

# Anatomy of the first spinal nerve – a review

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## Abstract

In this simple review we discuss some important anatomical and functional aspects of the first cervical nerve (C1). The C1 has considerable clinical importance, and the particulars of this nerve are conflicting among several authors, thus, the present review shall be essential for health sciences and those who keep some interest in pathologies associated with the nerves of the neck. For the preparation of this text were consulted papers published in English and textbooks. The articles were accessed from a basic search on SciELO, MEDLINE, PubMed, LILACS, Google Scholar and ScienceDirect.

**Keywords:** neuroanatomy, spinal nerve, first cervical nerve.

## 1 Introduction

### 1.1 Segmentation within the spinal cord

During the embryonic development of the nervous system, the spinal cord develops in close accord with the vertebral column. Thus, a pair of right and left spinal nerves exits between each pair of vertebrae, which are the individual bones of the vertebral column. The region of the cord from which one set of spinal nerves emerges is known as a spinal segment. The term spinal segmentation is sometimes disconcerting to newcomers to spinal anatomy because they expect to see something like the segmentation of a worm and this is not the case. The surface of the spinal cord is smooth, with the exits of the spinal nerves giving the only clue to the location of the spinal segments (BUTLER and HODOS, 2005).

### 1.2 Anatomical considerations

There are 31 pairs of spinal nerves: 8 cervical, 12 thoracic, 5 lumbar, 5 sacral and 1 coccygeal. Initially, these nerves originate in the spinal cord as rootlets that converge to form two nerve roots. A root anterior (ventral) is composed of motor fibers (efferent) leaving the bodies of nerve cells in the anterior horn of the gray matter of the spinal cord to effector organs located in the periphery. A root posterior (dorsal) is composed of sensory fibers (afferent) cell bodies in sensory ganglia or spinal root ganglion posterior (dorsal) that extend peripherally and centrally to sensory endings to the posterior horn of the spinal cord gray matter. The dorsal and ventral nerve roots come together within or immediately

proximal to the intervertebral foramen to form a spinal nerve (WILLIAMS, WARWICK, DYSON et al., 1995; MOORE, DALLEY and AGUR, 2011).

### 1.3 Functional considerations

The spinal nerves pass from the spinal cord to the periphery of the body (the limbs and internal organs such as the gut, the heart, e.g.). Each spinal nerve innervates a “segmental field” of the skin called a dermatome. The distribution of dermatomes for all spinal segments has been mapped by studying sensation and reflex responsiveness that remain after injury to dorsal roots (KANDEL, SCHWARTZ and JESSELL, 2000; BUTLER and HODOS, 2005; GUYTON and HALL, 2006).

The first cervical nerve (C1) has considerable clinical importance, and the particulars of this nerve are scarce and conflicting. Furthermore, the correct identification of C1 can be very important in neurosurgical procedures (TUBBS, LOUKAS, YALÇIN et al., 2009).

Some authors (DYER and THORNDIKE, 2000) commented that the anatomy’s status as a science has diminished in recent years and this underlines the need to apply rigorous methods to anatomical problems. In addition, there is no unanimity among several authors (WILLIAMS, WARWICK, DYSON et al., 1995; APRIL, 1997; RHOTON, 2003) to classify the presence or absence of dorsal root nerve C1. Therefore, the purpose of this review is to discuss some anatomical and functional implications of the C1.

## 2 Material and methods

To perform this study were consulted papers published in English and available on databases SciELO (Scientific Electronic Library Online), MEDLINE (U.S. National Library of Medicine), PubMed (National Library of Medicine and The National Institute of Health), LILACS (Latin American and Caribbean Health Sciences), Google Scholar and ScienceDirect. The search on databases was conducted using terms such as “first cervical nerve” and “spinal nerve”. Studies presented at conferences and textbooks were also used in this review.

## 3 Results

Lang (1993) identified 1-10 dorsal rootlets for C1. This author has also reported that these rootlets are absent in 5% and 9% of right and left sides, respectively. This absence may be found bilaterally (CROSBY, HUMPHREY and LAUER, 1962). Hollinshead (1982) and Rhoton (2003) described that this root is infrequently present, which is also being reported that is never present (APRIL, 1997).

