ORIGINAL RESEARCH

Otoendoscopic Tympanic Repair of Tympanic Perforations Secondary to Chronic Otitis Media Using Porcine Small-intestine Membrane

Wenya Li, MD; Lina Zhao, MD; Xiuwen Jiang, MD

ABSTRACT

Context • The most common cause of hearing loss is chronic otitis media. Patients often exhibit ear tightness, ear plugging, conductive hearing loss, and even secondary perforation of the tympanic membrane. Patients require antibiotics to improve symptoms, and some patients need surgical repair of the membrane.

Objective • The study intended to examine the effects of two methods of surgical transplantation using porcine mesentery under an otoscope on the surgical outcomes of patients with tympanic-membrane perforation secondary to chronic otitis media, with the intent to provide a basis for clinical practice.

Design • The research team conducted a retrospective case-controlled study.

Setting • The study took place at the Sir Run Run Shaw Hospital of the College of Medicine at Zhejiang University in Hangzhou, Zhejiang, China.

Participants • Participants were 120 patients with tympanic membrane perforations that were secondary to chronic otitis media who had been admitted to the hospital between December 2017 and July 2019.

Intervention • The research team divided the participants into two groups according to the surgical indications for repair of their perforations: (1) for patients with the central type of perforations with a rich residual tympanic membrane, the surgeon used the internal implantation method, and (2) for patients with a marginal or central perforation with a low residual tympanic membrane, the surgeon used the interlayer implantation method. Both groups received the implantations under conventional microscopic tympanoplasty, and the Department of Otolaryngology Head & Neck Surgery at the hospital provided the porcine mesenteric material.

Outcome Measures • The research team compared the differences between the groups in operation time, blood loss, changes in the level of hearing loss between baseline and postintervention, air-bone conductivity, treatment effects, and surgical complications.

Results • The operation time and blood loss of the internal implantation group were significantly greater than those of interlayer implantation group ($P < .05$). At 12 months postintervention, one participant in the internal implantation group had perforation recurrence, and two participants in the interlayer implantation group had infections and two had perforation recurrence. No significant difference existed between the groups in the complication rate ($P > .05$).

Conclusions • Endoscopic repair of tympanic membrane perforations that were secondary to chronic otitis media, using porcine mesentery as the material for implantation, is a reliable treatment with few complications and good postoperative hearing recovery (*Altern Ther Health Med.* 2023;29(3):166-171).

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The most common cause of hearing loss is chronic otitis media, with patients often exhibiting ear tightness, ear plugging, conductive hearing loss, and even secondary perforation of the tympanic membrane. Trauma, chronic or acute otitis media, or tympanic membrane catheterization can cause a perforation. The tympanic membrane is a protective barrier for the middle ear.

Patients require antibiotics to improve symptoms, and some patients need surgical repair of the membrane. Tympanoplasty is the most common surgical method in otorhinolaryngology, head, and neck surgery. Currently, surgeons make the repair of a perforation using tympanic-membrane-perforation surgery.[1,2]

Otologists have been trying to reduce the trauma and improve the success rate of tympanic membrane repair. The traditional linear field of vision in microscopic surgery is limited, is unable to expose the tympanic membrane, and often requires an incision of the posterior ear, which can increase postoperative auricular numbness.[3] Due to those limitations, traditional microscopic surgery can't provide a complete picture of the tympanic membrane, especially for patients with distortion and stenosis of the external auditory canal.

Endoscopic Surgery

Surgeons can repair the tympanic membrane using endoscopic surgery. The surgeon can access the tympanic membrane and the tympanum of the middle-ear cavity through the external auditory canal and middle ear using endoscopy. Moving and adjusting the endoscopic lens allows doctors to obtain a clear view, avoiding the need to move the patient's head or the microscope to adjust the surgical field.[4]

Moreover, the exploratory area of the ear, nose, and throat (ENT) is direct and wide, providing a wide range of visual effects; this gives the surgeon a comprehensive, three-dimensional view, thereby obtaining more comprehensive information of the surgical area.[5] Zhang et al found that an otoscope can maneuver around surgical instruments that block the surgical field or the surgeon can visualize the surgical field around the instrument's anterior segment, which solves the problem of surgical-field occlusion that can affect the surgeon's normal procedure and which can improve the operation's safety.[6]

Graft Materials

The most commonly used materials for grafts are the temporal muscle fascia and the ear cartilage membrane. In recent years, otologists have gradually replaced autologous grafts with allogeneic grafts.[7] During an operation, autologous grafts require the surgeon to obtain the temporal fascia or ear-cartilage membrane using an incision on one side of the scalp, in addition to the incision necessary for accessing the tympanic membrane; this requires the patient's hair to be cut and potentially affects his or her appearance.[8] With the progression of graft research in recent years, the use of substitutes for the patient's own graft tissue for xenotransplantation has gradually occurred.

