Passive-Locking Implant-Retained Auricular Prosthesis Attachment

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Abstract

Auricular implants are typically used to treat the absence of an ear. The current locking mechanism for prosthetic attachment is an o-ring snap-fit which attaches a titanium magnetic housing to three ferrous pins implanted into the mastoid bone. Within the housing is a neodymium magnet which anchors the device. The disadvantage of the O-ring is the large force required for disengagement. After assessing three possible new designs, a magnetically induced sliding mechanism for retention was deemed the best replacement.

Background

Auricular prosthetics are required in cases such as:

- Congenital defects
- Cancer treatment
- Traumatic injury (burns, lacerations, etc.)

The history of Auricular Prosthetics

- Originally retained through adhesives
  - Poor retention
  - Abnormal movement of prosthetic
  - Allergen concerns
- Prosthetic integration directly into the skull began in the 1970's
  - Improved retention
  - Allows for a more natural and consistent look

Current Design

O-ring system

- 3 abutments implanted within the mastoid bone
- Magnetic caps housed within prosthetic attach to corresponding abutments
- Retained with O-rings in each magnetic cap
- Difficult to remove and attach

Figure 1: (Left) O-ring system within mock prosthetic. (Center) Outside of a single O-ring magnetic cap. (Right) 3 abutments that are implanted into a clay base.

Bar system

- Bar implanted into the mastoid bone
- Corresponding clip housed within prosthetic attaches to bar through snap-fit design
- Difficult to remove and attach and also prone to break

Figure 2: (Left) Bar system within mock prosthetic. (Center) Close up of clips within mock prototype. (Right) Bar implanted into clay base.

Design Requirements

- Create solid attachment of prosthetic
- Utilize existing hardware
- User friendly
- Hypo-allergenic
- Maintain aesthetics

Previous Design Projects

Prototype 1:

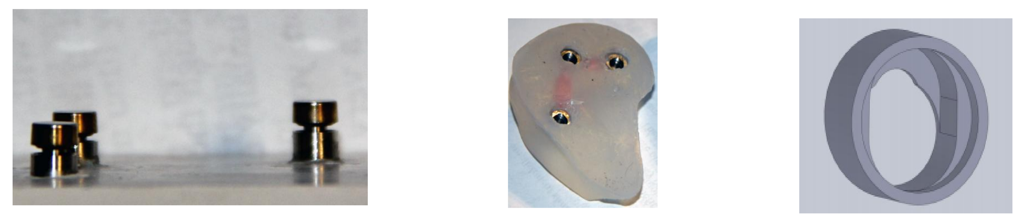


Figure 3: (Left) Existing magnetic abutments with spacer. (Center) Gravity lock device within mock prototype. (Right) Profile of the gravity system, which is pulled down to lock in place

Prototype 2:

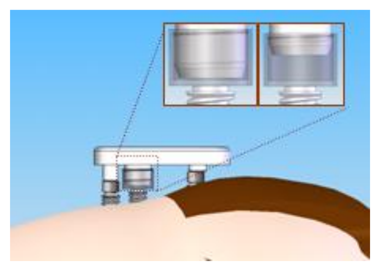
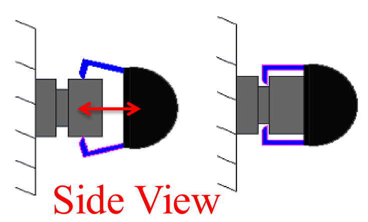


Figure 4: Three-pin system to attach prosthetic. Middle pin involves 360° rotation for attachment removal.

