EVALUATION OF THE EFFECT OF TEMPOROMANDIBULAR JOINT ANKYLOSIS AND RELEVANT GAP ARTHROPLASTY ON AUDITORY FUNCTIONS

Sayed A, Rashed*; Mamdouh Sayed**; Nadia M. Kamal***; M. Dehis**** and Abeer Kamal*****

ABSTRACT

Objective: The present study was designed to evaluate the effect of temporomandibular joint bony ankylosis and its relevant gap arthroplasty on hearing quality.

Patients and methods: Eight patients with 14 bony ankylosed TMJ were selected from those attending the out-patient Clinic of Oral and Maxillofacial Surgery Department of Faculty of Oral and Dental Medicine, Cairo University. Gap arthroplasty was utilized for management of such patients. Pure tone audiometry and immittancemetry with tympanometry and acoustic reflex have been performed preoperatively, two weeks and three months postoperatively for assessment of auditory functions.

Results: Some degree of hearing impairment has been detected preoperatively in TMJ bony ankylosis patients. A deficient middle ear volume has been detected. Negative values of tympanic peak pressure have been observed preoperatively and certain improvement has been detected at the end of follow up with a positive values.

Conclusion: Gap arthroplasty combined with jaw mobilization applied in the current investigation and improvement of swallowing mechanism help in aeration of middle ear via Eustachian tube. Gap arthroplasty has no deleterious effects on hearing quality.

KEYWORDS: TMJ ankylosis, arthroplasty, hearing impairment, pure tone audiometry, tympanometry.

INTRODUCTION

Temporomandibular joint (TMJ) ankylosis usually impairs the growth of lower jaw and lead to facial deformities. Gap arthroplasty is one of the standard surgical techniques for release the temporomandibular ankylosis. Skeletal deformities that induced by TMJ ankylosis have received several attentions however, its impact on hearing defect still unclear. Previous studies were concerned with the release of (TMJ) ankylosis by different methods and the improvement of such techniques with limited emphasis on the response of the adjacent
and associated structures. The ear is an example for little research attention.\(^{(1-4)}\)

Temporomandibular joint ankylosis may affect hearing and speech. It has been reported that the patients with TMJ disorders might suffer from aural signs and symptoms such as tinnitus. It has been reported that patients with true TMJ ankylosis suffer from speech difficulty due to limitation of jaw mobility and function. TMJ ankylosis interferes with normal mandibular growth with retro and/or micrognathia and induces facial deformity. Psychological, respiratory distresses as well as obstructive sleep apnea were considered another problem of ankylosis. Local disabilities include an inadequate semisolid diet have been reported.\(^{(4-6)}\)

Temporomandibular disorders (TMD) are characterized by various signs and symptoms of pain and dysfunction, most of which have been extensively studied. Complaints can occur in all areas of the face, the neck, the temporal, occipital and frontal zone of the head, and even in the ear. Ear symptoms are otalgia, tinnitus, and hearing loss. The prevalence of tinnitus in the TMD population seems to be greater than that found in the general population. Few studies in the literature focus on the occurrence, prevalence, and treatment of otalgia in TMD patients. It has been reported that 21% of patients with TMD arthroplasty complained of earache. Recently earache appeared to increase with increasing severity of arthroplasty.\(^{(7-10)}\)

**Audiological Evaluation** starts by asking questions about medical and hearing history. Otological examination of ears using an otoscope has been performed to check for anything in the ear canal that might affect the test results. A series of tests to assess hearing quality have been carried out: whether there is a hearing loss or not, the cause of the hearing loss, the degree and configuration of hearing loss and the best treatment options. Audiologic tests include Pure-Tone Testing, Speech Testing, Tests of the Middle Ear, Auditory Brainstem Response (ABR) and Otoacoustic Emissions (OAEs).\(^{(11,12)}\)

**Pure-tone Audiometry** is a hearing test conducted under ideal listening conditions in a soundproof closet. The test includes different pitches and intensities and the results are conveyed in graphical form. If there is hearing loss an audiogram helps distinguish conductive loss (outer/middle ear) from sensorineural loss (cochlea/cochlear nerve). An audiogram is indicated to evaluate any suspected hearing loss, tinnitus, vertigo and other ear symptoms. It is also useful for screening for hearing loss in people regularly exposed to loud noises and for certain patients on ototoxic medications. Pure-tone Audiometry, is a painless hearing test, the audiologist will usually perform otoscopy initially.\(^{(13)}\)

