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EXPERIMENTAL STUDY

A microdissection study of facial nerve at the labyrinthine and tympanic segments in adults

Yetişkinlerde fasiyal sinirin labirentin ve timpanik parçalarında mikrodiseksiyon çalışması

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Objectives: To determine the relationship in detail between the tympanic and the labyrinthine segments of the facial nerve and the relationship between the bony structures and the neighboring nerve.

Material and Methods: Measurement of the length of the segment of the facial nerve within the internal auditory canal and the lengths of the labyrinthine and tympanic segments were made on fourteen temporals bones collected from eight fresh cadavers.

Results: The minimum distance between the point where the facial nerve leaves the internal auditory canal and the tympanic segment was measured 4.71±0.54 mm. The angle between the labyrinthine and the tympanic segments at the geniculate ganglion was measured 73°85´±10°.89´. The angle between the labyrinthine and the superior vestibular nerve are measured 34°35´±5°51´.

Conclusion: We believe that the results of our measurements will help the surgeons to minimize the complications who works in this particular anatomic area.

Key Words: Ear, middle/surgery; facial nerve/anatomy & histology/surgery; mastoid/surgery; temporal bone/anatomy & histology/surgery; geniculate ganglion/anatomy & histology.

Amaç: Fasiyal sinirin timpanik ve labirentin segmentlerinin birbirleri ve komşuluğundaki kemik ve nöral yapılarla olan ilişkisi ayrıntılı olarak ortaya konuldu.

Çalışma Planı: Fasiyal sinirin timpanik ve labirentin segmentleriyle birlikte internal akustik kanal içindeki uzunluğu sekiz taze kadavradan elde edilen 14 temporal kemik üzerinde diseke edilerek ölçüldü.

Bulgular: Fasiyal sinirin internal akustik kanalı terk ettiği nokta ile timpanik segmenti arasındaki en kısa mesafe ölçümünde 4.71±0.54 mm saptandı. Genikülat gangliyonda fasiyal sinirin timpanik ve labirentin segmentlerinin yapmış olduğu açı 73°85´±10°89´ olarak ölçüldü. Fasiyal sinirin labirentin segmenti ile süperior vestibüler sinir arasındaki açı 34°35´±5°51´ olarak ölçüldü.

Sonuç: Elde ettiğimiz sonuçların bu anatomik bölge üzerinde çalışan cerrahların komplikasyonlarını en aza indirgemelerinde yardımcı olacağını inanıyoruz.

Anahtar Sözcükler: Orta kulak/cerrahi; fasyal sinir/anatomi & histoloji/cerrahi; mastoid/cerrahi; temporal kemik/anatomi & histoloji/cerrahi; genikulat ganglion/anatomi & histoloji.

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Temporal bone has is a complex formation which is difficult to understand and to work on because of its three dimensional structure where vascular and neural structures follow a complicated course. With the improvements in the operating microscope within the past 50 years, various surgical techniques have been developed concerning the course of the facial nerve from the internal auditory meatus to the stylomastiod foramen, and these procedures have been performed successfully. Recently, besides the developments in surgical procedures, the technological improvements in anesthesia and intensive care conditions have lead to an increase in middle fossa approaches. Moreover, it has been demonstrated in recent years that in idiopathic facial nerve palsy (Bell's palsy) and Herpes zoster oticus which show up with facial palsy, the labyrinthine segment and the geniculate ganglion are the most commonly involved portions. This causes an increase in the surgical techniques involving this area which requires further study due to its complex anatomic relationship with the cochlea and the semicircular canals. The segment of the facial nerve from where it exits the internal auditory canal to the geniculate ganglion, ie the labyrinthine segment, is in close relationship with the cochlea and the ampulla of the superior semicircular canal in a narrow field. Therefore, the surgeon who will work in this area needs perfect anatomic knowledge as well as experience, and this is maintained with repeated temporal bone dissections.[1]

The main purpose of this study is to make the measurements which will guide surgery and facilitate dissection in the area from where the facial nerve exits the internal auditory canal at the geniculate ganglion to the point where it enters the Fallopian canal while performing the transmastoid approach as an alternative for the middle fossa approach. Therefore, the perpendicular segment between the point where the facial nerve quits the internal auditory canal and the tympanic segment, and the angle between the labyrinthine segment and the superior vestibular nerve are measured. In addition to these, measurements concerning the lengths of the facial nerve within the internal auditory canal, the labyrinthine and the tympanic segment, and the angle formed by the latter two segments were made and compared with the results from other studies.

