Ergonomic Prosthetic Ear Attachment

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Abstract

Auricular prostheses are often used to correct deformities of the ear resulting from physical trauma, cancer, or birth defects such as microtia. When reconstructive surgery or slip-on prostheses are not an option, the remaining ear is often removed and a new prosthetic ear is made. To hold the prosthetic ear in place, magnetic abutments are implanted into the skull while matching magnets are set into a silicone prosthesis. Though the prosthesis is easy to attach with this method, it is easily displaced due to posterior or anterior forces. Last semester our group developed an attachment method that allows the prosthesis to slide into a locked position. This design offers additional attachment strength while allowing the user to easily attach, remove, and clean the prosthesis. This design does not work when the abutments are not parallel to each other and has the potential to damage the skull bone if the prosthesis encounters a large force. This semester we modified the abutment cap so that our sliding method works with non-parallel abutments and breaks away before the skull is damaged.

Need for a New Method

- Observable ear defects are a source of psychological trauma [1]
- The need for an ear prosthesis may result from physical trauma, cancer, or birth defects such as microtia [1]
- Prosthesis attachment and detachment is simple for the user with the magnetic attachments, but difficult with the bar and clip method [2]
- Security of attachment is at stake
  - Concern with anterior and posterior forces
  - Attachment is often too strong with bar and clip method and compromises the integrity of bone and surrounding tissue

Figure 1. Child with microtia where a silicone prosthesis has disguised the deformity [3].

Attachment Methods

Figure 2. Magnetic abutments [3].

Figure 3. Bar attachment method [4].

Figure 4. Spring and sheath design [5].

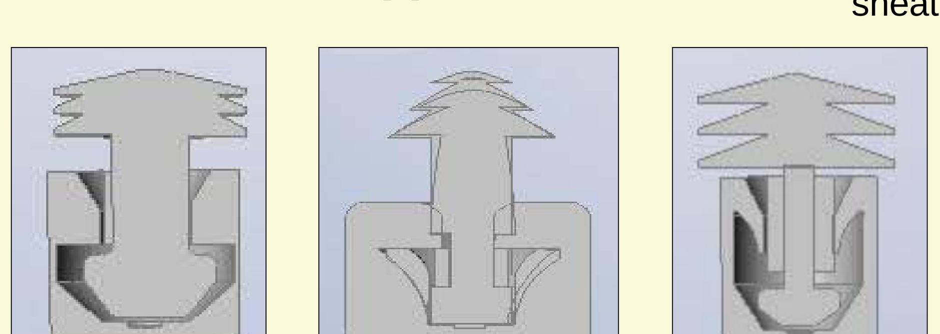

Figure 5. Prong and flange design [6].

Design Criteria

- Resists unintentional dislodgement
- Withstands anterior and posterior forces
- Fails before bone is damaged
- Integrates with titanium implants
- Requires minimal effort to remove and attach
- Applies to a variety of abutment orientations and head topographies
- Costs less than current method ~ $110 per attachment

New Attachment System

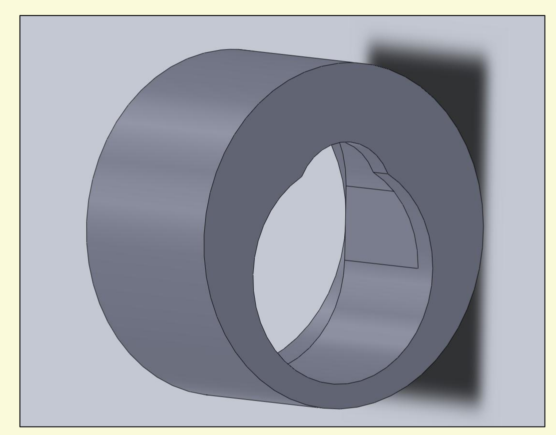

Figure 6. SolidWorks model of attachment focused on abutment insert hole.

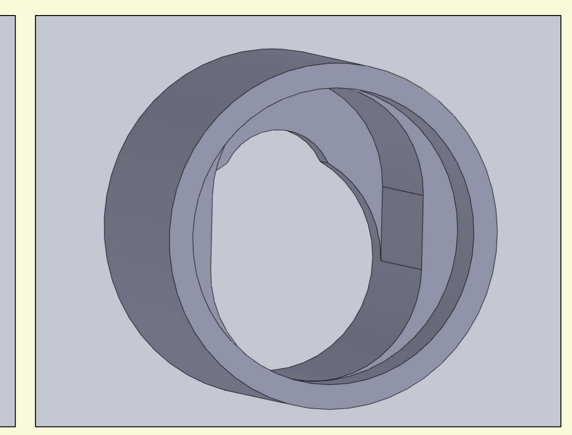

Figure 7. SolidWorks model of attachment focused on magnet housing hole.

