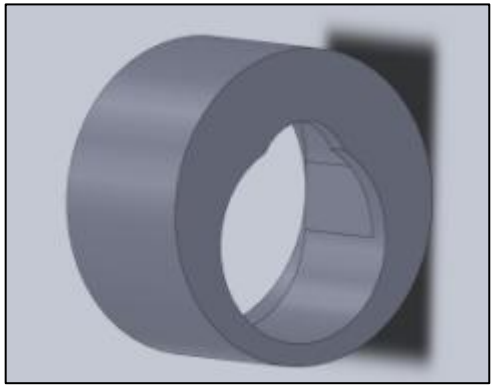
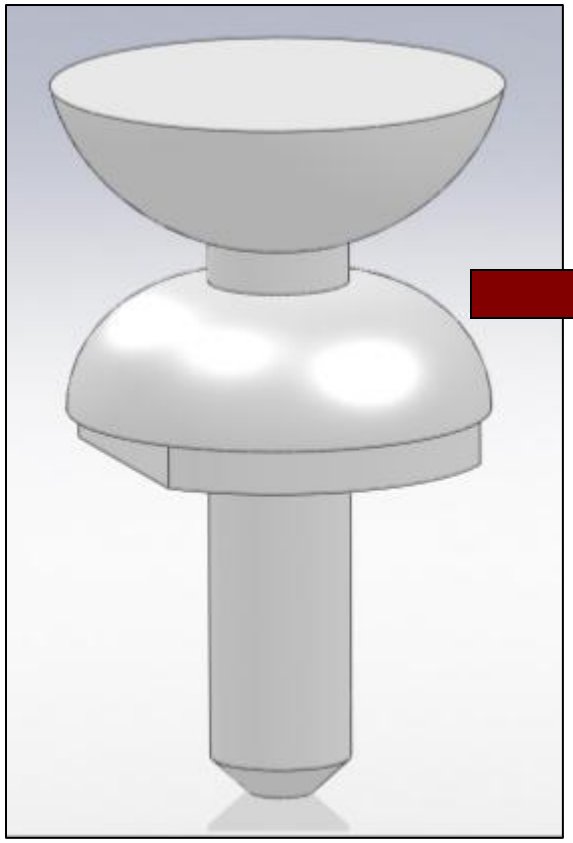
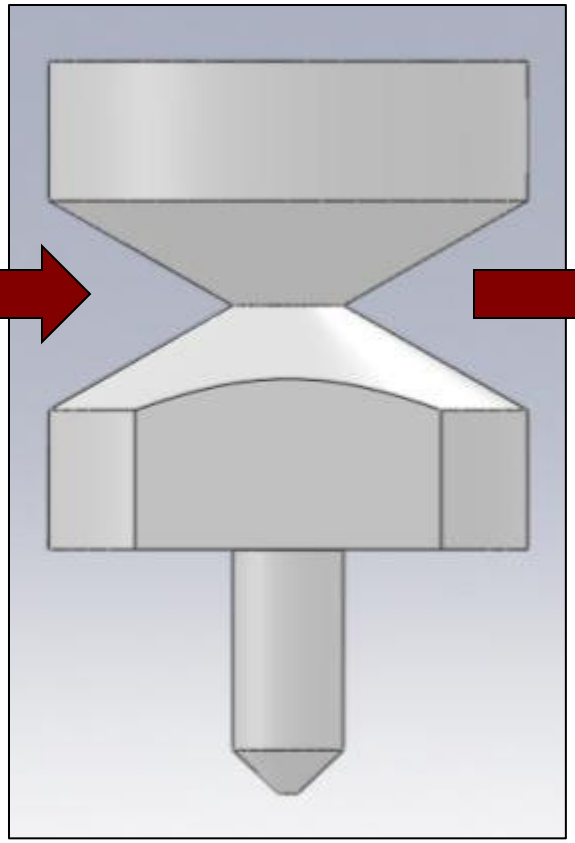
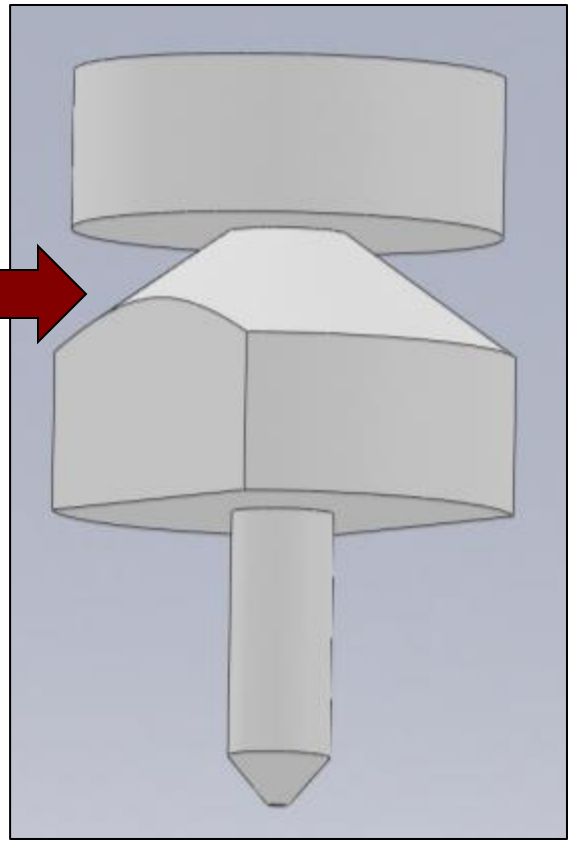


