Vibration Effect of Drill on Facial Nerve Motor Functions During Mastoidectomy

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Cite this article as: Topak M, Kökeş Ü, Paltura C, Develioğlu ÖN, Çağlar E. Vibration Effect of Drill on Facial Nerve Motor Functions During Mastoidectomy. JAREM 2017; 7: 82-5.

ABSTRACT

Objective: We aimed to evaluate the vibration effect of drilling on facial nerve motor functions during mastoidectomy and to investigate the impact of this round of interest with its duration of use.

Methods: Twenty-three patients with a diagnosis of chronic otitis media were enrolled. Using electroneurography, all patients were determined to have pre- and postoperative bilateral facial nerve. The duration of drill during the operation was calculated, and the possible damage over the nerve and its association with the duration of drilling were investigated.

Results: The study included 23 patients, with 10 (43.5%) male and 13 (56.5%) female patients, There was no statistically significant deteriorating effect on facial nerve motor functions (p>0.05).

Conclusion: It is currently considered that facial nerves might be damaged only by direct contact during mastoidectomy. However, the nerves could be damaged by the vibration and temperature effects of the drill. Therefore, unnecessary drilling in the mastoid cavity should be avoided, and blunt-ended drills should be used.

Keywords: Mastoidectomy, surgical drill, facial nerve

INTRODUCTION

Chronic otitis media (COM) is characterized by ear discharge, hearing loss, and tympanic membrane perforation, which result from chronic infection and inflammation of the middle ear and mastoid lasting for ≥3 months (1). One of the main steps of COM surgery is to reach certain anatomic structures by opening and cleaning the infected cells after drilling the bone in the mastoid cortex. It has been reported that the noise level generated by a drill is above 100 dB. Experimental and clinical studies have demonstrated that drill-generated noise can damage the cochlea through the bones and cause hearing loss both in the operated ear and in the contralateral ear (2-4).

Drilling during mastoidectomy also leads to vibration in the bony tissue and noise. In an experimental study investigating the effect of vibration on arterial endothelial cells, a decrease was reported in the thickness and number of endothelial cells (5). In another experimental study, it was found that short-term vibration prevented axoplasmic transport in the peripheral nerves (6). Moreover, in an animal study, it was revealed that vibration could lead to hearing loss in laboratory animals (7).

F-wave responses are late responses of motor neurons that are antidromically activated (8). Damages in the peripheral or central nervous systems can be detected with F-wave responses. Latency in the proximal segment of the nerve is evaluated by recording F-wave responses. F-wave responses were measured and slowing nerve conduction was demonstrated in some diseases, such as Charcot-Marie-Tooth, Guillain-Barre syndrome, alcoholism, entrapment neuropathies, chronic renal failure, amyotrophic lateral sclerosis, and nerve root damages (9).

In this study, we aimed to investigate whether vibration caused by drilling in a mastoid surgery negatively affected facial nerve motor functions and to examine the relationship between this effect and duration of drilling.

METHODS

This study included 23 patients who underwent mastoidectomy due to the diagnosis of COM in the Clinic of Otorhinolaryngology, Health Sciences University Gaziosmanpaşa Taksim Training and Research Hospital. After the patients were informed regarding the processes that would be performed preoperatively and possible complications, written informed consents were obtained in accordance with the Declaration of Helsinki. In the preoperative period, both facial nerves were evaluated through electroneurography by the same specialist physician in the electrophysiology laboratory of the neurology clinic in our hospital and F-wave response recordings were obtained. The duration of drilling was recorded using a chronometer during mastoidectomy. Electroneurographic examination of the facial nerves was performed again in the postoperative period and F-wave response recordings were obtained for both facial nerves. The findings were evaluated statistically.

Statistical Analysis

Inspection of normality was performed using the Shapiro–Wilk test, histogram, Q-Q plot, and box plot graphs. The data were presented as median, minimum-maximum, frequency, and percentage. Preoperative and postoperative comparisons was analyzed using the Wilcoxon test. The Spearman correlation test was

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Received Date: 21.07.2016 **Accepted Date:** 21.11.2016

Available on-line at www.jarem.org
DOI: 10.5152/jarem.2017.1251

employed to evaluate the relationship between the net duration of drilling and other variables. A bidirectional p value <0,05 was considered significant. The data were analyzed using the NCSS 10 software.

