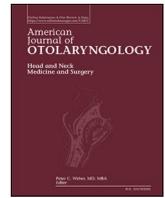


Contents lists available at [ScienceDirect](https://www.sciencedirect.com)

American Journal of Otolaryngology–Head and Neck Medicine and Surgery

journal homepage: www.elsevier.com/locate/amjoto

Minimally invasive surgery for hyperacusis-enhanced round and oval window reinforcement procedure

Herbert Silverstein^{*}, Neil Nayak, Sean Holmes, Allen Young, Kadie Nausha

Ear Research Foundation, 1901 Floyd Street, Sarasota, FL 34239, United States of America

ARTICLE INFO

Keywords:

Hyperacusis
Enhanced oval and round window reinforcement
Decreased noise intolerance

ABSTRACT

Hyperacusis is an audiological disorder in which patients become persistently sensitive and intolerant to everyday environmental sounds. Patients suffering from hyperacusis not only experience pain and discomfort, but also undergo impairments in social, occupational, recreational, and day-to-day activities, resulting in poor quality of life. Previously, a senior author (HS) reported a minimally invasive surgical technique to help hyperacusis patients via reinforcement of the oval and round windows with temporalis fascia (Silverstein, 2015). In a recent publication (Young, 2024), patients with (Loudness Discomfort Level) LDLs above 70 dB had an 80.1 % satisfaction with the round and oval window reinforcement and would recommend the surgery. However, in the group of patients whose LDLs were below 70 dB indicating extreme hyperacusis only 49 % were satisfied and would recommend the surgery. To improve the results, a modification of the original technique was used by enhancing the reinforcement in patients with severe hyperacusis. Enhanced reinforcement of the oval and round windows and tympanic membrane resulted in a superior reduction in hyperacusis symptoms.

1. Introduction

Hyperacusis is an audiological disorder in which patients become persistently overly sensitive and intolerant to everyday environmental sounds that are normally well tolerated by most people [1]. Patients suffering from hyperacusis not only experience pain and discomfort, but also undergo impairments in social, occupational, recreational, and day-to-day activities, resulting in poor quality of life [10]. Hyperacusis must be differentiated from recruitment, phonophobia, and misophonia. Phonophobia is a persistent, abnormal fear of sound [1]. Misophonia is an acquired adverse reaction to specific sounds such as chewing or breathing and is associated with emotional responses such as anger [2]. Recruitment is commonly seen in patients with Meniere's disease when there is a sudden increase in sound sensitivity above the hearing loss level.

The prevalence of hyperacusis ranges from 5.9 % to 17.2 % [3,4,15]. There is an association between hyperacusis and tinnitus which has been reported previously [5,6]. Roughly 40 % of patients with hyperacusis also have tinnitus (1). Diagnosis of hyperacusis has relied heavily on self-report, the Hyperacusis Questionnaire (HQ), and the Tinnitus Retraining Therapy (TRT) interview [15].

Hyperacusis is associated with cochlear damage secondary to loud

noise in 62.5 % of cases and other associations include head trauma, depression, anxiety, and adverse medication reactions [1,4]. However, there is no known cause for many patients. The mechanism of onset is not fully understood but is believed to be due to acoustic overexposure resulting in increased central auditory pathway gain [7,8]. Pathologies such as superior semicircular canal dehiscence, perilymphatic fistula, and stapes hypermobility have also been proposed as possible etiologies of hyperacusis [4,9,10]. Treatment for hyperacusis includes avoidance of noise stimuli, wearing ear plugs, tinnitus retraining therapy (TRT), cognitive behavioral therapy (CBT), and gradual sound exposure therapy [15]. However, there has been insufficient evidence to identify any of these strategies as an effective treatment for hyperacusis [15]. Stapes hypermobility has been observed in some hyperacusis patients undergoing reinforcement of the oval and round windows [4,11–13].

Previously, we reported a surgical technique for which results were stratified based on pre-op LDL testing. Patients with LDLs above 70 dB had 80.1 % success and would recommend surgery for hyperacusis. However, in patients with LDLs below 70 dB, only 49 % would recommend surgery [14]. To improve the results enhanced tissue reinforcement was used in a series of patients. The results indicate superior results using the new technique and the enhanced reinforcement procedure is being used now on all patients undergoing surgery.

^{*} Corresponding author.