Alternative Designs

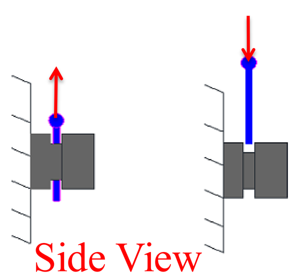
Snap-Fit Design

Lower portion of cap (Blue) is made of an elastic material which can snap into place around the abutment (Gray) to lock



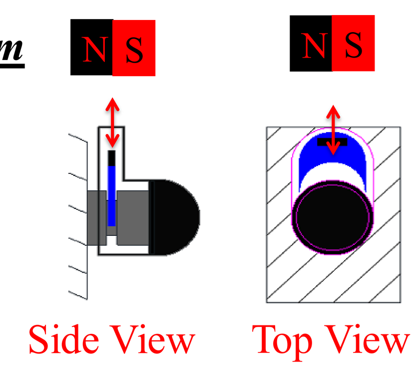
Pin Securing System

External pin (Blue) can be pushed in, through the abutment (Gray) to lock and pulled out for release



Magnetic System

Crescent slider (Blue) can fall into place around abutment (Gray) due to gravity and released with an external magnet



Design Matrix

Criteria	Magnet	Pin	Snap Fit
Feasibility (25)	20	18	16
Durability (20)	18	18	10
Ergonomics (20)	14	16	12
Concealment (15)	13	8	15
Safety (10)	10	10	10
Client Preference (10)	10	8	6
Total (100)	85	78	69

Final Design

Features

- Ease of release while maintaining retention capabilities
- Fits over existing abutments
- Can be incorporated into existing 3-pin design
- Gravity locking slider for retention
- Release of slider from abutment through external magnet
- Three concentric rings on exterior for incorporation and retention within prosthetic polymer

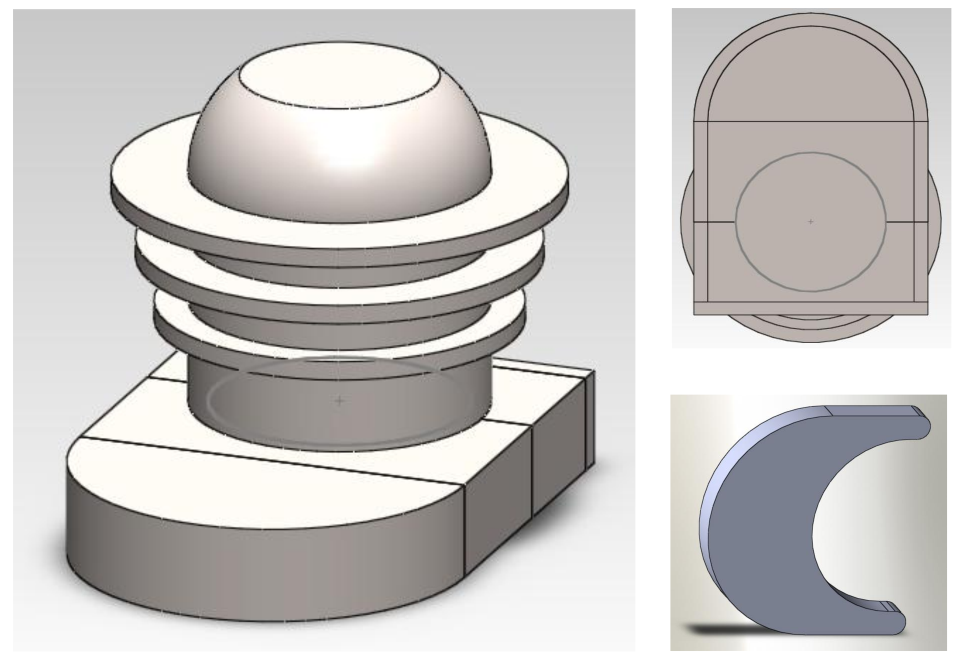


Figure 5: (Left) Isometric view of final design. (Top Right) Bottom view looking into housing of final design without cover piece. (Bottom Right) Sliding device for final design.

Results

How close does the magnet have to be to unlock the slider?

- Maximum acceptable distance was determined to be 1.2 cm

At what angles will this distance give full slider retraction?

