Evaluation of Auditory Changes in Patients Undergoing Temporomandibular Joint Discectomy

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Purpose: Discectomy is one of the preferred temporomandibular joint (TMJ) surgical procedures for the treatment of internal derangements when conservative and minimally invasive treatments have failed. The purpose of the current study is to investigate whether a TMJ discectomy operation influences auditory function and clinical variables.

Methods: This prospective study was composed of patients who underwent a TMJ discectomy operation between 2016 and 2020. Auditory function was evaluated with pure tone audiometry, tympanometry, and acoustic reflex tests at preoperatively (T_0), postoperative first week (T_1), first month (T_2), and third month (T_3). Clinical parameters including maximum mouth opening (MMO) and TMJ pain were also evaluated at T_0, T_1, T_2, T_3, and sixth month (T_4).

Results: The study consisted of 17 patients (5 males, 12 females) with a mean age of 42.65. A significant reduction in visual analogue scale (VAS) pain scores and MMO values compared to baseline values was achieved in all follow up periods ($P^{T0\text{-}T1} = .001$; $P^{T0\text{-}T2/T3/T4} < .001$). In pure tone audiometry, a significant increase in T_1-T_0 comparisons at 1000 Hz, 2000 Hz, 6000 Hz, 8000 Hz frequencies, and pure tone average ($P = .008$; $P = .005$; $P = .012$; $P = .002$; $P = .001$) was observed. In T_3-T_0 comparisons, a statistically significant decrease was observed in pure tone thresholds at 125 Hz and 8000 Hz frequencies ($P = .008$; $P = .01$). There was no statistically significant difference in middle ear pressure and compliance values at T_1, T_2, and T_3 compared to T_0 ($P > .05$). Type C tympanogram was seen in 3 patients at T_1 and in 1 patient at T_2. Acoustic reflex tests were positive in all patients.

Conclusions: Although mild changes occurred in auditory tests in the early postoperative period, TMJ discectomy procedure has no permanent effect on auditory function.

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Temporomandibular joint (TMJ) disorders are the main cause of chronic pain, nondental pain, and disability in the orofacial area.[1,2] TMJ internal derangements are among the most common TMJ disorders and are seen in approximately 25% of the entire population. TMJ internal derangements refer to conditions with the articular disc displaced from its original position on the mandibular condyle. The most common forms of TMJ internal derangements are disc displacement with reduction and disc displacement without reduction.[1-3]

TMJ surgery for the treatment of internal derengaments can be performed when conservative (medical treatments, occlusal splints, physiotherapy) and minimally invasive treatments (intra-articular injections, arthrocentesis) are failed.[4,5] Approximately 5% of patients with TMJ disorders (TMD) may require surgical intervention, especially in patients who do not respond to conservative treatments.[6]

The TMJ disc is attached to condyle with discal and capsular ligaments and to middle ear with the discomalleolar ligament.[7,8] The discomalleolar ligament is continuous with the posteromedial portion of the disc and articular capsule, and it enters the middle ear through the petrotympanic fissure.[9] The relationship between TMJ disorders and aural symptoms is based on this anatomical structure.[7,9] Excessive tension of the discomalleolar ligament can cause auditory symptoms. However, other authors doubt this will happen.[7]

In the TMJ discectomy procedure, integrity of the joint capsule is disrupted, and the entire disc is removed. The TMJ-middle ear relationship may be disrupted by discectomy operation, and effects of this operation on auditory function are unknown.

Many studies in the literature have evaluated the relationship between TMJ disorders and auricular symptoms and auditory function. To the authors' knowledge, there is no study in the literature that evaluates the relationship between TMJ discectomy and auditory function. Therefore, the aim of this study is to investigate whether a TMJ discectomy operation influences auditory function and clinical variables.

