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A retrospective study on the outcomes of stapedotomy with vein graft interposition and vein graft surround techniques

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Abstract

Objective. This study evaluated audiological outcomes of stapedotomy using two different techniques, vein graft interposition and vein graft surround, for sealing the stapes fenestra.

Method. A retrospective study of 130 patients who underwent stapedotomy for otosclerosis was performed. A total of 84 patients underwent the vein graft surround procedure and 46 underwent the vein graft interposition procedure. Post-operative hearing outcome was compared between them.

Results. A total of 55 of 130 patients had a post-operative air–bone gap of less than 10 dB. A total of 57 patients had an air–bone gap within 20 dB. The average air–bone gap was 13.16 dB at 3 months with a mean improvement of 22.06 dB (11.98 dB for vein graft interposition and 13.80 dB for vein graft surround; $p = 0.79$).

Conclusion. There was no significant difference in hearing outcome between the two techniques. The vein graft interposition technique is preferred for large fenestra or stapedectomy cases and in cerebrospinal fluid gusher cases. The vein graft surround technique is easier to perform and preferred in small fenestra stapedotomy.

Main Article

Dr S Colvin takes responsibility for the integrity of the content of the paper

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Introduction

Otosclerosis is a bone remodelling disorder of the otic capsule that causes stapes footplate fixation leading to progressive conductive hearing loss.[1] Hearing loss with occasional tinnitus are the main complaints of such patients.[2] Otosclerosis is estimated to cause about 10 per cent of all hearing loss and 18–22 per cent of conductive hearing loss. Hearing aids and stapes surgery are the main management options.[3] In the last few decades, the technique of stapes surgery has evolved from stapedectomy to stapedotomy, with or without tissue interposition.[4] Small fenestra stapedotomy is presently the treatment of choice for otosclerosis.[5] However, despite this modification there have been incidences of perilymph fistula, post-operative sensorineural hearing loss and dizziness.[1]

In 1986, Johannes Kessel described the use of connective tissue and vein graft for sealing the oval window after stapedectomy.[6] In 1956, Shea described the first stapedectomy with vein graft interposition.[7] Different autologous materials, such as adipose tissue, blood, vein, fascia, perichondrium and heterologous gelatin sponge (Gelfoam®) and esterified hyaluronic acid (Merogel®), have been used for sealing the fenestra after stapedotomy and stapedectomy.[8,9] Vein graft serves as a medium for conduction of sound with reduced risk of fistulas and cochlear damage.[10] It is also better when compared with other tissue grafts because vein grafts contain sufficient elastic fibres to provide compliance and resistance that is similar to the annular ligament, and it helps in long-term protection against perilymph leak.[5]

With the vein graft interposition technique, a stapedotomy is made in the posterior half of the footplate, usually with a laser or a microdrill (typically 0.8 mm or more in diameter) and is covered with a vein graft. The piston is placed over the graft and crimped onto the incus. The adventitia faces the vestibule so that it sticks to the footplate and prevents adhesions between the tympanic membrane and medial wall of the middle ear.

However, when making a small fenestra (0.6 mm or less) with a manual perforator, it is difficult to use the vein graft interposition technique as visibility of the stapedotomy through the graft becomes limited. Therefore, in our institution we have adopted a modification of the technique where the vein graft is slit half-way and positioned with the adventitia facing the vestibule around the piston and covering the stapedotomy. We called this the vein graft surround technique.

The aim of this study was to compare the audiological outcomes of the two techniques of using vein graft (vein graft interposition and the vein graft surround) in small fenestra stapedotomy.

Materials and methods

A retrospective chart review of all patients who underwent stapedotomy at our tertiary care hospital from 1 January 2014 to 1 March 2020 was performed after institutional

review board and ethics committee clearance. Demographic, clinical, surgical and audiological data were collected. All the patients included in the study had a pre-operative, clinical and audiological assessment completed, and they were followed up after surgery and re-assessed.