**The tympanometry** is an objective measure of middle ear and Eustachian tube dysfunction. It provides information about the compliance or mobility of the tympanic membrane, the pressure within the middle ear and the volume of the external ear canal. Tympanograms are classified as type A (normal), type B (indicating fluid behind the tympanic membrane) or type C (indicating Eustachian tube dysfunction). The objective data obtained by tympanometry are a useful adjunct in the diagnosis and follow-up of middle ear diseases.\(^{(14,15)}\)

Recent studies using **high-frequency immittance measurements** have led to clinical recommendations for middle ear assessment. Immittance is a collective term for the reciprocals impedance and admittance. Impedance is the opposition to energy flow into a medium and admittance is consequently the ease with which energy flows into a medium. In modern middle ear analyze admittance is the property that is displayed. During immittance monitoring, some well-defined alterations are made, either an air pressure sweep (tympanometry) or presentations of stapedius reflex-eliciting stimuli (acoustic reflex measurements). The resulting probe-tone reflections are responses to such pressure sweeps or reflex stimuli. Sweep frequency tympanometry is the measurement of acoustic immittance of the middle ear as a function of ear canal air pressure in which the probe tone is swept through a series of
frequencies e.g. from 250 to 2000 Hz. It is possible to assess the resonant frequency of the middle ear system. The resonant frequency is the probe-tone frequency at which susceptance becomes zero due to the counteractive forces of its compliance and mass elements. The interaction between the compliance elements and the mass elements is called susceptance.\(^\text{[16,17]}\)

Pure tone and immittance audiometry have been utilized in the present study as reliable calipers of auditory functions. Pure tone audiometry is an instrument to distinguish hearing sensitivity in TMJ ankylosis. Immittance testing is an integral part of test battery; this test measures the status of the tympanic membrane and the middle ear function. The obtained findings of the current research will elucidate the effect of temporomandibular joint TMJ bony ankylosis and its relevant gap arthroplasty on one of the most important function of temporal bone i.e. auditory functions.

Review of literature concerning the TMJ ankylosis showed that this subject has received considerable attention regarding etiology, epidemiology, diagnosis and treatment at the same time it has failed to detect the possible changes in hearing that might be induced in response to affection of the TMJ ankylosis and its correction by gap arthroplasty. This study has been designed to clarify the effect of TMJ ankylosis and changes that may be induced in hearing after gap arthroplasty. The obtained results are expected to contribute of better understanding the effect of TMJ ankylosis and gap arthroplasty on hearing and possibly minimize drawbacks if any that might be related to the ear.

**PATIENTS AND METHODS**

The present study comprises eight Egyptian patients suffering from temporomandibular joint (T.M.J) bony ankylosis with 14 ankylosed joint. Their age ranged from 18-45 years with mean equal 29.5 years. The cases were selected from those attending the out-patient clinic of Oral and Maxillofacial Surgery Department, Faculty of Oral and Dental Medicine, Cairo University. Diagnosis of ankylosis has been established on the basis of careful history, thorough clinical and radiographic examinations. Every patient has been subjected to laboratory routine investigation for general anesthesia. All patients have been managed by Gap arthroplasty to release the TMJ ankylosis. In addition two cases needed coronoidectomy to release difficult extended ankylosis bony mass. Preoperative and postoperative audiological tests comprised pure tone audiometry and immittance with tympanometry and acoustic reflex have been performed. Patient clinical data are shown in table (1).

