

1 **Original research papers**

2 **Evaluation of the Incidence of Complications and Their Causes after Stapedotomy in**  
3 **Patients with Otosclerosis**

4 *This work was carried out in collaboration among all authors. 'Mohamad Mohseni' and 'Ahmad Daneshi'*  
5 *designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the*  
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7 *managed the literature searches. All authors read and approved the final manuscript.*

8

9 **Abstract**

10 **Introduction:** In order to treat the symptoms of otosclerosis, various surgical and  
11 medical treatments are suggested. Surgical treatments are the choice. This study aimed  
12 to determine the incidence of vertigo and its cause in Iran, and the present study  
13 focused on this issue.

14 **Methods:** This was a prospective cohort study carried out on patients with otosclerosis  
15 undergoing stapedotomy referred to Rasoul Akram hospital, Tehran during 2017-18.  
16 The patients aged below 18 or those who had a history of vertigo were excluded.  
17 Diapasonic and audiometric tests were carried out. The follow-ups included the time of  
18 admission (the day after surgery) for the presence of vertigo using visual analogue  
19 scale and diapasonic tests, one week after surgery using visual analogue scale and  
20 diapasonic tests, and one month after surgery using visual analogue scale and  
21 audiometry. The data were imported to SPSS v.22 software and analyzed.

22 **Results:** The surgical complications that occurred after stapedotomy for patients in this  
23 center were as follows: 12.1% of subjects had vertigo one day after surgery, 8.6% had  
24 vertigo one week later, and 1.7% had vertigo one month later, thus, the frequency of  
25 vertigo was reduced overtime. Meanwhile, 91.4% of the patients had a better sense of  
26 hearing and only 1.7% suffered from tympanic membrane perforation. In 8.6% of  
27 subjects, there was a disturbance in the taste. Tinnitus was only observed in 5.2% of the  
28 surgical patients in this center. Among women, vertigo was higher one day and one  
29 week after surgery. Logistic regression showed that age is significant predictor of  
30 dizziness one day after surgery (OR: 1.37, P=0.03).

31 **Conclusion:** According to the results, the frequency of vertigo was decreased overtime.  
32 In this study, it was found that the complications of stapedotomy surgery were less than  
33 other surgical methods, but those who were older had significantly higher vertigo a  
34 week and one day after surgery indicating effective role of age on postoperative  
35 complications. Those who underwent surgery by tympanomeatal method had a better  
36 vertigo one day and one week after surgery.

37 **Keywords:** Stapedotomy, Tympanomeatal, Otosclerosis, SNHL

38

39 **Introduction**

40 **Otosclerosis is the most common cause of progressive hearing loss in adults** (1). The  
41 prevalence of otosclerosis in the normal population is less than 1% (2, 3). There are  
42 various surgical and medical treatments. Surgical treatment is the choice, which  
43 improves the hearing of almost 95% of patients (4). Vertigo is one of the complications  
44 that can be caused by stapes operation (2, 5). Among other surgical complications, the  
45 **sensory neural hearing loss**, facial paralysis, tinnitus, tympanic membrane perforation,  
46 perilymph fistula, and taste disorder can be mentioned (5). A small number of patients  
47 have noted the postoperative tinnitus which is often associated with serous  
48 labyrinthitis. The taste disorder occurs in 9% of patients **related to lengthening of**  
49 **chorda tympani (not perforation)**. It is often improved within 3-4 months. The  
50 perforation of tympanic membrane is often small and marginal with **rapid** response.  
51 The perilymph fistula is an uncommon post-stapedectomy complication with incidence  
52 of 3-9%, in which is much less likely to occur after stapedotomy. A mild vertigo is  
53 common after stapes surgery occurring in one per 20 cases. **It takes several hours and is**  
54 **rarely severe. The main care is supportive actions** (1).

55 In a study by Plaza Mayor G et al., 115 patients were examined and only 2 patients  
56 (2.6%) noted vertigo during a 12-month follow-up (6). In various studies, different  
57 causes are noted for vertigo after stapes surgery, including serous labyrinthitis,  
58 perilymph aspiration, perilymph fistula, and inner ear trauma, and vertigo can be cured  
59 depending on the cause (7, 8).

