Research Article

Radiological assessment of middle cranial fossa dural plate in patients with chronic otitis media

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Introduction

The middle cranial fossa dural plate is an important surgical landmark especially during tympanomastoidectomy. The risk of iatrogenic dural plate trauma or other dural injuries is high in patients with a low dural plate. This may cause serious complications such as cerebrospinal fluid leakage, epidural abscess, meningitis, brain abscess and encephalocele or meningocele. [1-5]

Awareness of level of tegmen particularly if it is low in position is very important for the surgeon in the preoperative period and may be more meaningfully evaluated with the depth of the dural plate beyond the point of greatest protrusion of the superior semicircular canal into the middle cranial fossa. If the tegmen height was known to be low from measurements made in the preoperative period, it would alert surgeons to the risk and ensure appropriate care was taken.

The aim of this study is to illustrate the level of tegmen in patients with chronic otitis media (COM) and to study different factors which can affect depth of middle cranial fossa dural plate in a hope to illustrate risk factors that danger this important surgical landmark during ear surgery.

Patients and methods

This prospective study was conducted at Otolaryngology, Head and Neck surgery department, Minia, Egypt. The study was approved by the Institutional Review Board at Minia University. The study included 180 subjects attended our outpatient clinic between March and October 2018. We selected our subjects according to the following inclusion criteria: 1-Unilateral or bilateral tubo-tympanic (safe mucosal) CSOM defined as the presence of tympanic membrane (TM) perforations with continuous discharge of mucoid material for the periods of 6weeks to 3months, despite adequate medical treatment (in the form of: topical antibiotics, topical antiseptics, oral antibiotics and repeated ear cleansing.[6] 2- Patients with attico-antral CSOM (cholesteatoma); suspected from otoscopic examination, or diagnosed from characteristic CT findings, 3- Subjects presented to our ENT clinic over the same period with complaints other than chronic otitis media, such as vertigo and tinnitus.

We excluded from the study: 1- Patients with congenital ear abnormalities, 2- Patients with secretory or adhesive otitis media, 3- Patients with history of head injury or history of previous ear surgery, 4- Pregnant female subjects.

We assessed multislice computed tomography (CT) temporal bone images by Toshiba Aquilion, obtained in 1 mm sections in the coronal plane. On a workstation, axial plane images with 1-mm-thick slices were digitally reformatted to 0.5-mm-thick axial and coronal multiplanar reformat (MPR) images. We classified studied ears into 3 groups: Group I: (214 ears) including ears of normal subjects and normal ears of patients with unilateral COM. Group II: (116 ears) with the diagnosis of CSOM and group III: (30cears) with the diagnosis of CSOM with cholesteatoma.

Patients had full otorhinolaryngology examination. We identified the middle cranial fossa dural plate in CT scan, and then measured the depth of the dural plate beyond the point of greatest protrusion of the superior semicircular canal into the middle cranial fossa.[7] If the dural plate extended to a point level with the semicircular canal, the depth was taken to be 0.0 mm; if it extended beyond this level, the length of the difference was recorded in millimeters**.** To reduce bias, two radiology experts separately evaluated the scans, and the average of the measurements was calculated. Possible differences in depth of the middle cranial fossa dural plate were reported.

Statistics:

SPSS 16 program was used for statistical analysis. Averages and standard deviations were calculated. The Mann–Whitney U test was used for comparisons between the groups. The Pearson χ^2 and Kruskal–Wallis tests were used to compare the distribution within the pathology groups. Statistical significance was set at ≤ 0.05.

Results

This study included CT scan of 180 patients (360 ears) including 94 male patients (188 ears, 52.2%) and 86 female patients (172 ears, 48.8%). Table 1 presents the demographic data of the study patients. Tab 2 presents the different ear groups of the study according to type of pathology and laterality of disease. The age distribution was from 2-80 years (mean age, 27.22±18.42 years) in normal subjects, 2-80 years in patients with CSOM (mean age, 27.34±19.04years) and 2-60 years in patients with CSOM with cholesteatoma (mean age, 26.77±16.11 years).

