Tympanic Membrane Repair Using a Novel Delivery System in a Chinchilla Model

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Abstract

**Objectives:** Over one million procedures to insert pressure equalization tubes (PETs) are performed each year in the United States alone. Chronic tympanic membrane perforation can result from retained PETs, chronic infection, or trauma. Several methods currently exist for TM perforation closure. We present the novel use of a selectively polymerizable hydrogel for use as a multi-purpose surgical scaffold with drug delivery capabilities for tympanic membrane repair.

**Study Design:** A chinchilla model was used to model chronic tympanic membrane perforations. The protocol was reviewed and accepted by the Institutional Animal Care and Use Committee (IACUC). Twelve adult chinchillas, with 24 total tympanic membranes were utilized in the study. Tympanic membrane perforations were induced in the chinchillas using thermal cautery according to an existing model. Chinchillas have large tympanic membranes (6-9mm) that approximate human size and which are accessible via a transcanal approach. The perforations were examined weekly, and additional cautery was performed on healed tympanic membranes as necessary. Perforations that persisted for four weeks were considered to be chronic.

**Methods:** Animals were anesthetized and perforations were performed surgically under microscopic examination. Tympanic membranes were re-examined and edges were cauterized to ensure patency. Perforations were considered chronic if patent for a period of four weeks. The material was applied to perforations and polymerized with light in situ. The polymerized hydrogel patch was used to close the perforations, which were then re-examined to determine healing at subsequent intervals.

**Results:** Chronic tympanic membrane perforations were achieved in the majority of the chinchillas. The photopolymerizable hydrogel successfully closed 78% of chronic tympanic membrane perforations. Perforations remained patent in 75% of the control group.

**Conclusion:** Our new photopolymerizable hydrogel can be used as a scaffold to repair chronic tympanic membrane perforations.

Methods

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Methacrylated chitosan, hyaluronic acid, riboflavin monophosphate, and ciprofloxacin were mixed in water and loaded into a syringe. This pre-polymerized solution was then ejected onto an ear loop curette and transferred to the perforation. The material was cured using a dental curing light. The gel-patched perforations were monitored weekly, and the healing rate compared to control perforations.

Discussion

The chinchilla offers several advantages for use as an animal model of tympanic membrane perforation. It has a short, straight, and wide ear canal permitting transcanal access for manipulation. Additionally the chinchilla TM is approximately 6 to 9mm, approximating human size. Other sources have investigated the uses of various substances for TM repair. The use of acellular dermal matrix (AlloDerm), calcium alginate, and poly(glycerol sebacate)(PGS) have been described in repair of chronic TM perforations in a chinchilla model. Most recently, the use of cross-linked hydrogel in PETs has been described. Success rates with those substances were comparable to our gel using a similar number of animal perforations. AlloDerm treated chinchilla perforations closed 80% (8/10) of TM perforations when compared to a control of 90% (9/10) treated with fascia tympanoplasty. In using calcium alginate plugs 9/13 (69%) healed in the plug group compared to 22% (2/9) in a paper patch group and 1/1 (11%) in a control group. PGS plugs were successful in repair of 10/11 (91%) chinchilla TM perforations.

We believe our substance offers superior characteristics to those described above. Both calcium alginate and PGS must be fashioned into a plug before inserted into the TM. Our photopolymerizable hydrogel can be delivered transcanal as a liquid onto the TM perforation followed by curing with the light guide. Ultimately, we believe this could allow for in office use. Our hydrogel also has the ability for drug delivery, potentially aiding in the closure of chronically infected perforations. Further investigation is ongoing, including histological analysis.

Conclusion

This new gel patch shows promise as a novel method for tympanic membrane repair and may offer an alternative repair in the clinic as opposed to surgery.

References