Figure 11. Attachment front.

Figure 12. Abutments in patient.

Break Away Design

Hemispherical Cap	Angled Top Cap	Flat Top Cap
		
Round surfaces were not necessary to obtain required angles for varied abutment arrangements	Angled top slid out of attachment too easily	Full upper cylinder secured the cap in the attachment embedded in prosthesis

Fabrication Options

Figure 13. Simplomatic PRO-63 Injection Molder

Figure 14. Epilog 40W Laser Cutter

Figure 15. Eisen Machinery CTL-618DT

Figure 16. EMCO ConceptTurn 55 CNC Lathe

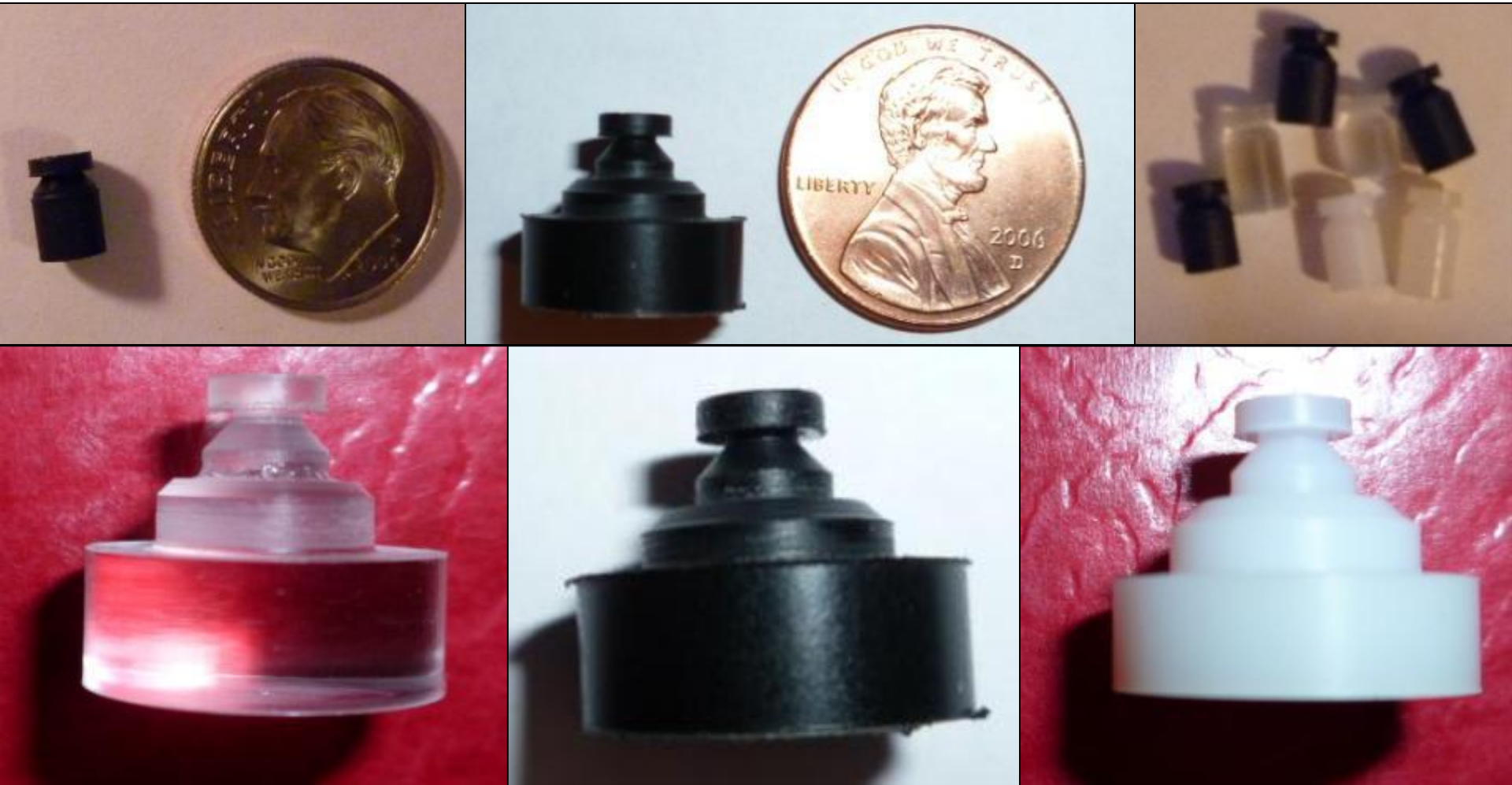
Figure 17. Grizzly Manual Lathe

Fabrication Matrix

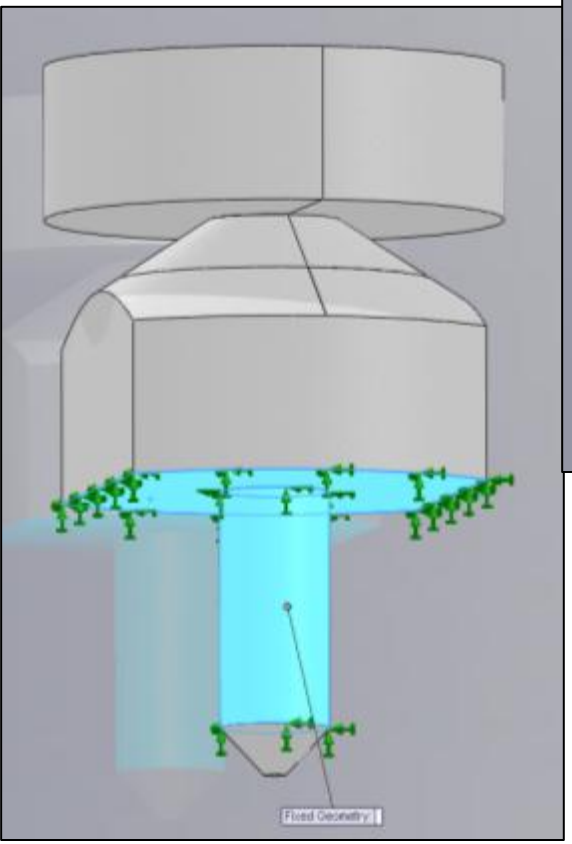
Criteria	Injection Molding	Mini CNC Lathe	Small, Manual Lathe	Eisen Lathe
Cost (40)	5	20	35	35
Feasibility (20)	2	2	15	18
Repeatability (20)	20	20	15	19
Accuracy (20)	18	10	15	17
Total (100)	45	52	80	89