**TABLE (1) Clinical data of patients included in the present study.**

<table>
<thead>
<tr>
<th>Pt. No.</th>
<th>Sex</th>
<th>Age</th>
<th>Duration of ankylosis in years</th>
<th>Etiology of ankylosis</th>
<th>Side of involvement</th>
<th>Number of recurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Female</td>
<td>21</td>
<td>20</td>
<td>Congenital</td>
<td>Bilateral</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Female</td>
<td>36</td>
<td>20</td>
<td>Trauma</td>
<td>Bilateral</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>Female</td>
<td>32</td>
<td>25</td>
<td>Trauma</td>
<td>Left</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>Female</td>
<td>45</td>
<td>40</td>
<td>Trauma</td>
<td>Bilateral</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>Female</td>
<td>29</td>
<td>19</td>
<td>Trauma</td>
<td>Bilateral</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>Male</td>
<td>27</td>
<td>15</td>
<td>Trauma</td>
<td>Right</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>Female</td>
<td>28</td>
<td>22</td>
<td>Trauma</td>
<td>Bilateral</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>Male</td>
<td>18</td>
<td>11</td>
<td>Congenital</td>
<td>Bilateral</td>
<td>0</td>
</tr>
</tbody>
</table>
Preoperative Radiographic Investigations

Standard panoramic view, axial, coronal and three-dimensional reconstruction computerized tomography scans have been obtained for better clarification of the site of cutting, visualization of ankylosing bony mass size and its extent, relation of the ankylosis to infratemporal fossa, level of mandibular foramen, shape and configuration of coronoid process and its relation to zygomatic arch (fig.1,2).

Audiological Assessments

Two calipers have been utilized for audiological testing of patients; preoperatively, two weeks and three months postoperatively, they included: pure tone audiometry to evaluate the hearing threshold and immittance audiometry (tympanometry) to verify middle ear function and tympanic membrane conditions. The data were collected and statistically analyzed. The records of Pure-tone audiometry and Immittancetometry (tympanometry) were applied for both right and left ears. Equality test have been performed and showed no significant difference between right and left ear so the result have been summed up into 14 affected ears.

I. Pure -tone Audiometry: The test sound is generated by an audiometer (Interacoustics AC40, Kamplex KC50). The pure-tone is presented to the patient’s tested ear by air conduction (AC) (through a monoaural ear phone) and testing by bone conduction (BC) involves a vibrator similar to headphones that sits over the mastoid process at frequencies of 125, 250, 500, 1000, 2000, 4000, and 8000 Hz. The audiologist has performed otoscopy for each patient. Patients entered a soundproof room and wear headphones. They are required to press a button or indicate when they hear different sounds. The responses are recorded on a chart called an audiogram that shows intensity levels for each frequency tested.

Fig. (1): Panoramic view case no. 4 showing obliteration of the joint space and disturbed anatomy.

Fig. (2): Axial, coronal and 3D reconstructions case no. 1 showing ankylosing bony mass
Pure-tone audiometry records include

Preoperative versus postoperative pure tone audiometric results of 14 ears preoperatively, two weeks and three months postoperatively.

II- Immittancemetry (tympanometry): First the probe of tympanometer (GSI TympStar) is inserted into the external auditory canal till an air-tight seal is obtained. A tested 226 and 678-Hz tones are transmitted through the probe, and the compliance of the tympanic membrane is measured while the external canal pressure is varied. The pressure at which peak occurs is recorded. Tympanometry equipment also provides an estimate of the external ear canal volume.

Immittancemetry (tympanometry) records include

A) Conventional 226-Hz Tympanometry

1- Preoperative versus postoperative 226-Hz tympanometry results of tympanometric Peak Height (Tymp H) and Peak Pressure (Tymp Pr) of 14 Ears
2- Ear Canal Volume (ECV) of right and left ears preoperatively, two weeks and three months postoperatively.

B) 678-Hz Tympanometry

Preoperative versus postoperative 678–Hz tympanometry results of tympanometric Peak Height (Tymp H) and Peak Pressure (Tymp Pr) of 14 Ears preoperatively, two weeks and three months postoperatively.

C) Sweep Frequency Tympanometry (Resonant Frequency)

Preoperative versus postoperative resonant frequency results of 14 ears preoperatively, two weeks and three months postoperatively.

D) Acoustic Reflex (contralaterally elicited)

Preoperative versus postoperative acoustic reflex results of 14 ears preoperatively, two weeks and three months postoperatively.

Surgical procedures

All surgical procedures have been performed under general anesthesia using fiber-optic nasal endotracheal intubation technique. All cases were operated in Educational Hospital, Faculty of Oral and Dental Medicine, Cairo University.

