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Original Article

Connections between the facial and trigeminal nerves: Anatomical basis for facial muscle proprioception

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ABSTRACT

Proprioception is a quality of sensibility that originates in specialized sensory organs (proprioceptors) that inform the central nervous system about static and dynamic conditions of muscles and joints. The facial muscles are innervated by efferent motor nerve fibers and typically lack proprioceptors. However, facial proprioception plays a key role in the regulation and coordination of the facial musculature and diverse reflexes. Thus, facial muscles must be necessarily supplied also for afferent sensory nerve fibers provided by other cranial nerves, especially the trigeminal nerve. Importantly, neuroanatomical studies have demonstrated that facial proprioceptive impulses are conveyed through branches of the trigeminal nerve to the central nervous system. The multiple communications between the facial and the trigeminal nerves are at the basis of these functional characteristics. Here we review the literature regarding the facial (superficial) communications between the facial and the trigeminal nerves, update the current knowledge about proprioception in the facial muscles, and hypothesize future research in facial proprioception.

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Introduction

Proprioception is the quality of mechanosensibility that informs the central nervous system about the static and dynamic conditions of muscles and joints.[1,2] It originates in specialized sensory organs (proprioceptors) that include muscle spindles and Golgi's tendon organs.[3–5] Furthermore, capsular joint mechanoreceptors and certain kinds of cutaneous mechanoreceptors can also work as proprioceptors.[6–9] Proprioception applies for all skeletal muscles, including the craniocephalic ones. However, although muscles innervated by the trigeminal nerve (cranial nerve V: CNV) contain proprioceptors,[10,11] those innervated by the facial (cranial nerve VII: CNVII) or the glossopharyngeal nerves[12,13] lack typical proprioceptors. However, facial proprioception plays a key role in facial expression, the coordination of facial movement,[14,15] regulation of the masticatory force in conjunction with jaw muscles, oromotor behaviors, and nonverbal facial communication and in orofacial reflexes related to speech, swallowing, cough, vomiting, or breathing.[16–19]

Some decades ago, Baumel[20] suggested that proprioceptive impulses from facial muscles are conveyed through the branches of CNV, which innervate the skin of the facial muscles regulating facial expression and establish multiple communications with the branches of CNVII. Presently, it is widely accepted that the proprioception of all the craniocephalic muscles depends on CNV,[13,22] and the connections between CNV and CNVII may explain, at least in part, why trigeminal afferents transmit proprioceptive information from the face to the mesencephalic trigeminal nucleus for processing.[13]

Moreover, and despite the facial muscles lacking typical proprioceptors, proprioceptive acuity of the orofacial muscles has been found to be more accurate than that of the jaw.[21] All together, these data suggest complex interaction between CNV and CNVII, which is of capital importance to understand the clinical features of these nerves and in the surgery involving them to preserve proprioception in face transplantation as much as possible,[22,23] in reconstructive and cosmetic facial plastic surgery,[24] or in minimally invasive procedures (i.e., botulinum toxin; Refs. 25–28).

Here we review the literature and add our own experience devoted to the facial (superficial) communications between CNVII and CNV. In addition, we updated the current knowledge about proprioception in the facial muscles, which provide an anatomical support in these communications.

An overview of the trigeminal and facial nerves

CNV and CNVII are both mixed cranial nerves that carry motor and sensory fibers responsible for both the motor and sensory innervation of the face, respectively. Moreover, with several deep and superficial connections, CNV is considered responsible for the proprioceptive innervation of the head muscles. Moreover, CNVII and some branches of CNV contain pre- and postganglionic parasympathetic nerve fibers.[29–31]

CNV is responsible for the sensory innervation of the face and the motor innervation of several craniocephalic muscles (*temporalis*, *masseter*, *pterygoideus medialis* and *lateralis*, *mylohyoideus*, *venter anterior digastricus*, *tensor veli palatine*, and *tensor tympani*). It originates with two roots at the midlateral surface of the pons that reach the Gasser's ganglion (*ganglion trigeminale*) where it divides into three branches: ophthalmic (*n. ophthalmicus*, sensory V1), maxillary (*n. maxillaris*, sensory V2), and mandibular (*n. mandibularis*, mixed V3). The soma of the sensory neurons is localized in the *ganglion trigeminale* and terminates in the brainstem trigeminal sensory nuclei (*nucleus spinalis nervi trigeminalis* and *nucleus principalis nerve trigemini*). However, the proprioceptive neurons that innervate the craniofacial muscles innervated by V3 are located in the *nucleus mesencaphalicus nervi trigemini* instead of the *ganglion trigeminale*. The motor axons originate from neurons located in the masticator nucleus (*nucleus motorius nerve trigemini*) and are integrated into the mandibular nerve. From a developmental perspective, the ophthalmic branch innervates the derivatives of the frontonasal process of the embryos, and the maxillary and mandibular branches innervate the derivatives maxillary and mandibular processes of the first branchial arch.

CNVII is responsible for the innervation and control of the movements of all the craniofacial muscles, with the exception of the jaw muscles. Moreover, it innervates the *platysma*, *venter anterior*