E-mail address: Hsilverste@aol.com (H. Silverstein).

<https://doi.org/10.1016/j.amjoto.2025.104615>

Received 3 February 2025;

Available online 19 April 2025

0196-0709/© 2025 The Authors. Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

2. Methods

A retrospective case series of 7 adult patients with hyperacusis who underwent enhanced oval and round window reinforcement surgery by two surgeons (HS, NN) at a tertiary referral center was reviewed. All patients had a pre-operative CT of the temporal bone to rule out superior semicircular canal dehiscence. Ten, 2 mm pieces of temporalis fascia (Fig. 1) were used to reinforce the oval window. The grafts were made using a 2 and 4 mm dermatological biopsy punch (fig. 2a,2b). The oval window was enhanced by adding a 4 mm round tissue placed as a tent over the incus (Fig. 3). The round window was reinforced with two 2 mm pieces and a 4 mm piece of temporalis fascia (Fig. 4). A 6 mm square piece of temporalis fascia was used to enhance the posterior half of the eardrum (Fig. 5). The ear canal was packed with Teflon strips and gel

foam for one week. Postoperative audiogram and LDLs were done at one week, one month, and yearly post-operatively if able. Patients were asked to relate improvement in hyperacusis using a 1–10 scale with 10 being the worse. (See Table 1.)

3. Results

Patients improved their LDLs by an average of 17.5 dB with the average post-operative LDL being 86 dB. Six of the seven patients were very happy with the results. One patient had reported no benefit even though the LDL was significantly improved after the surgery. On a scale from 1 to 10, every patient except for one patient reported improvement to a 1 or 2 in the operated ear. It should also be noted that some of the post operative LDL values were obtained at only 1 month after surgery

