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The use of a CT scan to predict the feasibility of decompression of the first segment of the facial nerve via the transattical approach

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Abstract
Total surgical decompression of the facial nerve can be offered to patients severely affected by Bell's palsy whether via the transattical or middle fossa approach. We prefer, when feasible, the transattical approach because it does not violate the cranial vault. The purpose of this study was to find the anatomical parameter of the temporal bone, measured by means of computed tomography (CT scan) and to decide which of these approaches should be offered. Sixty temporal bones were studied by CT scan, and then dissected in order to perform total facial nerve decompression via the transattical approach. Correlation between the two studies was established. Results suggest that measurement by CT scan of the attical area in the axial plane (AAA) may determine those patients for whom the transattical approach to facial nerve decompression should be undertaken.

Key words: Facial paralysis, surgery; Tomography, X-ray computed

Introduction

The facial nerve traverses the longest bony canal of any cranial nerve, and this may act as a strangulating tunnel in neuroimflamatory processes. The narrowest point of this canal is the so-called meatal foramen (the entrance of the facial nerve to its fallopian canal) averaging 0.61 mm in diameter (Fisch, 1981; Proctor, 1991). Disregarding the many theoretical causes, anatomical, electrophysiological, radiological, clinical and pathological evidence supports entrapment at the meatal foramen and labyrinthine segment of the fallopian canal as a final common pathway of nerve ischaemia and degeneration (Marsh and Coker, 1991).

Given the potential for diminishing sequelae in patients severely affected by Bell's palsy, surgical decompression should be offered to selected patients who meet the proper clinical and electrophysiological criteria (Marsh and Coker, 1991). If surgical treatment of Bell's palsy is to be performed, total decompression of the nerve needs to be carried out (Fisch, 1969; Fisch and Esslen, 1972; Nyberg and Fisch, 1984).

Meatal and labyrinthine segments of the facial nerve can only be decompressed via the middle cranial fossa approach or via the transattical approach. The transattical (transmastoid subtemporal) approach has been advocated to gain access to the labyrinthine segment of the facial nerve without violating the cranial vault or destroying the labyrinth (Salaverry, 1974; May,1979; Salaverry, 1982). However, the transattical approach is not feasible in all patients because of a poor pneumatization of the temporal bone in some. Therefore, the degree of pneumatization of the temporal bone is the limiting factor and should be known in advance. In those patients who need decompression of the facial nerve, an accurate anatomical study of the temporal bone is necessary before surgery.

Computed tomography (CT) has been used to visualize the intratemporal segment of the facial nerve and to assess its relationship with the surrounding anatomical structures (Wadin *et al.*, 1987; Swartz, 1989; Bradley, 1991).

The purpose of this study was to find the anatomical parameter of the temporal bone measured by means of a CT scan. This parameter should indicate the degree of pneumatization of the temporal bone. From this we would decide preoperatively if the transattical approach was feasible or if the middle fossa approach should be offered.

Materials and methods

Specimens

Sixty adult temporal bone specimens (30 right and

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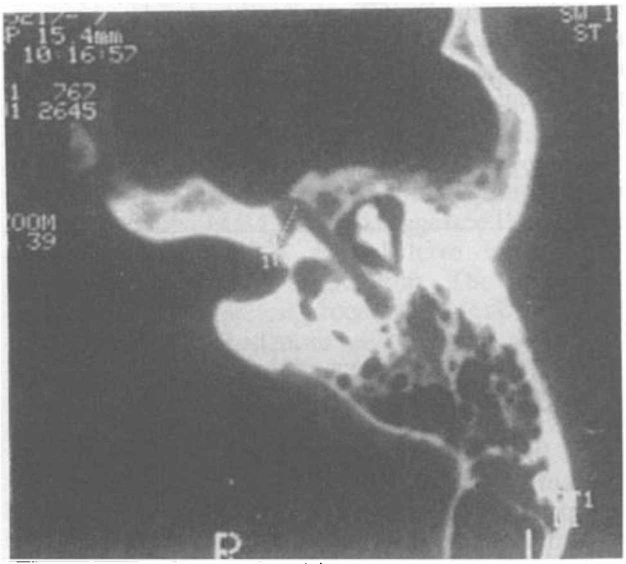
30 left) without ear diseases, were studied. Every specimen had to include the mastoid, the temporal squama, the external auditory canal, the middle ear cavity with undamaged ossicular chain and tympanic membrane, and the petrous bone. Any specimen lacking one or more of these anatomical structures or presenting any kind of disease was excluded from the study.