The patients were draped to isolate the surgical site in a routine way. A piece of sterile gauze has been placed in the external auditory canal to protect against entrance of foreign material into the canal and also to accentuate the area of incision to facilitate the dissection. Gap arthroplasty has been carried out through the modified preauricular incision (fig. 3)

Fig. (3): A- The modified preauricular incision, B- Blunt dissection following direction of perichondrium of the external auditory meatus, C- The ankylotic bony mass, D- Bony cut in the ankylosing mass, E- The created gap-arthroplasty, F- Skin closure and drain inserted.
Postoperatively all patients were placed in intensive care and recovery unit. They were placed in post-tonsillectomy position and vigilant attention was directed to monitor vital signs and maintenance of clear air way. The patients were recovered without problems and so they were encouraged for early ambulation.

Muscle rehabilitation program started on the first post-operative day. The patients have been encouraged to use mouth gag or increasing numbers of inter-incisal wooden tongue blades for forced mouth opening. After discharge the patients have been taught to do the exercises by themselves at home at regular intervals ranged from 4 to 5 times per day for about 15 minutes. Recall visits have been regulated from every day per week in the two postoperative months to twice per week in the next four months to once per month for 6 months postoperatively.

RESULTS

The postoperative course was uneventful except for patient number (2). This patient showed mild facial paresis that was successfully managed with medication and physiotherapy within three months. Other patients resumed normal activities early as they were encouraged for early ambulation and discharge from the hospital at the second day of surgery. The clinical findings revealed that almost all cases showed good healing. Follow up of the patients was carried out at the outpatient clinic.

I- Pure Tone Audiometry results

Preoperative versus postoperative pure tone results of 14 ears

On studying the mean of air conduction threshold of the affected 14 ears using paired samples test it was detected that there is no statistically significant changes of hearing thresholds at 2 weeks and 3 months postoperatively as compared with preoperative value. Bone conduction thresholds of all patients throughout the results were within normal ranges (table 2, 3).

II. Tympanometry (Immittancemetry) results

A) Conventional 226-Hz Tympanometry

Preoperative versus postoperative 226 -Hz Tympanometry results of 14 ears

Statistically it was detected that there was significant decrease of ear canal volume at two weeks and three months postoperatively as compared with preoperative result at p-values (0.002, 0.000) respectively. Also statistically significant decrease has been observed in tympanometry peak height at three months interval on comparing with preoperative result at p-value (0.002). Tympanometry pressure at three months postoperatively showed statistically significant decrease as compared with two weeks postoperatively at p-values (0.004). Table (4)

Distributions of Tympanometric Curve of of 14 ears

On studying the tympanograms curve of 14 ears: it was detected that all ears exhibited type A tympanometric curves, according to Jerger classification preoperatively except ears (5Rt & 6Rt) showed type C and ears (4Lt & 7Lt) showed type B. At two weeks postoperatively all ears showed type A tympanometric curve except ear (7 Rt) showed type C curve. At three months postoperatively all ears showed type A curve.

B) 678-Hz Tympanometry

Preoperative versus postoperative 678 Hz Tympanometry results of 14 ears:

Statistically highly significant decrease of tympanometry peak height at two weeks and three months postoperatively as compared with preoperative level at p-values (0.008, 0.004) respectively. Again statistically significant decrease at three months on comparing with two weeks at 0.029 p-values has been observed. Statistically significant decrease of tympanometry pressure at three months on comparing with two weeks at p-values of (0.046) has been detected. Table (5)
TABLE (2) Means of Air conduction thresholds in decibels (dB) of (14) ears at (0.25, 0.5, 1, 2, 4, 8 KHz) preoperatively, two weeks and three months postoperatively.

<table>
<thead>
<tr>
<th></th>
<th>AC 0.25KHz</th>
<th>Ac 0.5 KHz</th>
<th>AC 1 KHz</th>
<th>AC 2 KHz</th>
<th>AC 4 KHz</th>
<th>AC 8 KHz</th>
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</thead>
<tbody>
<tr>
<td>Pre</td>
<td>22.14</td>
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<td>16.78</td>
<td>17.14</td>
<td>22.14</td>
<td>28.21</td>
</tr>
<tr>
<td>2 W post</td>
<td>22.50</td>
<td>20.00</td>
<td>16.07</td>
<td>16.92</td>
<td>22.14</td>
<td>31.78</td>
</tr>
<tr>
<td>3 M post</td>
<td>22.85</td>
<td>21.42</td>
<td>18.92</td>
<td>18.84</td>
<td>22.85</td>
<td>33.57</td>
</tr>
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</table>

TABLE (3) Paired sample test of mean, standard deviations (SD), and p-value (P) of air conduction (AC) at (0.25, 0.5, 1, 2, 4, 8 KHz) preoperatively, two weeks and three months postoperatively of 14 ears.