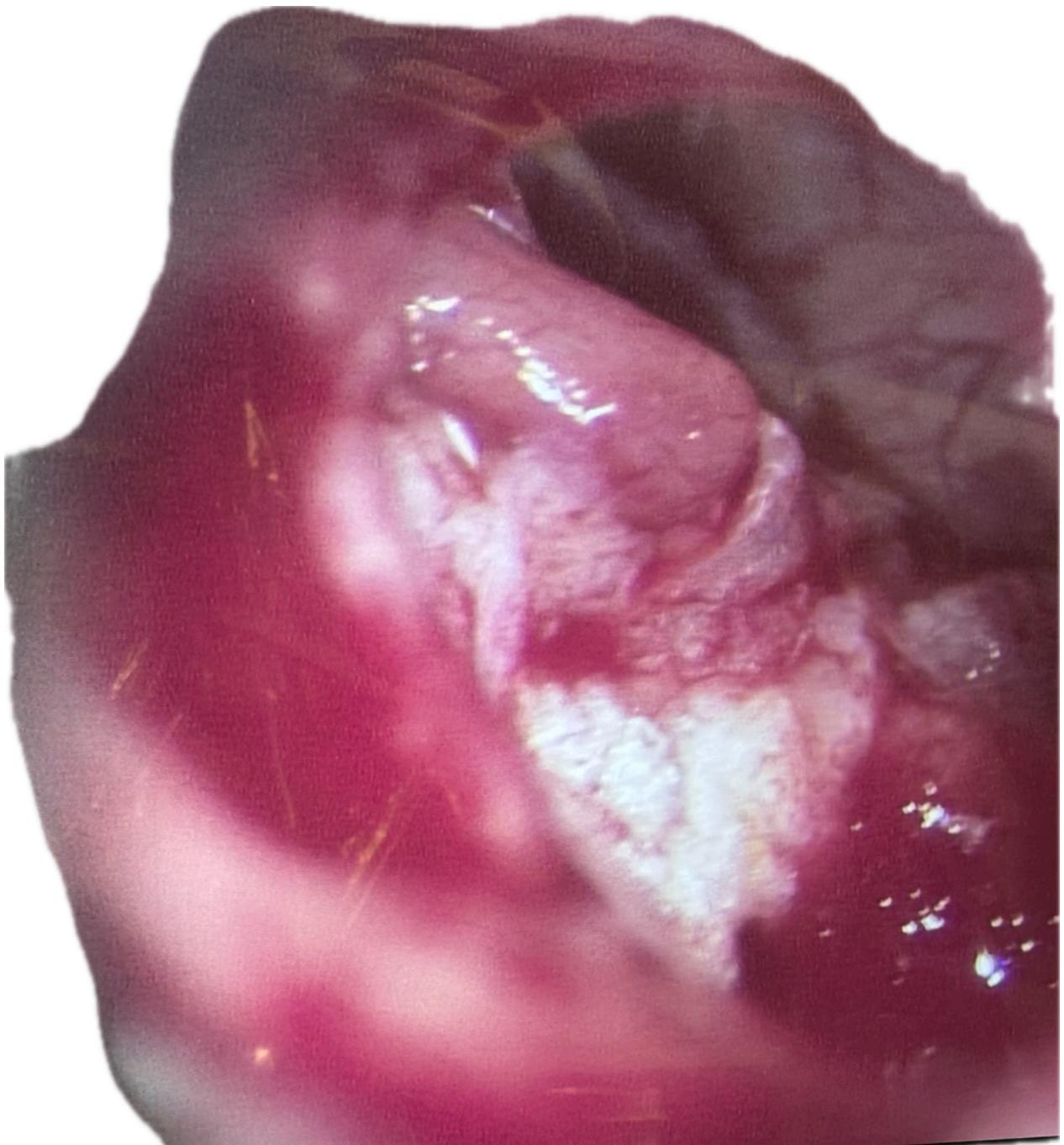


Fig. 1. Ten pieces of 2 mm temporalis fascia placed around stapes to reinforce the oval window.

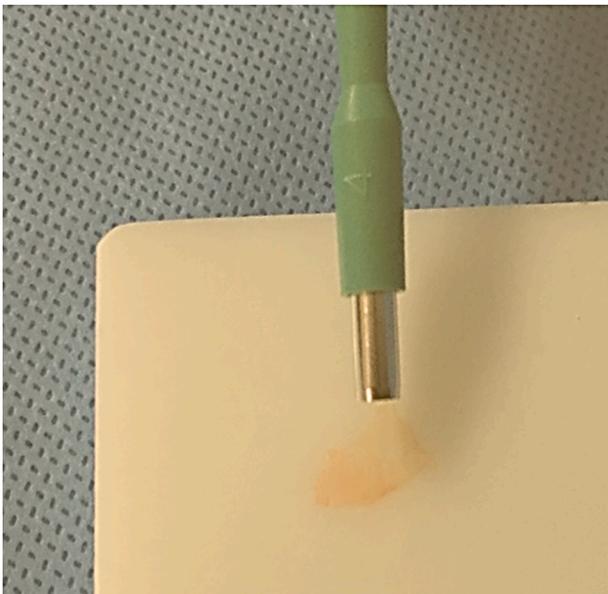


Fig. 2a. A dermatological punch biopsy tool is used to make temporalis fascia grafts.

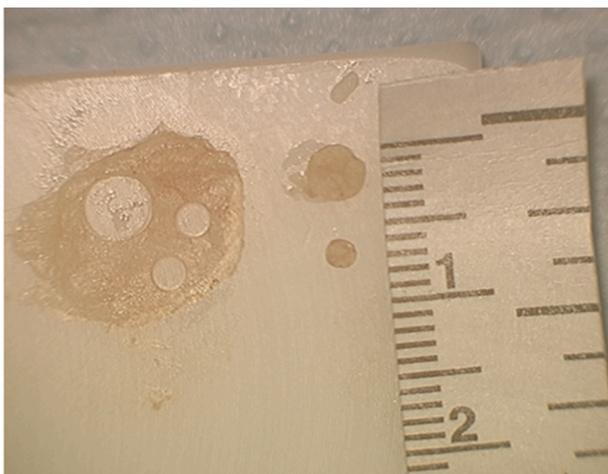


Fig. 2b. 2 mm (arrow) and 4 mm pieces fashioned from the temporalis fascia graft.

and it is possible even further improvement could be made. Some patients may have a small conductive hearing loss by tuning fork exam immediately post-operatively which usually resolves with time.

4. Discussion

It appears that adding more tissue to the middle ear results in improved results in patients undergoing surgery for severe hyperacusis. In some patients, there may be a small temporary conductive loss. But hearing usually returns to preop level. Adding more tissue appears to improve the results of most patients.

In reviewing our experience from the onset, the results improved with each group of patients as more tissue was added to the reinforcement.

