Electrophysiological Mapping of the Temporal Branch of the Facial Nerve

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Abstract

Background   Minimized frontal and frontolateral approaches have been proposed for the clipping of aneurysms and for removal of deep-seated supra- and parasellar lesions. To avoid postoperative facial nerve palsy, anatomical studies have been conducted; however, only one electrophysiological investigation has been reported. We studied the course of the facial nerve in the temporal region and identify the optimal pterional keyhole craniotomy from the perspective of facial nerve protection.

Materials and Methods   We stimulated the temporal branch of the facial nerve in nine healthy volunteers and identified its course electrophysiologically. Electromyographic (EMG) responses were recorded from the superior orbicularis oculi, corrugator, and frontal muscles. The course of the temporal branch of the facial nerve was identified by tracking the stimulation points that elicited the best EMG responses.

Results and Conclusion   The distances from the tragus to the canthus, the tragus to the point where the facial nerve crosses over the zygomatic arch, the tragus to the first nerve bifurcation, the tragus to the second nerve bifurcation, and from the orbit to the middle rami were 80.8 ± 1.8 mm, 40.2 ± 1.6 mm, 58.1 ± 2.8 mm, 79.1 ± 3.4 mm, and 16.4 ± 0.9 mm, respectively. We found that the temporal branch of the facial nerve innervates each muscle in posterior-anterior direction. Based on these results, we prefer the pterional keyhole approach and incise the skin at a site posterior to the temporal branch of the facial nerve.

Keywords

► facial nerve
► neurophysiology
► pterional approach
► keyhole
► aneurysm
► clipping

Introduction

The pterional approach established by Yasargil et al[1] to clip anterior circulation aneurysms has been the gold standard for more than 30 years. However, the supraorbital keyhole approach, first reported by Perneczkey in 1998, is less invasive and yields good surgical results.[2] It provides for wide intracranial exposure in patients with deep-seated supra- and parasellar lesions[3] and for sufficient space for microscopic manipulation.[2,3] Subsequently, Hernesniemi et al[4] and Cheng et al[5] proposed the lateral supraorbital and pterional keyhole approach, respectively. Since 2001, we have used the pterional keyhole approach to clip anterior circulation aneurysms in more than 300 patients and obtained favorable outcomes.

Although frontal and frontolateral keyhole craniotomies appear to be less invasive, more efficient, and safe, they raise the possibility of iatrogenic injury to the temporal branch of the facial nerve because of its anatomical location. The

occurrence of facial nerve palsy in patients undergoing supraorbital keyhole craniotomy has been reported.[6]

To avoid facial nerve palsy in patients treated by keyhole craniotomies, the surgical anatomy of the temporal branch of the facial nerve has been studied,[7–11] and one electrophysiological investigation has been reported.[12]

Materials and Methods

Our study population consisted of nine healthy volunteers (four women, five men) ranging in age from 23 to 62 years (39.1 ± 4.2 [mean ± standard error of the mean]). All gave informed consent before entry into the study; our institutional ethics committee approved the procedures.

Electromygraphic Recording

With the volunteers in the supine position, surface electromyographies (EMGs) were recorded unilaterally from the superior orbicularis oculi, corrugator, and frontal muscles using 0.9-cm diameter silver/silver chloride surface electrodes. The active electrode was placed over each motor point, with the reference electrode over the nasion. Responses were recorded with an MEB4204 instrument (Nihon Kohden Corp., Tokyo) using three channels with high and low gains; they were filtered with a time constant of 3 msec through a high-pass filter set at 3000 Hz.

Electric Stimulation

The facial nerves were stimulated with monophasic square pulses of 200 µsec duration. Stimuli were delivered with a constant current stimulator attached over the skin with the cathode placed on the optimal point for eliciting responses from each muscle; the anode was placed distal to the cathode so that the current flowed along the course of the facial nerve. The stimulus intensity was gradually increased to a supramaximal level to recruit all nerve fibers.

