

Course and termination of 2nd order neurons of general sensory from oral structures and taste pathways: Contradictory views

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Abstract

Introduction

Injuries to the neurovascular structures leading to various complications are a common in clinical practice. Such injuries can lead to abolition of different types of sensations. In dental practice, the administration of local anaesthetics can cause damage to the nearby nerve leading to neuropathy or loss of particular sensation carried by that nerve. Consciousness of sensations can be achieved only when the impulses reach the higher centres in the cerebral cortex. Therefore, the knowledge of the sensation pathways from the receptors to the higher centres is of utmost importance for the interpretation of the level of injury. Unfortunately, simple areas like sensory pathways of oral structures and taste remain to be debatable for the learners.

Conclusion

Different text books of Anatomy and Physiology describe the 2nd order neurons of these sensation pathways differently. Considering this, we have discussed the different contradicting views expressed by different authors. These contradictions may create confusion and difficulties for the learners and more so for the dental practitioners.

Introduction

In clinical practice, injuries to the neurovascular structures leading to various complications are common features. Such injuries can lead to abolition of different types of sensations. Even in dental procedures, particularly the administration of local anaesthetics can cause damage to the nearby nerve leading to neuropathy or loss of particular sensation carried by that nerve. Consciousness of sensations can be achieved only when the impulses reach the higher centres in the cerebral cortex.¹ Therefore, the knowledge of the sensory pathways from the receptors to the higher centres is of utmost importance for the interpretation of the level of injury. In other words, thorough knowledge of the pathways is essential to know the possible loss of types of sensations when the site of injury is established.

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Unfortunately, the neuroscience is one of the fields with many areas of controversy. It is also a territory of maximum research. Most of the studies depend on the results of experiments in animal models or clinical studies in humans. Yet, simple areas like sensory pathways of oral structures and taste remain to be debatable for the learners. Different text books of Anatomy and Physiology describe the 2nd order neurons of these sensory pathways differently as crossed or uncrossed and some books do not mention at all.

The uncontroversial fact is that general sensations from most of the oral structures (tongue, gums, teeth), face and temporomandibular joint are carried by the peripheral processes of the cells of the ganglia of 5th, 9th and 10th cranial nerves; but special sense of taste from the taste buds is carried by the peripheral processes of the cells of ganglia of 7th, 9th and 10th cranial nerves. It is also well accepted that most of the central processes of these cells carrying the general sensations synapse in the sensory nuclei of trigeminal nerve and fibres carrying taste sensations by the above three cranial nerves constitute tractus solitarius to synapse in the nucleus of tractus solitarius.^{1,2} Though these primary neurons of the sensory ganglia are generally regarded as unipolar /pseudounipolar, some books describe them as bipolar³. Diverse views are stated in different books about the second order neuron pathways; in their terminology, position etc.

Diverse views on 2nd order neurons of general sensations from oral structures:

According to Gray's Anatomy which is considered as the bible of Anatomy, most of the fibres of the sensory nuclei of 5th cranial nerve cross to the opposite side and ascend in the trigeminal lemniscus to synapse in the cells of contralateral ventral posteromedial nucleus (VPM) of thalamus, but some fibres of trigeminal nuclei ascend to the VPM of ipsilateral thalamus². A Clinical neuroanatomy text book by Richard S Snell describes that the axons of the cells of main sensory nucleus, spinal nucleus and the central processes of the cells of the mesencephalic nucleus cross the median plane and ascend as trigeminal lemniscus to terminate on the cells of VPM of thalamus, without referring to the uncrossed fibres¹. Some authors describe that the interneurons may modulate the nociceptive transmission from the primary afferents to the second order neurons of the subnucleus caudalis of trigeminal nucleus⁴. Axons of the second order neurons cross to the opposite side and ascend as trigeminothalamic tract to

Competing interests: None declared. Conflict of interests: None declared.
All authors contributed to conception and design, manuscript preparation, read and approved the final manuscript.
All authors abide by the Association for Medical Ethics (AME) ethical rules of disclosure.

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FOR CITATION PURPOSES: Somayaji K, Rao M. Course and termination of 2nd order neurons of general sensory from oral structures and taste pathways: Contradictory views. *OA Anatomy* 2014 Aug 17;2(3):23.