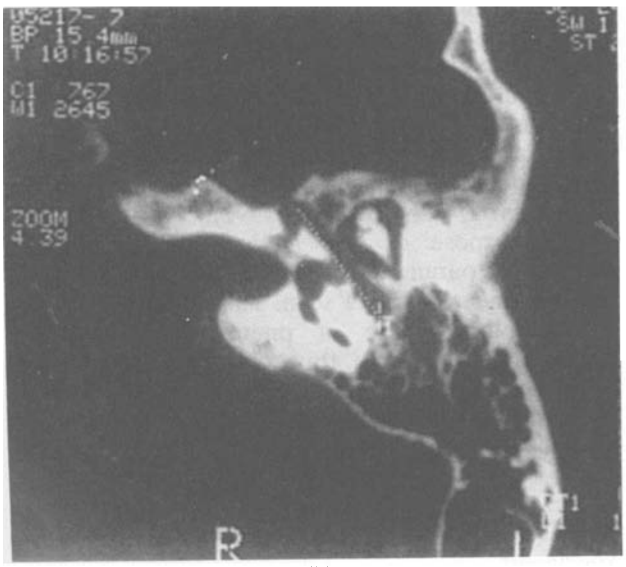
CT scan study

The specimens were studied by CT scan (Elscint Exel 2400) in axial and coronal projections. We attempted to find an anatomical parameter measured by CT scan that allowed us to predict preoperatively the feasibility of the transattical surgical approach to the labyrinthine portion of the nerve.

Several anatomical parameters with possible implications for facial nerve decompressive surgery via the transattical approach were identified on each bone and measured for: (a) the length of the three segments of the facial nerve (L1, L2, L3) for the first, second and third portion of the facial nerve respectively (Figure 1a and b); (b) the distances between the ossicular chain and the internal attical wall (A1) and the external attical wall (A2) (Figure 2); (c) the attical area at the malleus-incus joint level in both the coronal (ACC) (Figure 3a) and axial (AAA) (Figure 3b) projections; and (d) the attical volume (AV). We used computer functions supplied by the manufacturer to calculate AAC, AAA and AV parameters.



(a)



(b)

FIG. 1

(a) CT-measured length of the first segment of the facial nerve (L1). (b) CT-measured length of the second segment of the facial nerve (L2).

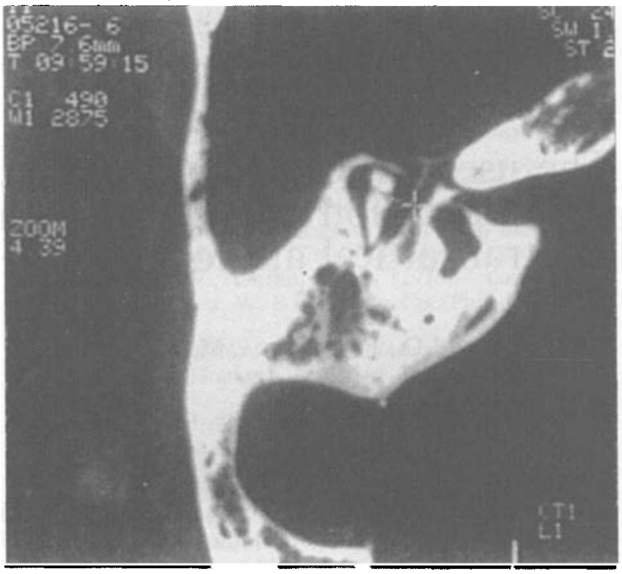
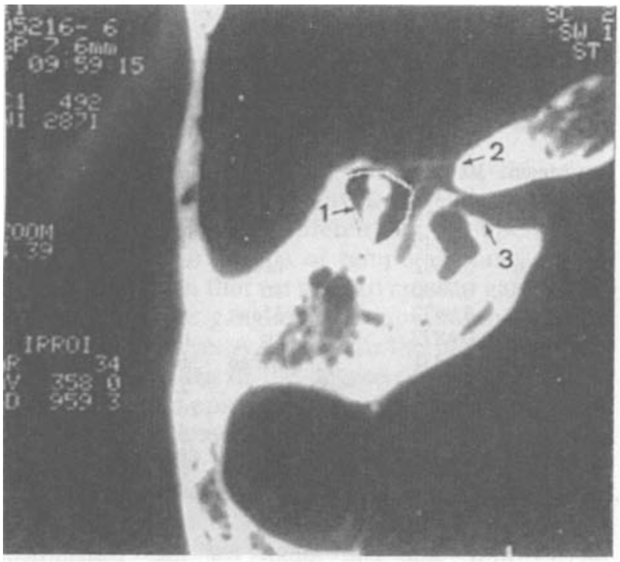