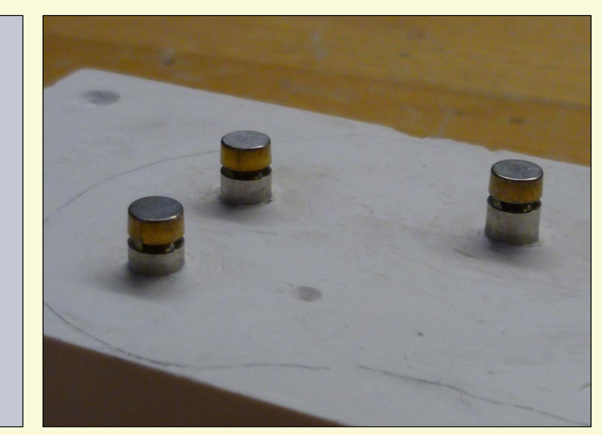

Figure 8. Abutment model showing groove under abutment caps.

Abutment Redesign

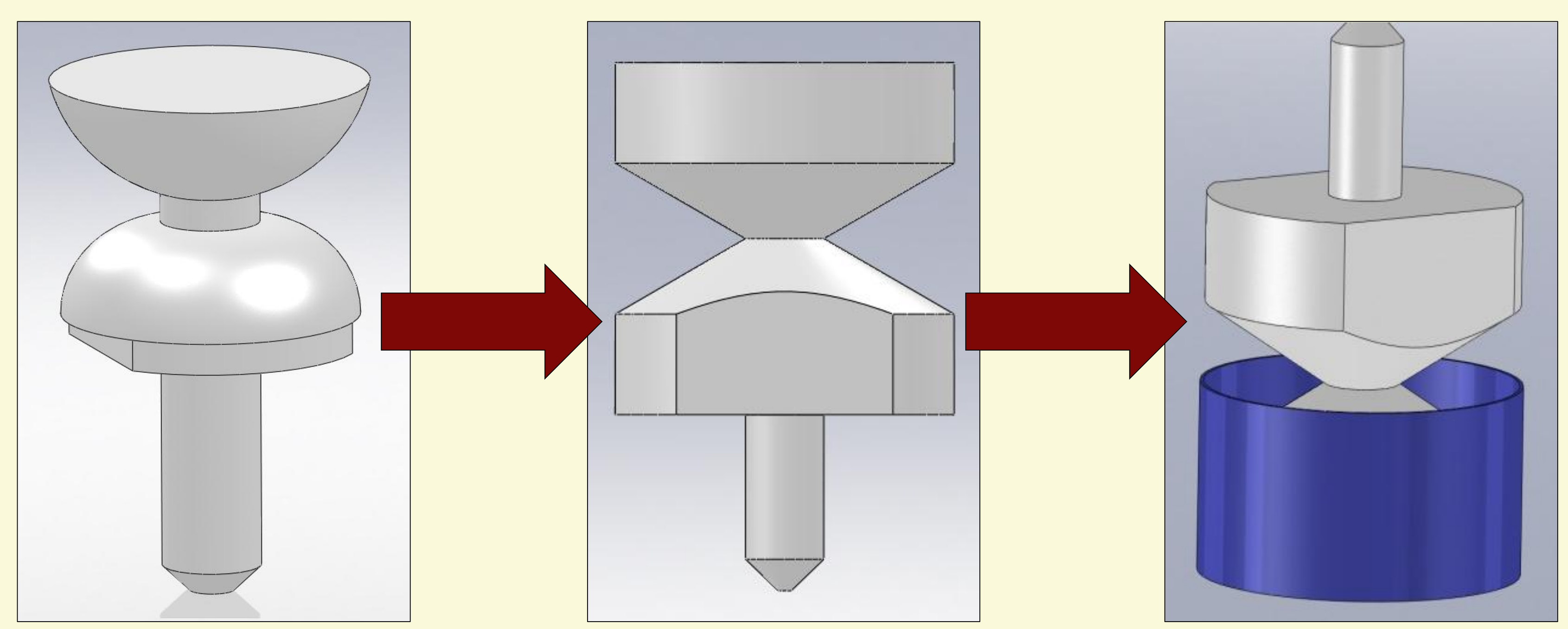

Figure 9. SolidWorks progression of abutment redesign going from the hemisphere design to the angled cylinder design and finally to the fabrication of the full cylinder top and angled bottom.

