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ORIGINAL ARTICLE

Anatomy of the Extratemporal Facial Nerve inRats

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OBJECTIVE: This study aims to measure peripheral branching of the facial nerve and to describe electromyographic findings after transection of the nerve in rats.

MATERIALS AND METHODS: Ten male Wistar rats were anaesthetized by an intramuscular injection of ketamine and Xylocaine. The facial nerve was skeletonized after a skin incision extending from the postauricular area to the angle of the mouth. The length of the peripheral branches was measured. The mandibular, buccal, and ocular branches of the facial nerve were transected in 5 of the rats to follow the acute functional and electrophysiological outcome of traumatic facial paralysis. The latency, amplitude, and duration of motor unit action potentials were obtained from the orbicularis and buccal muscles after stimulation of the main trunk of the facial nerve with a needle electrode.

RESULTS: Mean length of the main trunk, postauricular, frontal, buccal and mandibular branches were 4.8±0.62 mm, 6.5±0.91 mm, 12.3±3.04 mm, 22.8±1.39 mm, and 21.9±2.11 mm, respectively. The latency of the evoked potentials ranged from 1.50 msec to 1.58 msec, and the amplitude of the potentials was 6.3 mV. The duration of the potential was 2.4 to 4.1 msec. No response was observed after transection of the facial nerve.

CONCLUSION: The rat model provides an excellent platform for facial nerve research.

An animal model for facial nerve work would provide opportunities for experimental research. Analysis of physiological outcomes of facial nerve compression or transection, measurement of the effect of the radiation therapy on facial nerve grafting, work with facial nerve repair, and analysis of motor fiber organization are possible in animal models[1, 2, 3, 4]. Rats provide a suitable model because they are inexpensive, easy to breed, and anesthesia is not a problem. However, there is little information on the facial anatomy of these animals. We measured the length and peripheral branching of the extratemporal portions of the rat facial nerve to further assist others considering the same model.

MATERIALS AND METHODS

Ten male Wistar Albino rats (Gulhane Military Medical Academy, Research and Development Center, Ankara/Turkiye), weighing 220-280 g (12-16 week), were housed individually. The study was approved by the local ethics committee for experimental research. For surgery, rats were anaesthetized by an intramuscular injection of ketamine (150 mg/kg), Xylocaine (4 mg/kg). The right side was dissected in all rats. The nerve was exposed by transecting the skin from the postauricular area to the angle of the mouth. After delineating the peripheral branches of the nerve, the configuration, length, and the angularity of the bifurcations were measured and given as mean±standard deviation (SD). The mandibular, buccal, and ocular branches of the facial nerve were transected in 5 of the rats to follow the acute functional and electrophysiological outcomes of traumatic facial paralysis. Dissections were recorded with video and photographs to ensure the precision of the anatomic relationships and proportions in the drawings. Photographs were taken with no magnification.

Insulated needle electrodes were used for nerve stimulation. Motor unit action potentials were obtained from the orbicularis and buccal muscles after stimulation of the main trunk of the facial nerve (Dantec, Keypoint, Denmark). Stimulus duration was 50 msec with a 0.2 msec square wave pulse, and the intensity was 0.9 mA or 6.4 mA in 2 different recordings. The latency, amplitude, and the duration of the potentials were calculated (Figure 1, upper 2 recordings). The facial nerve was then transected, and the recording for compound motor unit potentials was reviewed (Figure 1, lower 2 recordings). The rats were given 100 mg penicillin, intramuscularly, for prophylaxis.

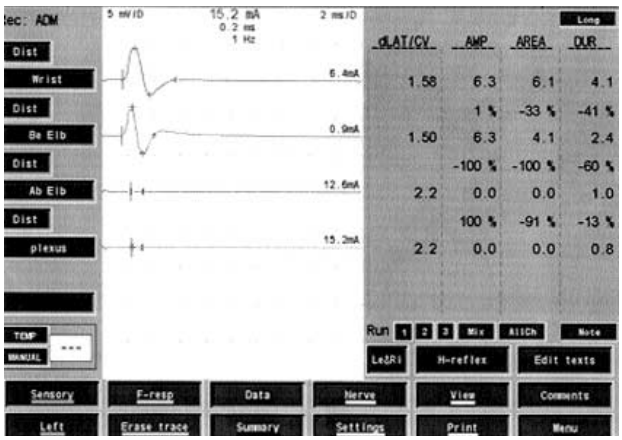

Figure 1: Electromyographic recordings from the rat facial nerve before and after facial nerve transection

RESULTS

Nerve measurements.