FIG. 2

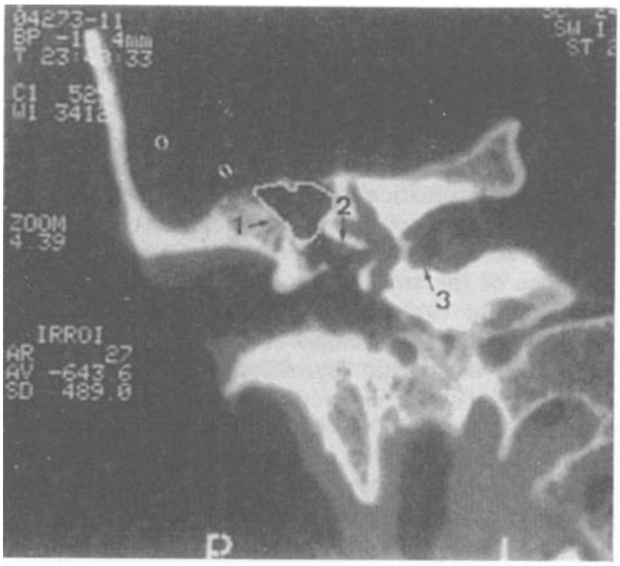
CT-measured distance between the ossicular chain and the internal attical wall (A1).

Surgical procedures

The surgical part of the study was carried out in our laboratory using a Zeiss Oberkochen OPMI1 microscope and House's irrigation-suction system. The bones were dissected as one would perform total facial nerve decompression using the transattical approach (Figure 4). A modified cortical mastoidectomy with extended drilling anteriorly towards the attic and the root of the zygoma was undertaken. A posterior tympanotomy was performed next. Exposure to the level of the cochleariform process was obtained without dislocating the incus. We continued the dissection toward the geniculate ganglion. The ampullated ends of the superior and lateral semicircular canals were thinned but not violated. As the labyrinthine segment medial to the geniculate ganglion is approached, the dura overlying the middle cranial fossa must be retracted. The ultimate extent of safe exposure will be determined by the anatomical structures that limit full exposure i.e., the dura and its level relative to the canals, the pneumatization of the anterior epitympanic (attical) space, and the degree to which blue-lining the canals allows for optimal visualization. In each case the feasibility or infeasibility was detected.



(a)



(b)

FIG. 3

(a) CT-measured attical area in the axial projection (AAA): (1, atticum; 2, geniculate ganglion; 3, internal auditory canal). (b) CT-measured attical area in the coronal projection (AAC): (1, atticum; 2, facial nerve; 3, internal auditory canal).

Then, we classified the temporal bone specimens according to the results of their dissection into two groups: (1) transattical approach feasible; (2) transattical approach not feasible. Finally, we correlated these groups with the anatomical measurements obtained from the CT scan.

Statistical methods

The statistical analysis of the correlation between the two groups of bones and the anatomical measurements obtained by CT scan was carried out using BMDP Software (Engelman, 1988). First, we described the different variables (CT-obtained anatomical measurements) through mean and standard deviation. Then, we performed the Wilks' test to detect the normality or non-normality of each

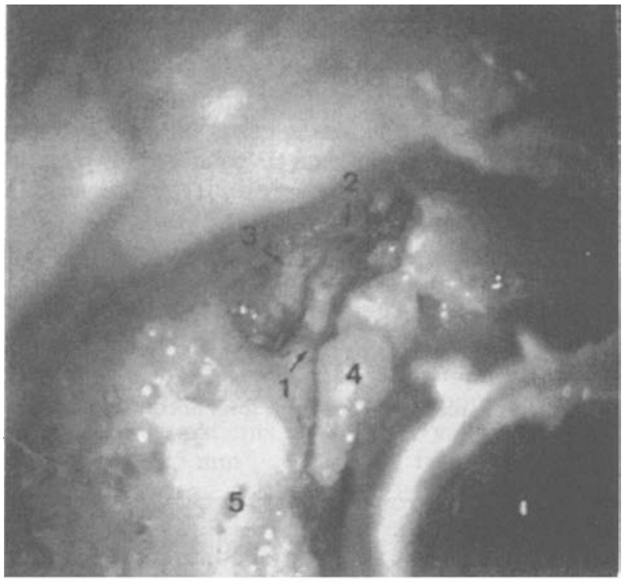


FIG. 4

Decompression of the first segment of the facial nerve via the transattical approach: (1, tympanic portion of the facial nerve; 2, geniculate ganglion; 3, labyrinthine portion of the facial nerve; 4, incus; 5, lateral semicircular canal).

distribution. Since the sample is small from the statistical viewpoint most of the variables did not follow a normal distribution.