One substitute is the submucosal tissue of the porcine small intestine, mesenteric tissue. Intestinal submucosa is a kind of cell-free biological tissue, that surgeons can use as a scaffold for tissue repair and remodeling.

The portion of the tympanic membrane that the surgeon repairs with that tissue has three layers, including the upper cortex. The surgeon uses a graft as the intermediate layer and replaces the fibrous layer, also known as the intermediate layer. The inner side is the mucosal layer.

Zhang et al used porcine small-intestine submucosa to repair the tympanic membrane, including the epithelial, intermediate, and mucosal layers.[6] Minaga et al performed tympanoplasty to repair perforations of the tympanic membrane using autologous cartilage on one side of the ear and porcine tissue on the other side.[9] Five participants had been cured with submucosal intestinal tissue, and five participants had been cured with autologous cartilage.

Current Study

The current study intended to examine the effects of two methods of surgical transplantation using porcine mesentery under an otoscope on the outcomes of patients with tympanic-membrane perforation secondary to chronic otitis media, with the intent to provide a basis for clinical practice.

METHODS

Participants

The research team conducted a retrospective case-controlled study. The study took place at the Sir Run Run Shaw Hospital of the College of Medicine at Zhejiang University in Hangzhou, Zhejiang, China. Potential participants were patients with tympanic membrane perforations that were secondary to chronic otitis media who had been admitted at the hospital between December 2017 and July 2019.

The study included potential participants if they: (1) were aged 18 to 75 years, (2) had recurrent chronic otitis media, dry ear, or active otitis media and traumatic perforation of the tympanic membrane, and (3) had a diagnosis based on the diagnostic criteria from *Otolaryngology Head and Neck Surgery, Eighth Edition*.[10]

The study excluded potential participants if they: (1) had an ear-canal malformation, (2) had a history of head or neck tumors, (3) had bone chain interruption or tympanic mastoid lesions, (4) had purulent secretions in the tympanic cavity, or (5) had other types of surgical contraindications.

Procedures

Groups. The research team divided the participants into two groups according to the surgical indications for repair of their perforations. For participants with the central type of perforations with a rich residual tympanic membrane, the research team used the internal implantation method. For participants with a marginal or central perforation with a low residual tympanic membrane, the research team used the interlayer implantation method, the sandwich method. Both groups received the implantations under conventional microscopic tympanoplasty, and the Department of Otolaryngology Head & Neck Surgery at the hospital provided the porcine mesenteric material.

Internal implantation method. The surgeons used the ear endoscope 7220AA (Karl Storz, Tuttlingen, Germany) to perform the implantation after achieving satisfactory general anesthesia.

The surgeons: (1) visualized the residual tympanic membrane approximately one mm away from the fibrous tympanic ring; (2) removed any scars at the edge of the tympanic membrane perforation under an otoscope; (3) filled the tympanic cavity with Naximian (Polycare, Beijing, China); (5) cut submucosal tissue of the appropriate size from the porcine mesentery; (5) flattened the tissue at the perforation on the inner side of the tympanic membrane and filled the outer side with Naximian and (6) compressed the outer part of the external auditory canal with gauze impregnated with ofloxacin antibiotic ointment (Santen Pharmaceutical Co.,Ltd., Suzhou, Jiangsu province, China).

