Nerve cells in the intracranial part of the trigeminal nerve of man and dog

Anatomical study of the fifth cranial nerve

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Nerve cells histologically similar to the ganglionic cells of the trigeminal nerve were observed in the proximal part of the sensory root and in the motor root of the human trigeminal nerve. They were also seen in the sensory root of the trigeminal nerve of the dog. Counting of the nerve fibers showed doubling of the number of nerve fibers in the three divisions compared with the fibers in the sensory root adjacent to the trigeminal ganglion. There was also an increase in the number of fibers within the sensory root as it courses centrally, while a decrease was seen in the number of fibers in the proximal part of the motor root. Intermediate nerve bundles were seen leaving the motor root near the pons and joining the sensory root centrally. The fibers of the sensory root corresponding to each peripheral division maintained their specific location in the sensory root during the whole course centrally.

KEY WORDS: trigeminal nerve · motor root · sensory root · ganglion cells

The complex anatomy and function of the trigeminal nerve have still not been fully investigated. It is the purpose of this paper to clarify some anatomical points in an effort to improve our knowledge of the etiological treatment of trigeminal neuralgia.

Material and Methods

For histological quantitative studies of the trigeminal nerve, fresh postmortem material was collected from young adults very soon after death, and from dogs sacrificed by ether and chloroform. There were 20 human autopsies and 20 dogs used.

The three peripheral divisions of the trigeminal nerve, the trigeminal ganglion, and the two roots were removed en masse from the skull (Fig. 1). Sections 5 μ thick were made and stained. Counting of the nerve fibers within the nerve bundles was carried out according to the technique of Schnitzlein and Foley. The peripheral divisions were counted near the ganglion, while the human sensory root fibers were counted in the proximal, middle, and distal parts. The motor root fibers were counted near the pons and at the foramen ovale.

Results

Table 1 shows the mean number of nerve bundles and nerve fibers of the peripheral divisions and the sensory and motor roots of the human trigeminal nerve stained with
TABLE 1

Mean number of nerve bundles and nerve fibers of the peripheral divisions, sensory and motor roots of the human trigeminal nerve

<table>
<thead>
<tr>
<th>Peripheral Divisions near Ganglion, Sensory and Motor Roots</th>
<th>Mean No. of Nerve Bundles</th>
<th>Mean No. of Nerve Fibers</th>
</tr>
</thead>
<tbody>
<tr>
<td>ophthalmic division</td>
<td>37</td>
<td>52,393</td>
</tr>
<tr>
<td>maxillary division</td>
<td>30</td>
<td>67,145</td>
</tr>
<tr>
<td>mandibular division</td>
<td>22</td>
<td>83,515</td>
</tr>
<tr>
<td>sensory root near the ganglion</td>
<td>83</td>
<td>102,049</td>
</tr>
<tr>
<td>sensory root in its middle part</td>
<td>82</td>
<td>126,676</td>
</tr>
<tr>
<td>sensory root near the pons</td>
<td>52</td>
<td>139,507</td>
</tr>
<tr>
<td>motor root near the pons</td>
<td>7</td>
<td>7,845</td>
</tr>
<tr>
<td>motor root at the foramen ovale</td>
<td>11</td>
<td>13,624</td>
</tr>
</tbody>
</table>

modified nitroacetone silver method. The total number of nerve fibers in the three peripheral divisions (203,053) was double that of nerve fibers in the sensory root near the trigeminal ganglion (102,049). The number of nerve fibers of the sensory root increased by 25% in its middle part and by 38% near the pons. Serial longitudinal sections of the three peripheral divisions adjacent to the ganglion revealed the presence of numerous bifurcating nerve fibers which were most evident among the thinner fibers (Fig. 2 left). Bifurcating nerve fibers in a lesser degree were also observed in the sen-

Fig. 1. Diagram of the human trigeminal nerve (left side) showing the motor and sensory roots, the intermediate and the crossing bundles.