MATERIALS AND METHODS

Fourteen temporal bones were obtained from 8 cadavers, within the first 2-3 hours of death, without taking the age, sex and race into consideration. With the use of Zeiss S21 operating microscope and by the middle fossa approach segments of the facial nerve within the internal auditory canal, labyrinthine and tympanic segments and the geniculate ganglion were exposed. Tegmen tympani and tegmen antri were removed and incus was taken out. The horizontal segment of the facial nerve was exposed. The lengths of the segments of the facial nerve in the internal auditory canal, labyrinthine and tympanic segments were measured. The minimum distance (#) between the point where the facial nerve exits the internal auditory canal and the tympanic segment was measured (Fig. 1). The angle (α) at the geniculate ganglion formed by the labyrinthine and the tympanic segment and the angle (β) between the superior vestibular nerve and the labyrinthine segment were also estimated (Fig. 1).

An imaginary line parallel to the tympanic segment at the meatal foramen is constructed while measuring the minimum distance (#) between the point where the facial nerve exits the internal auditory canal and the tympanic segment. From this line a perpendicular line to the tympanic segment was drawn, thus the distance between the meatal foramen and the aspect of the facial nerve facing the

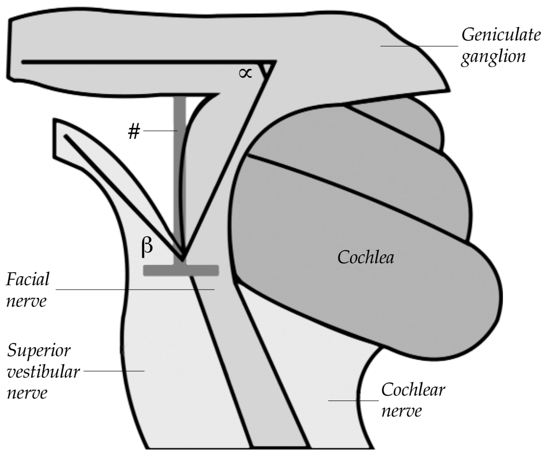

Fig. 1 - *(#) The shortest distance of the facial nerve from where it exits the internal acoustic canal to the tympanic segment; (α) the angle between labyrinthine and tympanic segments; (β) the angle between superior vestibular nerve and labyrinthine segment of facial nerve.*

TABLE I

THE RESULTS OF MICRODISSECTION STUDY

Temporal bone	Length of intenal acoustic canal (mm)	Length of labyrinthine segment (mm)	Length of tympanic segment (mm)	Distance from fundus to tympanic segment (mm)	Angle at the geniculate ganglion	Angle between labyrinthine segment and superior vestibular nerve
Left (1)	8	4	11	4.5	83°	30°
Right (1)	9.5	4.5	10.5	4.5	84°	33°
Left (2)	8	6	10.5	6	83°	40°
Right (2)	11	6	11	5	71°	36°
Left (3)	11	5	10	4.5	92°	38°
Right (3)	11	5	10	5.5	84°	25°
Right (4)	11	5	10.5	5.5	86°	34°
Left (4)	11	6.5	10	4	58°	42°
Right (5)	11	4	12	4	69°	39°
Left (5)	11.5	5	12	5.5	65°	24°
Left (6)	11	5	11	5	65°	35°
Right (6)	10.5	6.5	11	5	64°	30°
Left (7)	12	5	11	6.5	65°	40°
Left (8)	11.5	6.5	11	6.5	65°	35°

meatal foramen was measured using millimetric caliper.