The length of the main trunk (from exit to bifurcation) ranged from 4.5 mm to 6 mm (mean ± SD, 4.8 ± 0.62 mm). The length of postauricular branch from the main trunk to the muscle ranged from 5.5 mm to 7.5 mm (6.5 ± 0.91 mm). The length of the frontal branch from the bifurcation to the lateral canthal ligament of the eye ranged from 11.5 mm to 15 mm (12.3 ± 3.04 mm). The length of the neural branch (buccal) from bifurcation to the cheek ranged from 21 mm to 29 mm (22.8 ± 1.39 mm), and the length of the neural branch (mandibular) from bifurcation to the labial commissure ranged from 18.5 mm to 27 mm (21.9±2.11 mm).

Neuroanatomy of the extratemporal portion of the rat facial nerve.

The stylomastoid foramen is located in the posterosuperior part of the external auditory canal. The tendon of the trapezius muscle partly covers the exit point of the nerve and should be retracted laterally to visualize the main trunk just inferior to the cranium (Figure 2). The posterior auricular branch leaves the nerve superiorly, posterior to the auricle, as soon as the main trunk emerges from the foramen.

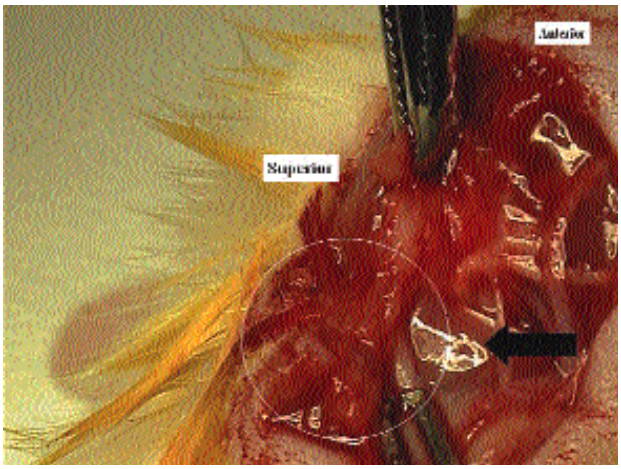

Figure 2: The facial nerve emerges from the stylomastoid foramen at the postero-superior part of the ear canal. The facial nerve is marked with a circle; the tympanic membrane is marked with an arrow.

The posterior auricular branch extends to the posterior auricular muscle, which is not rudimentary in rats unlike humans . The sternocleidomastoid muscle is located posterior to the nerve, whereas the posterior belly of the digastric muscle is located inferior to it. The main trunk, just posterior to the cartilaginous portion of the ear canal, has a 75-degree to 80-degree turn around the canal before the bifurcation (Figures 3 and 4).

Bifurcation occurs beneath the parotid gland, and it is difficult to follow the nerve without excision of the large parotid. The nerve does not pass through the gland, but is located underneath, so removing the gland is easy without damaging the nerve. The main trunk can be completely mobilized and visualized without the need of a microscope, and is appropriate for

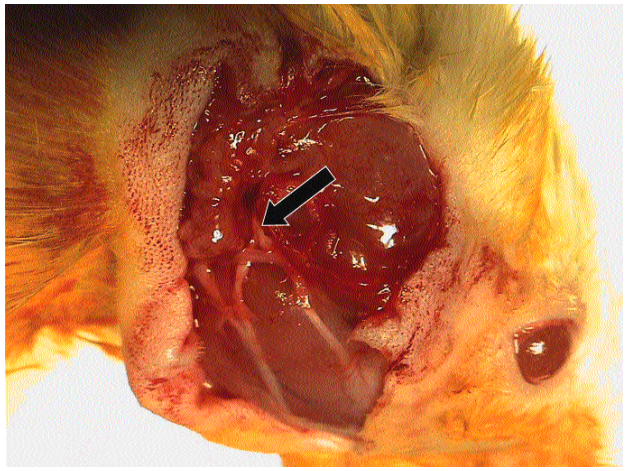

Figure 3: The main trunk of the facial nerve (marked with arrow) turns posteriorly around the ear canal.

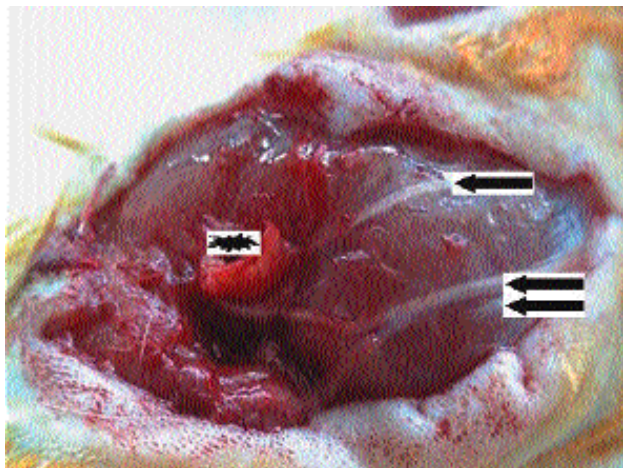

Figure 4: The inferior view of the main trunk passing inferiorly to the ear canal (asterisk). The buccal branch (single arrow) and mandibular branch (double arrow) are clearly exposed.

electrode placement, transaction, and end-to-end anastomosis. The external jugular vein crosses the nerve laterally after bifurcation, and can be coagulated and dissected for better exposure of the nerve without problems, since the vertebrobasilar return is sufficient because of the patent circle of Willis.