1-Differences in depth of the middle cranial fossa dural plate between normal ears: when we compared dural plate depth in normal ears in different study groups we found:

A- Mean depth in normal subjects' ears was (3.12±1.86) vs. (3.28±1.98) in normal ears of patients with unilateral CSOM; with no-significant difference (P=0.589).

B- Mean depth in normal subjects' ears was (3.12±1.86) vs. (3.56±1.89) in normal ears of patients with unilateral CSOM with cholesteatoma; with no-significant difference (P=0.399).

C- Mean depth in normal ears of patients with unilateral CSOM ears was (3.28±1.98) vs. (3.65±1.98) in normal ears of patients with unilateral CSOM with cholesteatoma ears; with no-significant difference (P = 0.622).

2- Differences in depth of the middle cranial fossa dural plate between normal and diseased ears: when we compared mean depth of normal ears and diseased ears in different study groups we found:

A- The mean middle cranial fossa dural plate depth for all ears with chronic otitis media, disregarding sidedness and gender, was 4.05±2.03mm (median, 3.63mm; range from 0 to 11mm) and that was significantly higher than mean depth for all normal ears (mean 3.19±1.89mm, median, 2.95mm and range from 0 to 11mm) (P=0.0001*) .

B- Mean depth in CSOM ears was significantly higher than depth in normal ears (4.15±2.08 vs. 3.19±1.89 respectively) (P = 0.0001*) .

C- There was no-significant difference mean depth between CSOM with cholesteatoma ears and normal ears; mean (3.64± 1.80 vs. 3.19±1.89 respectively) (P =0.241).

3- Differences in depth of the middle cranial fossa dural plate in patients with unilateral disease: when we compared mean depth of the middle cranial fossa dural plate of normal ears and diseased ears in patients with unilateral disease we found:

A- There was a significant difference in mean depth between CSOM ears and normal side; mean (4.07±1.90 vs. 3.28±1.98 respectively) (P= 0.037*).

B- There was a no-significant difference in mean depth between CSOM with cholesteatoma ears and normal side; mean (3.58± 1.27vs. 3.56±1.89 respectively) (P = 0.971).

4. Differences in depth of the middle cranial fossa dural plate between diseased ears in patients with CSOM vs.

diseased ears in patients with CSOM with cholesteatoma:
There was no-significant difference in mean depth in CSOM ears and CSOM with cholesteatoma; mean (4.15±2.08 vs.3.64± 1.80 respectively) (P = 0.219).

5- Differences in depth of the middle cranial fossa dural plate according to sex:
A- There was no-significant difference in mean depth of normal ears in male subjects and normal ears in female subjects; mean (3.28±2.04 vs. 3.10±1.73 respectively) (P= 0.491).
B- There was no-significant difference in mean depth of COM ears in male subjects and COM ears in female patients; mean (3.90±1.90 vs.4.22±2.17respectively) (P= 0.340).
C- There was no-significant difference in mean depth of CSOM ears in male patients and CSOM ears in female patients; mean (3.91±2.04 vs. 4.46±2.11 respectively) (P= 0.154) .
D- There was no-significant difference in mean depth of CSOM with cholesteatoma ears in male subjects and CSOM with cholesteatoma ears in female patients; mean (3.86±1.14 vs. 3.45±2.26 respectively) (P= 0.550).

6- Differences in depth of the middle cranial fossa dural plate according to age:
A- There was no-significant difference in mean depth of normal ears in children and normal ears in adults; mean (3.49±2.09 vs. 3.02±1.75 respectively) (P= 0.077).
B- There was no-significant difference in mean depth of COM ears in children and COM ears in adults; mean (4.36±2.23 vs. 3.85±1.88 respectively) (P= 0.144).
C- There was no-significant difference in mean depth of CSOM ears in children and CSOM ears in adults; mean (4.44±2.36 vs. 3.99±1.89 respectively) (P= 0.260).
D- There was no-significant difference in mean depth of CSOM with cholesteatoma ears in children and CSOM with cholesteatoma ears in adults; mean (4.12±1.79 vs. 3.27±1.78 respectively) (P= 0.211).

