

1 **Determining the Incidence of Complications and Their Causes after Stapedotomy in** 2 **Patients with Otosclerosis**

3

4 **Abstract**

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

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

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

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

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

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34 **Introduction**

35 Otosclerosis is the most common cause of progressive hearing loss in adults. It is
36 typically more common in women (1). The prevalence of otosclerosis in the normal
37 population is less than 1% (2, 3). There are various surgical and medical treatments.
38 Surgical treatment is the choice, which improves the hearing of almost 95% of patients

39 (4). Vertigo is one of the complications that can be caused by stapes operation (2, 5).
40 Among other surgical complications, the nervous sensory hearing loss, facial paralysis,
41 tinnitus, tympanic membrane perforation, perilymph fistula, and taste disorder can be
42 mentioned (5). A small number of patients have noted the postoperative tinnitus which
43 is often associated with serous labyrinthitis. The taste disorder occurs in 9% of patients
44 and is mostly related to elongation of chorda tympani than its perforation. It is often
45 improved within 3-4 months. The perforation of tympanic membrane is often small and
46 marginal with rapidly response. The perilymph fistula is an uncommon post-
47 stapedectomy complication with incidence of 3-9%, in which is much less likely to
48 occur after stapedotomy. A mild vertigo is common after stapes surgery occurring in
49 one per 20 cases. It usually lasts for several hours and is quickly solved but is rarely
50 long or severe. Its control is mainly supportive (1).

51 In a study by Plaza Mayor G et al., 115 patients were examined and only 2 patients
52 (2.6%) noted vertigo during a 12-month follow-up (6). In various studies, different
53 causes are noted for vertigo after stapes surgery, including serous labyrinthitis,
54 perilymph aspiration, perilymph fistula, and inner ear trauma, and vertigo can be cured
55 depending on the cause (7, 8).

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

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66 **Methods and materials**

67 This was a prospective cohort study carried out on patients with otosclerosis
68 undergoing stapedotomy referred to Rasoul Akram hospital, Tehran during 2017-18.
69 The patients aged below 18 or those who had a history of vertigo were excluded. Prior
70 to surgery, the Temporal HRCT was carried out for all studied patients. Stapedotomy
71 surgery was performed in patients undergoing total intravenous anesthesia (TIVA) by
72 transcanal or endaural approaches. Twenty one patients received endaural incision in
73 addition to tympanomeatal flap.

74 The information about the patient and surgery was recorded after the surgery. The
75 follow-up of patients in regard of vertigo was performed by questionnaire, and the
76 diapasonic and audiometric tests were carried out. The tympanic perforation on a visit a
77 month after surgery, postoperative SNHL, prosthesis displacement, postoperative facial
78 paralysis, postoperative tinnitus, postoperative taste disorder, perilymph fistula, and

79 toxic labyrinthitis were evaluated. The vertigo follow-ups included diapasonic tests a
80 week after surgery using visual scale, diapasonic tests a month after surgery via visual
81 scale, and the audiometry. Moreover, the age, gender of patients and also the side of
82 body suffering from arteriosclerosis were also recorded. The patients who didn't visit
83 for follow-up for any other reason or those who underwent revision surgery were
84 excluded.

85 *Ethical issues*

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

89 *Statistical analysis*

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

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98 **Results**

99 In this study, 58 individuals were included in the study, 21 (36.2%) of them were male
100 and 37 individuals (63.8%) were female. The mean age was 30.60 ± 5.98 years. After
101 surgery, it was found in 56 (96.6%) individuals, the improved hearing as gap reduction
102 was above 15 db for 53 subjects (91.4%) and below 15 db for 3 subjects (5.2%).
103 Frequency and percentage of some baseline characteristics of participants are listed in
104 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)

	Endaural	19 (32.7)
Surgical approach	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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113 In comparison between the complications, it was found that there was no significant
114 difference in dizziness by gender one day, one week, and one month after surgery ($P >$
115 0.05). In those who had a shorter time interval between fenestration and prosthesis
116 insertion, the vertigo a month after surgery was lower ($p = 0.019$). Also, the relationship
117 between tympanomeatal and endaural surgery with vertigo at measured times showed
118 that surgical approaches with headache incidence did not show significant relationship
119 between these three times ($P > 0.05$). To investigate the relationship between variables

120 with vertigo during one day after surgery using logistic regression model, there was not
 121 a significant relationship between surgical approach, surgeon and gender with vertigo
 122 at one day postoperatively ($P>0.05$) but with an increase in the age unit, the odds ratio
 123 of dizziness increased by 1.37 (95% CI, 1.02-1.84) one day after surgery ($P=0.03$).
 124 Table 3 shows the logistic regression model. Patching the prosthesis to connective
 125 tissue caused less tympanic perforation, perilymph fistula, and SNLH after surgery
 126 ($P<0.05$). The number of attempts for surgical repair was significantly related to less
 127 hearing improvement, higher vertigo after a day and a week, as well as prosthesis
 128 displacement ($P<0.05$).

