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Caliber spectrum analysis of the trigeminal nerve root and its mandibular division

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A CALIBER SPECTRUM ANALYSIS OF THE TRIGEMINAL NERVE ROOT AND ITS MANDIBULAR DIVISION

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A C K N O W L E D G M E N T

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INTRODUCTION

It is the purpose of this study to determine the caliber spectra of the myelohyoid, inferior alveolar, lingual, and mandibular nerves in the cat, and also to provide more data on the spectra of the trigeminal nerve root in this animal.

Several studies have been performed in the past regarding caliber spectra of the trigeminal nerve and some of its branches. (Table 1). Koch '16 studied the caliber spectrum of the trigeminal root in both the dog and cat, and discovered a bimodal spectrum with essentially similar peaks. Sjogvist '38 and Fujii '59 studied the portio major of the human and monkey respectively and found bimodal caliber spectra with identical peak size. Wasano '62 and Fujii '59 studied the caliber spectrum of the portio minor in monkeys and again results of these two studies were essentially identical.

Fujii '59 studied the caliber spectra of the mandibular division in the monkey and found a trimodal spectrum with peaks at 4-5, 8-9, and 12-13. No study could be found in the literature dealing specifically with the mandibular division and its branches in the cat.

METHODS

Studies were carried out on six adult cats anesthetized with pentobarbital and exsanguinated by cutting the abdominal aorta. The head was profused with 10 per cent Formalin after removal of the skin and masseter and temporalis muscles to facilitate penetration with the Formalin. After 24 hours, the nerves to be studied were removed and placed in a 4.8% solution of Potassium Dichromate for seven days. The nerves were then imbedded and sectioned at 5 microns. These sections were then stained with Sudan Black B in Propylene Glycol.

Photomicrographs using a red filter were taken of the nerve sections. The final magnification of the enlarged prints was approximately 2300 times. A montage of each nerve was composed and fibers measured and counted. All measurements are the outside diameters of myelin sheaths, and were determined by use of calipers. The technic used did not permit the identification of non-myelinated fibers.

RESULTS

Myelohyoid Nerve

The myelohyoid nerve in the cat is a small nerve arranged in a single fiber bundle. Fiber counts were made at the point on the nerve behind the angle of the mandible 5.0 mm. distal to its separation from a common bundle with the inferior alveolar nerve. (Figure 1).

The total number of fibers ranged from 350 fibers to 632 fibers with an average fiber number in six animals of 475 fibers. The fibers ranged from 1-18 microns in diameter; the average caliber spectrum (Fibure 2) was bimodal with peaks at 2-4 microns, and at 8-10 microns.

Inferior Alveolar Nerve

This nerve presents as a single fiber bundle with no separations into fascicles. Fiber counts were made at a point on the nerve behind the angle of the mandible 5.0 mm. distal to its separation from a common bundle with the myelohyoid nerve. (Figure 1). The total number of fibers ranged from 3,658 to 4,162 with an average of 3,901. The fibers ranged from 1-18 microns in diameter. The average caliber spectrum (Figure 2) shows this nerve to be bimodal with peaks at 2-4 microns and at 6-8 microns.

Lingual Nerve

This nerve presents as a single fiber bundle without fascicles. Fiber counts were made at a point on the nerve immediately proximal to where it is joined by the chorda tympani nerve. (Figure 1). The total number of fibers ranged from 1500 to 2,426 with an average of 1,953. Fibers ranged from 1-14 microns in diameter with an average caliber spectrum which was bimodal with peaks at 2-4 microns and at 6-8 microns.

Portio Minor

The Portio Minor was observed to be composed of 4-5 loosely arranged fascicles of approximately 600 fibers each. Fiber counts were made 2.0 mm. distal to the nerve's exit from the brain stem. The total number of fibers ranged from 2,780 to 3,365 with an average of 3,024. Fibers ranged in diameter from 5-21 microns with an average caliber spectrum which was bimodal with peaks at 2-4 microns and at 8-10 microns.

Mandibular Nerve

The fibers of the motor root of the trigeminal nerve were observed to remain close to the periphery of the mandibular nerve at its posteroinferior edge where they are conspicuous because of their relatively greater fiber diameters. These fibers are included in fiber counts of the mandibular nerve. Fiber counts were made at a point on the nerve immediately proximal to its exit through the foramen ovale. The total number of fibers ranged from 9,310 to 11,630 with an average of 9,750. The fibers ranged in diameter from 1-20 microns and the average caliber spectrum was trimodal with peaks at 2-4, 6-8, and 14-16 microns.