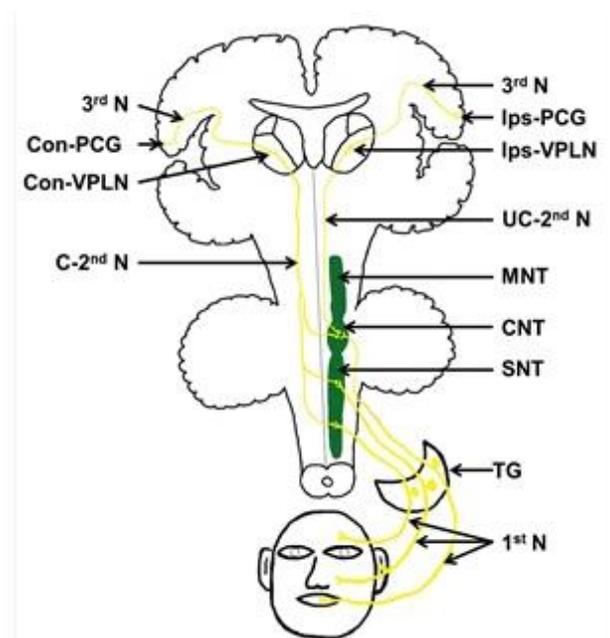


Figure 1: A diagrammatic representation of general sensory pathway from oral structures (tongue, gums, teeth), face and temporomandibular joint (trigeminal pathway) showing 1st order neurons (1st N) having their cell bodies in trigeminal ganglion (TG) ending at spinal nucleus of trigeminal nerve (SNT) and chief sensory nucleus of trigeminal nerve (CNT). Most of the 2nd order neurons are shown crossing the midline (C-2nd N) to end in the contralateral ventral posterior lateral nucleus of thalamus (Con-VPLN). 3rd order neurons (3rd N) from here end in the contralateral post-central gyrus of cerebrum (Con-PCG). However, some of the 2nd order neurons are shown ascending upwards on the same side (UC-2nd N) to end in the ipsilateral ventral posterior lateral nucleus of thalamus (Ips-VPLN). 3rd order neurons (3rd N) from here end in the ipsilateral post-central gyrus of cerebrum (Ips-PCG). (MNT- mesencephalic nucleus of trigeminal nerve).

synapse in the cells of VPM as well as intralaminar nuclei of thalamus⁴. (Figure 1)

Other view is that the axons of the cells of the dorsomedial part of the principal nucleus are uncrossed and they form dorsal trigeminal tract, whereas the fibres from the ventral part of the nucleus form crossed trigeminothalamic fibres which ascend in close relationship with medial lemniscus⁵. According to Murry L. Barr crossed and uncrossed fibres from sensory trigeminal nuclei constitute ventral and dorsal trigeminal tracts which together form trigeminal lemniscus.⁶ Axons of trigeminal nuclei cross the midline to form trigeminal lemniscus as evidenced by activation of crossed trigeminal lemniscal and trigeminothalamic pathways by tooth pulpal stimulation³ (Figure 1).

Thalamocortical projections from VPM of thalamus are almost uniformly stated by all that these fibres pass through the posterior limb of internal capsule to postcentral gyrus^{1,2} (Figure 1).

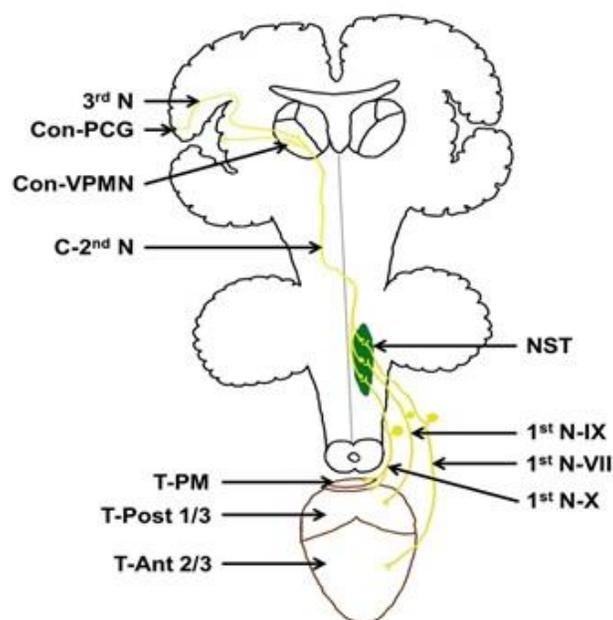


Figure 2: A diagrammatic representation of crossing type of taste sensory path way from the different parts of the tongue showing 1st order neurons (1st N-VII) from anterior 2/3rd of the tongue (T-Ant 2/3), 1st order neurons (1st N-IX) from posterior 1/3rd of the tongue (T-Post 1/3) and 1st order neurons (1st N-X) from posterior most part of the tongue (T-PM). All the 1st order neurons end at the nucleus of solitary tract (NST). The 2nd order neurons are shown crossing the midline (C-2nd N) to end in the contralateral ventral posterior medial nucleus of thalamus (Con-VPMN). 3rd order neurons (3rd N) from here end in the contralateral post-central gyrus of cerebrum (Con-PCG).