7- Differences in depth of the middle cranial fossa dural plate according to side:
A- Mean depth in normal ears (3.43±1.98) in right side vs. (2.93±1.75) in left side; with no-significant difference (P= 0.056).
B- There was no-significant difference in mean depth of COM ears in right side and COM ears in left side; mean (4.30±2.11 vs. 3.83±1.95 respectively) (P= 0.162).
C- There was no-significant difference in mean depth of CSOM ears in right side and CSOM ears in left side; mean (4.34±2.18 vs.3.98±1.99 respectively) (P= 0.350).
D- There was no-significant difference in mean depth of CSOM with cholesteatoma ears in right side and CSOM with cholesteatoma ears in left side; mean (4.12±1.85 vs. 3.32±1.76 respectively) (P= 0.243).

Table (1): Demographic data and distribution of pathology of studied subjects.

		Patients (ears)	%
Sex	**Female**	86 (172 ears)	47.8%
	Male	94 (188 ears)	52.2%
Age group	**<18 years**	68 (136 ears)	37.8%
	>18 years	112 (224 ears)	62.2%
Normal subjects		72 (144 ears)	40.0%
Bilateral CSOM		26 (52 ears)	14.4%
Bilateral CSOM with cholesteatoma		3 (6 ears)	1.7%
Unilateral CSOM		55 (110 ears)	30.6%
Unilateral CSOM with cholesteatoma		15 (30 ears)	8.3%
Mixed		9 (18 ears)	5.0%

Table 2

	Right ear n° of ears		Left ear n° of ears		Total n° of ears	
	N	%	N	%	N	%
CSOM	55	30.6%	61	33.9%	116	32.2%
CSOM with cholesteatoma	12	6.7%	18	10%	30	8.3%
Normal subjects	113	62.8%	101	56.1%	214	59.4%

Table (3): Difference in depth of the middle cranial fossa dural plate between normal ears.

		Normal subjects n° of ears	CSOM n° of ears	CSOM with cholesteatoma n° of ears	P-value
All ears	**n°**	144	55	15	P1 = 0.644 P2=0.589 P3=0.399 P4 = 0.622
	Mean ± SD	3.12±1.86	3.28±1.98	3.56±1.89	
Right ear	**n°**	72	30	11	0.529 P1=0.288 P2=0.562 P3=0.901
	Mean ± SD	3.27±1.94	3.73±2.08	3.64±2.09	
Left ear	**n°**	72	25	4	0.779 P1=0.585 P2=0.704 P3=0.550
	Mean ± SD	2.97±1.79	2.75±1.74	3.32±1.43	

Group I (normal ears of normal subjects), group II (normal ears of unilateral CSOM), group III (normal ears of CSOM with cholesteatoma).

Table (4): Difference in depth of the middle cranial fossa dural plate between normal and diseased ears:

	Normal ears	COM ears		P-value
n°	214	146		0.0001*
Range	0-11	0-11		
Mean ±SD	3.19±1.89	4.05±2.03		
	Normal subjects n° of ears	**CSOM n° of ears**	**CSOM with cholesteatoma n° of ears**	P1= 0.0001 P1=0.0001* P2=0. 241 P3=0. 200
n°	214	116	30	
Range	0-11	0-11	0-8.37	
Median± SD	3.19±1.89	4.15±2.08	3.64±1.80	

Group I (normal ears of normal subjects), group II (diseased ears of unilateral CSOM), group III (diseased ears of CSOM with cholesteatoma).

Table (5): Difference in depth of the middle cranial fossa dural plate between normal and diseased ears of patients with unilateral COM.

