Scholarly Journal of Otolaryngology

DOI: 10.32474/SJO.2024.10.000345

ISSN: 2641-1709

Research Article

The Distribution Pattern of Facial Nerve Fibers in The Trunk and it's Physiological Significance

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Received: April 05, 2024 **Published:** April 18, 2024

Abstract

Background: The running distribution pattern of facial nerve fibers in the trunk and its physiological significance were rarely reported.

Objective: To study the running distribution pattern of facial nerve fibers in the trunk and its physiological significance.

Material and Methods: 18 healthy Wistar rats were divided randomly into partial neurotomy group, complete neurotomy group and control group. The facial nerve fibers regeneration and distribution pattern of the degeneration and necrosis fibers was observed at first and the 4th week.

Results: In the partial neurotomy group, the distribution pattern of the degeneration and necrosis fibers was interlaced with the normal facial nerve fibers at the first week. At the 4th week the facial nerve fibers regeneration was obvious, there was no distinct fibrosis in the facial nerve trunk. In the complete neurotomy group, the most facial nerve fibers got necrosis at the first week; at the 4th week, there was no distinct regeneration, and the fibrosis in the facial trunk was obvious. In the control group, there was no obvious degeneration and necrosis in the facial nerve trunk.

Conclusions and Significance: The nerve fibers in the facial nerve trunk constantly run from one nerve bundle to another. It helps facial never maintain a good skeleton structure in partial injury and create a favorable micro-environment for its regeneration.

Keywords: Facial nerve trunk; Nerve fiber; Distribution; Physiology: Regeneration

Level of evidence: NA

Background

Facial nerve is the cranial nerve which travels the longest distance in bone canal. Because of this special anatomical feature, it is the most vulnerable cranial nerve in skull base fracture [1-3]. It is known that most nerve fibers in the trunk of peripheral nerve constantly move from one nerve bundle to another, interlacing with each other, so that the size, number and location of nerve bundles are constantly changing. The degree of interlacement between nerve fibers is also related to the functional properties of nerve fibers. There are more fibers interlaced between the bundles of the motor never [4-7]. The basic nature of facial nerve belongs to peripheral nerve, and the facial nerve fibers are mainly motor fibers. Therefore, according to the above-mentioned peripheral nerve structural principles, the nerve fibers in the facial nerve trunk should move from one nerve bundle to another, and interlace with each other. The size, number and location of nerve bundles are constantly changing. But whether it is true or not, there is still rare anatomical report. In order to solve this problem, the running distribution of facial nerve fibers in the facial nerve trunk and its physiological significance were studied in an animal experiment.

Materials and Methods

Laboratory animal groups

18 healthy Wistar rats were randomly divided into three groups: partial amputation group, complete amputation group and control group, with 6 rats in each group. They were observed for several days before the experiment. There was no facial paralysis in all. Single cage and general pellet feed was applied.

Establishment of facial nerve injury model in rats

General anesthesia was taken by intraperitoneal injection of 3% pentobarbital sodium 1ml/kg. After anesthesia, the animals were strictly disinfected and covered with towels. In the partial amputation group, the posterior incision of the left ear was taken to expose the facial nerve canal under aseptic condition. Under the microscope, the auditory vesicles were exposed, the bone from the posterior wall of the external auditory canal was removed, the malleus and incus were removed, and the 3/4 left side facial nerve canal was abraded from the horizontal segment to the stylomastoid frame. The upper half of the facial nerve was cut off transversely at the proximal end of the exposed facial nerve. At the site of nerve rupture, the epineurium was marked with 6-0 non-invasive suture. The operative cavity was washed with sterile saline. Finally, the wound was sutured layer by layer. The right ear was not treated. In the complete amputation group, all the procedures were the same as those in the partial amputation group, except the facial nerve trunk was completely amputated. The control group received the same treatment as the partial neurotomy group except that the nerve was kept in tack.