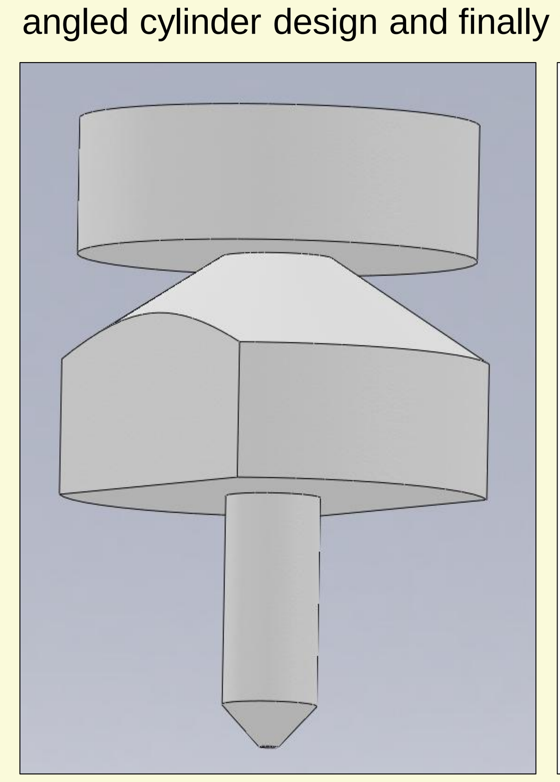

Figure 10. SolidWorks model of final abutment redesign.

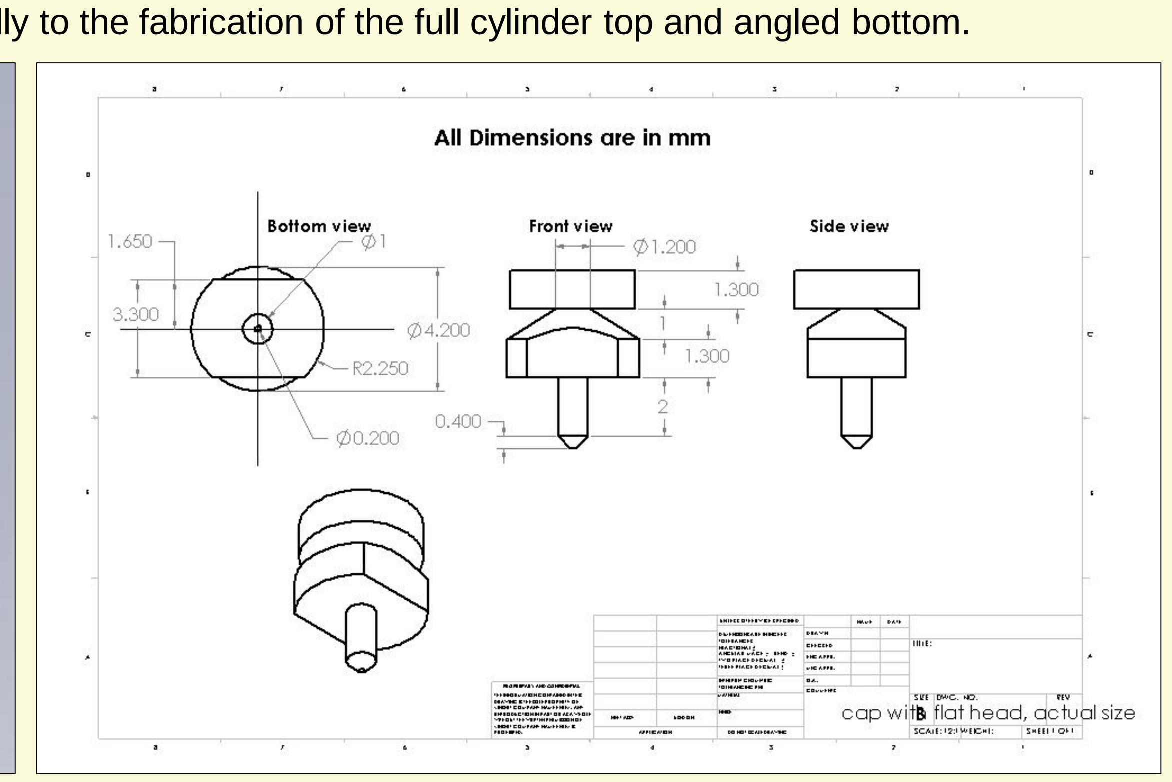

Figure 11. SolidWorks drawing of final abutment redesign highlighting dimensions.