In the first group of patients, only the round window was reinforced, in the second group of patients, the round and oval windows were reinforced, and in the third group; the enhanced reinforced group; the round window, oval window, and tympanic membrane were reinforced.



Fig. 3. A 4 mm fascia tent is placed over incus to enhance reinforcement of oval window.

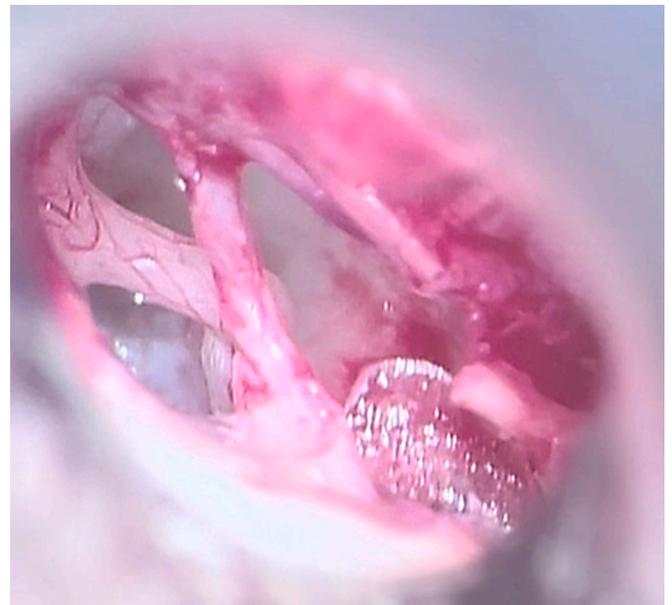


Fig. 4. Round window is reinforced with two 2 mm pieces and a 4 mm piece of temporalis fascia.

5. Conclusion

Enhanced round and oval window reinforcements and adding temporalis fascia under the posterior half of the tympanic membrane appear to give superior results in patients undergoing surgery for hyperacusis. Some patients will receive no benefit, and the cause is probably a central defect in noise suppression. If a patient has undergone traditional medical treatments and is severely handicapped, minimally invasive enhanced reinforcement round and oval window surgery is a reasonable option for the patient giving excellent reduction in noise tolerance.

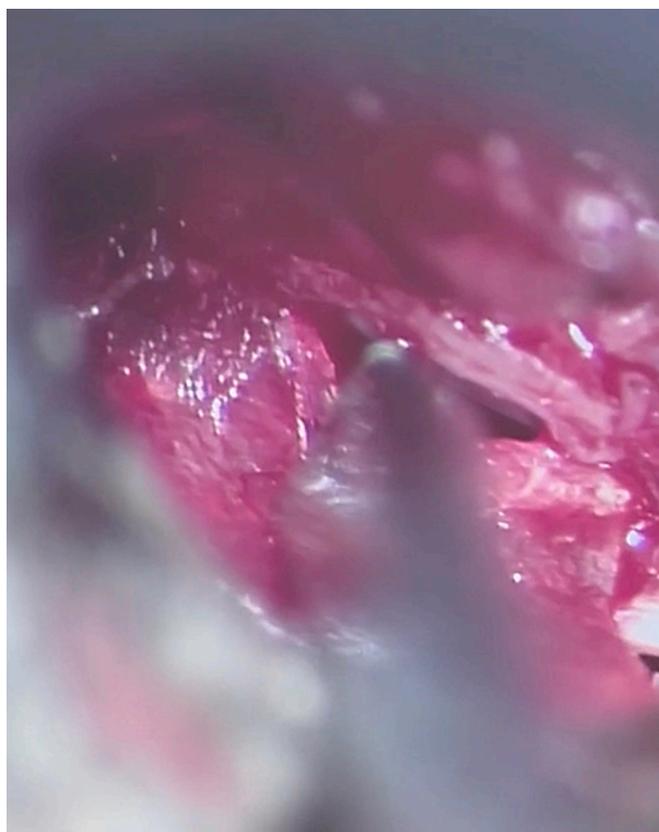


Fig. 5. Tympanic membrane reinforced with 6 mm square piece of temporalis fascia. The graft was placed medial to the posterior half of the tympanic membrane and tympanomeatal flap.

Table 1
Pre and post-operative LDL averages.