Material and Methods

STUDY DESIGN

The authors designed a prospective clinical study to investigate the effects of the TMJ discectomy procedure on auditory function. The present study consisted of patients who underwent TMJ discectomy operation between 2016 and 2020 at the Karadeniz Technical University, Faculty of Dentistry, Department of Oral and Maxillofacial Surgery. The study was conducted in accordance with Principles of the Declaration of Helsinki and with the approval of the Human Ethics Committee of Karadeniz Technical University (2015/114). Patients were fully informed about the procedures and possible complications, and they signed detailed written consent forms.

TMJ internal derangements were diagnosed according to the source of the pain and dysfunction, history, clinical examination, and radiographic evaluation. Conservative and minimally invasive treatments were used as the first-line treatment; if these procedures failed, a TMJ discectomy operation was performed. Inclusion criteria were patients who underwent unilateral TMJ discectomy operation, patients with normal hearing threshold levels and normal ear findings (intact tympanic membrane, type A tympanometry), and patients who were examined by a national board-certified ear, nose, and throat (ENT) doctor, with no otolaryngological abnormalities detected. Patients were excluded if they presented any of the following: congenital or degenerative TMJ disorders, history of TMJ surgery for any reason, indication for bilateral TMJ discectomy, history of otitis media, and middle ear disorders due to Eustachian tube dysfunction.

Pure tone audiometry, tympanometry, and acoustic reflex tests were used to assess auditory function. These tests were applied to the patients preoperatively (T_0), postoperative first week (T_1), first month (T_2), and third month (T_3). Pure tone audiometry and tympanometry tests were performed on the operated side, and an acoustic reflex test was performed bilaterally. All tests were carried out by the same audiometrist.

Clinical parameters, including maximum mouth opening (MMO) and TMJ pain, were also evaluated. These values were recorded at T_0, T_1, T_2, T_3, and postoperative sixth month (T_4). Patients were asked to open their mouths as wide as possible without help, and the MMO was measured between the edges of the upper and lower central incisors by a millimeter ruler. To measure the pain level, patients were asked to rate their pain on a visual analog scale (VAS) from zero (absence of pain) to 10 (maximum pain).

In pure tone audiometry, different frequencies of audio signals were sent to the ear, and hearing thresholds were evaluated. An Interacoustics AC40 Clinical Audiometer (Denmark) was used for pure tone audiometry. Audiometric pure-tone thresholds from 125 to 8000 Hertz (Hz) were obtained for all patients in decibel (dB) units. Pure tone average (PTA) was calculated by the mean value of the hearing threshold at 500−1000−2000−4000 Hz. Thresholds are considered to be within normal limits when they range from zero to 25 dB.[10]

In the tympanogram, middle ear pressure, compliance, and type of tympanogram were evaluated. An Interacoustics AT235 Clinical Tympanometer (Denmark) was used for tympanometry and acoustic reflex

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tests. The pressure value at the peak in the tympanogram was defined as the middle ear pressure measured in decapascals (daPa). Normal middle ear pressure ranges from −100 daPa to +50 daPa and represents normal Eustachian tube function. Middle ear pressure values below −100 daPa indicate poor Eustachian tube function. Compliance indicates the transmission of sound through the middle ear and is measured in milliliters (mL). It is plotted vertically on the tympanogram, and maximum compliance of the middle ear system occurs when air pressure on both sides of the tympanic membrane is equal.[11,12] Middle ear compliance values from 0.3 to 1.5 mL are considered normal.[13] Tympanograms were classified into 5 groups based on their quantitative pattern and shape. Type A: normal pressure range−normal compliance of tympanic membrane. Type As: normal pressure range with low compliance of tympanic membrane. Type Ad: normal pressure range with high compliance of tympanic membrane. Type B: pressure measurement compromised, indicating middle-ear effusion or other space-occupying lesions of the middle-ear. Type C: negative middle ear pressure.[13,14]

The acoustic reflex is the contraction of the stapedius muscle in response to an acoustic stimulus of 70 to 90 decibels (dB) over the threshold of hearing.[15] This measurement is performed at frequencies of 500, 1000, 2000, and 4000 Hz. Acoustic reflex tests were evaluated as positive (+) and negative (−).