Interlayer implantation method. The surgeons again used the ear endoscope 7220AA (Karl Storz, Tuttlingen, Germany) to perform the implantation after achieving satisfactory general anesthesia. The surgeons: (1) used rigid ear endoscopes that were 4 mm in diameter, 0°, and 18 cm long; (2) cut the external auditory canal flap 5 cm from the tympanic ring and lifted the external auditory canal flap; (3) separated the tympanic membrane's epithelial layer of the external auditory canal and exposed the tympanic ring and membrane fiber layer; (4) filled the tympanic cavity with sponge; (5) took the appropriate size of porcine mesenteric submucosa tissue and laid it flat between the tympanic membrane fiber layer and the flap of the external auditory canal; (6) restored the flap; and (7) when the outer side of the flap defect was filled with Naximian, compressed gauze impregnated with ofloxacin antibiotic ointment (Santen Pharmaceutical Co., Ltd., Suzhou, Jiangsu province, China) against the outer segment of the external auditory canal.

Postoperative care. The gauze strips were drawn out and keep the Naximian inside the ear canal at one week postoperatively, and the surgeon sucked out the Naximian in the ear canal at three weeks postoperatively.

Outcome measures. The research team compared the differences between the groups in operation time, blood loss, changes in the level of hearing loss between baseline and postintervention, air-bone conductivity, treatment effects, and surgical complications.

Outcome Measures

Blood loss. Because medical personnel usually estimate blood loss from a surgical wound using the gauze, the research team evaluated surgical bleeding by weighing the sterile gauze pre- and postoperatively. The team recorded the difference between the two plus the blood in the attractor as the total blood loss.

Hearing status. The research team evaluated participants' hearing using a test with a the ticking sound of a watch, which the team placed in the same place each time because the sounds are transmitted through the air. The normal hearing range is between 0 dB and 25 dB.

Pneumatic bone conductance. The research team assessed conductance by measuring the auditory threshold. To transmit sound to the inner ear, the team made the participants' skull vibrate using a bone vibrator located in the mastoid or forehead behind the ear. The team compared the groups' air-conduction hearing ability and the air-bone gap at baseline and at one month, 6 months, and 12 months postintervention.

Therapeutic effects. The research team evaluated therapeutic effects based on Durgut and Dikici's guidelines[11]: (1) the disappearance of clinical symptoms, such as tinnitus, ear blockage, and ear tightness, (2) The increase of speech frequency of pure tone audiometry greater than 20 dB, and (3) cure of the tympanic membrane perforation; Alleviation of clinical symptoms such as tinnitus, ear blockage and ear tightness, and the increase of speech frequency of pure tone audiometry of 10–20dB. When participants' clinical symptoms and the results of their pure-tone test results didn't improve and the tympanic membrane perforation didn't heal between baseline and 12 months postintervention, the team considered the treatment to be unsuccessful.

Tympanic-membrane healing rate. The research team successful healing based on Umamaheswaran et al's guidelines[9]: (1) the tympanic membrane graft had survived, and the thickness was similar to that of the original normal tympanic membrane; (2) the surface of the healing tympanic membrane was smooth; (3) the color of the graft was similar to that of the normal tympanic membrane; and (4) no atrophy, thinning, or adhesion of the graft had occurred.

Statistical Analysis

The research team performed all statistical analyses of data using the SPSS 21.0 software (IBM, Armonk, NY, USA). The team: (1) tested participants' measurement indexes, such as hearing loss and air-bone conductance, for normal distribution, and all data were all in line with approximate normal distribution or normal distribution; (2) expressed measurement data as means ± standard deviations (SDs) and used students *t* test for comparisons between the two groups; (3) expressed the enumeration data as numbers and percentages (%) and performed comparisons using the χ^2 test. $P<.05$ indicated a significance result.

RESULTS

Participants

Table 1 shows that no significant differences existed between the groups at baseline in ages, genders, body mass indexes (BMIs), or diameters of the tympanic membrane perforation ($P>.05$).

Operation Time and Surgical Blood Loss

Table 2 shows that interlayer implantation group's operation time, at 48.9 ± 5.0 min, was significantly higher than that of the internal implantation group, at 45.3 ± 4.1 ($P=.001$). The interlayer implantation group's blood loss, at 16.2 ± 4.1 mL, was also significantly higher than that of the internal implantation group, at 13.0 ± 4.4 ($P=.003$).

Air Conduction Hearing

Table 3 and Figure 1 show that no significant difference existed between the groups in participants' air conduction hearing ability at baseline or at one month, 6 months, or 12 months postintervention ($P>.05$).

