Effect of temporomandibular joint bony ankylosis and surgical sequelae of gap arthroplasty on middle ear volume
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Aim The aim of this study was to evaluate the effect of temporomandibular joint bony ankylosis and surgical sequelae of gap arthroplasty on middle ear volume (MEV).

Patients and methods Sixteen Egyptian individuals were selected and divided into two equal groups. The first group (group I) included eight patients with 14 bony ankylosed joints; the second group (group II) included eight normal individuals. The operated patients were chosen from those attending the outpatient clinic of the Department of Oral and Maxillofacial Surgery, Faculty of Oral and Dental Medicine, Cairo University. Gap arthroplasty was utilized for the management of such patients. Radiographic assessments for MEV for the first group were obtained for all the participants preoperatively and also 3 months postoperatively. Comparison of MEV was carried out with normal individuals both preoperatively and 3 months postoperatively.

Results It was observed that there was a significant decrease in MEV of ankylosed patients preoperatively when compared with normal individuals and a significant decrease in MEV 3 months postoperatively when compared with the preoperative volume.

Conclusion Patients with temporomandibular joint bony ankylosis showed a decrease in MEV compared with normal individuals; also, gap arthroplasty has a decreasing effect on MEV. Egypt J Oral Maxillofac Surg 4:72–77 © 2013 The Egyptian Association of Oral & Maxillofacial Surgeons.


Keywords: computed tomography, gap arthroplasty, middle ear volume, temporomandibular joint ankylosis

Introduction and review of the literature

Trauma was reported to be the first etiologic factor in temporomandibular joint (TMJ) bony ankylosis. Hemarthrosis and the anatomical nature of joints in children are believed to be the major cause, whereas condylar fractures with iatrogenic factors were found to be the major etiologic factor in adults. TMJ disruption was reported to be involved in massive head trauma complicated with the presence of a temporal bone fracture. It was hypothesized that displaced fracture of the posterior wall of the TMJ may affect the middle ear because of a concomitant perforation, leading to ossicular chain discontinuity. High-resolution computed tomography (CT) is an appropriate investigation for the detection of middle ear changes with ossicular disruptions showing separation of the incudostapedial joint, fracture of the stapes, and dislocation of the incus [1–3].

The treatment of TMJ ankylosis poses a significant challenge because of its technical difficulties and a high incidence of recurrence. Gap arthroplasty has been described as a simple and effective surgical technique in the management of TMJ ankylosis. It is the technique of resecting a segment of the bone at some point between the base of the skull and the site of the mandibular foramen. The gap created usually ranges from 0.6 to 1.5 cm and up to 2 cm as recommended by Topazian [4]. The induced gap should be established at the most superior part of the ramal height, to minimize the possibility of occurrence of anterior open bite, and to increase the chance of normality of postoperative mandibular function [5–7].

The ear and the TMJ are embryologically, physically, and anatomically very close to each other and have a strong influence on proper functioning of each other. Pain of the TMJ may lead to contraction of the little muscles (the tensor tympani and tensor veli palatini) inside the tympanic cavity. These muscles hold the ear bones (malleus, incus, and stapes) in place. All these three ear bones are essential to the function of hearing. The contraction and spasm of these muscles cause hearing impairment by affecting the proper functioning of the ear bones [8,9].

Posterior displacement of the condyle has been reported to exert pressure on the auriculotemporal nerve and the chorda tympani, as well as the Eustachian tube. Pressure on these structures might induce erosion of the tympanic plate. Eustachian tube dysfunction has been attributed to reflex disturbances of the tensor tympani and the veli palatini muscles. Bettega et al. [10] and Ioannides and Hoogland [11] reported that the otomandibular (e.g. diskomalleolar and tympanomandibular) ligaments are among the structural causes for aural symptoms. It is hypothesized that patients with TMJ disorders have muscle spasms responsible for regulating the activity of the Eustachian tube [12–17].

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It has been reported that the average middle ear volumes (MEVs) in the normal ears, as measured using CT, were 5.6–7.9 ml [18–20]. Ahn et al. [21] reported that the MEVs were 1.1 ± 0.8 ml in 44 ears with chronic otitis media, which were smaller than the normal values. Acquired cholesteatoma is the main complication of chronic otitis, resulting from ingrowth of the keratinizing squamous epithelium from the external acoustic meatus to the middle ear through the tympanic membrane. It was represented on the CT scan in the form of a soft-tissue mass-like opacity in the middle ear cavity and mastoid antrum associated with smooth bony erosion of the ossicles and expansion of adjacent structures [22]. CT examination of patients with osteopetrosis showed conductive hearing loss, and this was attributed to exostosis projection into the middle ear cavity, calcified and sclerotic ossicles, recurrent otitis media, and poor aeration of the mastoid air cells, with no evidence of internal auditory canal narrowing [23–25]. A CT scan of Paget’s disease of the skull showed thickening of the auditory ossicles and stapes suprastructure was not visible; these findings explain the hearing impairment in patients with Paget’s disease [26].