<table>
<thead>
<tr>
<th>air conduction (AC)</th>
<th>comparison of preoperative in relation to 2 weeks and 3 months postoperatively</th>
<th>Paired Differences</th>
<th>P</th>
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<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>SD</td>
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<tr>
<td>AC 0.25</td>
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<td></td>
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<tr>
<td>pre</td>
<td>post 2w</td>
<td>-.35714</td>
<td>8.65232</td>
</tr>
<tr>
<td>pre</td>
<td>post3M</td>
<td>-.71429</td>
<td>7.03211</td>
</tr>
<tr>
<td>post 2w</td>
<td>post3M</td>
<td>-.35714</td>
<td>4.98624</td>
</tr>
<tr>
<td>AC 0.50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pre</td>
<td>post2w</td>
<td>-.35714</td>
<td>4.98624</td>
</tr>
<tr>
<td>pre</td>
<td>post3M 3</td>
<td>-1.78571</td>
<td>3.72473</td>
</tr>
<tr>
<td>post 2w</td>
<td>post3M</td>
<td>-1.42857</td>
<td>4.97245</td>
</tr>
<tr>
<td>AC 1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pre</td>
<td>post2w</td>
<td>.71429</td>
<td>5.13553</td>
</tr>
<tr>
<td>pre</td>
<td>post3M</td>
<td>-2.14286</td>
<td>5.78934</td>
</tr>
<tr>
<td>post2w</td>
<td>post3M</td>
<td>-2.85714</td>
<td>6.41941</td>
</tr>
<tr>
<td>AC 2.00</td>
<td></td>
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<tr>
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<td>post2w</td>
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<tr>
<td>pre</td>
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<td>post2w</td>
<td>post3M</td>
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<tr>
<td>AC 4.00</td>
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<tr>
<td>pre</td>
<td>post 3M</td>
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<td>5.49725</td>
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<tr>
<td>post2w</td>
<td>post3M</td>
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<tr>
<td>AC 8.00</td>
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<td></td>
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<tr>
<td>pre</td>
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<tr>
<td>post2w</td>
<td>post3M</td>
<td>-1.78571</td>
<td>6.68153</td>
</tr>
</tbody>
</table>
C) Sweep Frequency Tympanometry (Resonance Frequency) results:

Preoperative versus postoperative Resonant Frequency of 14 ears

On studying the preoperative versus postoperative results of resonant frequency of the affected 14 ears it was detected that the preoperative results ranged from 400 to 1410 with a mean equal 945 Hz, at the postoperative two weeks it was ranged from 350 to 1590 with mean equal 859 Hz while in the 3 months postoperative time it was ranged from 400 to 1230 with a mean equal 817 Hz. (Table 39) the results of resonance frequency values decrease at two weeks and three months postoperatively however, this decrease was statistically insignificant. (Table 6)

D) Acoustic Reflex (contra laterally elicited) (AR) Results:

Preoperative versus postoperative Acoustic Reflex results of 14 ears

It was detected that there is statistically significant increase of acoustic reflex at 0.5 KHz on comparing preoperatively with two weeks postoperatively. At 1 and 2 KHz significant increase is seen at both two weeks and three months postoperatively as compared with preoperatively while at 4 KHz changes was statistically insignificant. (Table 10, 11)

DISCUSSION

The present study utilized audiological investi-
gations to clarify the auditory functional changes in patients with temporomandibular joint (TMJ) bony ankylosis and its relevant gap arthroplasty. Several pathophysiological mechanisms have been proposed in the literature to explain the aural symptoms reported by temporomandibular joint disorders (TMD) patients. The current study is a small incremental bite in assessment of the audiological status of temporomandibular joint (TMJ) ankylosis patients with special emphasis on the impact of surgery of gap-arthroplasty.