Table 1. Comparison of Demographic and Clinic Characteristics of Participants in Internal and Interlayer Implantation Groups at Baseline (N = 120)

Implantation Group	n	Age, y Mean ± SD	Gender Male n (%)	Gender Female n (%)	BMI, kg/m² Mean ± SD	Perforation Diameter, mm Mean ± SD
Internal	21	36.3 ± 6.0	13 (61.90)	8 (38.10)	23.5 ± 1.9	4.03 ± 0.85
Interlayer	99	34.8 ± 6.4	59 (59.60)	40 (40.40)	23.8 ± 2.2	4.20 ± 0.72
t/χ^2		0.986	0.038		-0.580	-0.952
P value		.326	.844		.563	.343

Abbreviations: BMI, body mass index.

Table 2. Comparison of Operation Time and Blood Loss of Participants in Internal and Interlayer Implantation Groups (N = 120)

Implantation Group	n	Operation Time, min Mean ± SD	Surgical Bleeding, mL Mean ± SD
Internal	21	45.3 ± 4.1	13.0 ± 4.4
Interlayer	99	48.9 ± 5.0	16.2 ± 4.1
t		3.513	3.062
P value		.001[a]	.003[a]

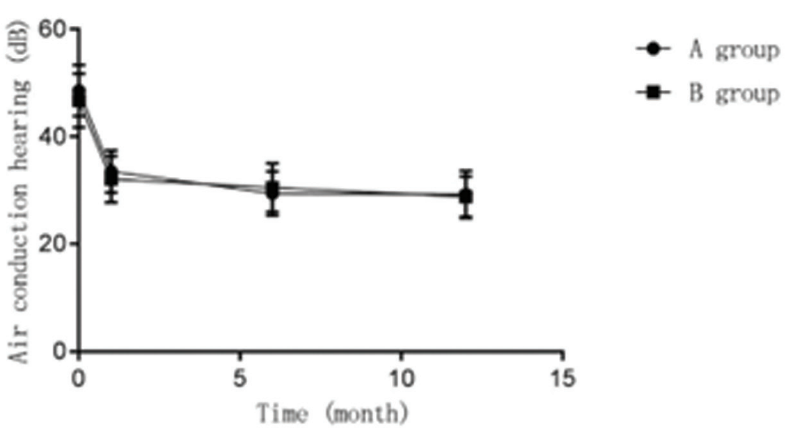
[a]$P < .05$, indicating that the operation time and surgical bleeding were significantly higher for the internal group than for the interlayer group

Table 3. Comparison of Air Conduction Hearing Ability Between Baseline and 12 Months Postintervention for the Internal and Interlayer Implantation Groups (N = 120)

Implantation Group	n	Baseline Mean ± SD	1 Month Postintervention Mean ± SD	6 Months Postintervention Mean ± SD	12 Months Postintervention Mean ± SD
Internal	21	48.56 ± 4.77	33.50 ± 3.91*	29.43 ± 4.11*	29.20 ± 4.45*
Interlayer	99	46.71 ± 5.02	32.08 ± 4.28*	30.50 ± 4.50*	28.84 ± 3.82*
t		1.547	1.401	-1.004	0.381
P value		.125	.164	.317	.704

[a]$P < .05$, indicating that the air conduction hearing of both groups had significantly decreased between baseline and one month, between baseline and 6 months, and between baseline and 12 months postintervention

Figure 1. Trend Chart of Changes Between Baseline and 12 Months Postintervention in the Air Conduction Hearing of Participants in the Internal and Interlayer Implantation Groups (N = 120).



The internal implantation group's air conduction hearing ability had significantly decreased between baseline, at 48.56 ± 4.77, and one month postintervention, at 33.50 ± 3.91; between baseline and 6 months postintervention, at 29.43 ± 4.11; and between baseline and 12 months postintervention, at 29.20 ± 4.45 ($P > .05$).

The interlayer implantation group's air conduction hearing ability had significantly decreased between baseline, at 46.71 ± 5.02, and one month postintervention, at 32.08 ± 4.28; between baseline and 6 months postintervention, at 30.50 ± 4.50; and between baseline and 12 months postintervention, at 28.84 ± 3.82 ($P > .05$).