For the estimation of the angle (α) between the labyrinthine and the tympanic segments at the geniculate ganglion an imaginary line from the midpoint of the meatal foramen to the midpoint of the lateral part of the labyrinthine segment was drawn. Another line was drawn along the long axis of the the tympanic segment. The measurement of the angle between these two lines was done by placing a thin wire on the nerve as mentioned above and carrying the angle (α) onto a protractor. In measuring the angle (β) between the labyrinthine segment and the superior vestibular nerve, a line was drawn from the midpoint of the meatal foramen to the midpoint of the lateral part of the labyrinthine segment. Another line from the midpoint of the meatal foramen to the midpoint of the medial part of the superior vestibular nerve was constructed. The angle (β) formed by these two lines were estimated by placing a wire on the angle and then transferring it onto a protractor, as mentioned before.

Millimetric caliper was used to measure the labyrinthine, tympanic segments and the portion of the facial nerve within the internal auditory canal.

RESULTS

In 14 temporal bones, the measurements of the angles and the lengths were made for the segment of the facial nerve within the internal auditory canal, the labyrinthine and the tympanic segments. Furthermore, the measurements for the angle (β) between the labyrinthine segment and the superior vestibular nerve, and the minimum distance (#) between the point where the facial nerve leaves the internal auditory canal and the tympanic segment were made (Fig. 2a-c). The results were given in Table I.

The length of the facial nerve within the internal auditory canal ranged between 8-12 mm (mean±SD: 10.57±1.22). For the labyrinthine segment minimum distance was measured as 4 mm while the maximum distance was 5 mm, mean: 4.57 mm (SD: 0.43). These values were between 10.5-12 mm for the tympanic segment (mean±SD: 10.82±0.63). The minimum distance between the point where the facial nerve exits the internal auditory canal and the tympanic segment varied between 4 mm and 5.5 mm (mean±SD: 4.71±054). The angle between the labyrinthine and the tympanic segments at the geniculate ganglion was measured as 58°-92°

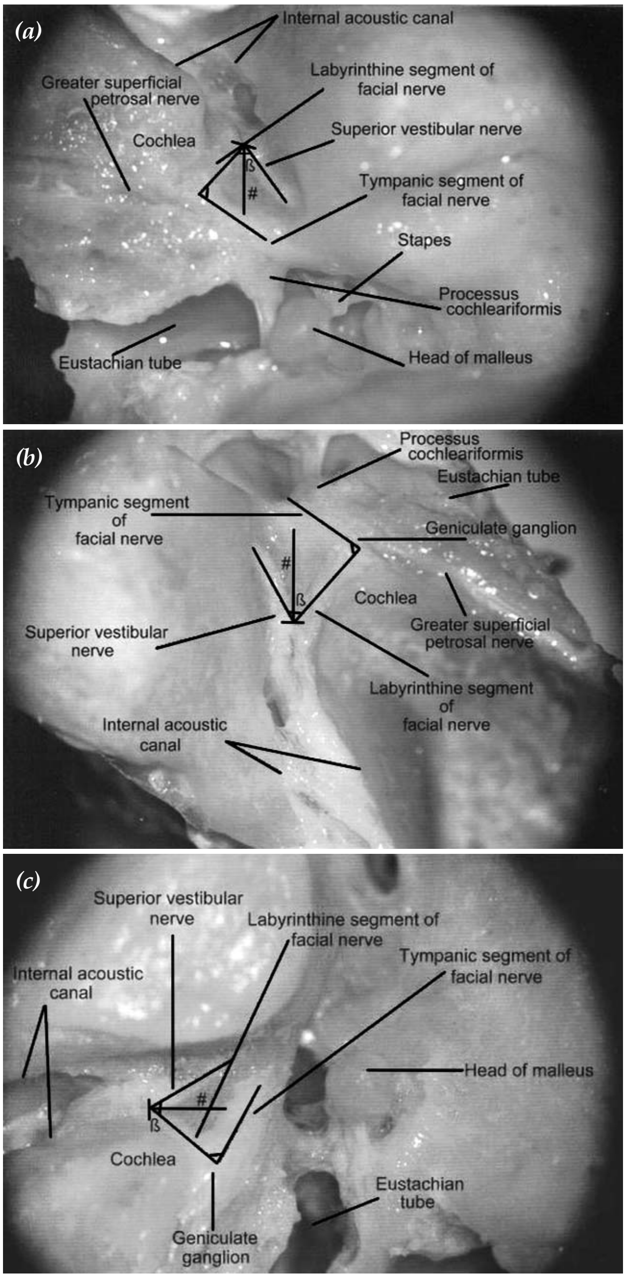

Fig. 2 - *View of the labyrinthine and tympanic segments of the facial nerve in the left temporal bone from,* ***(a)*** *medial,* ***(b)*** *lateral,* ***(c)*** *anterior.*