Some degree of hearing impairment was detected among the present sample of patients; it was represented in cases number (4) of right & left ears and case number (7) with right ear only at low and high tested frequencies in the present study. The current study considered hearing loss when hearing threshold exceeds 25 decibels in any of the tested frequencies according to the international published studies (18-22). This was statistically demonstrated with mean of air conduction threshold above 25 dB at (8 KHz) preoperatively. In the present study, hearing loss was observed in (21.4 %) of the examined ears at low and high tones. These findings are in agreement with the other studies that reported hearing loss prevalence in non-ankylosed TMJ patients. (23-25)

Hearing loss could be attributed to the mechanical degradation of sound conduction system e.g. increased mass, and/or stiffness. Although significant hearing loss was not seen in this study, there was hearing impairment at a frequency of 8 kHz, which might be attributed to the mechanical stimulus of the cochlear base. Also tympanometric studies of Eustachian tube dysfunction that will be elaborated in the next section of present discussion could explain low tones hearing impairments. Higher thresholds in air conducted sounds than bone conducted throughout the results could indicate a conductive hearing loss.

Innervation of the tensor velipalatini, tensor tympani, masseter, temporalis and pterygoid muscles by the motor nucleus of the trigeminal nerve might be the underlying cause of the

| Table (7) Paired sample test of mean, standard deviations (SD), and p-value (p) of acoustic reflex preoperatively, two weeks and three months postoperatively of 14 ears at 0.5, 1, 2, 4 KHz. |
|-----------------|-----------------|-----------------|
|                | Paired Differences | P               |
| Mean | SD        |          |
| AR 0.5 | pre post 2w | -6.25000 | 9.07669 | .036 |
|        | pre post 3m | -5.41667 | 9.40462 | .071 |
|        | post 2w post 3m | .83333 | 1.94625 | .166 |
| AR 1.0 | pre post 2w | -5.00000 | 6.03023 | .015 |
|        | pre post 3m | -6.25000 | 4.82654 | .001 |
|        | post 2w post 3m | -1.25000 | 4.33013 | .339 |
| AR 2.0 | pre post 2w | -5.90909 | 6.64010 | .014 |
|        | pre post 3m | -5.00000 | 5.00000 | .008 |
|        | post 2w post 3m | .90909 | 6.25227 | .640 |
| AR 4.0 | pre post 2w | -4.54545 | 8.50134 | .107 |
|        | pre post 3m | -4.50000 | 8.95979 | .147 |
|        | post 2w post 3m | -1.50000 | 4.11636 | .279 |
hearing impairments in temporomandibular joint ankylosis patients. The results of previous studies suggested that temporomandibular joint disorders TMD peripherally sensitizes the trigeminal (V) and facial (VII) nerve pairs that could potentiate the tonic spasm of these middle ear muscles (26-28). This process partly may explain low tones hearing loss. The tensor velapalatini dysfunctions may change the position of tympanic membrane and malleus due to its anatomic association with the tensor tympani. Strong sounds lead to stapedius muscle contraction, which improves auditory discrimination, while tensor tympani muscle plays a role in the discrimination of low tones. Tensor tympani muscle also contracts in strong sounds, protecting from sound trauma, and vocalization, chewing, swallowing and facial muscle contraction. Malcontraction of the tensor tympani muscle pulls the ossicular chain medially in the middle ear and thus may alter the hearing conductive system.

The tensor tympani and stapedius are antagonistic muscles, and with the tympanic membrane are responsible for the appropriate balance and function of the ossicular chain in the middle ear (malleus, incus and stapes). If the tensor tympani or stapedius contract inappropriately, then the perilymphatic and endolymphatic pressures in the inner ear are expected to change via the oval window leading to vestibular and cochlear impulse imbalance. These changes in endolymph pressure could possibly affect the hair cells of the inner ear, leading to high frequency hearing impairments. This explanation is in agreement with Axelsson et al. (29)

As the Eustachian tube is actively opened by the tensor palatini and passively opened by the levatorpalatini muscle, in temporomandibular joint ankylosis, the tensor tympani muscle is hypertonic, so its normal mechanism is impeded (26-28). Loss of jaw movement interferes with yawn mechanism leading to poor Eustachian tube function. Long standing temporomandibular joint ankylosis might deprive the muscles of mastication from its motor impulses of trigeminal nerve; hence innervation of tensor tympani muscle may be affected centrally. This neurological discrepancy may consequently affect hearing quality. Extensive neurological assessments of such muscle are needed.

