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Evaluation of Vestibular Disorder Risk Associated with Middle Ear Surgery

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Abstract

Objective: There are many reports that have assessed the hearing outcome of tympanoplasty, but few reports have assessed vestibular disorders associated with this surgery. Therefore, the objective was to investigate the postoperative vestibular disorder risk associated with each operative variation of middle ear surgery.

Methods: The data were obtained from 233 cases that underwent microscopic middle ear surgery performed on 202 cases of tympanoplasty at our institute from April 2012 to March 2014. We investigated the presence or absence of subjective vestibular symptoms on the day after surgery. In the cases of cholesteatoma, we also investigated lesion extent and location.

Results: A total of 8.2% of the postoperative patients had vestibular disorders, with all of them showing rapid recovery and getting discharged as scheduled. Older patients ($p<0.01$) or those who had past history of vestibular symptoms ($p<0.01$) were found to have a high risk. Vestibular disorder incidence rate was significantly higher in the group that did not undergo ossiculoplasty than in the group that underwent ossiculoplasty ($p=0.02$). There were statistically significant differences in cases with a blue line of prominence of the lateral semicircular canal and exposure of the dura mater and mastoid lesions in cholesteatoma cases.

Conclusion: The risk of vestibular disorder associated with middle ear surgery was high in patients who had inflammatory lesions causing bone destruction and requiring mastoidectomy. Cholesteatoma cases with occurrence in the mastoid region or extensive lesions also had high risk.

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Introduction

Middle ear surgery has many operative variations including mastoidectomy to preserve the external auditory canal, ossicular chain reconstruction, and one-stage or two-stage surgeries that aim to reduce the postoperative risk of recurrent inflammation or improve long-term hearing prognosis. Operations of the middle ear that are more invasive have increased risk of postoperative complications such as facial nerve paralysis, intracranial inflammation, sensorineural hearing loss, and vestibular disorders due to surgical areas. There are many reports which have assessed the hearing outcome of tympanoplasty but few reports have assessed vestibular disorders associated with this surgery. However, some cases have been diagnosed with otitis media when they presented with first symptoms of a vestibular disorder. In these cases, the inflammation caused by the lesion was thought to extend beyond the bone labyrinth and affect vestibular function. Leonetti et al. [1] reported that 38%of patients who had preoperative complaints of vertigo improved after canal wall down mastoidectomy. In contrast, since the lesion which causes vestibular disorders needs to be removed, it is expected that iatrogenic postoperative vestibular disorders are likely to occur. In cholesteatoma cases, the risk may change depending on the extent of progression. Due to the difference in the degree of surgical invasion, each ossiculoplasty technique may be considered to have various levels of vestibular disorder risk. We investigated the cases which developed postoperative vestibular disorders out of all the cases of microscopic middle ear surgery performed in our institute and clarified the risk factors.

Table 1: Background of subjects. N=233.

			vestibular symptoms	
	Variances		**Yes n (%)**	**No n (%)**
subjects' background				
	age		65 ± 18.24	52 ± 21.84
	sex	Male	12 (10.8)	99 (89.2)
		female	7 (5.7)	115 (94.3)
	pathology	chronic otitis media	4 (6.7)	56 (93.3)
		cholesteatoma	14 (9)	141 (91)
		Other	1 (5.6)	17 (94.4)
	past history of vestibular symptoms	Yes	11 (16.2)	57 (83.8)
		No	8 (4.8)	157 (95.2)
	operative strategy	one-stage	6 (6.6)	85 (93.4)
		two-stage(the first stage)	10 (11.4)	78 (88.6)
		two-stage(the second stage)	3 (5.6)	51 (94.4)
operative variation				
	ossiculoplasty	Yes	6 (4.4)	130 (95.6)
		No	13 (13.4)	84 (86.6)
	mastoidectomy	None	1 (2.5)	39 (97.5)
		canal wall up	5 (5.6)	84 (94.4)
		canal wall down	13 (12.5)	91 (87.5)
operative findings				
	dural exposure	Yes	10 (26.3)	28 (73.7)
		No	9 (4.6)	186 (95.4)
	dehiscence of the fallopian canal	Yes	9 (16.4)	46 (83.6)
		No	10 (5.6)	168 (94.4)
	blue line	Yes	7 (46.7)	8 (53.3)
		No	12 (5.5)	206 (94.5)
	duration of surgery(minutes)	<90	6 (6.7)	83 (93.3)
		≧90	13 (9)	131 (91)