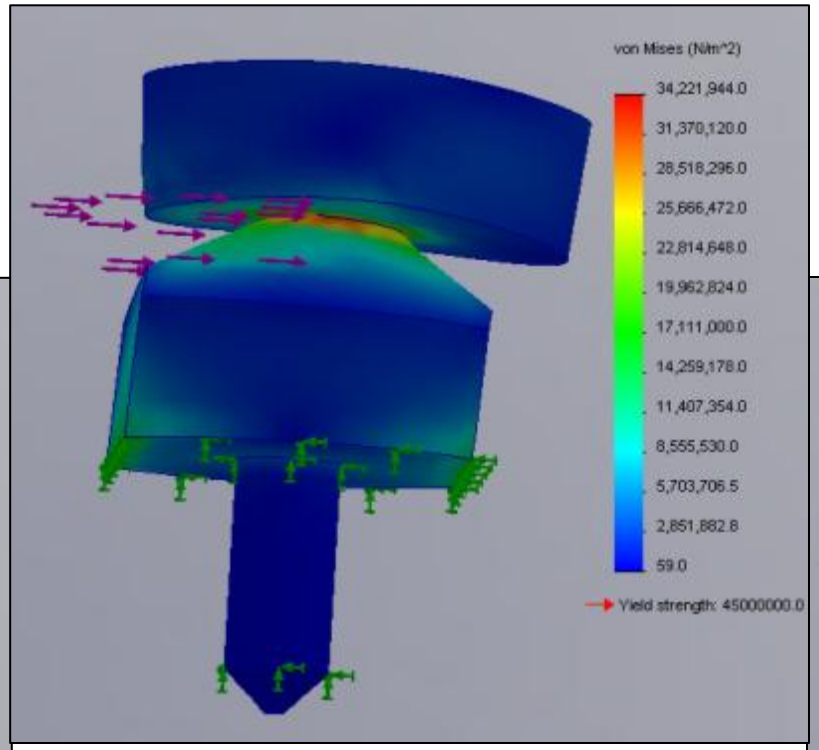
Fabrication Progress to Date

- 4 Acrylic (clear, bottom left), 6 PC (black, bottom middle), and 3 PS (white, bottom right) caps were machined on the Eisen CTL-618DT Lathe
- PP and UHMWPE were not machinable



Testing of Cap in SolidWorks





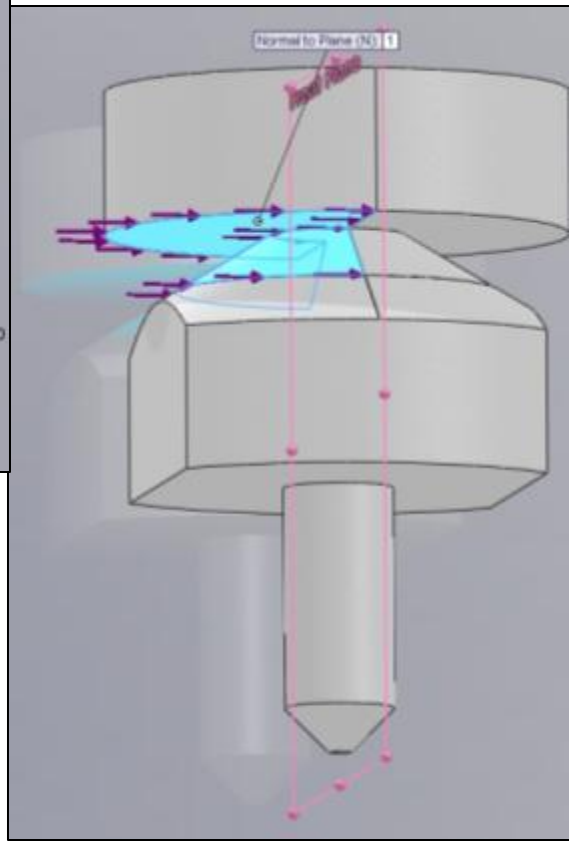


Figure 18. The left image shows the anchoring of the implant, the middle shows where the force is applied, and the right shows the stresses present in the abutment.