The means of the 'transattical approach feasible' and the 'transattical approach not feasible' temporal bones' groups were compared for all parameters. We used the Student's *t*-test or the Mann-Whitney U-test depending on whether or not the parameter had a normal distribution. The level of statistical significance was established at $p<0.05$.

In order to determine the most highly-discriminating parameter between the two groups, we created different logistic regression models (LRM) (Cornfield, 1962; Gordon, 1974; Hosmer, 1989). One LRM was built for every parameter that showed statistically significant differences between means of the two groups with either the Mann-Whitney U-test or the Student's t-test. In the Logistic Regression Models the dependent variable (dichotomic) was feasibility (yes or no) and the independent variable (continuous) was the different anatomical measurements obtained by CT scan.

The logistic function estimates the probability of the given value of the independent variable (CT-obtained anatomical measurement) to be one of the dichotomic values (feasibility or not):

$$p = \frac{e^{a+bx}}{1 + e^{a+bx}}$$

where 'p' is the probability of the surgical decompression to be feasible determined by the model and 'x' the different values of the independent variable.

Results

Correlation between the CT-obtained anatomical parameters and the two groups obtained from

TABLE I

MEANS OF ALL MEASUREMENTS

Measurement	Feasible group (n = 52)		Not feasible group (n = 8)	
L1 (length of first segment of facial nerve)	Mean	3.2654	Mean	3.0000
	SD	0.4669	SD	0.3891
L2 (length of second segment of facial nerve)	Mean	10.0096	Mean	9.3000
	SD	0.9365	SD	1.3082
L3 (length of third segment of facial nerve)	Mean	13.3019	Mean	12.2250
	SD	0.9249	SD	1.5764
A1 (distance between ossicular chain and internal attical wall)	Mean	5.0692	Mean	4.7875
	SD	0.7780	SD	0.3227
A2 (distance between ossicular chain and external attical wall)	Mean	5.8172	Mean	5.1250
	SD	0.4872	SD	0.5064
AAA (attical area at malleus–incus level in axial projection)	Mean	48.6731	Mean	36.0000
	SD	6.5671	SD	2.1876
AAC (attical area at malleus–incus level in coronal projection)	Mean	28.5481	Mean	26.0000
	SD	6.1932	SD	3.1282
AV (attical volume)	Mean	68.4615	Mean	58.7500
	SD	8.4910	SD	3.5355

surgical dissection i.e. temporal bones on which total decompression of the facial nerve via the transattical approach was feasible or, temporal bones on which total decompression of the facial nerve via the transattical approach was not feasible was established. Table I shows the data for means of all measurements in the feasible/not feasible groups.

The difference between the means of the two groups of temporal bones for the parameters L1, L2, L3, A1 and AAC was not statistically significant. In spite of that, as far as L3 is concerned, some differences did exist between the means of the two groups.

The only statistically significant difference between the means of the two groups of temporal bones was observed for the following parameters: attical area measured in the axial projection (AAA), distance between the ossicular chain and the external wall of the atticum (A2) and attical volume (AV) measured by CT scan.

The tomographical results showed that the area of the atticum at the malleo-incudal joint measured in the axial projection (AAA) of the 60 temporal bone specimens studied ranged between 33.0 mm^2 and 70.0 mm^2 (average = 46.983 mm^2; SD = 7.531). The mean for the 'transattical approach feasible' was 48.673 mm^2 and the mean for the 'transattical approach not feasible' was 36.0 mm^2. These differences are statistically significant ($p<0.001$).

Statistically significant differences ($p<0.001$) were also observed for the parameter A2 (distance between the ossicular chain and the external wall of the atticum).

As far as the AV (attical volume) parameter is concerned, statistically significant differences were observed too ($p<0.05$). Nevertheless, such a parameter was very difficult to measure accurately because of the small size of the atticum; we had a 35 per cent variation in the measured volume in retests on the same temporal bone.

Models of logistic regression were built for the parameters which showed a statistically significant difference between the means of the two groups of temporal bones: AAA, A2 and AV. At the logistic regression test, the AAA parameter was the most highly discriminating parameter (χ^2; $p<0.005$), and the parameter with the 'closest to reality' mathematical model (χ^2 for goodness of fit; $p = 1$).