Portio Major

The Portio Major consisted of numerous fascicles of 750-1000 fibers. Fiber counts were made on the nerve 2.0 mm. distal to its exit from the pons. The total number of fibers ranged from 24,000 to 28,000 with an average of 27,000. Fibers ranged in diameter from 1-16 microns and showed a bimodal caliber spectrum with peaks at 1-2 microns and 8-10 microns.

DISCUSSION

The trigeminal nerve root and the typical spinal nerve roots are quite dissimilar as far as their caliber spectra are concerned. The sensory root of the spinal nerve has been shown by Rexed and Therman ('48) and Lloyd and Chang ('48) to be bimodal in the cat, with peaks at 2-3 microns, and at 12+ microns. The caliber spectrum of the sensory root of the trigeminal nerve in the same animal as observed in this study, shows a bimodal distribution with peaks at 1-2 microns and at 8-10 microns, with very few fibers over 10 microns. Sjogvist ('38), in humans and Fujii ('59) in monkeys, observed a similar pattern.

The ventral root of the typical spinal nerve shows a bimodal caliber spectrum in the cat (Rexed '44, and Rexed and Therman '48), with peaks at 4-5 and at 11-13 microns with range of 2-17 microns. In this study, the motor root of the trigeminal nerve has been observed to be bimodal with peaks at 2-4 microns and 8-10 microns, a range of 5-21 microns with an extremely large percentage of the fibers possessing a diameter larger than 8 microns, the bulk between 10-18 microns. The caliber spectra for spinal ventral roots do not show this shift to the right along the spectrum, but rather show an almost equal distribution around the two peaks.

Why should these developmentally and anatomically similar sensory and motor roots be so dissimilar in their caliber spectra? In spinal nerves, the afferent fibers from annulospiral and flower spray endings have their cells of origin in the dorsal root ganglion and central projections entering the spinal cord in the dorsal root. The ventral root carries efferent fibers from the spinal cord to the intrafusal muscle fibers. However, such is not the case in the motor and sensory roots of the trigeminal nerve. Corbin '40, has shown that the mesencephalic nucleus of the trigeminal nerve is the proprioceptive nucleus of the trigeminal nerve. May and Horsely '10, and later Pearson '49, and Corbin '40, observed the fibers of the mesencephalic group to pass mostly, if not entirely, into the motor root of the trigeminal. If the caliber spectrum of the portio major is compared to the caliber spectra of the dorsal spinal roots mentioned earlier, it will be noted that both dorsal spinal roots and the portio major have similar peaks at 2-3 microns and at 8-10 microns, but that the portio major lacks a peak above 12 microns, which the dorsal root has. Indeed, the portio major shows very few fibers above 12 microns.

The ventral spinal root and the portio minor are also different, although the difference is not so obvious as in the sensory roots. The caliber spectrum of the portio minor shows a peak near 5 microns and at 8-10 microns which is essentially the same as the caliber spectrum of the ventral spinal roots mentioned earlier. However, a large percentage of fibers at and over 12 microns were observed in the portio minor. This situation does not present itself in the ventral spinal roots observed in the previously mentioned papers. Although there is a peak at or around 12 microns, the percentage of fibers in this range is not nearly so high as the percentage in the portio minor.

Therefore, tying these facts together; (1) That proprioceptive fibers are contained in the motor root of the trigeminal nerve rather than in the sensory root as they are in spinal nerves, (2) That the sensory root of the trigeminal shows a lack of fibers at or around 12 microns while the sensory spinal root shows a fiber peak in this area, (3) That the motor root of the trigeminal shows a large percentage of fibers at or near 12 microns, while the motor spinal root shows a considerably smaller percentage of fibers in the same area, it seems logical to assume that these differences between trigeminal and spinal nerve roots are caused by proprioceptive fibers.

The mandibular division of the trigeminal nerve is a mixed nerve, and has been shown in this study to be trimodal in the cat, with peaks at 2-4, 6-8, and 14-16 microns. These results are similar to those obtained for the same nerve in the monkey by Fujii ('59). If the caliber spectrum of the mandibular nerve is compared to a mixed muscle nerve, in this case the nerve to the medial head of the gastrocnemius muscle in the rabbit (Fernand and Young '51), which shows a bimodal spectrum with peaks at 6-8 and 12-15 microns, it will be noticed that the two nerve spectra are quite similar except for the mandibular nerve's peak at 2-4 microns. Since the mandibular nerve has a cutaneous component and the muscle nerve mentioned does not, it may be assumed that the peak at 2-4 microns is composed primarily of fibers concerned with cutaneous innervation, especially since fibers transmitting pain, temperature, and touch sensations are widely known to be 4 microns or less in diameter. This assumption is reinforced by the findings of this study in comparing the mandibular nerve and the portio minor. Figure 2 shows the mandibular nerve and the portio minor of the trigeminal nerve compared plotting number of individual fibers at specific diameters against diameter in microns, and also percentage of fibers at specific diameters against diameter in microns. Since the portio minor contains all the motor and proprioceptive fibers of the trigeminal nerve, and since the mandibular nerve receives all the fibers of the portio minor illustrated in