SURGICAL TECHNIQUE

A preauricular approach was used on all patients. A preauricular incision about 3 to 4 cm in length was made, and skin and subcutaneous tissues were passed with sharp dissection. Temporal artery and vein were ligated when necessary. After incision of the superficial temporal facia, deep temporal facia was reached. The zygomatic arc was approached in this plane. The joint capsule was exposed with blunt dissection. The articular capsule was incised and the TMJ disc dissected from the lower and upper compartment. The entire disc was removed with hemostat and scissors, and abdominal dermis-fat graft was placed interpositionally. All patients were operated by the same surgeon.

STATISTICAL ANALYSIS

Statistical analyses were performed using SPSS for Windows 23.0 (SPSS, Inc, Chicago, IL). The normality of distribution was tested with the Shapiro-Wilk test. Friedman and Wilcoxon tests, and Bonferroni correction (if needed), were used for comparisons of nonparametric data. For all comparisons, statistical significance was set at $P < .05$.

Results

A total of 17 patients (5 males, 12 females) were included in the study. The mean age of the patients was 42.65 (24 to 62). No serious complications were observed in any of the patients during or after the operation, and all patients recovered uneventfully.

Table 1 presents the preoperative and postoperative values of clinical parameters. VAS pain scores showed statistically significant improvements compared to baseline values in all follow-up periods, and improvements were more pronounced at T_2, T_3, and T_4 ($P^{T0\text{-}T1}$ =.001; $P^{T0\text{-}T2/T3/T4}$ <.001). In all follow-up periods, significant improvement compared to baseline values was achieved in MMO values, and improvements were more pronounced at T_2, T_3, and T_4 ($P^{T0\text{-}T1}$= .001; $P^{T0\text{-}T2/T3/T4}$ < .001).

The pure tone audiometry test results are listed in Table 2. In T_1−T_0 comparisons, a statistically significant increase was observed in pure tone thresholds at frequencies of 1000 Hz, 2000 Hz, 6000 Hz, 8000 Hz, and pure tone average (P^{1000Hz} = .008; P^{2000Hz} = .005; P^{6000Hz} = .012; P^{8000Hz} = .002; P^{PTA} = .001). However, pure tone thresholds at all frequencies did not significantly differ between T_2 and T_0 ($P > .05$). In T_3−T_0 comparisons, a statistically significant decrease was observed in pure tone thresholds at 125 Hz and 8000 Hz frequencies (P^{125Hz} = .008; P^{8000Hz} = .01). There were no statistically significant differences at any other frequency.

Table 1. RESULTS OF CLINICAL PARAMETRES IN EACH FOLLOW-UP

Variables	T_0	T_1	T_2	T_3	T_4	*P* Value
VAS	8 (6-10) *, #	4 (2-8)	2 (1-6)	2 (1-4)	1 (0-3)	.001*, <.001#
MMO	23 (17-28) *, #	32 (22-38)	37 (26-40)	39 (30-43)	40 (34-44)	.001*, <.001#

Note: Data are presented as median (minimum-maximum).
Abbreviations: MMO, maximal mouth opening; VAS, visual analog scale.
* Statistically significant difference between T_0 and T_1.
# Statistically significant difference between T_0 and T_2, T_3, T_4.

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Table 2. RESULTS OF PURE TONE AUDIOMETRY TESTS (DB) IN EACH FOLLOW-UP.