High-resolution CT of the temporal bone is the method of choice for the evaluation of ossicular chain integrity and tympanic cavity walls. Axial high-resolution CT scans can ordinarily show the exact nature and placement of the ossicular fractures and dislocations. High-resolution CT of the middle ear is a useful noninvasive technique; it can detect the extent of the disease, exact location, structures involved, and possible bone erosion. It can be addressed in cases of traumatic and nontraumatic opacified middle ear, acute coalescent otomastoiditis, and chronic otitis media. Recently, virtual endoscopy and three-dimensional reconstructions of the middle ear as well as the tympanic cavity were used to assess middle ear pathologies and ossicular injuries using the standard high-resolution CT temporal bone as a template [27,28].

Patients and methods
This study included 16 Egyptian individuals. They were divided equally into two groups. The first group (group I) had 14 bony ankylosed TMJ. They were selected from those attending the outpatient clinic of the Department of Oral and Maxillofacial Surgery, Faculty of Oral and Dental Medicine, Cairo University, Egypt. The second group (group II) included normal individuals of the same age (range, mean) and sex distribution. They were recruited from among patients with other medical conditions of the temporal bone in whom no abnormalities of the middle ear were detected; consequently, CT was not performed specifically for the middle ear to avoid extra radiation hazard. The condition was explained and their consents were obtained. Every patient of group I was subjected to laboratory routine investigations for general anesthesia. Surgically, the preauricular approach was used in all patients to gain access to the TMJ area. Gap arthroplasty was applied to release the TMJ ankylosis. MEVs were measured preoperatively and 3 months postoperatively.

Radiographic assessment for ankylosis and for the middle ear was performed using multislice CT scan. Volumetric measurement of middle ear was estimated semidigitally. MEV was calculated starting from the tympanic membrane to the bony part of the Eustachian tube. Comparison of the MEV in TMJ ankylosis patients with normal individuals was carried out. Also, comparison between MEV preoperatively and postoperatively for detection of the effect of gap arthroplasty on the MEV was carried out. The data were tabulated and analyzed statistically (Fig. 1).

Radiological assessment of the middle ear
All the CT examinations were performed using a slice multidetector CT scanner (Aquillion 64; Toshiba, Tokyo, Japan). Scanning was performed on the standard axial plane using the helical technique (a field of view of 18 cm, a pitch of 0.562, a rotation time of 0.35 s, a section thickness of 0.5 mm, and a matrix of 512 × 512). The patients were scanned in a supine position to obtain the image plane parallel to the orbitomeatal line. All the image data sets were transferred from the CT scanner to the PC workstation and the data sets were analyzed using the three-dimensional medical imaging software (Medicor imaging Charlotte, North Carolina, USA) (on vitra workstation). MEVs were measured using the digital...
image processing CT program. The area of the air-containing cavity was measured semiautomatically. A volume of interest was applied manually on each slice. The volume of the air-containing cavity at each slice was computed by clicking on the air cavity within the volume of interest. The total volume of the air-containing cavity was calculated as the sum of the volumes of the air-containing cavities of each slice (Figs 2 and 3).

Radiological measurements of middle ear volume

(1) MEV of the right and left ears of the patient group (group I).
(2) MEV of the right and left ears of the control group (group II).
(3) Equality test of the right and left MEV
(4) Comparison of the preoperative results of MEV of TMJ ankylosed joints (group I) versus control joints (group II).
(5) Comparison between preoperative and postoperative results of MEV of ankylosed joints (group I).

Analysis of patients data

Group I included 14 bony ankylosed joints in eight patients (two men and six women, age range 18–45 years and mean age 29.5 years). The etiology of ankylosis was trauma in 75% of cases and congenital cause in the remaining 25%. The preoperative interincisal opening ranged from 0 to 6 mm, mean 3.2 mm. Seventy-five percent of cases had bilateral and
25% had unilateral involvement with fibrous ankylosis in the contralateral sides. Previous surgical intervention for the correction of TMJ ankylosis was reported in six patients: one of them was operated three times, three patients were operated two times, and two were operated only once.