Landmarks and Distances

To study the entire course of the facial nerve in the temporal region, we used four landmarks (►Fig. 1). They were the zygomatic arch, orbit, tragus, and canthus. Using these landmarks, we measured the distance from the tragus to the canthus, from the tragus to the point where the facial nerve crosses the zygomatic arch, from the tragus to the first and second bifurcation of the temporal branch of the facial nerve, and from the orbit to the middle rami of the facial nerve. These five distances were recorded for all volunteers and averaged.

Results

EMGs were successfully recorded from all subjects. As shown in ►Fig. 2, triphasic waveforms and compound muscle action potentials were recorded from each muscle. The averaged distance from the tragus to the canthus was 80.8 ± 1.8 mm; it was 40.2 ± 1.6 mm from the tragus to the crossing over the zygomatic arch, 58.1 ± 2.8 mm from the tragus to the first and 79.1 ± 3.4 mm to the second bifurcation, and
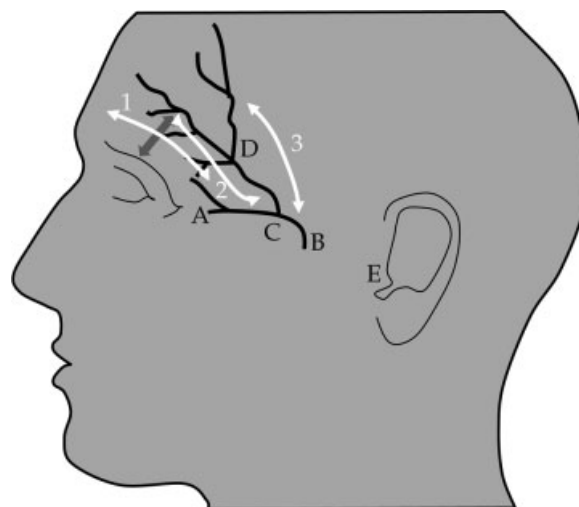
Fig. 1 Landmarks of the temporal branch of the facial nerve and relationship between the facial nerve and skin incisions of keyhole craniotomies, including the cathus (A) crossing point over the zygomatic arch (B), first bifurcation (C), second bifurcation (D), and tragus (E). 1 = supraorbital; 2 = outer canthal; 3 = pterional keyhole craniotomy. We measured the distance between the orbit and the middle rami of the facial nerve.
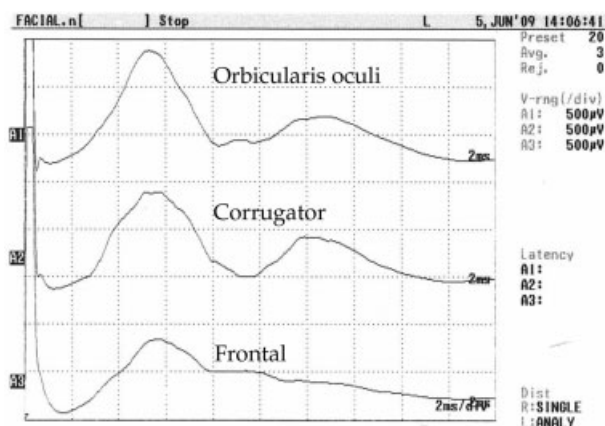
Fig. 2 Raw wave of compound muscle action potentials evoked by electrical stimulation of the facial nerve at each point from the orbicularis oculi (upper trace), corrugator (middle trace), and frontal muscle (lower trace).

16.4 ± 0.9 mm from the orbit to the middle rami. Stimulation in the area anterior to the middle rami evoked muscle responses from corrugator and superior orbicularis oculi muscles, indicating that the temporal branch of the facial nerve innervates each muscle in a posterior-anterior direction.