Figure 2, are of necessity caused by sensory fibers, not including proprioceptive fibers. Note the large peak in the mandibular nerve at 2-4 microns, and the smaller peak in the portio minor in the same range. If the number of fibers up to 4.8 microns in the portio minor (317) is subtracted from the number of fibers from 0-4 microns in the mandibular nerve (2843) the difference (2526 fibers) must be due to sensory fibers of pain, temperature and touch. Figure 2 also shows that sensory fibers from 8-12 microns are almost entirely lacking in the mandibular nerve. Therefore, it might be assumed that whenever fibers from 8-12 microns encountered in a branch of the mandibular nerve, the majority of these fibers are either motor or proprioceptive in function. The caliber spectra of the two nerves in the right of the figure show the relative differences between the nerves. The peak at 2-4 microns in the mandibular nerve composes 22% of the nerve, while the same peak in the portio minor composes only 10% of the nerve. Within the 8-12 micron range, 43% of the fibers of the portio minor, and only 16% of the fibers of the mandibular nerve are located.

The inferior alveolar and lingual nerves were found to have almost identical caliber spectra (Figure 1). This may be related to the fact that both innervate tissue arising from the same anlage, and elicit similar sensations; i.e. in the case of the lingual nerve, sensation from the mucosa of the tongue, and in the case of the inferior alveolar nerve, sensation from the dental pulp and the alveolus. The graphs of Figure 1 show that the inferior alveolar and lingual nerves possess peaks at 2-4 microns and at 6-8 microns, although these peaks are not of the same magnitude.

The mandibular nerve has been shown to possess few sensory fibers other than proprioceptive fibers between 8 and 12 microns, since most of the fibers of this diameter are either motor or proprioceptive in function. Therefore, the larger number of fibers in this range in the inferior alveolar nerve could be due to the presence of proprioceptive fibers, which would not be found in the lingual nerve.

The mylohyoid nerve in the cat is a motor nerve to the mylohyoid muscle and the anterior belly of the digastric muscle. This study showed the caliber spectrum of the mylohyoid nerve to be bimodal with peaks at 2-4 microns and at 8-10 microns. Fernand and Young ('51) found essentially the same picture in the rabbit when they analyzed one of the terminal branches of the mylohyoid nerve, the nerve of the digastric muscle. The nerve was bimodal in distribution with peaks at 6-8 microns and 12-14 microns. The findings also compare favorably with efferent spinal nerves, whose caliber spectra show two peaks, one at 4-5 microns, the other at 11-13 microns (Rexed and Therman '48). Compared to the lingual nerve (Figure 1), the mylohyoid nerve is seen to possess considerably fewer fibers from 2-4 microns. The mylohyoid has 79 fibers or 12 per cent in this range, while the lingual nerve has 701 fibers or 35 per cent in the same range. These findings are consistent with the fact that most of the fibers of 2-4 microns in diameter passing from the mandibular nerve to its branches are sensory fibers other than proprioceptive fibers. Hence, the lingual nerve, a sensory nerve, would be expected to possess more such fibers than the mylohyoid nerve, a motor nerve. Conversely, the mylohyoid nerve would be expected to possess relatively more fibers in the 8-12 micron range, since most of these fibers have been shown to be motor and proprioceptive in function in the mandibular nerve, and consequently its branches. Figure 1 bears out this hypothesis, showing the mylohyoid to have 42% of its fibers in the 8-12 micron range, and the lingual nerve to have only 24% of its fibers in the same range.

SUMMARY

A study of the Trigeminal nerve root, mandibular nerve, myelohyoid, inferior alveolar, and lingual nerves was performed on adult cats to demonstrate the caliber spectra of these nerves. A montage of each nerve was made using magnified photomicrographs, and the fibers counted.

A discussion of the differences between the trigeminal nerve root and its branches, and selected analogous spinal nerves is included. An explanation is offered that the differences between Portio major and Portio minor, and comparable dorsal and ventral spinal roots, is due to the presence of proprioceptive fibers in the motor root of the trigeminal nerve, a situation unique to that nerve.