All the surgical procedures were performed by senior surgeons with at least 6 years' experience after specialisation. A transmeatal stapedotomy was carried out under general anaesthesia. Stapes fixation was confirmed by gentle palpation of the ossicular chain. A microperforator was used for making a control fenestra of the footplate following which the incudostapedial joint was separated and the stapedial tendon was cut. The stapedial suprastructure was downfractured and removed, and the perforation was enlarged to a 0.5- or 0.6-mm opening. A stapes Teflon® piston of 0.4–0.6 mm diameter and appropriately measured length was placed in the fenestra followed by crimping of the piston on the long process of incus.

One of the two techniques were used to cover the oval window fenestra, using a small segment of thin vein harvested from the dorsum of the hand after removal of excess adventitia. With the vein graft interposition technique, the vein graft was placed over the oval window with the adventitia side facing and covering the fenestra. This was followed by placement of the piston over the graft and into the fenestra.[11] (Fig. 1a and b)

With the vein graft surround technique, the piston was first placed in the fenestra made in the oval window followed by placement of the vein graft around the piston with the adventitia side facing the fenestra and covering the rest of the exposed fenestra with the help of a slit in the graft (Fig. 2a and b). The tympanomeatal flap was finally repositioned after performing the bend and lift test.[12,13]

Audiological assessment

Air–bone gap (ABG), air conduction and bone conduction thresholds were measured pre-operatively and post-operatively. A 4-frequency pure tone average value was calculated for air conduction and bone conduction thresholds at 500, 1000, 2000 and 4000 Hz obtained pre- and post-operatively. All patients were followed up post-operatively for a minimum of 3 months and a maximum of up to 60 months with an average follow up of 12.28 months. In the vein graft surround group, 50 per cent had a minimum follow up of 1 year, and in the vein graft interposition group, 48 per cent had a minimum follow up of 1 year.

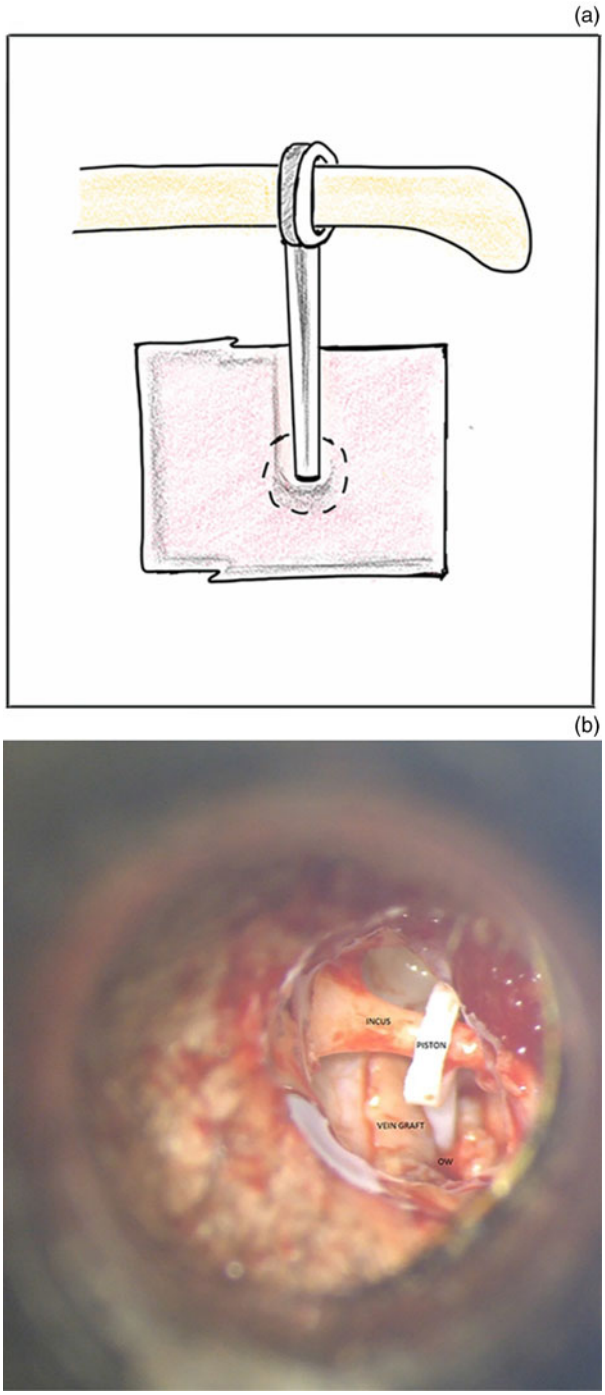

Figure 1. (a) Vein graft interposition diagram showing the piston placed over the vein graft. (b) Microscopic image of vein graft interposition technique. OW = oval window

