ORIGINAL ARTICLE

Cadaveric Temporal bone dissection: a Study of the Variations in the Course of the Facial Nerve by Measuring the Second Genu Angle

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Abstract

Objective: To study the variations in the course of the facial nerve by studying the second genu angle (S.G.A.) aiming to provide a more detailed description of the anatomy of the nerve, thus avoiding its injury during middle ear surgery.

Material and Methods: 35 adult temporal bones were studied by dissecting them at the temporal bone laboratory in Ain Shams University Specialized Hospital (ASUSH). The variations in the course of the facial nerve were studied by measuring the S.G.A., the length of the tympanic segment of the nerve as well as the distance between the S.G.A. and the oval window niche., in an attempt to find the relationship between these 3 variables.

Results: The study conveyed on 35 temporal bones showed that 28 (80%) had an obtuse S.G.A. of the facial nerve, 5 (15%) had a right S.G.A. and 2 (5%) had an acute S.G.A. with an overall mean of the S.G.A. was 116.97° + 18.07. The average length of the tympanic segment of the facial nerve in the 35 temporal bones was 12.47 mm + 0.435. The distance from the oval window niche to the S.G.A. in all the specimens varied from 2mm to 4.1 mm (mean= 3.314 + 0.435 mm). A relationship was found between the length of the facial nerve, the S.G.A. and the distance of the facial nerve from the oval window niche. The shorter the tympanic segment of the facial nerve, the more obtuse the S.G.A is and the closer the nerve to the oval window niche is. On the other hand the longer the tympanic segment of the facial nerve, the more acute the S.G.A is and the more the distance of the nerve from the oval window niche is.

Conclusion: The measurement of the S.G.A. and the distance between the S.G.A. and the oval window niche are variable depending on the length of the tympanic segment of the facial nerve. This might help the otologic surgeon to anticipate the position of the facial nerve to avoid its injury during middle ear surgery.

Keywords: Anatomy, facial nerve course, second genu angle, tympanic segment

Introduction

Iatrogenic facial paralysis is a feared of complication during ear surgery. The incidence of iatrogenic facial nerve injury is reported as 0.6-3.6% in all otologic surgical procedures, and increases to 4-10% in revision surgery (1). Moreover, in the recent years, there has been an increasing interest in the otologic literature about the intratemporal portion of the facial nerve, as surgical exposure has been commonplace in a variety of conditions (2). It is therefore important to have a deep knowledge of the nerve anatomy as much as possible.

The facial nerve follows a characteristic course within the temporal bone and is divided into three segments: labyrinthine, tympanic and mastoid. After the second genu, the nerve traverses the synonymously named vertical, descending, or mastoid segment en route to the stylomastoid foramen (3). As the facial nerve descends inferiorly in this portion, it gradually assumes a more lateral position. In its most inferior portion, the facial nerve takes on a close proximity to the digastric ridge and muscle, where the nerve is mostly medial and anterior to these structures (4).

Iatrogenic injury to the facial nerve during otological surgery occurs most often at the level of the second genu in the mastoid and is more frequent when the facial nerve has an aberrant course (5).

Measurement of the variations of the S.G.A. has only been addressed in the literature via a 3-D reconstruction of CT images of human temporal bones by Yusu et al in 2008 who found the S.G.A. to be 114.15° + 8.51° (6).

The purpose of this study is to answer the following questions: What are the variations in the measurement of S.G.A.? What is the relationship between the variation of S.G.A. measurement of the facial nerve and the length of the tympanic segment as well as the distance of the S.G.A. from the oval window niche.

Material and method:

35 human temporal bones (18 right and 17 left) were obtained and dissected with standard otologic instruments under magnification using Karl Kaps

(Germany) microscope at the temporal bone laboratory in ASUSH. The facial nerve was exposed in all the specimens completely all through its route in the middle ear. In the exposed nerve, the region of the second genu was identified. The angle between the horizontal and the vertical segments of the facial nerve was measured using a simple protractor.

The specimens were photographed for documentation (a red thread was glued to the facial nerve for photo clarification purposes). A Descriptive morphometric study describing the S.G.A. measurement and an analytic study of the relationship between the S.G.A. measurement, the distance of the S.G.A. from the oval window niche and the length of the tympanic segment of the facial nerve were done.