RESULTS

The study was performed on 23 patients. Of these patients, 10 (43.5%) were males and 13 (56.5%) were females. The ages of the patients varied between 13 and 57 years (mean, 32.26 years). Thirteen patients (56.5%) were operated from their right ears and 10 patients (43.5%) from their left ears. The mean duration of drilling was 26.13 min (standard deviation, 15,835). The mean preoperative F-wave latency was measured as 12.875 (standard deviation, 6.5227) ms and the mean postoperative F-wave latency as 12.402 (standard deviation, 3.3067) ms in the operated ears. The mean preoperative and postoperative M amplitudes were found to be 1,853 (standard deviation, 0.5885) mv and 2.1243 (standard deviation, 0.63990) mv, respectively, in the operated ears. In addition, the mean preoperative and postoperative M latencies were measured to be 3.2391 (standard deviation, 0.73089) ms and 3.2957 (standard deviation, 0.76508) ms, respectively. The mean preoperative and postoperative F-wave latencies were found to be 12.782 (standard deviation, 5.9937) ms and 11.894 (standard deviation, 3.0373) ms in the contralateral ears, respectively. Moreover, in the healthy ears, the mean preoperative m amplitude was measured as 1.887 (standard deviation, 0.5712) mv, the mean postoperative m amplitude as 1.8491 (standard deviation, 0.42649) mv, the mean preoperative m latency as 3.3278 (standard deviation, 0.77483) ms, and the mean postoperative m latency as 3.4957(standard deviation, 0.82139) ms (Table 1). In contrast, statistical analyses revealed that only the change in m amplitude in the operated ear was statistically significant (p=0,002; Table 2).

DISCUSSION

During the development of temporal bone surgery technique, many instruments were used to reach the mastoid and middle ear cavity. While mastoidectomy was performed with a gouge at first, then otologic drills were begun to be preferred with the development of modern technology (10). It was thought that sensorineural hearing loss could develop in patients because of the noise level of 100 dB caused by drilling and its vibration effect on the temporal bone (10). In the first studies conducted on this topic, hearing loss was considered to occur only in cases in which bone chain was directly affected (11). In the studies performed following the use of otoacoustic emission in otorhinolaryngology, it was found that hearing loss could develop not only in the operated ear but also in the contralateral ear (2-4).

Studies have shown that the structure of the endothelium and nerve conduction could be damaged by vibration effect of drilling and noise (5, 6). Urquhart et al. (12) reported in their study that they did not find early hearing loss associated with vibration after drilling, but they stated that long-term effects of drilling were unknown. In this study conducted in 1992, standard audiometric analysis was performed to test hearing. Zou et al. (7) performed a similar study on experimental animals in 2001 and they used electrocochleography for measurement. They concluded that hearing loss could occur in association with vibration and this was more common among the elderly population. Zou reported that this hearing loss could result from oscillation, which was caused by vibration conducted up to the cochlea through bone, throughout the whole tractus beginning from the cochlear compartments to the auditory nerve. In our study, the effects of drilling-induced vibration on the vestibulocochlear nerve and the facial nerve, which

Table 1. Statistical values of measurements

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	Valid	Missing	Mean	Standard deviation	Minimum	Maximum
Age	23		32.26	14.775	13	57
Duration of drilling	23		26.13	15.835	6	70
Operated ear, preoperative f ms	23		12.875	6.5227	8.2	41.0
Operated ear, postoperative f ms	22	1	12.402	3.3067	7.3	25.2
Operated ear, preoperative amplitude mv	23		1.853	,5885	1.1	3.2
Operated ear, postoperative amplitude mv	23		2.1243	,63990	1.40	3.96
Operated ear, preoperative latency ms	23		3.2391	,73089	1.00	4.44
Operated ear, postoperative latency ms	23		3.2957	,76508	1.42	5.44
Contralateral ear, preoperative f ms	23		12.782	5.9937	7.9	38.0
Contralateral ear, postoperative f ms	22	1	11.894	3.0373	7.1	23.2
Contralateral ear, preoperative amplitude mv	23		1.887	,5712	,9	3.1
Contralateral ear, postoperative amplitude mv	23		1.8491	,42649	1.27	3.32
Contralateral ear, preoperative latency ms	23		3.3278	,77483	1.12	5.16
Contralateral ear, postoperative latency ms	23		3.4957	,82139	1.72	5.64