Testing of Cap in SolidWorks

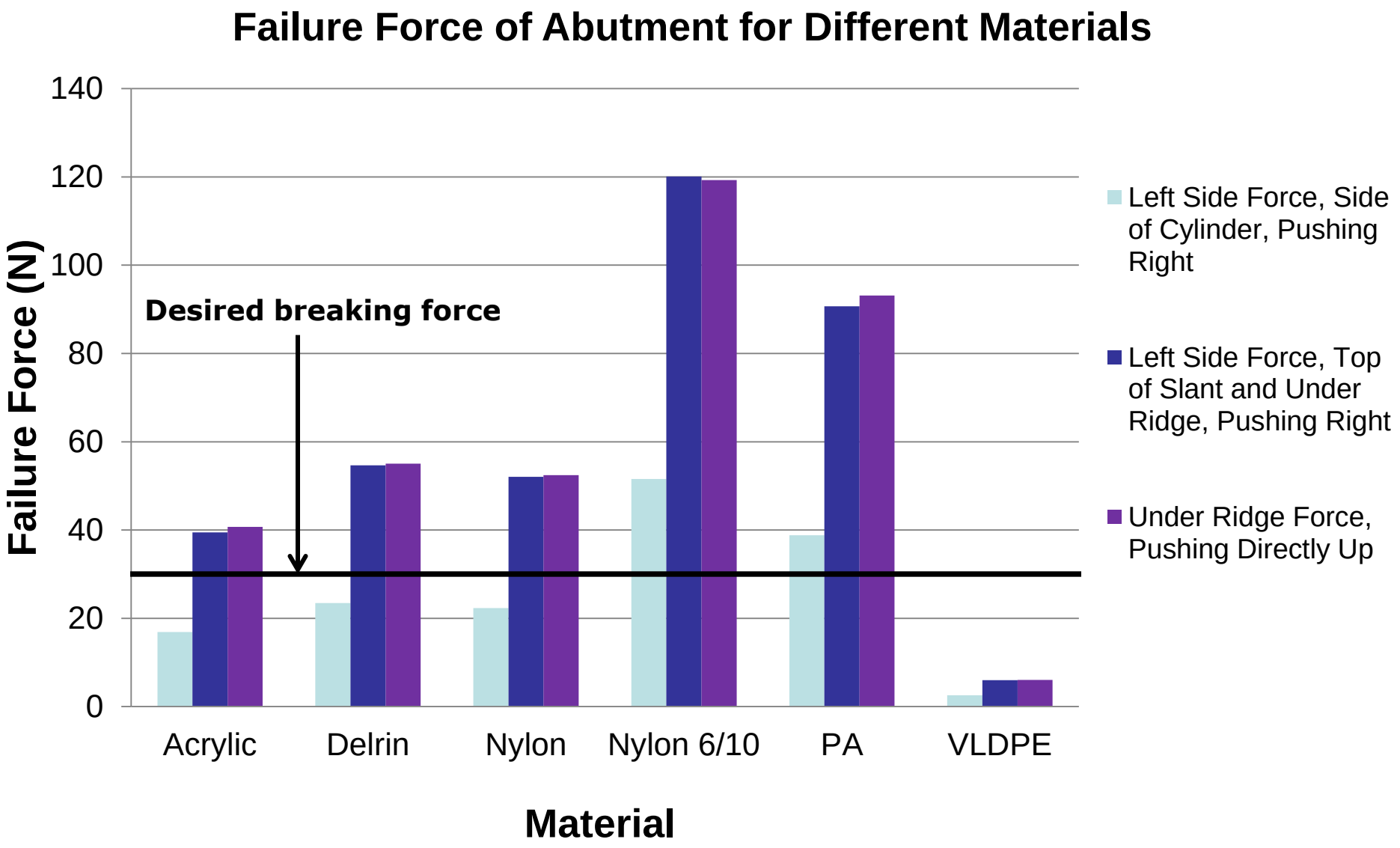


Figure 19. SolidWorks stress analysis.

Mechanical Testing of Caps

- MTS Insight 5 with 50 N Load Cell

- Manufacture caps from PC, PS, and Acrylic
- Perform compression test to determine force required to break cap
- Select plastic with appropriate mechanical properties
- Adjust break-away diameter

Where will we go from here?

- Continue to manufacture caps
- Manufacture attachments with laser cutter
- Begin force testing
  - Determine appropriate diameter
  - Determine best plastic properties
- Incorporate screws
- Finalize prototype as single unit
- Patient trials

Figure 20. Woman with ear prosthesis.

Acknowledgements

- Dr. Yen
- Greg Gion
- John Puccinelli
- Kristyn Masters
- Tom Wirth
- Matt Houdek

Questions?