In the current study, assessment of patients with TMJ ankylosis utilizing conventional 226-Hz tympanogram revealed preoperative slight increase of tympanometric peak height as compared to published data (30-33). These findings may be attributed to reflex spasm of tensor tympani muscle with influence on the sound conduction structure. Tympanometric peak height of the present study was still within normal range. Conventional 226-Hz tympanometry seems to be a far less sensitive method than sweep frequency tympanometry to detect subtle mechanoaoustic changes of mass and stiffness of the middle ear system. This represents a clarification of minor alterations in the conductive properties of the middle ear and seems to support the various hypotheses on the middle-ear origin of deteriorated hearing sensitivity in patients with TMJ disorders. This explanation is in agreement with the report of Maria Riga and associates (34). Preoperative middle ear pressure was within normal range with tendency toward negative values supporting opinion of poor aeration of middle ear via Eustachian tube.

Tympanogram of 678 –Hz probe tone showed preoperative hypercompliant values that might be attributed to ossicular chain disruption, flaccid tympanic membrane or due to excessive clearing of the ears under shift of ossicles to the middle ear wall by malcontraction on middle ear muscle. The findings of this tested high tone frequency tympanometry could partly augment to explain the observed hearing loss at high tones. Preoperative tympanometric pressure had negative values that denote poor aeration through Eustachian tubes and possible middle ear dysfunction of study sample. High 678-Hz probe tone tympanometry results
of present study are more significant than 226 Hz
conventional probe. Previous reports\(^\text{(35-37)}\) showed
that 678 Hz tympanometry seems to be more
accurate in detection of ossicular chain disruptions
compared to other investigations.

Sweep frequency tympanometry research has
shown that it is a useful clinical tool used to detect
pathologies such as ossicular chain disruption,
tympanic membrane abnormalities for these reasons
it was utilized in the present study\(^\text{(38)}\); this to
overcome the possible limitations of conventional
tympanometry. Tympanometry with 226 Hz probe
tone mainly detects stiffness related pathology of
the middle ear. Higher frequency probe tones can
provide information on mass-related pathology.
More and more clinical reports show that sweeping
with higher frequency probe tones seem to be a
far more sensitive method to explore changes in
the middle ear system. The application of sweep
frequency tympanometry has shown higher
sensitivity in middle ear diseases like otosclerosis,
ossicular chain lesions. Sweep frequency
tympanometry scans pressures and frequencies to
analyze the resonant frequency (RF) of the middle
ear, which determines the balance between mass and
stiffness elements of the system. So RF value can
reflect changes in different pathologies when either
mass or stiffness in middle ear system is affected.

In current research, there was a slight tendency for
increase in means of middle ear resonant frequency
(RF) more than the reported mean adult resonant
frequency that is about 900 Hz\(^\text{(34)}\). However, in
patients with TMJ ankylosis, the elevation of RF
values provides possible evidence of an increase in
the stiffness of the middle ear system and offers new
insight in the pathophysiology of hearing problems
and middle ear dysfunction of patients with TMJ
ankylosis. In particular, TMJ ankylosis seems to
be associated with an increase in the stiffness of
the middle ear system, which is demonstrated as
an increase in the middle ear resonant frequency.

Because of the wide range of normal RF values,
the results obtained for the ears to of TMJ ankylosis
were in accordance with the reference range for
measurements in healthy ear and this need further
explanation on wide sample

Acoustic reflex thresholds were utilized in current
research as another parameter within the battery of
immittancemetry. This is a measure of the stapedius
muscle reaction to exposure to high intensity sounds.
When the stapedius muscle contracts in response
to sound it stiffens the ossicles and the ear drum
altering the tympanometric values. Elevated or
absent acoustic reflex thresholds above 100 dB for
any given frequency may suggest a hearing loss in
the current study of 14 study ears sample. Reflexes
are absent if the patient has a tympanic membrane
perforation and may be absent with a middle ear
effusion due no measurable immittance peak. The
acoustic reflex cannot be recorded in patients with a
type B tympanogram. It also cannot be recorded in
patients with severe profound sensorineural hearing
loss. In this essence, tympanogram results can be
combined with the acoustic reflex measurements to
obtain an accurate picture of the middle ear.