Results

There were 202 cases of stapes surgery performed in the study period. There were 128 cases in the vein graft surround group and 74 cases in the vein graft interposition group, out of which 72 patients were not included because of lack of proper documentation, such as missing audiograms and a minimum follow up of at least 3 months.

Many of our patients came a great distance to our tertiary care centre and therefore did not return for a further follow up (this was particularly the case when the outcomes were good). Records of 130 patients who had at least a three-month follow up were analysed. Among these there were 84 patients in the vein graft surround group and 46 patients in the vein graft interposition group. The mean age of patients in the vein graft surround group was 38 years and in the vein graft interposition group was 39 years. There were 54 (64 per cent) males and 30 (36 per cent) females in the vein graft surround group compared with 25 (54.34 per cent) males and 21 (45.65 per cent) females in the vein graft interposition group. There were 46 right ears (54.76 per cent) and 38 left ears (45.23 per cent) operated on in the vein graft surround group compared with 21 right ears (45.65 per cent) and 25 left ears (54.34 per cent) in the vein graft interposition group. The average speech discrimination score pre-operatively for the patients in the vein graft surround group was 96 per cent, and this was 97 per cent in the vein graft interposition group. The type of stapedial otosclerosis seen intra-operatively, the complications and anomalies encountered, and the piston used are shown in Tables 1–3.

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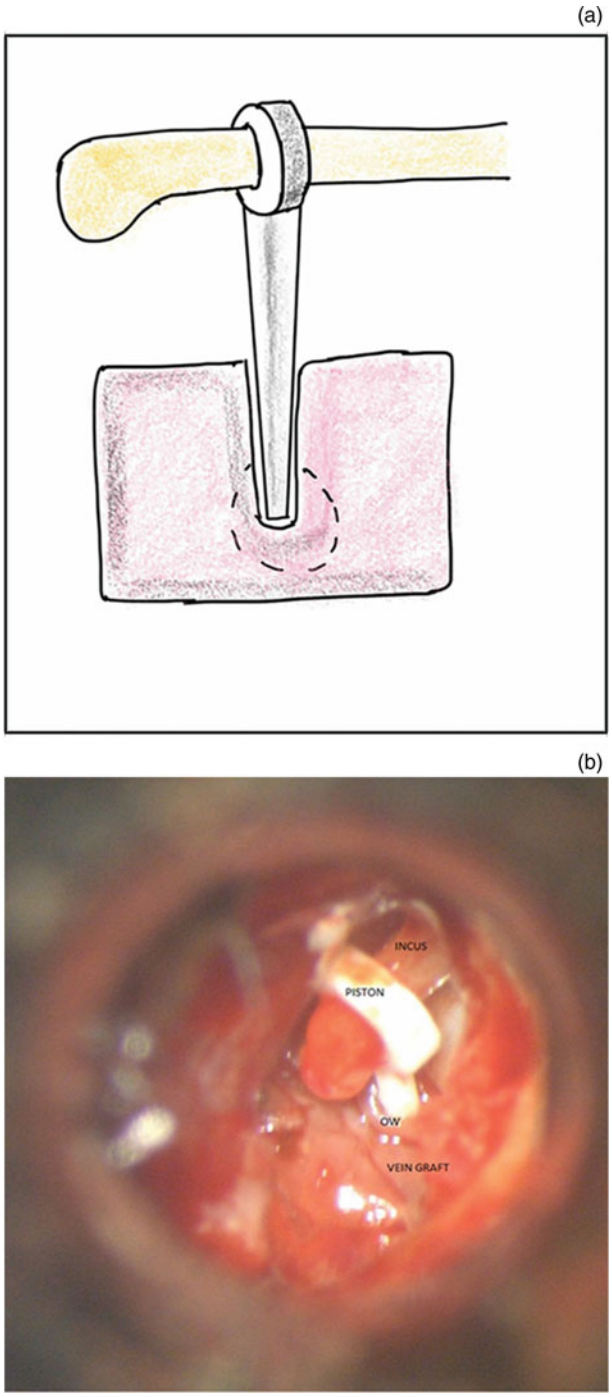