	Age	Pre-Op LDL	Post-Op LDL	Post-Op Speech LDL
Patient A	44	60	70	81
Patient B	61	56.5	98	95
Patient C	79	60	95	90
Patient D	59	42	90	61
Patient E	26	64	91	80
Patient F	59	95	87.5	83
Patient G	72	80	72	N/A

Credit authorship contribution statement

Herbert Silverstein: Conceptualization, Methodology, Supervision,

Writing – original draft, Writing – review & editing. **Neil Nayak:** Conceptualization, Data curation, Investigation, Methodology, Supervision. **Sean Holmes:** Conceptualization, Data curation, Formal analysis, Methodology, Writing – original draft. **Allen Young:** Methodology, Writing – original draft. **Kadie Nausha:** Data curation, Investigation, Methodology, Writing – original draft, Writing – review & editing.

References

- [1] Baguley DM, McFerran DJ. Hyperacusis and disorders of loudness perception. *Textbook of Tinnitus* 2011;13–23.
- [2] McFerran, Baguley DM, Fagelson M. Misophonia and Phonophobia. In: *Tinnitus Clin Res Perspect*. San Diego: Plural Publishing Inc; 2016. p. 245–60.
- [3] Hannula S, Bloigu R, Majamaa K, Sorri M, Maki-Torkko E. Self-reported hearing problems among older adults: prevalence and comparison to measured hearing impairment. *J Am Acad Audiol* 2011;22(8):550–9.
- [4] Silverstein H, Smith J, Kellermeyer B. Stapes hypermobility as a possible cause of hyperacusis. *Am J Otolaryngol* 2019;40(2):247–52. Mar - Apr.
- [5] Anari M, Axelsson A, Eliasson A, Magnusson L. Hypersensitivity to sound—questionnaire data, audiometry and classification. *Scand Audiol* 1999;28(4):219–30.
- [6] Jastreboff PJ, Jastreboff MM. Tinnitus retraining therapy (TRT) as a method for treatment of tinnitus and hyperacusis patients. *J Am Acad Audiol* 2000;11(3):162–77.
- [7] Herbert S, Fournier P, Norena A. The auditory sensitivity is increased in tinnitus ears. *J Neurosci* 2013;33:2356–64.
- [8] Knipper M, Van Dijk P, Nunes I, Uttiger LR, Zimmermann U. Advances in the neurobiology of hearing disorders: recent developments regarding the basis of tinnitus and hyperacusis. *Prog Neurobiol* 2013;111:17–33.
- [9] Chien WW, Janky K, Minor LB, Carey JP. Superior canal dehiscence size: multivariate assessment of clinical impact. *Otol Neurotol* 2012;33(5):810–5.
- [10] Aazh H, McFerran D, Salvi R, Prasher D, Jastreboff M, Jastreboff P. Insights from the first international conference on hyperacusis: causes, evaluation, diagnosis and treatment. *Noise Health* 2014;16:123–6.
- [11] Aazh H, Allott R. Cognitive behavioral therapy in management of hyperacusis: A narrative review and clinical implementation. *Aud Vest Res* 2016;25:63–74.
- [12] Silverstein H, Wu YH, Hagan S. Round and oval window reinforcement for the treatment of hyperacusis. *Am J Otolaryngol* 2015;36(2):158–62.
- [13] Silverstein H, Ojo R, Daugherty J, Nazarian R, Wazen J. Minimally invasive surgery for the treatment of hyperacusis. *Otol Neurotol* 2016;37(10):1482–8.
- [14] Young A, Holmes S, Nayak N, Silverstein H. Oval and round window reinforcement surgery leads to improvements in sound tolerance and quality of life for hyperacusis patients. *Am J Otolaryngol* 2024 May-Jun;45(3):104231. <https://doi.org/10.1016/j.amjoto.2024.104231> [Epub 2024 Mar 10. PMID: 38513514].
- [15] Fackrell K, Potgieter I, Shekhawat GS, Baguley DM, Sereda M, Hoare DJ. Clinical Interventions for Hyperacusis in Adults: A Scoping Review to Assess the Current Position and Determine Priorities for Research. *Biomed Res Int* 2017;2017:2723715. <https://doi.org/10.1155/2017/2723715>. Epub 2017 Oct 9. PMID: 29312994; PMCID: PMC5654244.