The superior temporofacial division of the main trunk includes the upper main temporal branch to the orbicularis oculi and the lower main zygomatic branch to the buccinator muscle and muscles of the upper lip. The inferior cervicofacial division of the main trunk contains the upper zygomatic and buccal branches and the lower cervical and mandibular branches to the

lower lip (Figure 5). All peripheral branches of the facial nerve lie over the facial muscles, so are very easy to follow. The branches lie under the superficial fascia of the facial muscles, so injury to the nerve during skin incision can be avoided by elevating the skin with forceps.

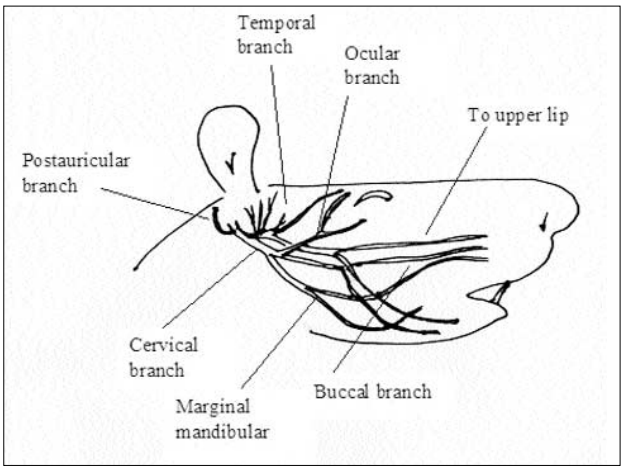

Figure 5: Schematic view of facial nerve branching.

Electromyography

Electromyographic recordings of the rat facial nerve are presented in Figure 1. The latency of the evoked potentials ranged from 1.50 msec to 1.58 msec, and the amplitude of the potentials was 6.3 mV. The duration of the potential was 2.4 to 4.1 msec. No response was seen after transection of the facial nerve, even with stimulus intensity of 12.6 mA or 15.2 mA (Figure 1).

DISCUSSION

The rat facial nerve is a good model for experimental studies. It is not difficult to follow the branches from the bifurcation to the endpoints just beneath the skin, even without a microscope. The parotid gland is large and covers the main trunk and the bifurcation, but the nerve does not pass through it, and the gland can be retracted off the nerve without any injury. After emerging from the cranium, the main trunk follows the external ear canal before branching. An average length of almost 5 mm provides an opportunity to study a thick nerve. Because of the shape of the cranium, the rat has very long buccal and mandibular branches, which may be suitable for experimental manipulations. However, the frontal branch is considerably shorter. Although there is some variability, the standard deviation of the length of the nerve among animals was not high, which allows comparative studies without excessive dissections.

The branching pattern is similar to humans. Stimulation of the mandibular and buccal branches produced muscle action potentials in both the upper and lower lips, emphasizing the cross-innervation of the mid and lower face by these branches, a feature of other nonprimate mammals. Cross-anostomosis between branches is seen during dissection of the nerve. Mattox and coworkers counted axons in the main trunk and major branches in serial sections, and showed that the main trunk of the nerve is histologically monofascicular[5]. Division of the nerve into fascicles by perineural connective tissue does not occur until the area of macroscopically identifiable branching, in contrast to humans, which suggests that differences in facial nerve regeneration in rats and humans might result from less misdirection of regenerating axons.

Electromyographic analysis of the rat facial nerve has been used to examine the severity of a conduction block due to a facial nerve lesion, or to measure axonal regeneration after nerve injury. Wiegand and coworkers showed that electromyographic monitoring of rat facial muscles allows detection of thermal facial nerve injury[6]. We showed that the latency of the action potentials is short, probably due to close anatomic distance between the stimulation and the recording points. However, the amplitude was very consistent. Terrell and Terzis showed that the double innervation of the rat eye muscle allows for selective sectioning of eye branches in order to have motor fibers from normal side without causing paralysis, a concept used extensively in cross-facial nerve-grafting procedures in humans with facial paralysis[7].

The rat facial nerve model has many advantages,

including simple housing of animals, amenability to anesthesia and follow-up, and straightforward nerve manipulation and dissection.

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