(mean±SD: 73°85´±10.89) and the angle between the labyrinthine segment and the superior vestibular nerve was measured as 24°-42° (mean±SD: 34°35´±5.51).

DISCUSSION

The abnormalities which affect the facial nerve may be located within the temporal bone anywhere between the internal auditory canal and the stylomastoid foramen. Surgical exploration of the nerve may be required for the decompression, grafting, rerouting (of the nerve) or for the excision of lesions such as cholesteatomas, acoustic tumors, meningiomas or facial nerve neurinomas. The surgical exposition of the facial nerve in the contemporary concept, aims to reach the facial nerve by no means of injury while preserving the vestibular and hearing functions, and not to create a mastoid cavity otherwise needed.[2] In our dissections on fourteen temporal bones no facial nerve abnormality along its course in Fallopian canal was seen.

The anatomy of the facial nerve is defined by the detailed temporal bone studies conducted by Proctor and Nager.[3,4] The blood supply and relationship of the nerve with its bony canal have been investigated for the labyrinthine, tympanic and the mastoid segments by Ogowa and Sando.[10] Ge and Spector[5] have performed a exhausive study which demonstrated the developmental and anatomic properties of the geniculate ganglion and the labyrinthine segment of the facial nerve in fetal and adult temporal bones. Depending on these studies many authors like Wadin and Wilbrand, Rupe and Wieder, Redleaf and Blough have conducted studies on the geniculate ganglion and the labyrinthine segment of the facial nerve.[6-8] In recent studies, the "compression theory" concerning the areas where the nerve/canal ratios are minimal, has been held responsible for idiopathic facial palsy (Bell's palsy) and Herpes zoster oticus associated with facial palsy.[1,9] Thus it is followed up with interest. Many authors had pointed out to the presence of lesions at the geniculate ganglion, the labyrinthine segment, and the proximal portion of the internal auditory canal in Herpes zoster oticus and other viral disease. Moreover, several other abnormalities have been found to be associated with this area. Clinical studies on facial nerve paralysis had demonstrated that also the proximal parts of the facial nerve may be the major sites for the pathologic lesions as well as the meatal and the labyrinthine segments.[5] Furthermore, the complex anatomy of this area and the close vicinity of the facial nerve with the organs of hearing and balance in a minute anatomic site require further investigations.[9]

In a study by Ogawa and Sando,[10] the ratio of spatial occupancy of the vessels to the canal and to the nerve were estimated for the labyrinthine segment. They found that the internal diameter of the main artery supplying the labyrinthine segment was less then 40% of the diameters in the other portions of the facial canal.

The labyrinthine segment of the facial nerve is beneath the middle cranial fossa and is the narrowest portion of the nerve within the Fallopian canal. Labyrinthine segment extends from the fundus of the internal auditory canal to the distal part of the geniculate ganglion. The narrowest part of the Fallopian canal is the entry which was estimated as 0.68 mm by Fisch.[1] The term "labyrinthine segment" corresponds the portion of the nerve exactly, because cochlea lies just in front of the nerve and the nerve lies just lateral to the ampulla of the horizontal semicircular canal. Critical anatomic relatioship exists between the basal turn of the cochlea and the labyrinthine segment of the facial nerve. In a study of 24 temporal bones, Redleaf and Blough[8] estimated this distance as 0.06-0.80 mm. Wadin and Wilbrand[6] found the distance as 0.05-1.06 mm (mean: 0.02). Moreover, Redleaf and Blough[8] measured the distance from the geniculate ganglion to the ampulla of the superior semicircular canal as 2.06-4.88 mm. When compared with the smallest diameter diamond drill of 0.6 mm it is obvious that an extremely difficult surgery is performed in a narrow field.