Frequency	T_0	T_1	T_2	T_3	*P Value*
125 Hz	14 (9-25) #	15 (10-25)	14 (8-24)	14 (7-24)	.008#
250 Hz	13 (7-23)	13 (9-24)	13 (7-23)	13 (8-23)	
500 Hz	11 (7-21)	11 (8-22)	10 (7-21)	10 (6-20)	
1,000 Hz	9 (5-19) *	10 (6-19)	10 (6-19)	9 (5-19)	.008*
2,000 Hz	7 (3-20) *	9 (4-19)	8 (5-16)	8 (4-16)	.005*
4,000 Hz	9 (5-18)	9 (5-18)	9 (5-18)	9 (5-18)	
6,000 Hz	11 (5-21) *	12 (7-23)	10 (6-21)	10 (6-21)	.012*
8,000 Hz	11 (6-19) *, #	13 (7-20)	12 (7-19)	10 (7-22)	.002*, .01#
PTA (Hz)	9,5 (5,25-18,25)*	10 (6-10)	9,5 (5,75-18)	9 (5-17,75)	.001*

Note: Data are presented as median (minimum-maximum).
Abbreviations: dB, decibels; Hz, hertz; PTA, pure tone average.
* Statistically significant difference between T_0 and T_1.
# Statistically significant difference between T_0 and T_3.

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Table 3 presents the middle ear pressure and compliance values according to the time frame. Middle ear pressure was slightly lower at T_1 than at T_0, but the difference was not statistically significant ($P^{T0\text{-}T1}$ = .289). There were no statistically significant differences in middle ear pressure values at T_2 and T_3 compared to T_0 ($P^{T0\text{-}T2}$ = .850; $P^{T0\text{-}T3}$ = .569).

Compliance values at T_1 showed a slight decrease compared to T_0, but this was statistically insignificant ($P^{T0\text{-}T1}$ = .361). There were no statistically significant differences in compliance values at T_2 and T_3 compared to T_0 ($P^{T0\text{-}T2}$ = .459; $P^{T0\text{-}T3}$ = .776) (Table 3).

In comparing typanogram types, type C tympanogram was seen in 3 patients in T_1 and 1 patient in T_2, but distribution of the types of tympanograms was not statistically significant between T_0 and T_1, between T_0 and T_2, or between T_0 and T_3 ($P^{T0\text{-}T1}$ = .083; $P^{T0\text{-}T2}$ = .317; $P^{T0\text{-}T3}$ = 1.000) (Table 4). Acoustic reflex tests were positive in all patients.

Discussion

Conservative and minimally invasive therapies are the first choice of treatment options for TMJ internal derangements. Surgical procedures, such as arthroscopy, condylotomy, disc repositioning, disc repair, and discectomy are considered when conservative and minimally invasive treatments are failed.[5,16,17] Auditory functions may be affected by TMJ surgical procedures due to the close relationship between middle ear structures and TMJ. Although the TMJ discectomy procedure is commonly used in the treatment of TMJ internal derangements, there is a lack of evidence about its effect on auditory function. In this study, we evaluated the effect of the TMJ discectomy procedure on clinical parameters and auditory function.

In their study, Miloro et al[18] performed TMJ discectomy in 30 patients with a mean age of 36.3 years, 93.3% females. Dimitroulis et al[6] performed TMJ discectomy in their study, which included 25 female and 4 male patients with a mean age of 42. Our results are compatible with the literature that most patients in our study were female, and the mean age was 42.65.

Pain during jaw movements and restricted mouth opening are commonly seen in TMJ internal derangements.[1,4,5] Many studies have demonstrated that TMJ discectomy is a successful approach in the treatment of TMJ internal disorders.[6,18-20] Based on the literature data, we performed

Table 3. MIDDLE EAR PRESSURE AND COMPLIANCE VALUES IN EACH FOLLOW-UP.

Variables	T_0	T_1	T_2	T_3
Middle ear pressure (daPa)	-22 (-37 to +5)	-30 (-123 to +6)	-26 (-120 to +15)	-23 (-44 to -2)
Compliance (mL)	0,84 (0,49 to 1,31)	0,79 (0,34 to 1,45)	0,82 (0,40 to 1,42)	0,87 (0,44 to 1,38)

Note: Data are presented as median (minimum-maximum).
Abbreviations: daPa, decapascal; mL, milliliter.