- Magnet was brought toward the encased slider
- Maximum distance of complete retraction was measured
- Angle of magnet presentation varied from 0° to 30° from the vertical axis

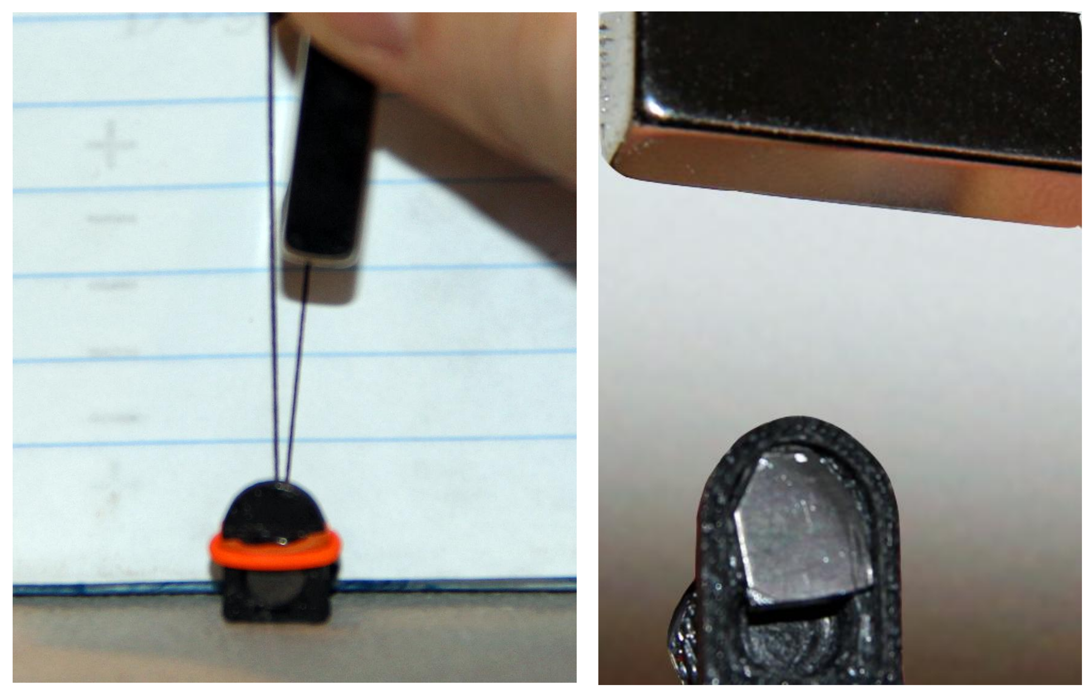
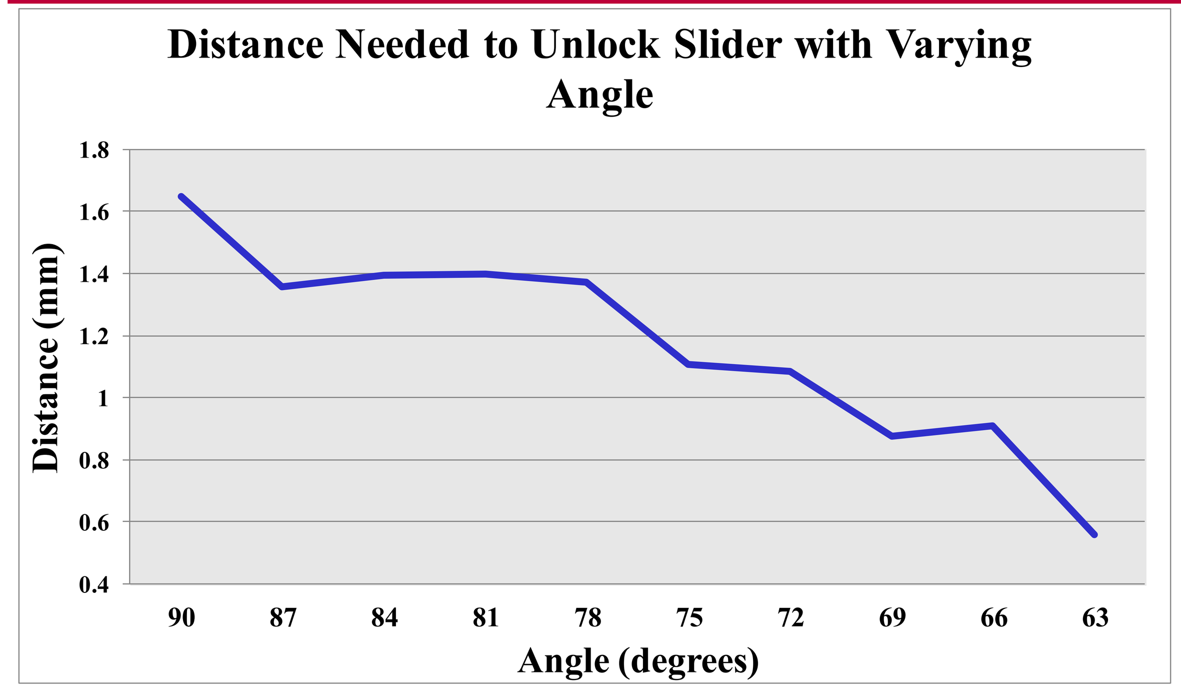