Results:

S.G.A was found obtuse in 28 bones (80%) (Figure 1) 26 of them had a mean angle= 121.95° + 5.99 (Table 1), two of them had a more obtuse angle with a mean = 160° + 2.83. 5 bones (15%) had a right S.GA (figure 2) and two bones (5%) had an acute angle (figure 3). There was a big variation in the measurement of the S.G.A with an overall mean of the S.G.A. = 116.97° + 18.07).

The length of the tympanic segment of the facial nerve was measured in the 35 temporal bones and was found to be = 12.47 mm + 0.435. measured The distance from the S.G.A to the oval window niche was also measured in all the specimens and was found to be variable ranging from 2 mm to 4.1 mm (mean=3.314 mm + 0.435 mm).

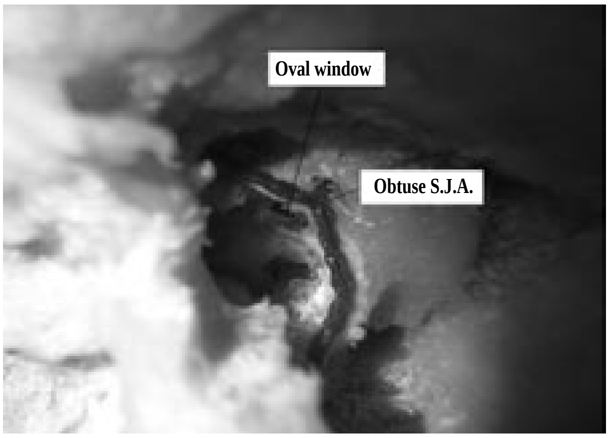

Figure 1: Obtuse S.G.A. in a left temporal bone.

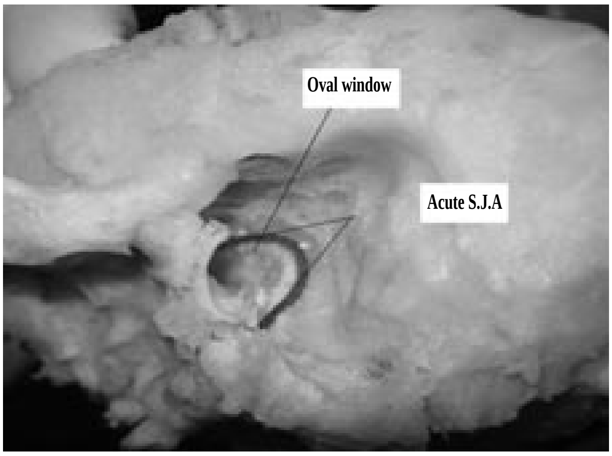

Figure2: Acute S.G.A. in a left temporal bone

T.B.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
S.G.A.	122	124	130	162	115	116	112	90	125	117	123	119
D.F.O.	3.2	3.1	3	2	3.4	3.4	3.4	4	3.1	3.4	3.3	3.4
L.F.N.	12.4	12.4	12	11.5	12.5	12.5	12.5	13	12.3	12.5	12.4	12.5
T.B.	13	14	15	16	17	18	19	20	21	22	23	24
S.G.A.	121	84	120	128	158	126	110	127	90	114	112	128
D.F.O.	3.4	4.1	3.4	3	2.3	3.1	3.5	3.1	3.8	3.3	3.4	3.1
L.F.N	12.5	13.5	12.5	12.2	11.5	12.3	12.6	12.3	13	12.5	12.6	12.1
T.B.	25	26	27	28	29	30	31	32	33	34	35	
S.G.A.	127	114	90	126	124	90	128	120	90	130	82	
D.F.O.	3.1	3.4	3.9	3.1	3.1	3.8	3.1	3.3	3.9	3	4.1	
L.F.N.	12.2	12.5	13	12.3	12.4	13	12.1	12.5	13	12	13.5	

Table 1: The measurements of the S.G.A. (T.B. =Temporal Bone, S.G.A. = Second Genu Angle in mm, D.F.O = distance between S.G.A. of the facial nerve and the oval window niche in mm, L.F.N. = length of the tympanic part of the facial nerve in mm).