**Surgical procedure**
Gap arthroplasty was performed to release TMJ ankylosis through a modified preauricular incision under fiberoptic nasoendotracheal intubation. Patients were admitted for general anesthesia in the Dental Educational Hospital, Faculty of Oral and Dental Medicine, Cairo University. The operation was followed by physiotherapy for 6 months to prevent recurrence (Fig. 4).

**Results**
The postoperative course passed without incidence and all patients resumed their normal activities early; they were encouraged for early ambulation and were discharged from the hospital at the second postoperative day. Follow-up was performed at the outpatient clinic. The maximum interincisal opening achieved at the end of 3 months postoperatively ranged from 24 to 50 mm, mean 35.3 mm.

On studying the MEV of right ears of the patient group, it was found that the preoperative values obtained ranged from 0.036 to 0.528 ml, with a mean of 0.26 ml. The 3-month postoperative volumes obtained ranged from 0.039 to 0.216 ml, with a mean of 0.09 ml (Table 1).

On studying the MEV of left ears of the patient group, it was found that the recorded preoperative values ranged from 0.043 to 0.676 ml, with a mean of 0.26 ml. The recorded 3-month postoperative volumes ranged from 0.021 to 0.184 ml, with a mean of 0.07 ml (Table 1).
The MEV of the right ears of the control group ranged from 0.742 to 2.193 ml, with a mean of 1.23 ml, whereas that of the left ears ranged from 0.864 to 1.854 ml, with a mean of 1.29 ml (Table 1).

**Equality test of right and left middle ear volumes**

On comparing the results of right and left MEVs of the operated and the control individuals, it was found that there was no statistical difference. Hence, the results of the right and left ears of eight patients with ankylosis and control individuals were summed up into 14 ankylosed joints and 16 normal joints.

**Comparison of preoperative results of middle ear volume of ankylosed temporomandibular joints (group I) versus control joints (group II)**

On taking the mean MEV of the control group as a reference point of comparison with the preoperative mean MEV of ankylosed joints, it was found that there was a significant deficiency in the MEV of ankylosed joints preoperatively at a $P$-value of 0.000 (Table 2).

**Comparison between preoperative and postoperative results of middle ear volume of ankylosed joints (group I)**

On comparing the MEV in ankylosed patients preoperatively and 3 months postoperatively, it was found that there was a significant decrease in the volume postoperatively at a $P$-value of 0.021 (Table 2; Fig. 5).

**Discussion**

There is a close embryological, anatomical, and clinical association between TMJ and the middle ear; for this, the hypothesis of the present investigation was raised. It was aimed to clarify the changes in MEV in response to TMJ bony ankylosis. Gap arthroplasty is a standard technique used widely in Egypt to release TMJ bony ankylosis. It was utilized in this study as it is simple, atraumatic, and led to fewer complications when compared with other techniques. It has a low cost and can be used in low socioeconomic communities. The effect of gap arthroplasty on some aspects of the orofacial area was studied [29–32]. This research aimed to elucidate the changes that were induced by gap arthroplasty on the MEV.

High-resolution CT was utilized in the current study as it is an excellent technique for determination of small abnormalities of the thin and complex bony structures of the middle ear; for this reason, it is the modality of choice in the study of conductive hearing loss. Most middle ear lesions cause impairment of one or more elements of the mechanical chain that transmits sounds from the eardrum to the oval window [33,34].

The current research showed a marked statistically significant deficiency of the preoperative MEV in the TMJ bony ankylosis sample when compared with the control group. The same findings were observed when compared with the international published results [35–37]. Skeletal changes associated with TMJ bony ankylosis extended to include facial skeleton; the detected decrease in MEV of the current study seems to be responsive to these changes. These findings could be attributed to the lack of functional stimuli transmitted from the jaw to the temporal bone by direct articulation with TMJ and indirectly through the temporalis muscle and its related fascia as well as the styloid process. This consequently interferes with the growth and development of the temporal bone as a whole and its contents, including
the middle ear. This explanation needs further investigation to explore the deficient aspect of the temporal bone and its relation in patients with TMJ ankylosis. This finding is supported by hearing impairment in ankylosed patients detected in a previous study [38].

The postoperative assessment of MEV showed a statistically significant decrease in response to gap arthroplasty. This might be ascribed to the negative pressure of the middle ear at that time with an inward movement of the tympanic membrane. Small MEV in ankylosic patients makes any change in the volume, however small, critical or significant. Surgery of TMJ ankylosis, although it deals with a huge bony mass, usually needs delicate manipulation to release the jaw from the forest of multiple abundant vital structures. In contrast, an atraumatic surgery in close proximity to the external and middle ears is highly needed. Surgical trauma and its associated vibration, effusion and collected hematoma are accused to be responsible for the decrease in MEV.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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