Methods

The data were obtained from 233 cases that underwent microscopic middle ear surgery performed on 202 cases of tympanoplasty at our institute from April 2012 to March 2014. All surgeries were performed under general anesthesia. A total of 233 tympanoplasties were performed (111 male and 122 female). Age ranged from 6 to 89 years, and average age was 53 ± 21.8 years old. Pathologically, 155 cases presented with cholesteatoma (66.5%), 60 cases with Chronic Otitis Media (COM) (25.8%), and 18 cases were others (7.7%, which included tympanosclerosis (n=8), congenital auditory ossicle malformation (n=4), post-traumatic ossicular disruption (n=3), cholesterol granuloma (n=2), and middle ear tumor (n=1)). Therapeutic strategy of tympanoplasty was divided into one-stage or two-stage tympanoplasty based on severity, pathogenicity, and aeration of the tympanic cavity. One-stage tympanoplasty cases presented with mild cholesteatoma and COM. In contrast, two-stage tympanoplasty cases presented with moderate to severe cholesteatoma and advanced COM. One year after the first stage, second stage tympanoplasty was performed. For this study, these operations performed by the same surgeon were extracted in order to eliminate the influence of the skill of the surgeon. We reviewed the medical record of all cases retrospectively and investigated the presence or absence of subjective vestibular disorder symptoms (namely, dizziness or vertigo) on the day after surgery. The outcomes were assessed based on the differences in age, sex, pathogenicity, operative strategy (one-stage surgery, two-stage surgery including the first and/or the second stage), ossiculoplasty, history of vestibular symptoms, method of preservation of external auditory canal in mastoidectomy, exposure of facial nerves from the fallopian canal, exposure of dura mater of the middle cranial fossa, and the presence of bone labyrinth thinning in the prominence of the lateral semicircular canal (blue line). Especially, in the cases of cholesteatoma, we also investigated the differences in terms of lesion extent and location. The extent and location were classified by STAM system, which was published by European Academy of Otology and Neurotology and Japan Otological Society in 2017 (Figure 1) [2]. The selection of cases excluded children under 6 years of age, who are expected to have increased difficulty in communicating their symptoms. Statistical significance was determined by the t-test, the chi-square test, and Fisher's exact test. When the p value was less than 0.05, the variance was statistically significant. Multivariate logistic regression was performed on the variances in which the p value was below 0.05. All statistical analyses were performed by R statistical

Table 2: Results of univariate analyses.

Variance	Odds ratio	95% CI	p value	
age	-	3.79-22.25	<0.01	**
sex	1.99	0.69-6.20	0.23	
pathology	1.08	0.46-2.55	0.85	
past history of vestibular symptoms	3.76	1.30-11.36	<0.01	**
operative strategy	1	0.55-1.84	0.99	
ossiculoplasty	0.3	0.09-0.89	0.02	*
mastoidectomy	4.01	0.52-31.00	0.18	
dural exposure	7.28	2.43-22.27	<0.01	**
dehiscence of the fallopian canal	3.27	1.10-9.55	0.02	*
blue line	14.62	3.84-55.74	<0.01	**
duration of surgery	1.37	0.46-4.58	0.63	

CI: confidence interval
*: p<0.05; **: p<0.01

software version 4.0.2.