Figure 2. (a) Vein graft surround diagram showing the piston placed in the oval window (OW) fenestra surrounded by vein graft. (b) Microscopic image of vein graft surround technique.

Pre- and post-operative audiological assessment

A total of 130 patients underwent pure tone audiometry before surgery along with speech audiometry (Table 4). All 130 patients had their pure tone audiometry performed at around 12 weeks after surgery. There was an improvement in air conduction and bone conduction thresholds for both groups along with significant ABG closure. None of the patients had any post-operative sensorineural hearing loss or worsening of conductive hearing loss.

The average post-operative air conduction was 28.33 dB (standard deviation (SD), 10.86 dB) with a mean improvement of 31.26 dB ($p = 0.000$). The post-operative bone conduction average was 15.22 dB (SD, 8.79 dB) with a mean improvement of 4.78 dB ($p = 0.000$) without any reduction in the bone conduction thresholds in any patient.

The post-operative ABG average of 130 patients was 13.16 dB (SD, 6.69 dB) at 3 months with a mean improvement of 22.06 dB ($p = 0.000$). Post-operative ABG average of 46 patients with vein graft interposition was 11.98 dB ($p = 0.000$), and in the 84 patients with vein graft surround it was 13.80 dB ($p = 0.000$). The mean post-operative ABG of both the groups at their last follow up was 13.75 dB.

Out of 130 patients, 55 had a post-operative ABG of less than 10 dB, 57 patients had ABG closure within 20 dB and the remaining 18 patients had a post-operative ABG of more than 20 dB at 3 months. At the last follow up, the ABG was less than 10 dB in 48 patients (36.9 per cent) and between 11 and 20 dB in 62 patients (47.7 per cent), with 20 patients having a post-operative ABG of more than 20 dB (Table 5).

In the vein graft surround group, the average ABG of 84 patients at 3 months was 13.80 dB, and at their last follow up it was 14.12 dB. In the vein graft interposition group, the average ABG of 46 patients at 3 months was 11.98 dB, and

Table 1. Types of stapedial otosclerosis encountered intra-operatively

Type	Vein graft interposition (*n* (%))	Vein graft surround (*n* (%))
Anterior focus	4 (8.6)	6 (6.9)
Posterior focus	35 (76.0)	67 (79.7)
Circumferential	–	2 (2.3)
Biscuit type	–	1 (1.1)
Obliterative	7 (15.2)	8 (9.3)

Table 2. Complications and anomalies encountered during surgery

Complication	Vein graft interposition (*n*)	Vein graft surround (*n*)
Stapedectomy/inadvertent removal of footplate	4	1
Facial nerve overhang	4	3
Cerebral spinal fluid gusher	1	
Perilymph ooze	1	
Tympanic membrane tear		1
Incus hypermobility		1

Table 3. Piston size in both groups

Piston	Size (mm)	Vein graft interposition (*n* (%))	Vein graft surround (*n* (%))
Diameter	0.4	5 (10.86)	3 (3.57)
	0.5	19 (41.30)	64 (76.19)
	0.6	22 (47.82)	17 (20.23)
Length	3.50	–	2 (2.38)
	3.75	3 (6.52)	12 (14.28)
	4.00	17 (36.95)	26 (30.95)
	4.25	19 (41.30)	30 (35.71)
	4.50	7 (15.21)	11 (13.09)
	4.75	–	3 (3.57)

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Table 4. Pre-operative audiological assessment of the groups