Fig. 2. Man. **Left:** Photomicrograph of longitudinal section of the peripheral division of the trigeminal nerve showing bifurcating nerve fibers (arrows). Modified nitroacetone silver stain, ×400. **Center:** Longitudinal section of the distal part of the sensory root of the trigeminal nerve showing bifurcating nerve fibers (arrow). Modified nitroacetone silver stain, ×400. **Right:** Longitudinal section of the proximal part of the sensory root of the trigeminal nerve showing bifurcating nerve fiber (arrow). Modified nitroacetone silver stain, ×400.
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Fig. 3. Man. Left: Photomicrograph of transverse section of the sensory root of the trigeminal nerve near the pons showing nerve cells. Modified nitroacetone silver stain, ×400. Center: Photomicrograph of transverse section of the sensory root of the trigeminal nerve near the pons showing nerve cell. H & E, ×400. Right: Photomicrograph of longitudinal section of the motor root of the trigeminal nerve showing nerve cell. Modified nitroacetone silver stain, ×400.

Both macroscopic (Fig. 1) and microscopic intermediate nerve bundles were seen leaving the motor root near the pons and joining the sensory root centrally. Nerve cells were observed in the proximal part of the sensory root and in the motor root of the human trigeminal nerve lying in between the nerve fibers at the periphery of the nerve bundles (Fig. 3). The mean dimensions of these nerve cells were 65 × 48 μ; there was a central nucleus. There were satellite cells surrounding these nerve cells exactly similar in arrangement to the trigeminal ganglionic cells.

In the dog material, similar nerve cells with no specific location were also observed (Fig. 4).

Transverse sections from the middle of the sensory root adjacent to the ganglion near the pons showed complete anatomical similarity of nerve bundles and fibers when compared with those in the three peripheral divisions. It was observed that the sensory root bundles were distributed in a specific size pattern. Small bundles near the motor root had thin fibers; the large lateral bundles had thick fibers; the medium-sized bundles in between had an intermediate thickness.

Discussion

The results of this work agree with the observations of Spiller and Frazier, Frazier and Whitehead. Frazier, Hyndman, and Kerr, that there is a specific location in the sensory root for the nerve bundles and nerve fibers subserving each peripheral division, with the ophthalmic division lying medially, the mandibular division laterally, and the maxillary in between.

The ratio of the total number of the nerve fibers in the three peripheral divisions to their number in the sensory root adjacent to
the trigeminal ganglion was found to be 2:1, which could be explained by the observation of bifurcating nerve fibers in each peripheral division. The increase in the number of nerve fibers in the middle part of the sensory root could also be explained by the finding of bifurcating nerve fibers.

In the pontine part of the sensory root there was an increase in the number of nerve fibers, and, although bifurcating fibers were observed, there was definite macro- and microscopic evidence of new fibers added by the intermediate nerve bundles leaving the motor root near the pons and joining the sensory root centrally. The decrease in the number of nerve fibers in the motor root at the pons compared with their number at the foramen ovale confirmed these findings.

Stibbe\textsuperscript{9,10} found nerve cells in the sensory root of the trigeminal nerve of man and monkey, as we have in man and dog. The nerve cells were localized in the proximal part of the sensory root of man but had no specific location in the sensory root of the dog. The presence of these nerve cells far from the trigeminal ganglion may indicate an accessory relay station for the trigeminal sensory fibers. These cells were considered by Stibbe to be responsible for the recurrence of the pain of trigeminal neuralgia after rhizotomy.

In the human motor root, we also observed similar nerve cells. The close similarity of these cells to the trigeminal ganglionic cells point to their sensory function. This fact, coupled with the presence of the intermediate nerve bundles described, suggests that the motor root carries afferent fibers and that these nerve cells act as a relay station. This may confirm the claims of van London\textsuperscript{11} and May and Horsley\textsuperscript{6} that proprioceptive fibers are carried by the motor root.

References

1. Frazier CH: Radical operations for major trigeminal neuralgia. JAMA 96:913–916, 1931
7. Spiller WG, Frazier CH: The division of the sensory root of the trigeminal for the relief of tic douloureux; an experimental, pathological and clinical study, with a preliminary report of one surgically successful case. Phila Med J 8: 1039–1049, 1901

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