Results

The incidence of vestibular disorders in each group was 9.0% cholesteatoma, 6.7% COM, and 5.6% others. In all cases with vestibular disorders, no extension of the planned hospital stay due to vestibular disorders was observed, and none of them developed a chronic disorder. In terms of the backgrounds of the cases, sex (p=0.23) and pathology (p=0.779) were not statistically significant for the occurrence of postoperative vestibular symptoms, but older patients (p<0.01) and those who had past history of vestibular symptoms (p<0.01) were found to have high risk. For operative strategy, one-stage surgery, first-stage surgery, and second-stage surgery were compared; however, no significant difference was observed (p=0.99). Compared with the method of reconstruction, the vestibular disorder incidence rate was significantly higher in the group that did not undergo ossiculoplasty than in the group that underwent ossiculoplasty (p=0.02). Duration time of operation (p=0.63) and the way of mastoidectomy (p=0.18) revealed no significant differences. In the operative findings, exposure of the dura mater of the middle cranial fossa (p<0.01), facial nerve exposure (p=0.02), and blue line appearance (p<0.01) were all statistically significant (Tables 1 and 2). We collected all variances with p values below 0.05 and performed a multivariate logistic regression analysis. The results are shown in Table3. Statistically significant differences were found in the exposure of the dura mater (p=0.015) and blue line appearance (p=0.013), while age (p=0.131), past history of vestibular symptoms (p=0.121), ossiculoplasty (p=0.535), and facial nerve exposure (p=0.817) were not statistically significant (Table 3). From these results, it was clarified that the findings which were commonly seen in advanced cholesteatoma cases such as blue line appearance and exposure of dura mater of the middle cranial fossa are associated with the development of vestibular disorders. In the cholesteatoma cases, we evaluated in terms of location and extent of lesion using the STAM system (Figure 1). Comparing the location of the lesions (Figure 2), only M legion cases were statistically significant in multivariate analysis (p=0.02, Table 4). Comparing the extent of the lesions, more widespread lesions were statistically significant in cases with vestibular symptoms (p<0.01, Table 5).

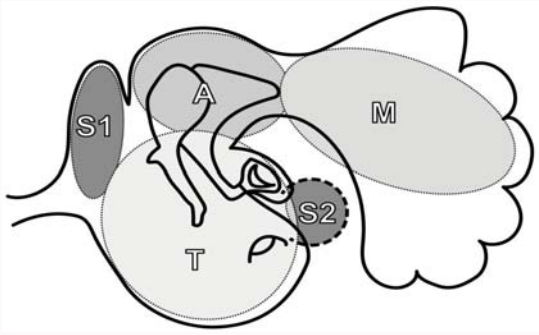

Figure 1: STAM system.
The STAM system was published by the European Academy of Otology and Neurotology and Japan Otological Society for the purpose of concisely assessing the extension and severity of cholesteatoma.
S1: Supratubal Recess; S2: Sinus Tympani; T: Tympanic Cavity; A: Attic; M: Mastoid

Table 3: Result of multivariate analyses.

Variances	Odds ratio	95% CI	p value	
age	1.03	0.99-1.07	0.131	
past history of vestibular symptoms	2.41	0.79-7.32	0.121	
ossiculoplasty	0.67	0.19-2.36	0.535	
dural exposure	4.96	1.37-18.00	0.015	*
dehiscence of the fallopian canal	1.1	0.32-3.83	0.817	
blue line	7.33	1.52-35.40	0.013	*

CI: confidence interval
*: p<0.05

Table 4: Results of multivariate analyses of cholesteatoma.

region	Odds ratio	95% CI	p value	
S1	2.17	0.54-8.70	0.28	
S2	0.78	0.18-3.20	0.72	
T	1.82	0.43-7.67	0.41	
A	0.79	0.05-11.80	0.87	
M	19.9	1.49-267.0	0.02	*

CI: confidence interval
*: p<0.05

Discussion

The total percentage of patients with postoperative vestibular disorders was 8.2%. The degree of vestibular disorders was mild, and no protracted vestibular disorder was observed. As a result, there were no long-standing vestibular complications that reduced the quality of life. In this study, the exposure of the dura mater of the middle cranial fossa and the blue line appearance were the factors considered to have the highest risk of vestibular disorder. These were characterized

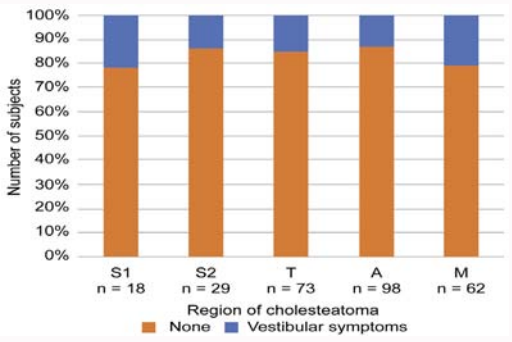

Figure 2: The percentage of patients with vestibular symptoms in relation to the region of cholesteatoma.