Table 4. Comparison of Differences in Air-Bone Conduction Between Baseline and Postintervention for the Internal and Interlayer Implantation Groups (N = 120)

Implantation Group	n	Baseline Mean ± SD	1 Month Postintervention Mean ± SD	6 Months Postintervention Mean ± SD	12 Months Postintervention Mean ± SD
Internal	21	27.66 ± 3.51	16.19 ± 2.52[a]	13.48 ± 2.71[a]	12.43 ± 2.20[a]
Interlayer	99	28.50 ± 3.85	15.74 ± 2.70[a]	13.20 ± 2.84[a]	11.96 ± 2.48[a]
t		-0.921	0.701	0.414	0.803
P value		.359	.484	.680	.423

[a]$P < .05$, indicating that the air conduction hearing of both groups had significantly decreased between baseline and one month, between baseline and 6 months, and between baseline and 12 months postintervention

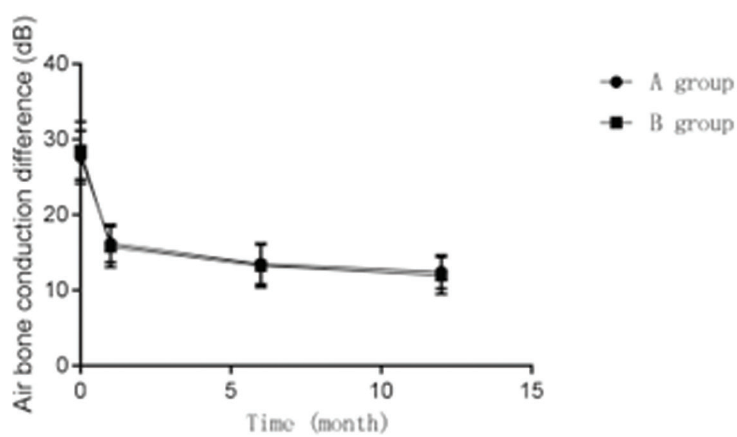
Air-Bone Conduction

Table 4 and Figure 2 show that no significant difference existed in participants' air-bone conduction between the groups at baseline or at one month, 6 months, or 12 months postintervention ($P > .05$).

The internal implantation group's air-bone conduction had significantly decreased between baseline, at 27.66 ± 3.51, and one month postintervention, at 16.19 ± 2.52; between baseline and 6 months postintervention, at 13.48 ± 2.71; and between baseline and 12 months postintervention, at 12.43 ± 2.20 ($P > .05$).

The interlayer implantation group's air-bone conduction had significantly decreased between baseline, at 28.50 ± 3.85 and one month postintervention, at 15.74 ± 2.70; between baseline and 6 months postintervention, at 13.20 ± 2.84; and between baseline and 12 months postintervention, at11.96 ± 2.48 ($P > .05$).

Figure 2. Trend Chart of Differences Between Baseline and 12 Months Postintervention in the Air-Bone Conduction of Participants in the Internal and Interlayer Implantation Groups (N = 120)



Total Effective Treatment Rate

At 3 months postintervention, the total effective rate for the internal implantation group was 85.71% and for the interlayer implantation group was 91.92% (Table 5)

No significant differences existed between the groups in therapeutic effect ($P > .05$), and both groups had a high therapeutic effect.

Table 5. Comparison of the Total Effective Rate of Treatment at 3 Months Postintervention for Participants in the Internal and Interlayer Implantation Groups (N=120)

Implantation Group	n	Cure n (%)	Efficient n (%)	Invalid n (%)	Total Effective Rate n (%)
Internal	21	15 (71.43)	5 (23.81)	1 (4.76)	18 (85.71)
Interlayer	99	73 (73.74)	23 (23.23)	3 (3.03)	91 (91.92)
χ^2					0.801
P value					.371

Surgical Complications

At 12 months postintervention, one participant in the internal implantation group had perforation recurrence, and two participants in the interlayer implantation group had infections and two had perforation recurrence (Table 6). No significant difference existed between the groups in the complication rate ($P > .05$).