Moreover, the LRM found different values for the AAA parameters (with their respective 'p to be feasible') that discriminate between temporal bones in which decompression via the transattical approach was feasible and those in which it was not feasible. All of them had values for the parameter between 38.75 mm^2 and 40.75 mm^2 and all of them discriminated between the two groups of bones with a sensitivity of 100 per cent, specificity of 100 per cent and 100 per cent of the temporal bones correctly classified (Figure 5).

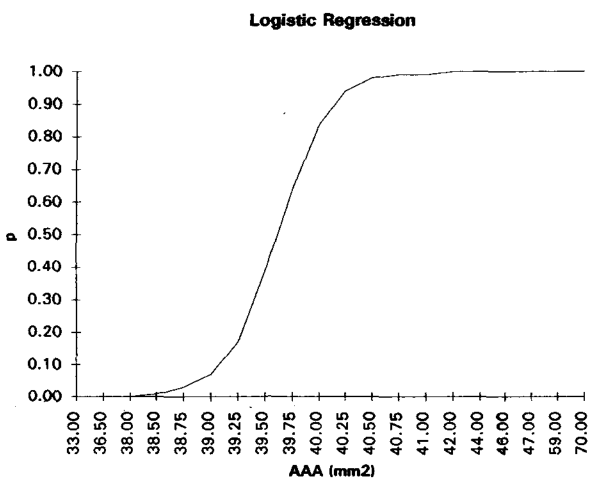


FIG. 5

Logistic regression model for AAA.

Discussion

Computed tomography (CT) is the best method of visualizing the intratemporal segments of the facial nerve, and also of making the surgeon aware of the anatomical relationship between these segments and the surrounding structures (Jackler, 1988). CT scan can also measure different distances, areas and volumes which allow us to quantify the degree of pneumatization of the temporal bone. Since the degree of pneumatization of the temporal bone is the limiting factor in the feasibility of decompressing the facial nerve via the transattical approach, CT measurements could be the cornerstones in the pre-operative decision on which surgical approach is to be used.

Among the CT-measured parameters, the parameter AAA (attical area in axial projection) was the best one with which to differentiate pre-operatively between the two groups of temporal bones. AAA measures an area that we need to cross to gain access to the geniculate ganglion and labyrinthine portion of the facial nerve. AAA is also the parameter that gives a better idea of the degree of pneumatization of the anterior epitympanic space. We found that AAA measurements accurately discriminated between the two groups of temporal bones. Those with values less than 38.75 mm^2 had 100 per cent sensitivity while those with values more than 40.75 mm^2 had 100 per cent specificity. Thus CT scan measurements of AAA seems to determine those patients in whom the transattical approach to facial nerve decompression should be undertaken.

L3 was the only length, to show some differences between the means of the two groups, though not statistically significant that could support the Müren and Wilbrand (1986) statement that the length of the third portion of the facial nerve showed a positive correlation to the degree of mastoid pneumatization, though this was not statistically significant in their study either.

We could not detect a good reason, from the surgical point of view, to explain why the parameter A2 presented differences between the means of the groups and the parameter A1 did not. Before doing the study we might have thought that A1 would have had these differences and A2 would not have had them, since the distance between the ossicular chain and the internal attical wall seemed more critical in order to have enough room to get to the geniculate ganglion.

The parameter ACC did not present statistically significant differences between the means of the two groups. Interestingly, AAC is not a good parameter with which to decide pre-operatively whether or not we will be able to decompress the labyrinthine portion and the geniculate ganglion of the facial nerve via the transattical approach.

The AV parameter was very difficult to measure accurately, even with the computer software of our Elscint Excel 2400, because of the small size of the atticum. We did obtain a 35 per cent variation in the measured volume in retests on the same temporal bone. So, even though differences between the means of the two groups did exist, it was not a good parameter to use.

Conclusion

Based on our experience, the measurement by CT scan of the attical area could be an essential aid to the decision as to whether the transattical approach to the first segment of the facial nerve would be feasible in a particular patient or whether the middle fossa approach should be offered.

If the attical area at the malleo-incudal joint, measured in the axial projection is greater than 40.75 mm^2 we would attempt to decompress the first portion of the facial nerve via the transattical approach first. If the attical area is smaller than 38.75 mm^2 the first segment of the facial nerve should be reached using the middle fossa approach. For areas between 38.75 and 40.75 mm^2, the transattical approach should be considered.

Further clinical studies need to be undertaken to validate the results of this experimental study, and, furthermore, to know which kind of approach should be offered to patients with AAA values between 38.75 and 40.75 mm^2.

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