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Research Report

Organization of projections from the spinal trigeminal subnucleus oralis to the spinal cord in the rat: A neuroanatomical substrate for reciprocal orofacial–cervical interactions

Laurent Devoize[a,b,c], *Sophie Doméjean*[c], *Céline Melin*[a,b,c], *Patrick Raboisson*[d], *Alain Artola*[a,b], *Radhouane Dallel*[a,b,c,*]

[a]*Clermont Université, Université d'Auvergne, Neurobiologie de la Douleur Trigéminale, BP 10448, F-63000 Clermont-Ferrand, France*
[b]*Inserm, U929, F-63000 Clermont-Ferrand, France*
[c]*CHU Clermont-Ferrand, Service d'Odontologie, F-63003 Clermont-Ferrand, France*
[d]*AstraZeneca R&D Södertälje, 15185 Södertälje, Sweden*

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ABSTRACT

The organization of efferent projections from the spinal trigeminal nucleus oralis (Sp5O) to the spinal cord in the rat was studied using the anterograde tracer Phaseolus vulgaris leucoagglutinin. Sp5O projections to the spinal cord are restricted to the cervical cord. No labeled terminal can be detected in the thoracic and lumbar cord. The organization of these projections happens to critically depend on the dorso-ventral location of the injection site. On the one hand, the dorsal part of the Sp5O projects to the medial part of the dorsal horn (laminae III–V) at the C1 level, on the ipsilateral side, and to the ventral horn, on both sides but mainly on the ipsilateral one. Ipsilateral labeled terminals are distributed throughout laminae VII to IX but tend to cluster around the dorso-medial motor nuclei, especially at C3–C5 levels. Within the contralateral ventral horn, label terminals are found particularly in the region of the ventro-medial motor nucleus. This projection extends as far caudally as C3 or C4 level. On the other hand, the ventral part of the Sp5O projects to the lateral part of the dorsal horn (laminae III–V) at the C1 level, on the ipsilateral side, and to the ventral horn, on both sides but mainly on the contralateral one. Contralateral labeled terminals are distributed within the region of the dorso- and ventro-medial motor nuclei at C1–C4 levels whereas they are restricted to the dorso-medial motor nucleus at C5–C8 levels. These findings suggest that Sp5O is involved in the coordination of neck movements and in the modulation of incoming sensory information at the cervical spinal cord.

* *Corresponding author*. Inserm U929, Neurobiologie de la Douleur Trigéminale, Faculté de Chirurgie Dentaire, 11 Bd Charles de Gaulle, 63000 Clermont-Ferrand, France. Fax: +33 4 73 17 73 06.
E-mail address: radhouane.dallel@u-clermont1.fr (R. Dallel).

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1. Introduction

Somatosensory inputs from the face and mouth are conveyed through the afferent component of the trigeminal nerve to the first central relay, within the trigeminal brainstem sensory nuclear complex. This complex can be divided into the principal sensory nucleus and the spinal trigeminal nucleus. The latter consists of three subnuclei named, from rostral to caudal, oralis (Sp5O), interpolaris and caudalis. The Sp5O is assumed to be involved in the processing of somatosensory inputs from the orofacial region (Dallel et al., 1990, 1999; Raboisson et al., 1995). Both non-nociceptive and nociceptive (specific or wide dynamic range) neurons can be recorded in the Sp5O. A remarkable feature of Sp5O neurons is the predominant location of their receptive fields in oral and perioral regions (Dallel et al., 1990; Boissonade and Matthews, 1993). Sp5O appears to also host interneurons involved in reflex activity (Abrahams and Richmond, 1977; Olsson et al., 1986). Anatomical studies have shown that Sp5O projects to the spinal cord of the cat (Matsushita et al., 1981) and rat (Burton and Loewy, 1977; Ruggiero et al., 1981; Leong et al., 1984; Falls, 1984a,b; Phelan and Falls, 1991; Dessem and Luo, 1999). However, the majority of these studies utilized retrograde tracing techniques. Such techniques do not allow a detailed topographical analysis of Sp5O-spinal connections. The aim of the present study was thus to analyze the distribution and organization of descending projections from the Sp5O to the spinal cord using small injections of the anterogradely transported Phaseolus vulgaris leucoagglutinin (PHA-L).