CSOM	Normal ears n°= 55	Diseased ears n° = 55	p-value
Range	0-11	0-9.82	0.037*
Mean ±SD	3.28±1.98	4.07±1.90	
CSOM with cholesteatoma	**Normal ears n° = 15**	**Diseased ears n° = 15**	
Range	0-6.98	2.16-7.38	0.971
Mean ±SD	3.56±1.89	3.58±1.27	

Table (6): Difference in depth of the middle cranial fossa dural plate between diseased ears of patients COM.

		CSOM Number of ears	**CSOM with cholesteatoma** Number of ears	**P-value**
All ears	**n°**	116	30	0.219
	Mean ±SD	4.15±2.08	3.64±1.80	
Right ears	**n°**	55	12	0.741
	Mean ±SD	4.34±2.18	4.12±1.85	
Left ears	**n°**	61	18	0.210
	Mean ±SD	3.98±1.99	3.32±1.76	

Table (7): Difference in depth of the middle cranial fossa dural plate in male vs. female subjects.

		Males Number of ears	**Females Number of ears**	p-value
Normal subjects ears	**n°**	109	105	0.491
	range Mean ±SD	0-11 3.28±2.04	0-9.16 3.10±1.73	
COM ears	**n°**	79	67	0.340
	range Mean ±SD	1.07-11 3.90±1.90	0-10.3 4.22±2.17	
CSOM ears	**n°**	65	51	0.154
	range Mean ±SD	1.07-11 3.91±2.04	0-10.3 4.46±2.11	
CSOM with cholesteatoma ears	**n°**	14	16	0.550
	range Mean ±SD	2.35-6.38 3.86±1.14	0-8.37 3.45±2.26	

Table (8): Difference in depth of the middle cranial fossa dural plate according to age of subjects.

		< 18 years Number of ears	**>18 years Number of ears**	p-value
Normal subjects ears	**n°**	80	134	0.077
	range	0-11	0-8.29	
	Mean ±SD	3.49±2.09	3.02±1.75	
COM ears	**n°**	56	90	0.144
	range	1.07-10.8	0-11	
	Mean ±SD	4.36±2.23	3.85±1.88	
CSOM ears	**n°**	43	73	0.260
	range	1.07-10.8	0-11	
	Mean ±SD	4.44±2.36	3.99±1.89	
CSOM with cholesteatoma ears	**n°**	13	17	0.211
	range	2.16-8.37	0-7.38	
	Mean ±SD	4.12±1.79	3.27±1.78	

Table (9): Difference in depth of the middle cranial fossa dural plate between right and left ears

		Right ear Number of ears	**Left ear Number of ears**	**p-value**
Normal subjects ears	**n°**	113	101	**0.056**
	range Mean ±SD	0-11 3.43±1.98	0-8.29 2.93±1.75	
COM ears	**n°**	67	79	**0.162**
	range Mean ±SD	0-11 4.30±2.11	0-10.8 3.83±1.95	
CSOM ears	**n°**	55	61	**0.350**
	range Mean ±SD	0-11 4.34±2.18	1.07-10.8 3.98±1.99	
CSOM with cholesteatoma ears	**n°**	12	18	**0.243**
	range Mean ±SD	1.51-8.37 4.12±1.85	0-7.38 3.32±1.76	