60 In a study by Magliulo G et al. on 141 patients undergoing surgery, 12 patients (8.5%)  
61 had symptoms similar to Benign paroxysmal positional vertigo (BPPV) after surgery  
62 and the onset of symptoms varies from day 5 until day 21 after surgery (9). In another  
63 study, **11 patients done Magnetic resonance imaging (MRI) who had suffered from**  
64 **Sensorineural hearing loss (SNHL) with or without vertigo**, two cases of reparative  
65 intravestibular granuloma, a case of intralabyrinthine hemorrhage and a case of  
66 bacterial labyrinthitis were reported (10). Given the differences in the results of studies  
67 in this field and the lack of domestic studies on this topic, a study was required to  
68 determine the incidence of vertigo and its causes in Iran, and the present study focused  
69 on this issue.

70

## 71 **Methods and materials**

72 This was a prospective cohort study. **Inclusion criteria were the patients with**  
73 **otosclerosis undergoing stapedotomy referred to Rasoul Akram hospital, Tehran during**  
74 **2017-18**. The patients aged below 18 or those who had a history of vertigo were  
75 excluded. Prior to surgery, the Temporal HRCT **for showing the anatomy and**  
76 **pathology of the temporal bone** was carried out for all studied patients. **Stapedotomy**  
77 **was performed using general anesthesia** by transcanal or endaural approaches. Twenty  
78 one patients received endaural incision in addition to tympanomeatal flap.

79 The information about the patient and surgery was recorded after the surgery. The  
80 follow-up of patients in regard of vertigo was performed by questionnaire, and the  
81 diapasonic and audiometric tests were carried out. The tympanic perforation on a visit a  
82 month after surgery, postoperative SNHL, prosthesis displacement, postoperative facial  
83 paralysis, postoperative tinnitus, postoperative taste disorder, perilymph fistula, and  
84 toxic labyrinthitis were evaluated. The vertigo follow-ups included diapasonic tests a  
85 week after surgery using visual scale, diapasonic tests a month after surgery via visual  
86 scale, and the audiometry. Moreover, the age, gender of patients and also the side of  
87 body suffering from arteriosclerosis were also recorded. The patients who didn't visit  
88 for follow-up for any other reason or those who underwent revision surgery were  
89 excluded.

### 90 *Ethical issues*

91 Human rights were respected in accordance with the Helsinki Declaration 1975, as  
92 revised in 1983. All phases of the study were supervised by the Ethics Committee of  
93 Iran University of Medical Sciences.

### 94 *Statistical analysis*

95 For data analysis, the information recorded in the forms was imported into SPSS v.22  
96 software. First, using descriptive statistics, the frequency of qualitative variables was  
97 calculated. Then, the analytical tests were performed on quantitative and qualitative  
98 variables of their relationship with the presence of the developmental disorder. In order  
99 to investigate the relationship between the studied quantitative variables and  
100 developmental disorder, initially the Kolmogorov–Smirnov test was performed to  
101 examine the normality of data distribution. The significance level was considered 0.05.

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### 103 **Results**

104 In this study, 58 individuals were included in the study, 21 (36.2%) of them were male  
105 and 37 individuals (63.8%) were female. The mean age was  $30.60 \pm 5.98$  years. After  
106 surgery, it was found in 56 (96.6%) individuals, the improved hearing as gap reduction  
107 was above 15 db for 53 subjects (91.4%) and below 15 db for 3 subjects (5.2%).  
108 Frequency and percentage of some baseline characteristics of participants are listed in  
109 Table 1 and complications were presented in Table 2.

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**Table 1:** Frequency and percentage of some baseline characteristics of participants

Variable		Frequency (%)
High blood pressure	Negative	58 (96.5)
	Positive	2 (3.50)
Previous SNHL	Negative	58 (96.5)
	Positive	2 (3.50)
Surgical approach	Endaural	19 (32.7)
	Tympanomeatal	19 (67.3)
Blood in the field during prosthesis insertion	Negative	47 (81.0)
	Positive	11 (19.0)
Surgeon	Professor	19 (32.7)
	Fellows	39 (67.3)
Time interval between filtration and prosthetic insertion	5min<	9 (15.5)
	5min>	49 (85.5)
Gaucher disease	Negative	57 (98.28)
	Positive	1 (1.72)
Patching the prosthesis to connective tissue	Negative	53 (91.3)
	Positive	5 (8.7)
Unilateral or bilateral disease	Unilateral conflict	30 (51.7)
	Bilateral conflict	28 (48.3)