2. Results

2.1. General findings

The results reported here are based on 15 experiments in which PHA-L injection sites were located in different regions of the Sp5O. The locations of the 15 injection sites are summarized in Fig. 1. Injection sites were distributed throughout the whole dorso-ventral as well as rostro-caudal extents of Sp5O. Overall, Sp5O projections to the spinal cord were restricted to the cervical cord, but there were differences, in terms of the density and organization of the descending axons and terminals. The organization of these projections happened to depend on only the dorso-ventral location of the injection site. Two representative cases, selected on the basis of both the location and size of the injection sites, which altogether covered most of the dorso-ventral extent of the Sp5O, will be used for illustrative purposes.

2.2. Injections into the dorsal part of the Sp5O

In 8 experiments, PHA-L injection sites were centered in the dorsal part of the Sp5O (D-Sp5O) without spreading to the adjacent spinal trigeminal tract or the parvicellular reticular nucleus (Figs. 2 and 3). A similar pattern of anterograde labeling was observed in all experiments with only minor differences in density: a representative example is illustrated in Figs. 2 and 3.

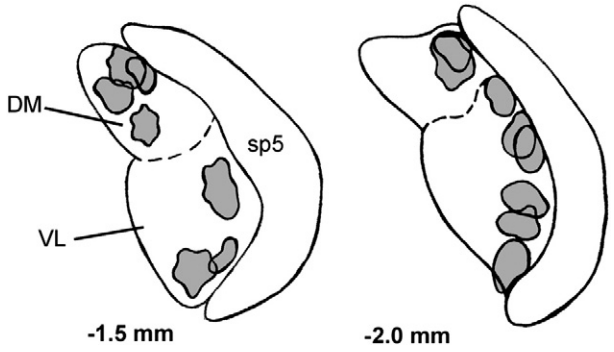

Fig. 1 – Location and extent of Phaseolus vulgaris leucoagglutinin (PHA-L) injection sites on a schematic representation of 2 coronal sections of the spinal trigeminal nucleus oralis (Sp5O). DM: dorso-medial Sp5O; VL: ventrolateral Sp5O; sp5: spinal trigeminal tract. The anteroposterior distance to the vertical plane through the interaural line according to the atlas of Paxinos and Watson (1997) is indicated.

Figs. 2A and 3A show the injection site, a dense core with numerous surrounding labeled cells distributed over a restricted portion of the D-Sp5O (width ~50 μm, rostro-caudal extent ~450 μm). This injection resulted in a dense terminal labeling in the dorsal and ventral horns of the cervical spinal cord (Figs. 2B and 3B–D).

In the dorsal horn (Figs. 2B and 3B, C), labeled terminal fibers with varicosities were observed on the ipsilateral side, particularly throughout the medial part of laminae III–IV, with some extension into the reticular aspect of lamina V, at the C1 level. Very few labeled terminals were noted below this level (Fig. 2B).

In the ventral horn (Figs. 2B and 3B, D), labeled terminal fibers with varicosities were mainly on the ipsilateral side. Ipsilateral labeled terminals were distributed throughout laminae VII (ventral part) to IX but tended to cluster around the dorso-medial motor nuclei, especially at low cervical levels. A high density of labeled terminals was noted in the medial part of laminae VIII–IX at the C2–C4 level that extended, although progressively decreasing, as far caudally as C8 level. No projection was observed in the thoracic and lumbar cord. At the C1–C2 level, some labeled fibers were observed around the dorso-lateral motor nuclei. Within the contralateral ventral horn, label terminals were found particularly in the region of the ventro-medial motor nucleus. This projection extended as far caudally as C3 or C4 level (Fig. 2B).

2.3. Injections into the ventral part of the Sp5O

In 7 experiments, PHA-L injection sites were centered in the ventral part of the Sp5O (V-Sp5O). A similar pattern of anterograde labeling, within restricted regions located in the dorsal and ventral horns of the cervical spinal cord, was seen across all 7 experiments with only minor differences in density. A representative example, illustrated in Figs. 4 and 5, is described below.

The injection site (Figs. 4A and 5A) showed a dense core located near the spinal trigeminal tract and surrounded by