The present study showed no statistically
significant differences between hearing thresholds
before and after surgery of gap arthroplasty at
two weeks and three months postoperatively. The
rationale was to make sure that patients had or no
organic ear disorder that would explain hearing
impairments. This means that surgery of gap
arthroplasty has no harmful effects on hearing quality.
However, the observed non-significant increase
of hearing thresholds at 8 KHz postoperatively
might be attributed to possible deleterious effect
of vibrations of high speed cutting tools used in
creation of gap arthroplasty. These vibrations could
be directly transmitted via the surrounding bone to
the adjacent middle ear and cochlea. On the light
these findings, revision of all cases was carried
out, it revealed that cases number (4 and 7) showed
the highest hearing thresholds and hearing loss at almost all tested frequencies. These cases recorded the most extensive ankylosing bony mass, extended operative time and they were a recurrent cases.

At 226 Hz, tympanometric peak height showed statistical significance decrease at three months postoperatively, this may be ascribed to possible extensive postoperative muscle rehabilitation program associated with pain and tonic spasm of masticatory muscle. This spasm may consequently affect the middle ear muscles. Increase negative values of middle ear pressure at this time that might attributed to the same malfunction of tensor and levatorvelipalatini lead to poor ventilation of the middle ear via Eustachian tube dysfunction. Thus it is recommended to carry out tympanometry test on long-term follow up after cessation of muscle rehabilitation program. Middle ear pressure at two weeks after surgery of gap-arthroplasty attained positive values that signifies the dramatic enhancement of middle ear ventilation with release of jaw and its freely mobilization, this circumstance allow the patients to swallow and yawn with normal function of Eustachian tube. Gap-arthroplasty has a good consequence on middle ear function. Negative middle ear pressure at intermediate three months postoperative follow up could be attributed to hypertonicity of middle ear muscles as well as inappropriate function of palatini veil muscles a consequence to aggressive muscle rehabilitation program with maximal muscle stretch at this period. Type A tympanogram was the outcome of all case at three month postoperative interval that indicate the improvement of middle ear function under the influence of gap-arthroplasty.

Significant decrease of external ear canal volume at postoperative period could be attributed to possible inflammatory reaction and extended hematoma associated with surgery, as the gaining access to the ankylotic bony mass was usually performed along the perichondrium of external auditory meatus.

At 678-Hz probe tone, statistically significant decrease of tympanometric peaks has been detected to be nearby the normal values and positive values of middle ear pressure at two weeks and three months. These findings might be ascribed to enhanced aeration of middle ear via Eustachian tube with jaw movement after release of TMJ ankylosis. The present study reports abnormally high admittant middle ears of performed 678 Hz conductance tympanometry return gradually to attain reasonable tympanometric peak and pressure under the effect of gap-arthroplasty. Decrease of resonant frequency after surgery of gap-arthroplasty denotes some degree of improvement in middle ear functions regards to decrease in stiffness.

Acoustic reflexes increased postoperatively but still within normal mean not more than 100 dB that denotes the intact stapedius muscles reflex. Absence of acoustic reflex in one case of the study sample at postoperative intervals might be attributed to perforated tympanic membrane.

This study investigated the bio-mechanics of the middle ear in patients with TMJ ankylosis. The objective documentation of middle ear dysfunction in these patients may finally provide some objective diagnostic proof for what has been for many years only a clinical suspicion. Additionally, it may contribute to the understanding of the pathophysiology of otological disabilities that may be detected in patients with TMJ ankylosis. The diagnostic sensitivity of 678-Hz probe tone and sweep frequency has been repeatedly proven higher than that of standard tympanometry because the latter often has failed to distinguish normal middle ears from ears with lesions that specifically affect the ossicular chain. This study provides a solid audiologic evidence for an association between TMJ ankylosis and middle ear conduction disorders and thus supports the author’s hypotheses. Further studies are needed for multifactorial pathophysiology (conductive, vascular, and somatosensory) whereas clinical observation finally becomes comprehensible.
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