Design Features

- Conical lower half of abutment to accommodate randomly angled implants
- Cylindrical upper half of abutment for secure fit in attachment
- Manufactured from a polymer: PS, LDPE, Nylon, or Acrylic

Testing Results

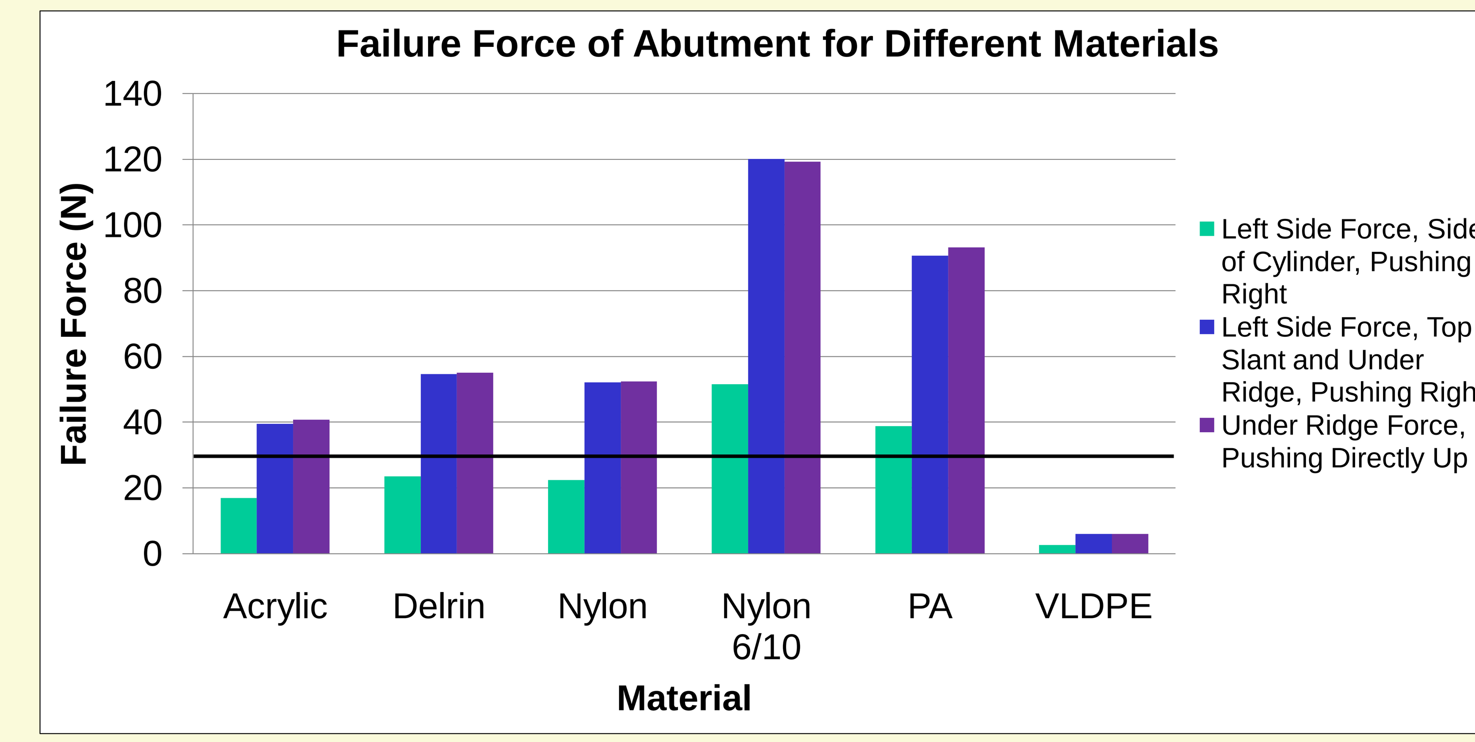

Figure 12. Failure force for different materials using SolidWorks modeling. Ideally we want failure to occur when a 30 N force is applied to the side of the abutment (black line).