Figure 6: (Left) Neodymium magnet being applied at a 6° angle from the vertical axis. (Right) Magnetic slider model being retracted without the cover piece.

Results (cont.)



Graph 1: Plot of the average distance needed to fully retract the model slider with varied presentation angle. At the maximum accepted distance of 1.2 cm, the effective angle of presentation is approximately 14° from center.

Discussion

- Full retraction is achieved as long as magnet is placed within 1.2 cm and 14° in either direction of the vertical axis
- Bottom attachment point may be out of range
- Incorporation of magnetic cap in place of slider in the bottom attachment would maintain securing mechanism

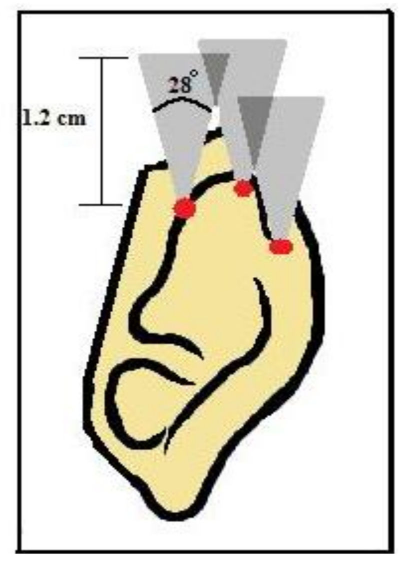


Figure 6: Conceptual depiction of the area that will be utilized for magnetically induced retraction of the ferrous slider

Future Work

- Mill a slightly larger metallic prototype
  - Use prototype to make a mold for a future polymer device
- Create multiple polymer based devices from the mold
- Incorporate three prototypes into a prosthetic ear
- Fabricate a magnetically induced slider piece

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References

1. Alvi R, McPhail J, Hancock K. Closed-field titanium magnets for the retention of complex craniofacial prostheses. Br J Plast Surg 2002;55:668Y670.
2. Sousa AA, et al. Magnetic Retention and Bar-Clip Attachment for Implant-Retained Auricular Prostheses: A Comparative Analysis. International Journal of Prosthodontics 2003;21:3.
3. Miles BA, Sinn DP, Gion GG. Experience with cranial implant-based prosthetic reconstruction. J Craniofac Surg. 2006;17(5):889-97.
4. http://www.medicalartprosthetics.com/content.php?page=process&sec=implant
5. homepages.cae.wisc.edu/~bme200/prosthetics_s07
6. bmedesign.engr.wisc.edu/websites/project