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**Table 2:** Frequency and percentage of Postoperative complications

Variable		Frequency (%)
Vertigo a day after surgery	Negative	51 (87.9)
	Positive	7 (12.1)
Vertigo a week after surgery	Negative	53 (91.3)
	Positive	5 (8.7)
Vertigo a month after surgery	Negative	57 (98.28)
	Positive	1 (1.72)
Tympanic perforation on a visit a month after surgery	Negative	57 (98.28)
	Positive	1 (1.72)
Postoperative SNHL	Negative	57 (98.28)
	Positive	1 (1.72)
Prosthesis displacement	Negative	56 (96.6)
	Positive	2 (3.4)
Postoperative tinnitus	Negative	53 (91.3)
	Positive	5 (8.7)
Taste disorder	Negative	53 (91.3)
	Positive	5 (8.7)
Perilymph fistula	Negative	57 (98.28)
	Positive	1 (1.72)
Toxic labyrinthitis	Negative	57 (98.28)
	Positive	1 (1.72)

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118 In comparison between the complications, it was found that there was no significant  
 119 difference in dizziness by gender one day, one week, and one month after surgery (P>

0.05). In those who had a shorter time interval between fenestration and prosthesis insertion, the vertigo a month after surgery was lower ( $p=0.019$ ). Also, the relationship between tympanomeatal and endaural surgery with vertigo at measured times showed that surgical approaches with headache incidence did not show significant relationship between these three times ( $P>0.05$ ). To investigate the relationship between variables with vertigo during one day after surgery using logistic regression model, there was not a significant relationship between surgical approach, surgeon and gender with vertigo at one day postoperatively ( $P>0.05$ ) but with an increase in the age unit, the odds ratio of dizziness increased by 1.37 (95% CI, 1.02-1.84) one day after surgery ( $P=0.03$ ). Table 3 shows the logistic regression model. Patching the prosthesis to connective tissue caused less tympanic perforation, perilymph fistula, and SNLH after surgery ( $P<0.05$ ). The number of attempts for surgical repair was significantly related to less hearing improvement, higher vertigo after a day and a week, as well as prosthesis displacement ( $P<0.05$ ).

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135 **Table 3:** Table 3: Logistic Regression Model for relationship between vertigo one day after  
136 surgery with surgical approach, surgeon, gender, and age

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Variable	OR*	95% CI*		P Value
		Lower	Upper	
Surgical approach	0.16	0.02	1.26	0.08
Surgeon	0.82	0.09	7.16	0.85
Gender	8.68	0.91	82.42	0.06
Age	1.37	1.02	1.84	0.03

138 OR: Odds ratio (Quantifier the strength of the association between two events)

139 CI: Confidence Interval (A type of interval estimate, computed from the statistics of the observed  
140 data)

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## 142 Discussion

143 The sensory neural hearing loss is the worst complication after surgery. The prevalence  
144 is about 1% and the cause is unknown. It could be mild or exclusively present at high  
145 frequencies. In case of clinical suspicion, prednisolone is started for the patient (5).  
146 Another complication is the serous labyrinthitis that is common because of  
147 inflammation in the inner ear. Clinically, it is seen as mild imbalance, positional  
148 vertigo or mild hearing loss in higher frequencies. The symptoms usually disappear  
149 within several days to several weeks. Facial paralysis is another surgery complication  
150 that is rare and usually occurs with delay and after the fifth day and remains stable for  
151 several weeks (1). The surgical complications that occurred after stapedotomy for  
152 patients in this center were as follows: 12.1% of subjects had vertigo a day after  
153 surgery, 8.6% had vertigo a week later, and 1.7% had vertigo a month later, thus, the  
154 frequency of vertigo was reduced overtime. Meanwhile, 91.4% of the patients had a

155 better hearing sensation and only 1.7% suffered from tympanic membrane perforation.  
156 In 8.6% of subjects, there was a disturbance in the taste sensation that was lower than  
157 earlier studies (5). The new tinnitus was only observed in 5.2% of the individuals in this  
158 center.