	Total		Vein graft interposition		Vein graft surround	
Parameter	Value (mean; dB)	Value (SD; dB)	Value (mean; dB)	Value (SD; dB)	Value (mean; dB)	Value (SD; dB)
Air conduction average	59.59	10.15	58.34	8.10	60.28	11.10
Bone conduction average	20	8.71	20.35	6.67	19.81	9.69
Air–bone gap average	39.22	6.73	37.77	6.08	40.01	6.97

SD = standard deviation

Table 5. Post-operative audiological assessment of the groups at 12 weeks

	Total		Vein graft interposition		Vein graft surround	
Parameter	Value (mean; dB)	Value (SD; dB)	Value (mean; dB)	Value (SD; dB)	Value (mean; dB)	Value (SD; dB)
Air conduction average	28.33	10.86	26.84	9.89	29.15	11.35
Bone conduction average	15.22	8.79	14.75	8.45	15.48	9.01
Air–bone gap average	13.16	6.69	11.98	6.96	13.80	6.50

SD = standard deviation

Table 6. Comparison of pre- and post-operative hearing thresholds in both vein graft surround and vein graft interposition groups

Parameter	Hearing threshold	Mean (dB)	Pre- to post-operative difference (dB)	*P*-value
Vein graft interposition	Pre-operative air conduction	58.34	31.49	0.000
	Post-operative air conduction	26.84		
	Pre-operative ABG	37.77	25.78	0.000
	Post-operative ABG	11.98		
Vein graft surround	Pre-operative air conduction	60.28	31.13	0.000
	Post-operative air conduction	29.15		
	Pre-operative ABG	40.01	26.20	0.000
	Post-operative ABG	13.80		

ABG = air–bone gap

at the last follow up it was 13.09 dB (Table 6). There was no significant difference in the mean ABG closure post-operatively in the two groups ($p = 0.79$).

Discussion

Stapes surgery is one of the most satisfying surgical procedures for an otologist. However, small differences in technique can play a large role in the hearing outcome. Many techniques of sealing a stapedotomy have been described using various autologous and heterologous materials, such as blood patch, fat, fascia, perichondrium, vein graft, Gelfoam and esterified hyaluronic acid (Merogel).[6,14]

In 1998, Shea documented stapedotomy on 5444 patients using vein graft in 55 per cent of cases (with the closure of ABG to 10 dB in 87.8 per cent), the middle ear lining in 25 per cent of cases (with a success rate of 89.7 per cent), Gelfoam in 9 per cent of cases (with a success rate of 80.3 per cent), loose connective tissue in 7 per cent of cases (with a success rate of 88.7 per cent), and fascia and perichondrium in 4 per cent of cases.[15]

Sheehy and Perkins, in 1976, documented a stapedio-vestibular margin membrane formation and oval window fibrosis as two major causes of failure when using Gelfoam, resulting in post-operative balance disturbance, sensorineural hearing impairment and oval window fibrosis.[16] Sheehy and Perkins and Incesulu and Häusler documented a higher incidence of fistula and sensorineural hearing loss with Gelfoam closure of the oval window when compared with tissue seal.[6,16]

Vein graft has been a good sealant material in stapedotomy surgery. It is readily available, less reactive and reduces the chances of a post-operative perilymph leak, sensorineural hearing loss and vertigo. The vein graft interposition technique has been used for a long time to cover the stapes fenestra. Schmerber *et al.* recommended a vein graft interposition over perichondrium because of 91 per cent ABG closure within 10 dB as compared with 76 per cent in the perichondrium group.[10]

Perkins and Curto suggested that vein graft interposition is superior to a blood patch around the prosthesis and demonstrated 86 per cent closure of ABG to 10 dB in the vein graft interposition group compared with only 59 per cent of patients with a blood patch.[17] In our study, we achieved an overall ABG closure within 20 dB in 84.6 per cent of patients, and only 36.9 per cent had an ABG of less than 10 dB.

The vein graft surround method is technically easier especially when using a manual microperforator for the fenestra. Visualisation is better when placing the piston in the fenestra, and the benefits of the sealant property of the vein graft are still obtained. Placing the vein graft around the piston may also act as a support for the piston.