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Table 4. DISTRIBUTION OF TYMPANOGRAM TYPES AND ACOUSTIC REFLEX TESTS RESULTS IN EACH FOLLOW-UP.

Variables	T_0	T_1	T_2	T_3
Tympanogram type, *n* (%)	17 (100%)			
Type A		14 (82.4%)	16 (94.1%)	17 (100%)
Type C		3 (17.6%)	1 (5.9%)	
Acoustic reflex, *n* (%)				
Reflex (+)	17 (100%)	17 (100%)	17 (100%)	17 (100%)
Reflex (-)	-	-	-	-

Abbreviation: *n*, number.

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discectomy + dermis fat grafting procedure in patients with TMJ internal derangements who did not heal with conservative and minimally invasive methods. According to our results, VAS pain scores and MMO values improved significantly at the 6-month follow-up.

In anatomical studies, it has been shown that articular disc and malleolus are connected by the discomalleolar ligament.[9, 21] The discomalleolar ligament is attached at the level of the neck and anterior process of the malleus. It extends along the petrotympanic fissure and enters the postero-medial region of articular capsule and retrodiscal region.[22] TMJ disc is divided into 4 compartments: anterior band, intermediate zone, posterior band, and bilaminar zone.[9] According to Valesca et al,[7] the posterior segment of the joint capsule corresponds to the bilaminar zone of the disc. The upper internal part of the posterior segment of the capsule is supported by the discomalleolar ligament.[7] The discomalleolar ligament can restrict anterior discal movements in extreme movements (maximal opening and propulsion).[23] Because the TMJ disc is connected to the middle ear by the discomalleolar ligament, this connection is disrupted by discectomy operation. This situation suggests the potential for discectomy procedures to affect hearing, leading to the design of the present study.

Pure tone audiometry is used to assess hearing loss and to specify hearing thresholds. This test depends on the patient's response to the amplitude level of audio signals of different frequencies.[10,13,24] Auditory changes in patients with TMJ irregularities are controversial. Some studies have demonstrated that patients with TMJ disorders have hearing loss usually in mid to high-frequency ranges.[25] Cebi et al[10] reported that pure tone audiometry test results of patients with disc displacement with reduction (DDWR) or disc displacement without reduction (DDWoR) were within normal ranges in their study. To ensure standardization, patients with preoperative audiometric threshold values within normal ranges were included in this study.

Although actual hearing loss was not seen in our study, a statistically significant increase was observed at 1000, 2000, 6000, and 8000 Hz and in pure tone average at the first week follow-up. This may be because pure tone audiometry is a subjective test with potential bias from psychological changes in recently operated patients, changes in middle ear pressure in the short-term postoperative period, and edematous effect in the area adjacent to the surgery. It was observed that hearing thresholds decreased significantly in low and high frequencies at T_3 compared to T_0, and statistically insignificant differences were noted at other frequencies and in pure tone averages between T_3 and T_0. The disappearance of surgical side effects over time is thought to be the reason for this. In addition, 1 study in the literature reported that after treatment of patients with TMJ disorders, objective improvement in cochlear function was achieved.[26] It is estimated that decreasing hearing thresholds at low and high frequencies is related to disappearing TMJ symptoms after the healing period.

Tympanometry has been a broadly accepted method to assess middle ear condition.[11] It is an objective test that assesses transmission and pressure in the middle ear; tympanometry records give valuable data about Eustachian tube dysfunctions.[27] Pekkan et al[25] reported that patients with TMJ disorders showed lower pressure levels in the middle ear and significantly higher compliance value compared to the control group. Roy et al[28] performed tympanometric evaluations in patients with oral submucous fibrosis. Type B curve was obtained in 11 ears preoperatively and in 13 ears immediately after surgery, and all patients showed normal tympanogram types on first- and third-month postoperative follow-ups. They reported that hearing is affected by the dysfunction of the eustachian tube relative to decreased capacity of mouth-opening because of fibrosis.[28] One study in the literature reported that improvement was observed in Eustachian tube function and hearing values after intermaxillary fixation was removed in patients who underwent orthognathic surgery.[24]