To avoid bias from far field activity of adjacent muscles, needle electrodes should be used for muscle recordings. However, because our study subjects were awake healthy volunteers, we used surface electrodes. Although there were some small effects from adjacent muscles, upon stimulation of the middle rami of the temporal branch of the facial nerve,

we were able to recognize all responses from the orbicularis oculi muscle.

Discussion

Although the pterional approach[1] has been the gold standard to clip anterior circulation aneurysms, it necessitates a semi-coronal long skin incision from a point near the tragus to the midline in the hairline. However, the clipping of common anterior circulation aneurysms does not require such a large craniotomy; a small bone window appropriately placed on the Sylvian fissure usually suffices. A cosmetic reason for using a large craniotomy is to hide the incision behind the hairline; another reason is to avoid facial nerve injury. However, this technique may result in postoperative numbness of the skin in the parietal region and may result in a long alopecia zone along the skin incision, atrophy of the temporal muscle, limited mouth opening ability because of cutting of the temporal muscle, and skull deformity.

Three less invasive surgical approaches—the supraorbital,[2,13] lateral supraorbital,[4,14,15] and pterional keyhole approach[5]—have been proposed to overcome the disadvantages of the pterional approach. They are characterized by a small craniotomy in the frontotemporal area, the site of the temporal branch of the facial nerve. To avoid facial nerve palsy after frontotemporal craniotomy, the surgical anatomy of the temporal branch of the facial nerve has been studied.[7–11,15] These studies showed that the temporal branch of the facial nerve resides in a 15- to 44-mm region measuring from the orbit, the zygomatic suture, and the anterior margin of the zygomatic arch and that a region within 15 mm of the supralateral to the orbit represents a safe zone. Furnas[11] recommends staying above the temporal root of the zygoma, 1 cm posterosuperior to the anterior hairline at the zygomatic arch, and 2 cm posterosuperior to the lateral edge of the eyebrow.

As shown in ►**Fig. 2**, with respect to positional relationships, the supraorbital keyhole craniotomy[2] is located anterior to the middle rami, the lateral supraorbital keyhole craniotomy[4,15] is placed between the anterior and middle rami, and the pterional keyhole craniotomy[5] is situated posterior to the whole temporal branch of the facial nerve. In our experience, supraorbital keyhole craniotomies sometimes result in postoperative facial nerve palsy, which resolves in about 6 months. Lan et al[6] reported a patient who presented with descensus of the eyebrow 3 months after undergoing a supraorbital keyhole craniotomy.

Park[12] reported that preoperative facial nerve mapping facilitates visualization of the entire nerve course on the skin and permits a more aggressive approach in dealing with facial skin and muscle flaps while reducing the risk of nerve injury. Our electrophysiological study of the temporal branch of the facial nerve showed that the distance from the orbit to the middle rami was 16.4 mm, a finding consistent with anatomical studies.[7–11,15] We also document that muscle responses from corrugator- and superior orbicularis oculi muscles were evoked by stimulation in the area anterior to the middle rami. This indicates that the temporal branch of the facial nerve innervates each muscle in posterior-anterior direction and that the supra- to lateral orbital area may not constitute a safe zone. We found that the zygomatic arch at around 40 mm from the tragus runs in the superoanterior direction and innervates muscles in a posterior-anterior direction. Although this distance is longer than reported by Miloro et al,[16] the difference is attributable to the use of different reference points. Whereat they measured from the most anterior aspect of the bony external auditory canal, our measurements were from the tragus. The site of the skin incision for pterional keyhole craniotomy coincides with the anterior margin of the temporal hairline; it is always behind the temporal branch of the facial nerve. Therefore, in our opinion, pterional keyhole craniotomy can be expected to yield excellent cosmetic results, and it avoids iatrogenic injury of the temporal branch of the facial nerve. However, because there may be variations in the course of the facial nerve among patients, we strongly recommend electrophysiological mapping, possibly with polygraph instruments, to record motor evoked potentials before skin incision for keyhole pterional craniotomies.

Conflict of Interest
None

References

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