Table 5: Comparison of the number of lesions in cholesteatoma to presence of vestibular symptoms.

		n (%)	average number of regions	95% CI	p value	
vestibular symptoms				0.79-2.29	<0.01	**
	Yes	14(9.0)	3.21			
	No	141(91.0)	1.67			

CI: confidence interval
**: p<0.01

as having inflammatory lesions causing bone destruction and requiring mastoidectomy. Another characteristic was the location of inflammation found from attic to mastoid. In contrast, the effects of mechanical stress applied to the inner ear from the vestibular window during ossiculoplasty and drill vibration due to the variances in mastoidectomy procedure were considered to be smaller. Park et al. [3] reported that of the patients who underwent temporal bone drilling, 1.03% developed Benign Paroxysmal Positional Vertigo (BPPV). It is possible that the cases with vertigo were due to drilling vibration where the bilateral utricles vibrated and the otolith particles broke off to cause the development of BPPV. Releasing otolith particles from the utricles is one of the mechanisms responsible for postoperative vestibular symptoms. This report also suggested that there are few cases of vertigo caused by the vibrational energy of drilling, and the majority of the resulting vestibular disorders are not BPPV. Ogawa et al. [4] reported that the subjective visual vertical of patients after tympanoplasty was found to be deviated towards the healthy side in most cases, and 6.2% of subjects were deviated towards the affected side. In those biased toward the affected side, positional nystagmus was highly observed. Deviation toward the healthy side was considered an increase in the resting activity of the utricular afferent nerve by mechanical stimulation of the semicircular canal and the otolithic organ. In contrast, deviation toward the affected side indicated otolithic dysfunction. Otolithic disorder may be one of the mechanisms of postoperative vestibular symptoms. Kitahara et al. [5] reported that in cases with tympanoplasty with lateral semicircular canal fistula, 20% of cases had postoperative nystagmus, 5% of cases had worsening bone conductive hearing level, and 15% of cases had equivalent preoperative hearing level. It is presumed that the mechanisms of vestibular disorder in semicircular canal fistula are not caused by labyrinthitis but, in many cases, by other pathophysiology. In our study, in the cases with blue line appearance, the ipsilateral lateral semicircular canal would be vulnerable and surgical invasion may cause relatively more stimulation to the semicircular canal and the utricle. Cholesteatoma dismantles bone structures. Osteoclastic resorption is one of the major causes of destruction in cholesteatoma [6]. The incidence of labyrinthine fistula was reported between 2.7% to 12.5% [7-10]. Schwarz et al. [11] reported that 6.5% of cholesteatoma cases had dural exposure. Shinnabe et al. [12] reported that pars flaccida cholesteatoma with fallopian canal dehiscence cases are highly associated with labyrinthine fistula and dural exposure. Our study also found that blue line appearance had statistically significant association with fallopian canal dehiscence. The cholesteatoma grows from pars flaccida and progresses from the attic to the mastoid portion, so that the case with blue line appearance in the prominence of the lateral semicircular canal means cholesteatoma may have already widely progressed .In our study, dural exposure was significantly associated with vestibular symptoms. It also means that fully progressed pars flaccida cholesteatoma cases may have more risk of vestibular symptoms.

Conclusion

The risk of vestibular disorder associated with middle ear surgery was highest in patients with blue line appearance of prominence of the lateral semicircular canal, dural exposure of the middle cranial fossa, cholesteatoma located in the mastoid region cases, and cases with extensive cholesteatoma.

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