Table (10): comparison between both ears among bilateral COM cases

Patient n	Right ear	Left ear	Patient n	Right ear	Left ear
1	CSOM (1.73mm)	CSMO (1.34mm)	**20**	CSOM with cholesteatoma (2.31mm)	CSOM with cholesteatoma (2.67mm)
2	CSOM (2.57 mm)	CSOM (2.91mm)	**21**	CSOM (2.85mm)	CSOM (2.63mm)
3	CSOM (5.56mm)	CSOM with cholesteatoma (9.56mm)	**22**	CSOM (2.5mm)	CSOM (2.08mm)
4	CSOM with cholesteatoma (8.37mm)	CSOM with cholesteatoma (5.72mm)	**23**	CSOM (4.2mm)	CSOM (4.22 mm)
5	CSOM	CSOM (1.69mm)	**24**	CSOM (2.46mm)	CSOM with cholesteatoma (3.44mm)
6	CSOM with cholesteatoma (4.59mm)	CSOM (2.39 mm)	**25**	CSOM with cholesteatoma (1.56mm)	CSOM with cholesteatoma (0 mm)
7	CSOM (6.29 mm)	CSOM (2.43 mm)	**26**	CSOM (2.19mm)	CSOM (3.39mm)
8	CSOM (5.89mm)	CSOM with cholesteatoma (6.38mm)	**27**	CSOM (3.80mm)	CSOM with cholesteatoma (1.12mm)
9	CSOM (4.44 mm)	CSOM (4.84mm)	**28**	CSOM (11mm)	CSOM (6.45mm)
10	CSOM with cholesteatoma (4.79mm)	CSOM (4.07mm)	**29**	CSOM (6.87mm)	CSOM (4.37mm)
11	CSOM (10.3 mm)	CSOM (5.97mm)	**30**	CSOM (5.3mm)	CSOM (4.14mm)
12	CSOM (3.12 mm)	CSOM (2.91mm)	**31**	CSOM (5.88mm)	CSOM (3,92mm)
13	CSOM (3.34 mm)	CSOM (2.91mm)	**32**	CSOM (3.33mm)	CSOM (1.66mm)
14	CSOM (2.71 mm)	CSOM (1.87mm)	**33**	CSOM with cholesteatoma (5.39mm)	CSOM (4.64mm)
15	CSOM (8.12 mm)	CSOM (10.8mm)	**34**	CSOM with cholesteatoma (3.99mm)	CSOM (3.42mm)
16	CSOM (5.39 mm)	CSOM (4.99mm)	**35**	CSOM (5.09mm)	CSOM (1.88mm)
17	CSOM (3.46 mm)	CSOM (8.55mm)	**36**	CSOM (6.87mm)	CSOM (3.75mm)
18	CSOM (4.93 mm)	CSOM (1.07mm)	**37**	CSOM (2.5mm)	CSOM (5.83mm)
19	CSOM with cholesteatoma (2.77 mm)	CSOM (0 mm)	**38**	CSOM (5.17mm)	CSOM (5.17mm)

Discussion

Middle cranial fossa can be injured in chronic otitis media patients with or without cholesteatoma, and also due to surgical intervention, congenital cranial base tumours, trauma, or radiotherapy.[1-3] Surgical trauma is the most frequent cause. Brain herniation into the tympanic cavity has been reported to occur following between 45.9% and 77% of mastoid surgery cases.[8,9] Awareness of middle cranial fossa dural plate prior to surgery is important. Computed tomography is the screening method of choice for the temporal bone. It is important for accurate middle cranial fossa dural plate anatomy, ossicular chain defects and internal ear fistulae.[9]

The middle cranial fossa dural plate generally crosses the arcuate eminence just below the most protruding point of the superior semicircular canal into the middle cranial fossa (in the horizontal plane), in the mastoid and attic region. If the level of middle cranial fossa dural plate is inferiorly than normal; it may cover the roof of the external auditory canal and he cranial cavity can be penetrated if the surgeon is unaware of this anatomical variation.[10]

In this study we tried to find answers for several questions; 1st question is there a difference between depth of middle cranial fossa dural plate in ears of normal subjects and normal ears in patients with COM which can predispose these patients to have pathology? Our results didn't show such significant difference. Some studies reported that mastoid bone development is insufficient in some subjects due to hereditary and environmental theories.[11, 12] The hereditary theory was first proposed by Diamant in 1940. This theory states that aeration is determined genetically and small cellular systems may be predisposed to chronic and acute otitis media. The environmental theory was developed by Wittmaack in 1918. This theory states that, for normal aeration, healthy mucosa is necessary, and emphasizes the negative effects of inflammation and Eustachian dysfunction.[12]