Discussion:

Facial nerve paralysis is a major complication associated with otologic surgery. Although facial nerve injury is at times unavoidable because of the extent of disease, most cases of postoperative facial paralysis are a result of unrecognized facial nerve trauma in the hands of an unskilled otologic surgeon(1). The facial nerve is the longest cranial nerve embraced in a bony canal in human beings, and it is not easy for otologists to get accurate spatial relationship between the nerve and its adjacent structures(4). Normal surgical landmarks are often distorted in the diseased mastoid, and positive identification of vital structures is mandatory to perform a successful procedure. Surgical discipline must be maintained during the procedure to identify vital structures in a systematic fashion as the surgery progresses. In particular, it is critical to identify the facial nerve throughout its course in the mastoid as soon as possible, which is best accomplished after the lateral semicircular canal and any ossicles within the posterior epitympanum have been identified. Less specifically, the distal portion of the second genu of the facial nerve is found just inferior to the level of the lateral semicircular canal (1). Minor variations and major anomalies often occur in the course of the facial nerve, predisposing the nerve to inadvertent surgical injury (5).

Recent publications have highlighted the use of histological sections for three-dimensional (3D) study of the temporal bone structures (7-9), but this method can't be applied to study patients' temporal bones. Computer-aided 3D reconstruction of CT images can effectively resolve this deficiency, especially with the advent of high-speed spiral CT, the 3D reconstruction technique has essentially changed (10).

CT imaging can show the anatomy of the temporal bone and the intratemporal structures as only two-dimensional (2D) cross-sectional slices (11). 2D images are inadequate for otolaryngologists to completely understand 3D structure characteristics. In 1980, Fargason et al (12) had successfully reconstructed 3D models for pituitary microadenomas using conventional 2D CT scan information. Therefore, neurosurgeons could observe the tumor and tumor size in a 3D model. Subsequently, the 3D reconstruction of CT images has been used in the diagnosis and surgical planning of craniofacial deformities or maxillofacial fractures (13-15).

3D reconstruction of the temporal bone from CT images could provide a more accurate anatomical location of deep structures, which could be used in surgery design (16). This technology has been called a "non-injury spatial anatomy(17).

Yusu et al. in 2008, measured radiologically the S.G.A. by 3-D reconstruction of CT images of temporal bones of 34 healthy adults and found it 114.15° + 8.51° (6).

Our cadaveric temporal bone dissection study showed that the measurement of S.G.A was 116.97° +18.07 which is the real measurement of the S.G.A. after exposing the nerve and closely correlates to what Yusu et al found in their radiological study.

Two important facts are recognized. First, that the S.G.A. measurement using 3-D reconstruction of CT images although accurate, as the nerve course could be followed in serial images. yet, only the distance between the S.G.A. and the stapes head could be measured, and not the true distance between the S.G.A. and the oval window niche. Furthermore, the averaging effect of CT affects the accuracy when measuring the distance between 2 different structures(18).

The second fact is that no clinical benefit could be gained from knowing the mean value of the S.G.A. or other facial nerve measurements in isolation, even when studied by temporal bone dissection, unless analyzing and correlating these values with other measurements of nearby structures.

So in our study, not only the real distance of the S.G.A. from the oval window niche was measured but also the length of the tympanic segment of the facial nerve. These measurements were correlated to the S.G.A. measurement .

Our study concerning the quantitative relationship of the three variables, could open the way in the future for the 3D CT to be of more clinical impact when measuring accurately one of these variables, i.e. the S.G.A. and thus anticipating better intraoperative orientation of other important landmarks based on the real relationship between the variables as studied in our cadaveric dissection of the temporal bone.

Cadaveric temporal bone dissection has shown anatomically that the shorter the tympanic segment of the facial nerve, the more obtuse the S.G.A. is and the shorter the distance between the S.G.A. and the oval window niche will be.

On the other hand, the longer the tympanic segment, the more acute the S.G.A. is and the more the distance between the S.G.A .and the oval window niche will be.

Consequently, by preoperative measurement of the S.G.A. in patients by using 3-D reconstruction of the CT images of temporal bones, one can predict the distance between the S.G.A. of the facial nerve and the oval window niche more accurately.

Anticipating the position of the facial nerve accurately in relation to fixed structures in the mastoid could be achieved by preoperative radiological assessment of specific measurements of the facial nerve if other anatomical variables are well known.

So more anatomical studies are needed to understand the variations in the facial nerve measurements and their relation to fixed anatomical nearby important structures or landmarks.

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