Localization and Size of Trigeminal Ganglion Neurons Innervating the Temporomandibular Joint in the Dog

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Abstract

Using the horseradish peroxidase (HRP) method, localization of the labeled cells of trigeminal ganglion (TG) neurons innervating the temporomandibular joint (TMJ) were studied and their size was compared with that of TG neurons innervating the tooth pulp.

Labeled TMJ cells were situated in the mandibular division of the TG; those in the tooth pulp of the upper canines were recognized in the maxillary division adjacent to the mandibular portion.

The size of labeled cells innervating the TMJ (38 ± 9.8 μm) was significantly smaller than that in the tooth pulp (50 ± 9.9 μm). It has been reported that most fibers innervating tooth pulp are 'Aδ and C-fibers'; the present study suggests that most TMJ neurons consist of small Aδ and C-fibers.

Key words: temporomandibular joint, tooth pulp, trigeminal ganglion, horseradish peroxidase, dog

INTRODUCTION

The temporomandibular joint (TMJ) is reportedly innervated by three nerve branches from the trigeminal mandibular nerve; the auriculotemporal nerve supplying several branches toward the posterior portion of the joint and the masseteric and posterior deep temporal nerves supplying some fibers to the anterior portion⁴.

There have a few reports as to the localiza-
MATERIALS AND METHODS

The experiment was performed using 4 adult dogs of either sex (B.W. 6.0–8.0 kg). The animals were anesthetized with sodium pentobarbital. The TM joint capsule was exposed and 25 μl of 25% HRP (Toyobo I-C) was injected into the joint on one side by a microliter syringe (Hamilton®) under visual control. A cavity was made on the lateral side of the upper canine of the other side, the tooth pulp was exposed and 10 μl of 25% HRP was injected into the pulp chamber and sealed with glass ionomer dental cement.

After 48 hours, the animals were sacrificed under deep anesthesia of sodium pentobarbital with perfusion of 200 ml of 0.9% saline followed by 1000 ml fixative [1.0% paraformaldehyde–1.25% glutaraldehyde mixture in 0.1 M phosphate buffer (pH 7.2)]. After the TG and brainstem were removed, serial sections of 60 μm thickness were obtained. The tetramethylbenzidine method was employed to visualize retrogradely transported HRP. 1.0% neutral red was employed as counterstain. Labeled cells were identified and examined under the bright field of the light microscope. The cells were either homogeneously labeled with HRP or showed relatively clear central nuclear zone.

The cell diameter was calculated as a mean between the longest diameter and a diameter perpendicular to and dividing the longest diameter into two equal halves—‘mean diameter’². We confirmed no labeling in the trigeminal or facial motor nucleus, to prove no leakage of HRP to the surroundings.

RESULTS AND DISCUSSION

Localization of labeled neurons in the trigeminal ganglion

Labeled cells were recognized in the TG in both HRP injection into the TMJ capsule and into the tooth pulp. In one section, 0–9 labeled cells were counted on the TMJ side (total number: 294), and 9–15 on the tooth pulp side (total number: 420).

Labeled TMJ cells were situated in the midst of the mandibular division in the TG (Fig. 1-A). The equivalent results were obtained in cats and rats in earlier studies.³⁴⁵. Labeled cells of tooth pulp of the upper canine were located in the maxillary division adjacent to the mandibular portion (Fig. 1-B).

There were no labeled cells in the mesencephalic nucleus. This result completely negates the possibility of mesencephalic nucleus neurons innervating the TMJ.

Size of labeled neurons in the trigeminal ganglion

The size distributions of TG neurons innervating TMJ and tooth pulp are compared in two sets of histogram in Fig. 2. The distribution pattern of neuron size was unimodal, with the mean at 38 μm for the TMJ and 50 μm for the tooth pulp, showing almost the same value of standard deviation. The diameter of labeled cells of the TMJ ranged from 16 to 74 μm, and that of the tooth pulp cells from 24 to 76 μm, the former being significantly smaller (t=16.00, d.f.=712, p<1×10⁻⁸).

Wyke reports that most axons innervating the TMJ in the cat are smaller than 5 μm, and probably carry nociceptive sensation from the TMJ to the brainstem.⁶

Widenfalk et al. also report that in the rat TG, small HRP-labeled cells innervating the TMJ (diameter: 15–20 μm) are most frequent (65%)³. Andoh et al., using the HRP method, demonstrates that in the cat TG, labeled cells diameter ranges from 11–65 μm, with labeled cells that can be roughly segregated at 35 μm into two groups of the same ratio. Those authors presume that about one-half of the labeled TG neurons belong to type C afferents and the others
**Fig. 1** Labeled cells in TG after injection of HRP into TMJ and tooth pulp. Dots show location of labeled cells in TG after injection of HRP into TMJ on one side (A), and tooth pulp on other side (B). I, II and III show ophthalmic, maxillary and mandibular branches of trigeminal nerves, respectively. Numbers at left side of each drawing indicate section number from dorsal surface of TG.

**Fig. 2** Comparison of size distribution of labeled cells in TG after HRP injection into TMJ and tooth pulp. Histogram shows total number of labeled cells (Y-axis) in TG of four different animals. X-axis indicates size of labeled cells. Size of labeled cell is expressed as arithmetic mean of length of long and short axes of cell body in µm. Labeled cells of TMJ are significantly smaller than those of tooth pulp (t=16.00, d.f.=712, p<1 × 10^{-8}).
to type A-δ and β afferents\(^1\).

In order to examine the size of neurons innervating an organ, it is essential to compare them with that of neurons of known size from an other organ.

Our results demonstrate that nerve fibers innervating the TMJ are composed of smaller cells than those innervating tooth pulp. As most of the latter are reportedly 'Aδ and C-fibers' according to anatomical methods\(^3\), most nerve fibers of the TMJ are represented to be small Aδ and C-fibers.

It is reported that the TMJ contains Paciniform receptors, Ruffini-like endings, Golgi-Mazzoni endings as well as free nerve endings\(^6,8\). In fact the TMJ sensation possesses somatic deep sensation such as vibrating or perception of condyle location, but free nerve endings that respond to noxious stimuli are dominant over other types of receptor formes\(^6,8\). This result corresponds well with our results, that smaller ganglion neurons that send forth small diameter sensory nerve fibers predominate, and probably connect free nerve endings in the TMJ.

REFERENCES


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