TABLE I

Reference	Nerve	Animal	Peaks	Peak size (microns)
Koch '16	Trigem. root	Dog	Bimodal	3-6, 12-16
Koch '16	Trigem. root	Cat	Bimodal	4-7, 12-16
Sjogvist '38	Portio Major	Human	Bimodal	3-4, 8-9
Fujii '59	Portio Major	Monkey	Bimodal	3-5, 7-9
Wasano '62	Portio Minor	Monkey	Bimodal	4-5, 12-13
Fujii '59	Portio Minor	Monkey	Bimodal	5-6, 13-14
Fujii '59	Ophthal. Division	Monkey	Bimodal	4-5, 9-10
Fujii '59	Maxill. Div.	Monkey	Bimodal	4-6, 9-10
Fujii '59	Mandib. Div.	Monkey	Trimodal	4-5, 8-9, 12-13
Fernand & Young '51	Nerve to Digastric	Rabbit	Bimodal	6-8, 12-14

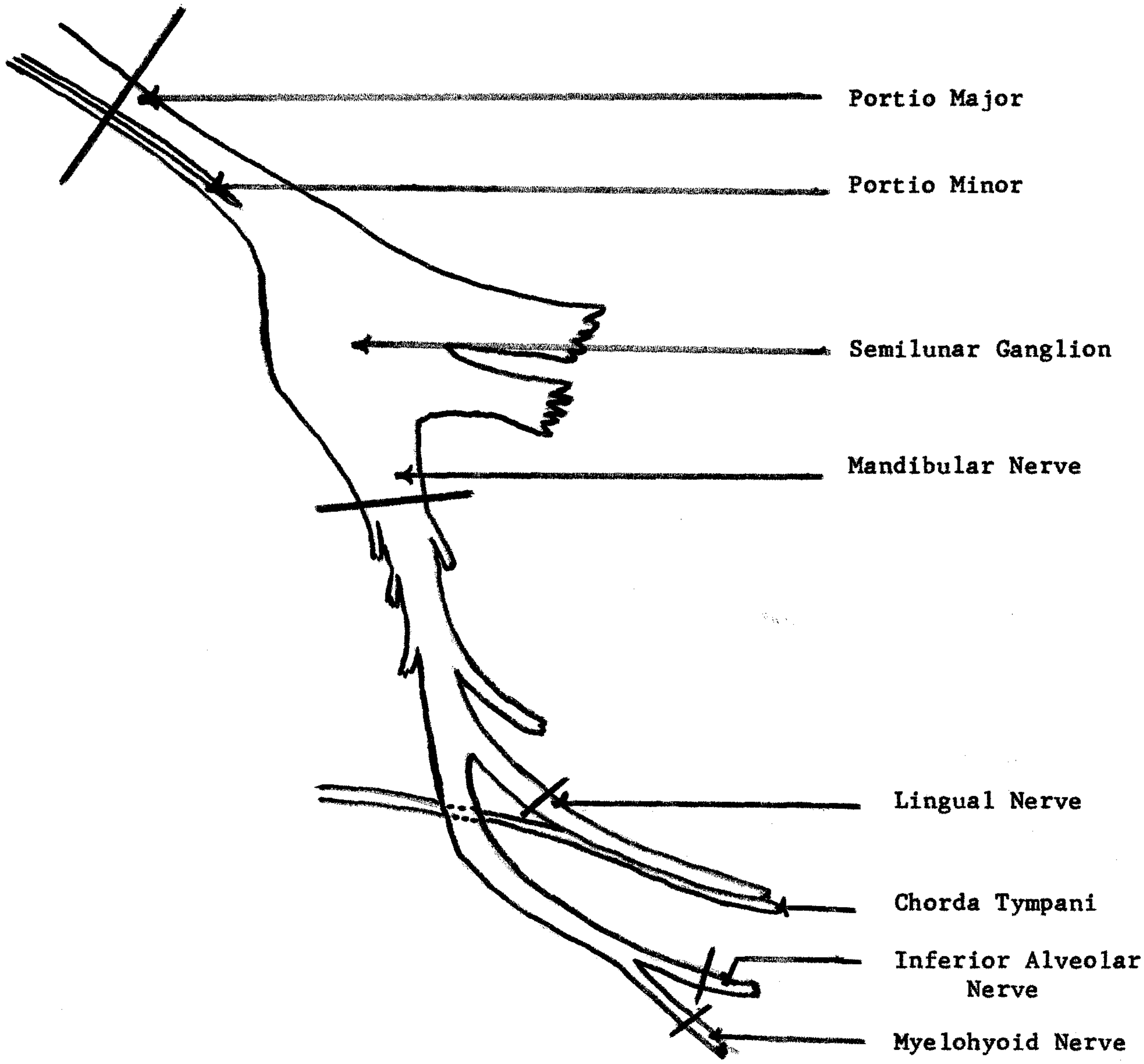

Figure 1:

Schematic drawing of the Trigeminal nerve showing the branches studied. Heavy lines indicate the points of section.