Ge and Spector,[5] in a study of 10 adult temporal bones, found that the bone overlying the geniculate ganglion was intact and had no dehissences, but in 2 temporal bones they showed that the bone was thin enough to reveal the pinkish yellow color of the geniculate ganglion. Rupa et al.[7] found that, of 11 temporal bones only 1 had a dehissence of the bone covering the geniculate ganglion. Among our dissections in 2 temporal bones, we encountered very thin bones overlying the geniculate ganglion so that the pinkish yellow color of neural structures were recognizable. In another temporal bone, it was easy to distinguish the ossicles underneath the tegmen tympani due to the bone's thin property.

The bony covering of the geniculate ganglion lacks in approximately 15% of the temporal bones, and this increases the risk of injury to the facial nerve during surgery directed towards the middle cranial fossa, especially in children. Moreover, the middle fossa plate and the bone over tegmen tympani may be quite thin.[1]

In literature the length of the facial nerve within the internal auditory canal is reported as 8-10 mm, the length of the labyrinthine segment and the tympanic segment as 3-5 mm and 11 respectively.[1] Ge and Spector[5] in their study of 10 temporals bones, measured the length of the labyrinthine segment between 2.25-3 mm (mean 2.82). Proctor and Nager[4] measured the length of the labyrinthine segment as 2.5-6 mm, the tympanic segment as 7-11 mm. Lee et al.[12] found the length of the labyrinthine segment as 4±0.8 mm. Wadin and Wilbrand[6] conducted a study on 200 temporal bones in which they found the length of the labyrinthine segment as 3.3 mm (mean), with the minimum of 1.6 mm and the maximum of 5.9 mm. They pointed out to the fact that while long labyrinthine segments had thinner facial canals, short canals were associated with broad facial nerves. They reported that all the canals were wider laterally. Rupa et al.[7] emphasized that the tympanic segment of the nerve had a wider attachment area at the geniculate ganglion compared with the labyrinthine segment. Ge and Spector[5] indicated by measurements that the narrowest part of the labyrinthine segment was at the meatus of the internal auditory canal or at the proximal part of the Fallopian canal; and the widest part was close to the geniculate ganglion at the distal portion of the canal. Our measurements revealed the length of the facial nerve within the internal auditory canal as 10.57 mm (range 8-12 mm), the labyrinthine segment as 4.57 (range 4-5 mm) and the tympanic segment as 10.82 mm (range 10.5-12 mm). Although we did not prove it with measurements we found that the proximal part of the labyrinthine segment was thinner compared with its distal part under the operating microscope. Furthermore, the labyrinthine segment appeared to be thinner with respect to the tympanic segment.

Wadin and Wilbrand[6] found the angle between the labyrinthine and the tympanic segments as 71° (45°-95°) whereas Nager and Proctor[3] estimated this angle as 75°.[3,6] Lee et al.[12] measured this angle via translabyrinthine approach and it was 26°±5°. In our study the angle between the labyrinthine and the tympanic segments were estimated between 58°-92° (mean 73.89°).

Uluğ[13] found the distance between the vertical cret and processus cochleariformis 5-6 mm in their study on temporal bones. The minimum distance between the point where it leaves the internal auditory canal and the tympanic segment was measured as 4-5.5 mm (mean 4.71 mm), in our study. The reason why the measuruments are different is that Uluğ designated the cochleariform processes, a little bit lateral anatomic structure from the tympanic segment of facial nerve, as a landmark. We also estimated the angle between the facial nerve and the superior vestibular nerve at this point where they exist in close vicinity. The minimum value was 24° and the maximum was 42° (mean: 34°35´). In our literature research we could not find any documents concerning these measurements, thus we cannot compare these results with the other reports.

CONCLUSION

While performing surgery of facial nevre, it is important to know the lengths of the parts of the nevre and the angles between these parts to minimize the complications and to disssect further around the geniculate ganglion and internal acustic canal. The data obtained from the dissections will help to go further for the surgeons.

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