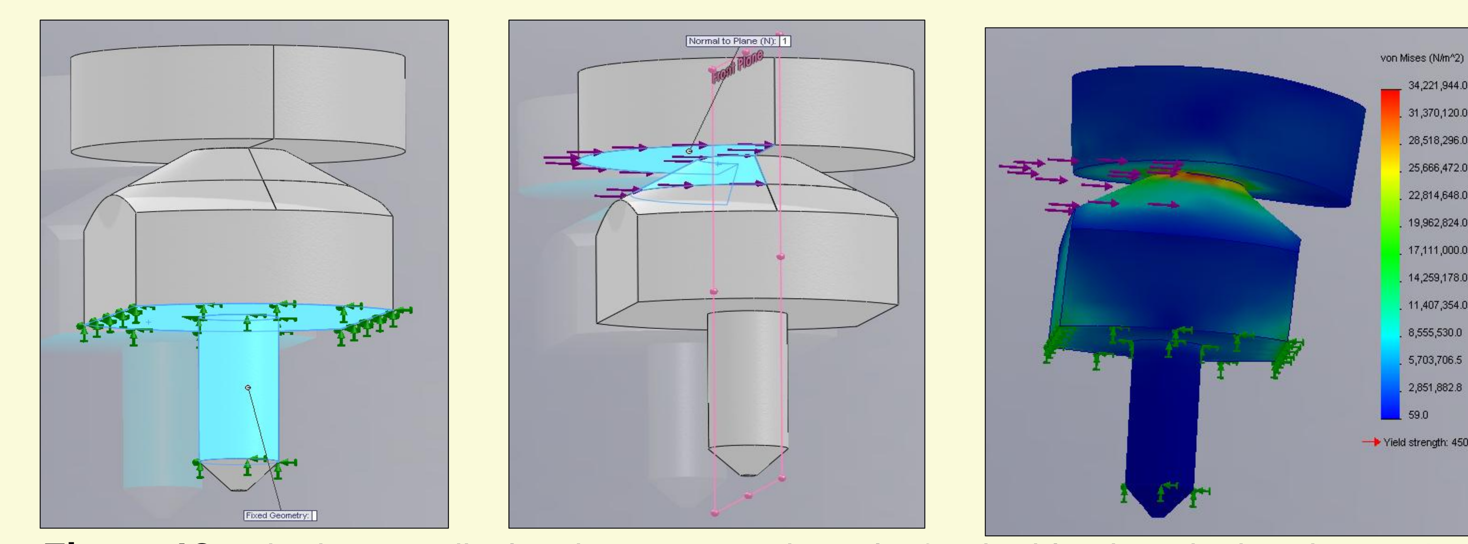

Figure 13. The images display the set-up and results for the blue bars in the Figure 12. The left shows the anchoring of the implant, the middle shows where the force is applied, and the right shows the stresses present in the abutment.

Future Considerations

- Fabricate real size abutment cap using injection molding
- Test new device for accuracy of break away force to ensure that no bone damage occurs
- Metal attachments should be disguised with a flesh color coating
- Usability testing should be performed with actual patients
- Develop a system to allow the client to easily align the attachments when putting them in a prosthesis

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References

[1] Eavey, R. D., Monroy, A., Nicolau, Y., and Shabdiz, F. 2006. Microtia repair: the case for surgical reconstruction. *J. Oral Maxillofac. Surg.* **64**(11): 1655-1663.
[2] Gion, G. G. 2006. Surgical versus prosthetic reconstruction of microtia: the case for prosthetic reconstruction. *J. Oral Maxillofac. Surg.* **64**(11): 1639-1654.
[3] Figure from: <http://medicalartprosthetics.com/content.php?page=galleries&gallery=auricular>.
[4] Figure from: <http://medicalartprosthetics.com/content.php?page=prostheses&sec=auricular>.
[5] Figure from: http://homepages.cae.wisc.edu/~bme300/ear_attachment_f09/secure/reports/ BME_300-Final_Report1.pdf
[6] Figure from: http://homepages.cae.wisc.edu/~bme300/ear_prosthesis_f08/secure/reports/ Ear_Prosthesis_Final_Report.pdf