Diverse views on 2nd order neurons of taste sensation:

One of the views about the 2nd order neurons of the taste pathway is that the fibres from gustatory nucleus run rostrally in the ipsilateral central tegmental tract through the midbrain and sub-thalamic regions to end in the most medial part of ventral posterior nucleus of thalamus.⁶ Similar view of ipsilateral course and termination of these neurons of taste pathway has also been expressed by certain other authors^{5,7,8} (Figure 2).

However, a contradictory view has been expressed in certain other text books. According to Snell, efferent fibres of nucleus of the tractus solitarius cross the median plane like the sensations from other intraoral structures and ascend to ventral posterior medial nucleus of opposite thalamus.¹ Grays Anatomy also supports this view of contralateral course of the 2nd order neurons of taste pathway². (Figure 3)

There are some authors like Bijalani, Guyton and Hall who do not comment on the crossing /uncrossing of these fibres^{9,10}. Further, it is interesting to note here that none of the books mention that this pathway can have both crossed and uncrossed fibres.

Apart from crossing / uncrossing, the course of these 2nd order neuron fibres are variably described as passing through the medial lemniscus, central tegmental fasciculus

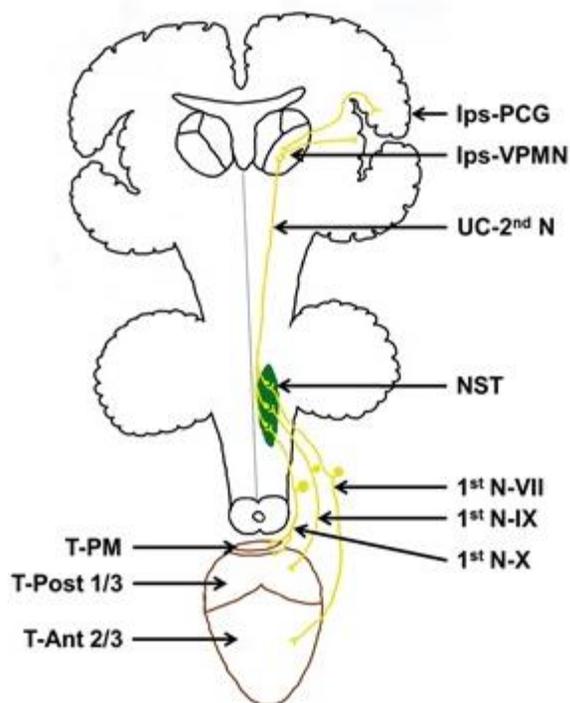


Figure 3: A diagrammatic representation of uncrossed type of taste sensory path way from the different parts of the tongue showing 1st order neurons (1st N-VII) from anterior 2/3rd of the tongue (T-Ant 2/3), 1st order neurons (1st N-IX) from posterior 1/3rd of the tongue (T-Post 1/3) and 1st order neurons (1st N-X) from posterior most part of the tongue (T-PM). All the 1st order neurons end at the nucleus of solitary tract (NST). The 2nd order neurons are shown ascending upwards on the same side (UC-2nd N) to end in the ipsilateral ventral posterior medial nucleus of thalamus (Ips-VPMN). 3rd order neurons (3rd N) from here end in the ipsilateral post-central gyrus of cerebrum (Ips-PCG).

or in a separate solitariothalamic tract to reach the thalamus^{2,6,8,10,11}. There are few reports of termination of some second order neurons in nucleus ambiguus, parabrachial nucleus, hypoglossal nucleus and hypothalamus^{1,2,5}. Even the cortical termination of the taste pathway has been differently described as; in the postcentral gyrus, in the postcentral gyrus and insula, in the parietal opercula of insula (Brodmann's area 43), and even in the cingulate gyrus^{1,2,5,7,8,9}. Literatures also report anterior insula and the frontal operculum as the primary gustatory cortex because of its composition.¹² Neurons of these areas were shown to respond to different types of taste sensations through extracellular unit recording techniques¹³(Figure 2, Figure 3).

Conclusion

Though we are in such an advanced scientific world, uncertainties are prevailing about the sensory second order neuron pathways from the oral structures regarding their terminologies and position (crossed or uncrossed). Literature describing the perception of these sensations in

patients with unilateral lesions of sensory cortex or second order neurons of trigeminothalamic and solitariothalamic pathways which may throw some light about the sensations is lacking. These controversies create confusion and difficulties for the learners, teachers and clinicians in medical school.

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