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The average pre-operative ABG in the vein graft interposition and vein graft surround groups were 37.77 dB and 40.01 dB, respectively, which were comparable. Other studies have documented a pre-operative ABG of 28 to 38 dB.[18,19,20]

The size of the piston (diameter and length) seems to play a role in the outcome of surgery. Cheng *et al.* reported a success rate of 67 per cent for ABG closure to 10 dB for a 0.6 mm diameter prosthesis versus 58 per cent for a 0.4 mm diameter prosthesis with a 4.5 mm long piston, and this was statistically significant.[21] Persson *et al.* documented better hearing results with larger diameter pistons because they seem to improve sound transmissions.[22] Individually measured length of piston for a loop-excluding prosthesis was measured from incus to footplate; some surgeons measured from the middle of the incus diameter, and some preferred measuring from the medial aspect of the incus (under the surface). However, we did not take into account the diameter and length of piston used in our analysis because our objective was to compare the two techniques of vein graft seal. No difference in method of measuring piston length was adopted based on the technique. Piston lengths ranged from 3.75 to 4.50 mm in the vein graft interposition group as compared with 3.50 to 4.75 mm in the vein graft surround group. We feel that the interposition of the vein graft offers a negligible difference in length of prosthesis.

A successful post-operative hearing outcome after stapes surgery is defined as an ABG closure of 10 dB or less without decline of speech discrimination of more than 10 per cent.[23] However, a review of several studies showed lower 'success' rates than that defined above. In 2013, Sarkar *et al.* documented ABG gap closure of less than 10 dB in 56 per cent and less than 20 dB in 100 per cent of stapedotomy cases.[24] In 2015, Naik *et al.* showed a 55 per cent success rate in stapedotomy with less than 10 dB ABG gap closure and with less than 20 dB ABG closure in 85 per cent. [25] Similarly, in 2016, Daneshi *et al.* documented a 58 per cent success rate and less than 20 dB closure in 95 per cent.[26] In 2020, Bianconi *et al.* documented less than 10 dB ABG closure in 78 per cent and less than 20 dB in 93 per cent.[27]

There could be several reasons attributed to residual large ABG gap post-stapedotomy. Some reasons described in the literature are: an unaddressed lateral chain fixation, excess tissue graft and reparative granuloma.[28,29] Progression of otosclerosis within the middle ear and recurrence of oval window pathology, tympanosclerosis and ossicular chain discontinuity from incus erosion or displaced prosthesis also cause a delayed hearing loss.[29,30] Raj *et al.* compared post-operative hearing outcomes with the two kinds of prosthesis. The nitinol piston prosthesis gave marginally better results when compared with Teflon pistons because it incorporates heat-sensitive crimping to preclude the difficult step of manual crimping. Post-operatively, mean ABG was 8.9 dB, which ranged from 15 to 20 dB in 11 per cent of cases, 10 to 15 dB in 49 per cent of cases and under 10 dB in 40 per cent of cases.[20]

- Vein graft surround technique is an option for sealing the fenestra during stapedotomy
- Significant improvement in post-operative air–bone gap is seen with the vein graft surround technique
- The post-operative hearing outcome with the vein graft surround technique is similar to that of the vein graft interposition technique
- Vein graft surround technique is preferred in small fenestra stapedotomy because it is simple and provides a good seal

In our study, one case of a cerebrospinal fluid gusher was encountered in the vein graft interposition group; however, this was controlled by the vein graft interposition technique and an additional lumbar drain. The vein graft interposition technique seems to be more suitable for a cerebrospinal fluid gusher as the graft with the piston over forms a good seal for the leak.

Conclusion

In conclusion, both the vein graft interposition and vein graft surround techniques of stapedotomy gave significant improvements in hearing thresholds after surgery, and there were no complications of sensorineural hearing loss in either group. There was no significant difference in the audiological outcomes between both the groups. The vein graft interposition technique is preferred for a large fenestra stapedotomy (0.8 mm or more) when there is a cerebrospinal fluid gusher or an inadvertent stapedectomy. However, the vein graft surround technique is preferred for a small fenestra stapedotomy (0.6 mm or less) as it is technically simple and provides a good seal around the stapedotomy.

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Competing interests. None declared.

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