Experimental Method

One week after operation, 3 rats in each group were anesthetized with sodium pentobarbital. The left posterior ear incision was opened and the labeled site was found under the microscope. The facial nerve trunk was cut from the marked site to the stylomastoid foramen. The facial nerve trunk was fixed with 4% formaldehyde and calcium solution for 20 hours and embedded in conventional paraffin. The modified trichrome staining method was used to observe the myelin sheath and axon of myelinated nerve fibers, as well as the nerve intima, perineurium and epineurium. The facial nerve trunk in the right side was cut, fixed and embedded in the same way. At 4 weeks after operation, the remaining experimental rats in each group were anesthetized with pentobarbital sodium. The left retro auricular incision was taken and the marked site was found under the microscope. The facial nerve trunk was cut from the marked site to the stylomastoid foramen. The facial nerve trunk was fixed with 4% formaldehyde and calcium solution for 20 hours and embedded in conventional paraffin. The modified trichrome staining method was used to observe the myelin sheath and axon of myelinated nerve fibers, as well as the nerve intima, perineurium and epineurium. The facial nerve trunk in the right side was cut, fixed and embedded in the same way.

Special Dyeing: Improved Trichrome Method

Modified trichrome staining is a staining method which can be observed by ordinary optical microscope. The axons and myelin sheaths of nerve fibers can be clearly observed. The fresh tricolor solution was used, including fixed green FCF, pigmentation 2R, phosphotungstic acid and hematoxylin for re-dyeing.

Results

17of 18 rats completed the experiment, including 6 in partial injury group, 5 in complete fracture group and 6 in control group. In the partial facial nerve neurotomy group, at the first week, the facial nerve fibers were in different sizes and shapes from the cross section. Some axons were obscure or disappeared. However, the endoneurium was kept in tack, the outlines of the degenerated and necrotic nerve fibers were able to be observed clearly, and there was no obvious regeneration sign. The distribution pattern of the degenerated and necrosis fibers was staggered with the normal facial nerve fibers. At the 4th week the facial nerve fibers regeneration was obvious, the newborn fibers were small in diameter, the axons of the newborn fibers were slim with a thin myelin sheath around them, there was no distinct fibrosis in the facial nerve trunk. In the complete facial nerve neurotomy group, the structures of the facial nerve trunks were in a mess, the most facial nerve fibers got necrosis and disintegrated at the first week at the 4th week, there was no distinct regeneration, and the fibrosis in the facial trunk was obvious. In the control group, the facial nerve fibers distributed equably, the thickness of myelin sheath was consisting with the diameter of axons, and there was no obvious degeneration and necrosis in the facial nerve trunk.

Discuss

It is known that most nerve fibers in the trunk of peripheral nerve do not always run parallelly, but continue to move from one nerve bundle to another, interpenetrating and interlacing with each other, constantly exchanging nerve fibers. The sizes and fiber numbers of nerve bundles are constantly changing. The degree of interlacement between nerve fibers is related to the functional properties of nerve fibers. There are more fibers interlaced in the bundles of the motor never. Generally, at the proximal end of the nerve, this kind of interlaced situation is more frequent [4-7]. Therefore, splitting and separating the nerve bundles in these areas will cause more damage to the nerve fibers during the operation. The basic nature of facial nerve belongs to peripheral nerve, and the facial nerve fibers are mainly motor fibers. According to the peripheral nerve structural principles, the nerve fibers in the facial nerve trunk should move from one nerve bundle to another, and interlace with each other. The size, number and location of nerve bundles are constantly changing.