159 A study in 2017 indicated that the otosclerosis is the cause of 5-9% of hearing loss. The  
160 aim of this study was to evaluate the results of treatment of otosclerosis surgery and to  
161 investigate the effect of disease stage, time of symptoms, age and gender on the results.  
162 In this study, 105 patients undergoing surgery were investigated. The postoperative  
163 hearing status was evaluated. The mean values of air- and bone-conduction (air bone  
164 gap) were compared a year after the treatment and at least 4 years after the surgery.  
165 The results of this study show that the disease stage, time of symptoms, age and gender  
166 had no effect on the results of treatment, but the difference in the mean hearing  
167 loss before and after treatment is significant (11). Meanwhile, in our study, those who  
168 were older had significantly higher vertigo a week and a day after surgery, and it shows  
169 that age had been effective on the postoperative complications.

170 In a study by Wegner in 2018, 230 patients were retrospectively investigated in terms  
171 of hearing improvement as a decrease in air bone gap after stapedotomy. In the study,  
172 the success rate of surgery was reported 95.7%. In the same study, the tympanic  
173 perforation after stapedotomy was reported 1.1% (12). In the present study, 91.4% of  
174 patients had hearing improvement as a decrease above 15 db in air bone gap, but the  
175 difference in surgery by attending physicians and fellows was not significant, and their  
176 complications were not significantly different. Also, there was a case of postoperative  
177 tympanic membrane perforation, which was a marginal microperforation.

178 In a study conducted in 2017, the results of the auditory and otoacoustic tests (OAE) of  
179 stapedotomy were compared. In this study, a total of 18 patients with otosclerosis  
180 participated in a cohort study. All patients underwent fenestra drill stapedotomy using  
181 the Causse fluoroplastic large loop piston prosthesis. The bone audiometries, pure tone  
182 air, audiometry, and OAE tests were performed. One year after surgery, these results  
183 were compared within the group and between the groups. The similar results of hearing  
184 after stapedotomy were found for 0.4 and 0.6 mm prostheses with small but  
185 considerable advantages in increasing BC and overclosure parameter for 0.6 mm  
186 prosthesis. The difference in OAE test was not found in evaluating the auditory results  
187 of stapedotomy, and also, the hearing rate of these individuals had significant results  
188 before and after surgery in all tests (13). In another study that was published by  
189 Mohammad Khorsandi et al. in 2018, the medical records of 995 patients with  
190 otosclerosis undergoing stapedectomy or stapedotomy was retrospectively investigated.  
191 The success rate of surgery in this study was reported 93.4% and it was said that the  
192 diameter of the prosthesis had no effect on the success rate, but the female gender and  
193 right ear involvement are reported as a prognostic factor in the good surgical outcome  
194 (14). In this study, the size and diameter of the prosthesis were not related to auditory  
195 outcome and postoperative complications. The gender of the patient had also no effect

196 on the success rate of the surgery, but the vertigo rate a day and a week after surgery  
197 was higher in women.

198 In a study carried out in 2018 to compare the measurement of the effect of treatment in  
199 tinnitus using multi-item outcome instrument, the aim was to determine the minimum  
200 important change in tinnitus, in which was clinically significant for patients with  
201 otosclerosis. To follow this goal in this study, 95 patients with otosclerosis who were  
202 suffering from tinnitus were investigated. They completed the tinnitus performance  
203 index before the stapedotomy and three months after surgery. The anchor-based  
204 approach using the external criterion (anchor) allows for determining the change in the  
205 tinnitus sensation that was significant for patients after stapedotomy. In this evaluation,  
206 it was shown that score 8.8 in Tinnitus Functional Index could be the criteria for the  
207 effectiveness of stapedotomy in patients with otosclerosis suffering from tinnitus. The  
208 hearing problems accompanying tinnitus can affect the concept of tinnitus variations  
209 and the hearing rate was also increased in these patients. In this study, 69.4% of  
210 individuals felt that their tinnitus was improved after surgery and had a significant  
211 difference with the other group (15).