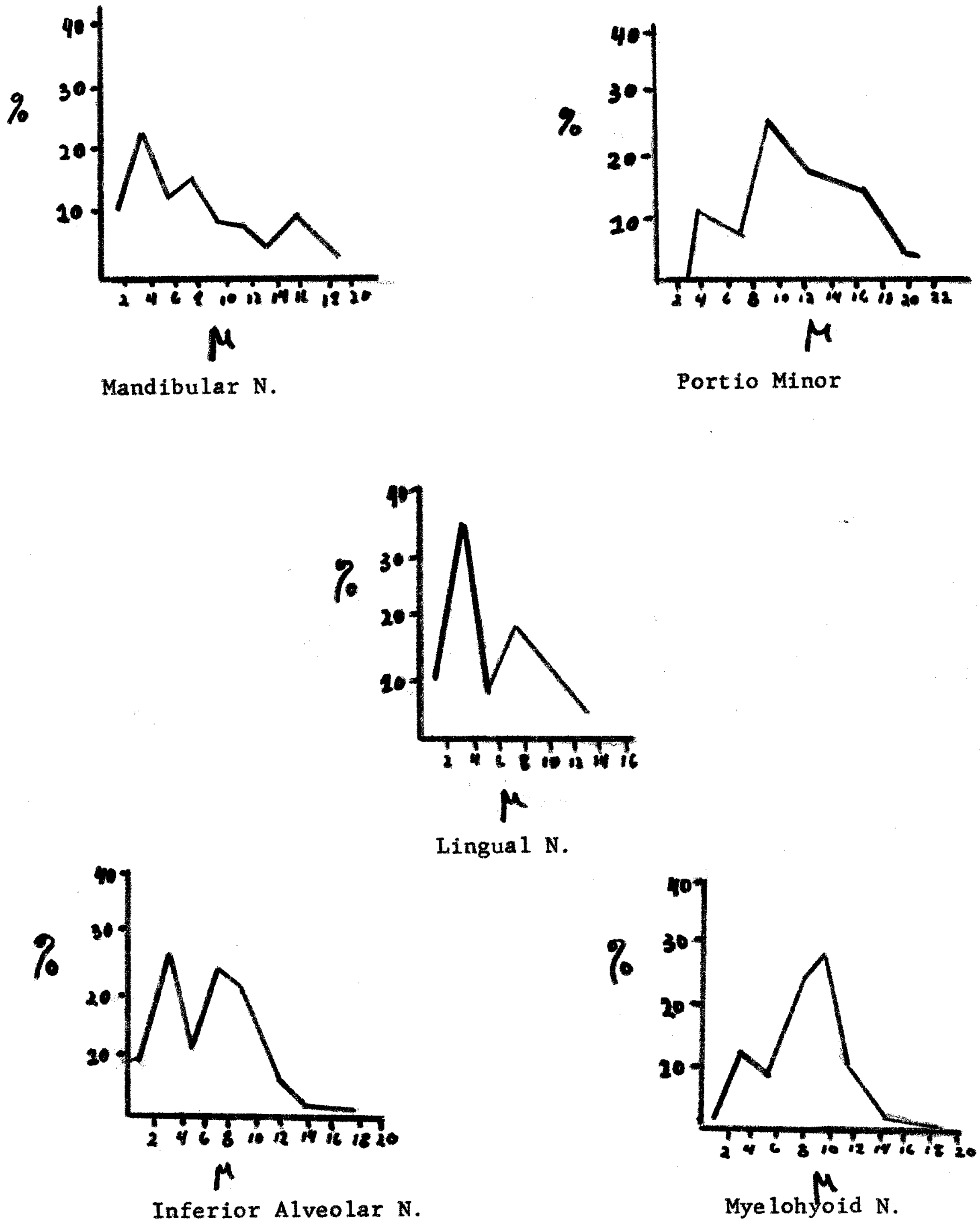

Figure 2: Graphs representing the caliber spectra of the nerves studied.

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