Table 6. Comparison of Surgical Complications Between Internal and Interlayer Implantation Groups (N=120)

Implantation Group	n	Secondary Infection n (%)	Pierced Again n (%)	Total Complication Rate n (%)
Internal	21	0 (0.00)	1 (4.76)	1 (4.76)
Interlayer	99	2 (2.02)	2 (2.02)	4 (4.04)
χ^2				0.023
P value				.881

Two Typical Cases

Figure 3 and Figure 4 show two typical cases. For a 37year-old participant with a perforation caused by chronic

Figure 3. The Central Tympanic Membrane of a 37-year-old Female Participant With a Perforation Caused by Chronic Otitis Media. The research team treated her with endoscopic implantation of porcine mesentery as the material for the repair of the perforation. Figure 3A shows the membrane before repair; Figure 3B shows it at the end of the repair; and Figure 3C shows it at three months after the repair. The tympanic membrane healed well after the repair.

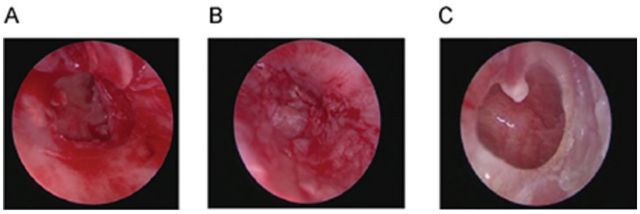
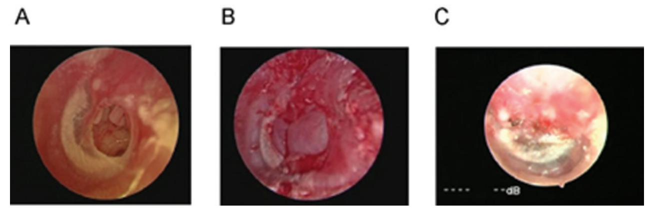


Figure 4. The Tympanic Membrane of the Left Ear of a 26-year-old Male Patient With a Perforation of the Posterior Edge Caused by Chronic Otitis Media. The research team used porcine mesentery as the material for the repair of the perforation and implanted it using an otoscope. Figure 4A shows the membrane before repair; Figure 4B shows it at the end of the repair; and Figure 4C shows it at three months after the repair. The tympanic membrane healed well after the repair.



otitis media, Figure 3A shows the membrane before repair; Figure 3B shows it at the end of the repair; and Figure 3C shows it at three months after the repair. For a 26-year-old male patient with a perforation of the posterior edge caused by chronic otitis media, Figure 4A shows the membrane before repair; Figure 4B shows it at the end of the repair; and Figure 4C shows it at three months after the repair.

DISCUSSION

In the current study, for the repair of a tympanic membrane perforation that was secondary to chronic otitis media, the operation time of the internal implantation group and the amount of intraoperative blood loss was significantly greater than that of the interlayer implantation group. This suggests that the use of porcine mesenteric material and interlayer implantation under an otoscope can shorten the operation time and reduce intraoperative bleeding.

In the current study, the air conduction hearing ability and the air-bone conduction of the two groups at 12 months postintervention were significantly lower than those at baseline. This suggests that the use of porcine small mesentery and implantation under an otoscope can significantly improve the hearing ability of participants and reduce the pre- and postoperative difference in air-bone conduction.

The current research team found during the course of surgery that the mesentery wasn't sticky and that the surgeons should fill the tympanic cavity with enough sponge that the patch and residual tympanic membrane are in sufficient contact. If the perforation is small, the tympanic cavity is relatively full; however, no filling lies under the residual tympanic membrane. Postoperatively, with the participant's activities, the sponge loosens, the patch falls into the tympanic cavity, and the tympanic membrane production loses the stent. The interlayer method can solve this problem.

In the current study, no significant difference existed in the treatment effects and surgical complications between the two groups, suggesting that the use of pig small mesentery as a material for implantation under otoendoscopy to is reliable and has few complications. Both can be considered as effective clinical treatment options.

The current study had some limitations. Physical activity was associated with many diseases.[12,13]The relationship between physical activity and chronic otitis media should be further explored . The number of participants included in the study was small, and the follow-up time was short. Future studies require further analysis and demonstration.

CONCLUSIONS

Otoendoscopic repair of tympanic membrane perforations that were secondary to chronic otitis media, using porcine mesentery as the material for implantation, is a reliable treatment with few complications and good postoperative hearing recovery.

AUTHORS' DISCLOSURE STATEMENT

The authors declare that they have no conflicts of interest related to the study.

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