In this study, we found that the running distribution of the distal damaged nerve fibers in the partial facial nerve injury model of rats was not always concentrated in one place, but showed a certain trend of dispersion. The damaged nerve fibers were interlaced with normal nerve fibers on the whole. A certain number of normal nerve fibers were mixed in the denatured and necrotic areas, and a small amount of denatured and necrotic fibers were also mixed in the middle of normal areas. Some degenerated and necrotic nerve fibers were bundled and some were scattered. It indicates that the nerve fibers in the facial nerve trunk do not always run parallelly to each other along one nerve tract, but continue to move from one nerve tract to another, interpenetrating and exchanging nerve fibers alone the tracts. Facial nerve fibers were interlaced mainly in the form of nerve bundles. It showed that the running distribution pattern of the facial nerve in trunk was consistent with the peripheral nerve.

At present, the studies of the peripheral nerve running distribution pattern are mainly concentrated on the distribution pattern of the nerve branches [8-12]. The explorations and studies of nerve fibers distribution pattern are still in infancy. It may be because of the current experimental methods for studying nerve fiber movement, especially in vivo, are not inadequate, and there are some difficulties in the research. The existing experimental methods, including immunofluorescence experiment and computer-aided imaging technology used to process fine and complex nerve fibers imaging, all seem to be somewhat inadequate [13-16]. In this experiment, the distribution pattern of denatured and necrotic nerve fibers in rat facial nerve was reflected well by using the good contrast between denatured and necrotic nerve fibers and normal nerve fibers. If this experimental technology is combined with computer-aided imaging technology, it could present precisely the actual distribution of facial nerve fibers. In order to achieve the best contrast effect between denatured and necrotic fibers and normal nerve fibers, the best observation time is one week after injury. At this time, the denatured and necrotic facial nerve fibers reach its peak, but the intima of nerve fibers is well preserved, and the contour of denatured and necrotic nerve fibers is still clear. The regeneration of damaged nerve fibers is weak and will not interfere with the experimental observation.

This distribution pattern of facial nerve has great physiological significance for nerve repair, especially in partial nerve injury. When facial nerve is partially injured, the injured nerve fibers will disperse rather than gather together. That is to say, the injured and degenerated nerve fibers are interlaced with the undamaged nerve fibers. After degeneration and necrosis of the injured nerve fibers, there are still a number of normal nerve fibers in the injured area. These normal nerve fibers may provide an affinity microenvironment for the regeneration of Schwann cells and axons after injury, and then guide the regeneration of axons to extend to the effectors. In the area of nerve damage, these normal nerve fibers may create a microenvironment which is not good to the proliferation of fibrous tissue, inhibiting the fibrosis in the area of nerve damage [16-19]. This is well reflected in this experimental study. At the 4th week after facial nerve injury, the fibrosis was almost absent in rats with partial facial nerve injury, while it was obvious in rats with complete facial nerve injury. In addition, after injured nerve fibers degenerate, a large number of nerves stimulating factors are produced, which may induce normal nerve fibers to generate collateral branches into the injured effector, and then the damaged nerve function could be restored in a short time. In this way, when the facial nerve is partially damaged, the undamaged nerve fibers preserve a good nerve skeleton structure for the damaged nerve fibers, creating a favorable micro-environment for their regeneration.

In short, the nerve fibers in the facial nerve trunk do not always run parallel to one bundle, but continue to move from one bundle to another, interpenetrating and exchanging nerve fibers between the bundles, so that the size and fiber number of nerve bundles are constantly changing. The pattern of facial nerve fibers distribution has important physiological significance for the regeneration of facial nerve injury. It enables the facial nerve to maintain a good skeleton structure during partial injury, creating a favorable micro-environment for its regeneration. It is able to significantly reduce the internal fibrosis of the nerve trunk at the same time.

Financial Disclosure

there is no funding to report for this manuscript entitled "The distribution pattern of facial nerve fibers in the trunk and it's physiological significance".

Conflict of Interest

We declare that this manuscript entitled "The distribution pattern of facial nerve fibers in the trunk and it's physiological significance" is original, has not been published. We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us. We understand that the Corresponding Author is the sole contact for the Editorial process. He is responsible for communicating with the other authors about progress, submissions of revisions and final approval of proofs.

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DOI: 10.32474/SJO.2024.10.000345