Min: minimum, Maks: maksimum

Table 2. Test statistics[a]

	Operated ear, postoperative f ms-operated ear, preoperative f ms	Operated ear, postoperative amplitude mv-operated ear, m preoperative m amplitude mv	Operated ear, postoperative m latency ms-operated ear, latency ms	Contralateral ear, postoperative f ms-Contralateral ear, preoperative f ms	Contralateral ear, postoperative m amplitude mv-Contralateral ear, preoperative m amplitude mv	Contralateral ear, postoperative m latency ms-Contralateral ear, preoperative m latency ms
Z	-,909[b]	-3.073[b]	-,365[b]	-,643[c]	-,552[b]	-1.796[b]
Asymp. Sig. (2-tailed)	,363	,002	,715	,520	,581	,073

a: Wilcoxon Signed Ranks Test, b: evaluated according to negative values, c: evaluated according to positive values

is adjacent to the internal acoustic meatus and very close to the surgical site in the mastoid process, was investigated.

F-wave responses have been used in the evaluation of peripheral nerve damage since they were defined by Magladery and McDougal in 1950 (13). Moreover, F-wave responses can provide information on the integrity of the peripheral nerve. When an axon is severely damaged or cut, F-wave responses disappear. Therefore, F-wave responses of the facial nerve can be used for evaluating intracranial and extracranial segments of the nerve (14). Wedekind and Klug (15) examined F-wave responses during and after acoustic neuroma surgery and they found them to be an appropriate method for the evaluation of nerve damage. In their study, they reported that disappearing F-wave during operation or then prolonged F-wave latency was associated with tumor size and the prognostic value was poor.

In our study, electromyography (EMG) examination results of 23 patients who underwent mastoidectomy were evaluated preoperatively and postoperatively. In conclusion, we found no significant difference in facial nerve functions with changing F waves in the preoperative and postoperative periods. Although this finding can be interpreted as the absence of any vibration-induced damage on the facial nerve, an accurate inference could not be reached because of small patient population. Therefore, further studies on larger populations are needed. Nevertheless, based on this knowledge, we suggest that the use of vibration-increasing blunt-ended drills and unnecessary drilling during operation will cause damage.

One of the difficulties that we encountered during this study was that some of our patients refused measurement with a needle electrode. For this reason, the study population prevented us to reach necessary number of patients for getting statistically accurate outcomes. Drilling processes were performed by a single surgeon to avoid variations associated with surgeons. One of the limitations of this study was that the same size drill end was not used during the procedure, but it is impossible to apply this surgically. For the prevention of personal variances, EMG measurements were performed by the same neurologist for standardization.

CONCLUSION

Mastoidectomy is a technique that is used by many otorhinolaryngologists. Vibration and noise caused by a drilling device can damage the nerves around the middle and inner ears. It is currently considered that facial nerves might be damaged only by direct contact. However, vibration effect of drilling can lead to harms as in hearing function, which cannot be measured. Therefore, unnecessary drilling and the use of blunt-ended drills in the mastoid cavity should be avoided.

Ethics Committee Approval: Authors declared that the research was conducted according to the principles of the World Medical Association Declaration of Helsinki "Ethical Principles for Medical Research Involving Human Subjects", (amended in October 2013).

Informed Consent: Informed consent was obtained from patients who participated in this study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – M.T., Ü.K., C.P., Ö.N.D., E.Ç.; Design - M.T., Ü.K., C.P., Ö.N.D., E.Ç.; Supervision - M.T., Ü.K., C.P., Ö.N.D., E.Ç.; Resources – M.T.; Materials – Ü.K.; Data Collection and/or Processing – C.P.; Analysis and/or Interpretation – M.T., Ü.K.; Literature Search – C.P., Ü.K.; Writing Manuscript – C.P., M.T., Ö.N.D.; Critical Review – E.Ç.;

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study has received no financial support.

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