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130 **Table 3:** Table 3: Logistic Regression Model for relationship between vertigo one day after
 131 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

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135 Discussion

136 The sensory neural hearing loss is the worst complication after surgery. The prevalence
 137 is about 1% and the cause is unknown. It could be mild or exclusively present at high
 138 frequencies. In case of clinical suspicion, prednisolone is started for the patient (5).
 139 Another complication is the serous labyrinthitis that is common because of
 140 inflammation in the inner ear. Clinically, it is seen as mild imbalance, positional
 141 vertigo or mild hearing loss in higher frequencies. The symptoms usually disappear
 142 within several days to several weeks. Facial paralysis is another surgery complication
 143 that is rare and usually occurs with delay and after the fifth day and remains stable for
 144 several weeks (1). The surgical complications that occurred after stapedotomy for
 145 patients in this center were as follows: 12.1% of subjects had vertigo a day after
 146 surgery, 8.6% had vertigo a week later, and 1.7% had vertigo a month later, thus, the
 147 frequency of vertigo was reduced overtime. Meanwhile, 91.4% of the patients had a
 148 better hearing sensation and only 1.7% suffered from tympanic membrane perforation.
 149 In 8.6% of subjects, there was a disturbance in the taste sensation that was lower than
 150 earlier studies (5). The new tinnitus was only observed in 5.2% of the individuals in this
 151 center.

152 A study in 2017 indicated that the otosclerosis is the cause of 5-9% of hearing loss. The
 153 aim of this study was to evaluate the results of treatment of otosclerosis surgery and to
 154 investigate the effect of disease stage, time of symptoms, age and gender on the results.

155 In this study, 105 patients undergoing surgery were investigated. The postoperative
156 hearing status was evaluated. The mean values of air- and bone-conduction (air bone
157 gap) were compared a year after the treatment and at least 4 years after the surgery.
158 The results of this study show that the disease stage, time of symptoms, age and gender
159 had no effect on the results of treatment, but the difference in the mean hearing
160 loss before and after treatment is significant (11). Meanwhile, in our study, those who
161 were older had significantly higher vertigo a week and a day after surgery, and it shows
162 that age had been effective on the postoperative complications.

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

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

191 In a study carried out in 2018 to compare the measurement of the effect of treatment in
192 tinnitus using multi-item outcome instrument, the aim was to determine the minimum
193 important change in tinnitus, in which was clinically significant for patients with
194 otosclerosis. To follow this goal in this study, 95 patients with otosclerosis who were
195 suffering from tinnitus were investigated. They completed the tinnitus performance

196 index before the stapedotomy and three months after surgery. The anchor-based
197 approach using the external criterion (anchor) allows for determining the change in the
198 tinnitus sensation that was significant for patients after stapedotomy. In this evaluation,
199 it was shown that score 8.8 in Tinnitus Functional Index could be the criteria for the
200 effectiveness of stapedotomy in patients with otosclerosis suffering from tinnitus. The
201 hearing problems accompanying tinnitus can affect the concept of tinnitus variations
202 and the hearing rate was also increased in these patients. In this study, 69.4% of
203 individuals felt that their tinnitus was improved after surgery and had a significant
204 difference with the other group (15).

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

217 The studies show that otosclerosis is more prevalent in men than women. In a study in
218 France on the complications of stapes surgery in these patients, 67% of patients were
219 female (1), and in a study in Spain, it was reported 68% (19) as well as occupation has
220 a role in hearing (20). In the present study, the prevalence was higher in women
221 (63.8%).

222 A study carried out in 2017 revealed that the surgical intervention was the preferred
223 treatment method for reduced conductive hearing associated with stapedia
224 otosclerosis. However, given that it is a difficult and delicate method, the surgery
225 might fail for various reasons. Therefore, it is very important to evaluate the success
226 rate of the surgical procedure used in each regional center. The aim of this study was to
227 evaluate the effectiveness of stapedotomy to improve hearing sensation for otosclerotic
228 patients. All cases that were subjected to stapedotomy during 1997-2009 were
229 retrospectively investigated. The preoperative and postoperative evaluations were
230 carried out. None of the studied cases in this study showed a nervous sensory hearing
231 loss caused by stapedotomy. It is concluded that stapedotomy is a safe and effective
232 treatment method for patients with otosclerosis (21).

233 In a study by Rao in 2018, the complications after endoscopic stapedotomy were
234 investigated in 40 patients. The vertigo and SNHL were reported in five and one
235 patients, respectively. In the present study, there was vertigo a day, a week, and a

236 month after surgery in seven, five and one patients, respectively. A case of SNHL was
237 developed after surgery that did not respond to medical treatment. (22)

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

246 In case of the association between HTN and otosclerosis, Yutaka performed a study in
247 2008 on the role of angiotensin II in bone remodeling in 186 patients with otosclerosis
248 and 526 patients in the control group. In this study, the pleomorphism of 3 genes
249 associated with ACE receptor was investigated, and the results of this study showed
250 that there is a significant relationship between the activity of renin-angiotensin system
251 and otosclerosis (24). In 2009, Isabelle Schrauwen examined the pleomorphism of
252 three genes investigated in the earlier study in a larger sample size and reported that
253 there was no significant relationship between this pleomorphism associated with
254 activity of the renin-angiotensin system and otosclerosis (25). In this study, in those
255 who had a shorter time interval between fenestration and prosthesis insertion (less than
256 5 min), the vertigo rate a month after surgery was lower. Also, in patients with higher
257 number of attempts for prosthesis insertion (more than 3 times), the rate of vertigo a
258 day and a week after surgery as well as prosthesis displacement was higher, but the
259 presence or absence of blood in the surgical field during prosthesis insertion was not
260 associated with an increase in complications.

261 **Conclusion**

262 In the study, the level of complications occurred after stapedotomy in patients with
263 otosclerosis was associated with variables such as age of patient, surgical procedure,
264 number of attempts for prosthesis insertion, as well as the time interval between
265 fenestration and prosthesis insertion.

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267 **References**

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UNDER PEER REVIEW