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Choi et al[29] performed tympanometric evaluations in patients who underwent adenotonsillectomy and reported that decreased pressure of the middle ear and tympanogram type changes in short-term postoperatively could be related to immediate dysfunction of the eustachian tube, and this dysfunction may have originated from surgical edema and blockage of the Eustachian tube by blood clots. Similarly, middle ear pressure decreased to -30 daPa at the first week follow-up, and Type C tympanograms were observed in 3 patients in our study. Type C tympanogram shows negative middle ear pressure, which indicates poor Eustachian tube function.[11] Thereafter, the values gradually recovered at T_2 and T_3. Proximity of the middle ear to the surgical area and the connection between the TMJ and the middle ear may cause fluid passage to the middle ear and blockage of the Eustachian tube. In addition, reduction of edema and increased mouth opening during follow-up periods may improve Eustachian tube function.

Measurements of the static compliance of the tympanic membrane and the volume of the tympanic cavity help to evaluate changes in the stiffness of the tympanic membrane, the decrease of middle-ear effusion, and volumetric alterations of the middle ear.[27] Haughton et al[30] stated that high static compliance values indicate decreased probability of middle-ear effusion. A slight decrease was observed in the static compliance values at the 1-week follow up, but this was not statistically significant. This may be due to probability of increase in middle ear effusion caused by the discectomy operation.

The acoustic reflex test is used to assess neurosensorial health and evaluate response to high audio signals. The acoustic reflex test provides information about both peripheral and central nervous systems.[15] In a healthy individual, ipsilateral and contralateral reflexes are seen when a stimulus is present above the acoustic reflex threshold. Thus, the inner ear is protected from high intensity sounds.[15] Absence of acoustic reflex could be related to conductive hearing loss.[14] Kaygusuz et al[31] evaluated auditory changes in patients with TMJ disorders and reported that all patients' acoustic reflex tests were positive. In this study, the acoustic reflex test was positive in all patients before and after surgery.

The results of this study revealed that TMJ discectomy operation decreased VAS pain scores and increased MMO values in patients with TMJ internal disorders who did not respond to conservative or minimally invasive treatments. There was no statistically significant change in pure tone audiometry, tympanometry, or acoustic reflex tests at the end of the follow-up period after the TMJ discectomy operation. Decreases in middle ear pressure, a slight increase in compliance value, and type C tympanogram were seen at T_1 and T_2, but these changes were not statistically significant and gradually improved at T_2 and T_3. This may be due to decreased Eustachian tube function, middle ear effusion, or the edematous effect of surgery. These results are consistent with those of McKenna and Hall,[32] who reported that arthrotomy has no effect on hearing ability. In addition, Coleman[33] and Smeele[34] argued that it is unlikely that movements of the TMJ meniscus, capsule, or condyle can induce malleus mobility in adults due to insertion of the discomalleolar ligament into the walls of the petrotympanic fissure.[35]

The limitations of the present study were the low number of patients and short follow-up period. The efficiency of the TMJ discectomy operation may change during longer follow-up periods and clinical symptoms of the patients may reoccur. Auditory changes may develop when symptoms of TMJ disorders occur.

In conclusion, data from the present study demonstrate that TMJ discectomy is an effective procedure in terms of relieving pain and improving mouth opening when conservative and minimally invasive therapies have failed in patients with TMJ internal derangements. Although some changes occurred in pure tone thresholds, middle ear pressure, compliance, and tympanogram type in the near postoperative period, these values returned to their approximate baseline values as the side effects of the TMJ discectomy procedure dissipated. This also supports that the TMJ discectomy procedure has no permanent effect on auditory function.

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