212 In a study by Cavalcante et al., done as a review of articles, eight papers were  
213 investigated on the tinnitus improvement after the stapes surgery. The degree of  
214 postoperative tinnitus improvement during this examination was reported 85.52% (16).  
215 In the present study, 84.4% of patients noted the postoperative tinnitus improvement.  
216 In two studies by Somers T and Sedwick JD, the comparison of surgical results in two  
217 methods of fenestration with micro-drill and CO2 laser was investigated, and no  
218 significant difference was reported in the results of the two groups in any of the studies  
219 (17, 18). In this study, laser was not used for fenestration in these patients. The only  
220 difference in surgical methods in patients in the present study was using both  
221 approaches of endaural and tympanomeatal. In the results of the examinations, those  
222 who were operated by tympanomeatal method had better vertigo rate a day and a week  
223 after surgery.

224 The studies show that otosclerosis is more prevalent in men than women. In a study in  
225 France on the complications of stapes surgery in these patients, 67% of patients were  
226 female (1), and in a study in Spain, it was reported 68% (19) as well as occupation has  
227 a role in hearing (20). In the present study, the prevalence was higher in women  
228 (63.8%).

229 A study carried out in 2017 revealed that the surgical intervention was the preferred  
230 treatment method for reduced conductive hearing associated with stapedia  
231 otosclerosis. However, given that it is a difficult and delicate method, the surgery  
232 might fail for various reasons. Therefore, it is very important to evaluate the success  
233 rate of the surgical procedure used in each regional center. The aim of this study was to  
234 evaluate the effectiveness of stapedotomy to improve hearing sensation for otosclerotic  
235 patients. All cases that were subjected to stapedotomy during 1997-2009 were  
236 retrospectively investigated. The preoperative and postoperative evaluations were

237 carried out. None of the studied cases in this study showed a nervous sensory hearing  
238 loss caused by stapedotomy. It is concluded that stapedotomy is a safe and effective  
239 treatment method for patients with otosclerosis (21).

240 In a study by Rao in 2018, the complications after endoscopic stapedotomy were  
241 investigated in 40 patients. The vertigo and SNHL were reported in five and one  
242 patients, respectively. In the present study, there was vertigo a day, a week, and a  
243 month after surgery in seven, five and one patients, respectively. A case of SNHL was  
244 developed after surgery that did not respond to medical treatment. (22)

245 In 2018, Shiao retrospectively examined 53 patients (56 involved ears). In this study,  
246 two methods were conducted by traditional stapes surgery and minimally traumatic  
247 stapes surgery. There was no significant difference in the hearing outcomes of patients  
248 between the two surgical methods, but the postoperative vertigo rate was lower in  
249 patients for whom the soft tissue sealant was used around their prosthesis (23). In this  
250 study, there was no relationship between patching prosthesis to connective tissue and  
251 postoperative vertigo rate, but failure to patch around the prosthesis was associated  
252 with a higher SNHL.

253 In case of the association between HTN and otosclerosis, Yutaka performed a study in  
254 2008 on the role of angiotensin II in bone remodeling in 186 patients with otosclerosis  
255 and 526 patients in the control group. In this study, the pleomorphism of 3 genes  
256 associated with ACE receptor was investigated, and the results of this study showed  
257 that there is a significant relationship between the activity of renin-angiotensin system  
258 and otosclerosis (24). In 2009, Isabelle Schrauwen examined the pleomorphism of  
259 three genes investigated in the earlier study in a larger sample size and reported that  
260 there was no significant relationship between this pleomorphism associated with  
261 activity of the renin-angiotensin system and otosclerosis (25). In this study, in those  
262 who had a shorter time interval between fenestration and prosthesis insertion (less than  
263 5 min), the vertigo rate a month after surgery was lower. Also, in patients with higher  
264 number of attempts for prosthesis insertion (more than 3 times), the rate of vertigo a  
265 day and a week after surgery as well as prosthesis displacement was higher, but the  
266 presence or absence of blood in the surgical field during prosthesis insertion was not  
267 associated with an increase in complications.

## 268 **Conclusion**

269 In the study, the level of complications occurred after stapedotomy in patients with  
270 otosclerosis was associated with variables such as age of patient, surgical procedure,  
271 number of attempts for prosthesis insertion, as well as the shorter time interval between  
272 fenestration and prosthesis insertion. As well as, there is no difference in dizziness by  
273 gender one day, one week, and one month after surgery. Headache was not related to  
274 surgical procedure. Among demographic characteristics, with an increase in the age  
275 unit, the chance of developing dizziness increased one day after surgery.

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