The 2nd question was if there is a difference between middle cranial fossa dural plate depth of normal ears and mean depth of COM ears? The overall mean middle cranial fossa dural plate depth was 4.05 ± 2.03 mm in the diseased ears and 3.19 ± 1.89 mm in the normal ears; this difference was statistically significant. Our results matches results of Genc et al.[7] and Karatag et al.[13] who compared the distance between the tegmen and Henle's spine in healthy and affected sides of unilateral chronic otitis cases and found that tegmen was lower in the side with chronic otitis media. This can be explained by the fact that middle cranial fossa dural plate is generally separated from the external auditory canal by some tegmental air cells. When cell aeration is lost, as in chronic otitis media or a more caudally located dural plate, the middle cranial fossa dural plate may be directly adjacent to the periosteum of the external auditory canal and this can obstruct the surgeon's access to the antrum and the epitympanum with the result of Iatrogenic injury of the dura and/or temporal lobe.[14] Experimental studies on pigs have shown the negative effect of chronic inflammation on mastoid development.[15]

The 3rd question was if the gender affects the level of middle cranial fossa dural plate? In our study, the mean middle cranial fossa dural plate depth was not statistically significant different in male versus female subjects either in diseased or in normal ears. In Genc et al.[7] study, they reported that the mean middle cranial fossa dural plate depth was not statistically significant between male and female subjects in patients with COM ears, however; the difference was significant in their control group.

The 4th question was if the side effects the level of middle cranial fossa dural plate? In our study, there was no significant difference in dural plate depth between right and left sides either in diseased or normal ears. Genc et al.[7] found mean dural plate depth was greater on the right side in both the study and control groups compared to the left side, with a statistically significant difference.

The 5th question was if type of pathology of chronic otitis media can affect the level of middle cranial fossa dural plate? In our study we didn't find a significant difference between mean depth of CSOM ears and mean depth of CSOM ears with cholesteatoma. This matches the results of Karatag et al.[13] who found no significant difference between three groups of their study (CSOM, CSOM with cholestaetoma and adhesive otitis media). However; they found the tegmen height was lower in patients where the dura was exposed as a complication of surgery than in patients without dura exposure. In their study; they measured the level of middle cranial fossa dural plate from the midpoint of Henle's spine to the lowest point of the tegmen. Henle's spine is located at the posterosuperior margin of the bony external auditory meatus and is vertical but slightly angled towards the anterior bone spur. Although; Henle's spine is visible to the surgeon at all times in the operation and may be easily used as a guide to evaluate its relationship with the lowest point of the tegmen. However; this measurement doesn't account for shape variations of the tegmen even though it gives the distance to the lowest point. [14, 15]

Makki et al.[16] investigated slope and shape variances of the tegmen in a study on the mastoid tegmen, they classified surgical risks based on the degree of convexity of the tegmen. They also measured the distance between the tegmen and the external acoustic canal (EAC). Two measurements of the medial and lateral external acoustic canal were used. When examined from the point of view of EAC shape, standardizing these measurements in patients was very difficult.

The last question was if the age affects the level of middle cranial fossa dural plate? In our study; there was no significant difference in mean depth in children and mean depth in adults either for normal or diseased ears. This means to us that duration of the disease seems not a factor that affects the middle cranial fossa dural plate in patients with COM. It is the first time (up to knowledge) to address this important point in the literature.

Our aim in this study was to illustrate the importance of tegmen height in patients with COM. These data also help the surgeon to distinguish between whether an observed structure was dura or antral cells. Tegmen height is not the only risk factor for dura exposure. In cases where the tegmen is normal or even high, the surgeon has to work near the dura during mastoidectomy, and the dura may be exposed. It may not change the surgical procedure, but it will alert the surgeon to be more careful when drilling. We found that the healthy ear has a higher tegmen in unilateral COM. Although the number of patients in our study was not large, further multicenter studies with larger number of patients will be able to assess the results.

Conclusion

In patients with chronic otitis media, the tagmen is significantly lower and this is a predictive risk during surgery. This level is not affected by gender, age and side of affected ears. The level of the middle cranial fossa dural plate should be assessed from temporal CT scans before surgery, and surgeon should be aware of this important point to avoid possible complications.

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