In a study performed by Rhoton (2003) was found 15 dorsal roots from 25 spinal cords. However, at the study was not discussed whether any of these roots were ipsilateral or bilateral. According to Lang (1993) the spinal accessory nerve joins with the rootlets of C1 in 82% of right and 52% of left sides, and that often, there is a swelling at the point of this connection. Kazzander (1891) have commented that this swelling represents the dorsal root ganglion of C1.

In a classical work, Grant (1940) stated that this potential ganglion is located on the posterior arch of the atlas. Crosby, Humphrey and Lauer (1962) have reported that when present, the C1 ganglia may be rudimentary or may even share a ganglion with the spinal accessory nerve and lies within the vertebral canal. Williams, Warwick, Dyson et al. (1995) described that the spinal root of the spinal accessory nerve usually passes through the first cervical dorsal root ganglion. The same authors commented that small aberrant ganglia may occur on upper cervical dorsal roots interposed between the dorsal root ganglia and spinal cord.

Some authors opined that these swellings contain tension receptors for the sternocleidomastoid and trapezius muscles. Others described that they represent accumulation of amyloid bodies or a connective tissue hyperplasia (LANG, 1993).

In a study performed by Ouaknine and Nathan (1973) was found a defined dorsal root of C1 in 46% of their subjects. In this work, was classified the relationships between the C1 roots and the spinal accessory nerve as: Type I (with no connections between these two nerves), Type II (with a communication between the spinal accessory nerve and the dorsal root at a midpoint between its entrance into the cord and fusion with the ventral roots), Type III (with a dorsal root that communicates to the dorsal spinal cord via the spinal accessory nerve) and Type IV (in which there were no posterior roots of C1 and therefore no connection to the spinal accessory nerve).

Oh, Chung, Koh et al. (2001) studied 100 spinal cord sides using the surgical microscope with the aim to evaluate the frequency of connections between the accessory nerve and the posterior root of the cervical nerve below the level of C1. It was reported that the connection was most frequently found in the C2 segment, followed by the C3, C4 and C5

segments, in decreasing. In other studies (LANG, 1992, 1993) was found a connection between the dorsal root of C1 and C2 in 29% of right and 24% of left sides.

Similarly, Oh, Chung, Koh et al. (2002) have studied the relationships between the spinal accessory nerve and the dorsal root of the C1 in 100 sides. In the most common type of connection (represented 38% of cases), either a branch from the C1 dorsal root was seen to course cranially and join the spinal accessory nerve, or the dorsal root and accessory nerve fused as they coursed orthogonal to one other. In the second most common type (represented 36% of cases), was found that the accessory nerve connected with a posterior C1 root that had no direct connection with the spinal cord. No connection was observed between the accessory nerve and the dorsal C1 root in the least common type (represented 6% of cases). Finally, in the next least common type (represented 20% of cases), the posterior C1 root was absent and a connecting branch was sometimes observed between the accessory nerve and the ventral C1 root.

Orhan, Saylam, Ikiz et al. (2009) studied the different types of connections between the accessory nerve and the posterior root of the C1. They commented that the connections between the posterior root of the C1 and the accessory nerve might carry the proprioceptive afferents from the motor supply area of the accessory nerve to the spinal cord. Alternatively, it is possible that afferents from the supply area of the posterior root of the C1 might reach the spinal cord via the connections and the part of the accessory nerve that is cranial to the connection.

In a study of 40 cadavers carry out by Tubbs, Loukas, Yalçın et al. (2009), was classified the C1 nerves into Types Ia, Ib and II, in 34, 9 and 37 sides, respectively. Type Ia was composed of ventral and dorsal roots with a dorsal root ganglion, Type Ib was composed of ventral and dorsal roots and no dorsal root ganglion, and Type II was composed of only ventral roots. All types contained both dorsal and ventral ramus. Mackenzie's nerve was identified on 2 left sides (2.5%). On 48 sides (60%), the C1 nerve received a mean of 2.5 dorsal rootlets. In the remaining specimens, C1 did not receive any dorsal rootlets. On the sides found to receive C1 dorsal rootlets, 14 (30%) were found to have a distinct dorsal root ganglion present, and in 21 (44%) the spinal accessory nerve joined with the dorsal rootlets. The first cervical vertebra in these cases did not possess a dorsal root ganglion. A dorsal ramus of the C1 spinal nerve was identified on all sides. Communication between the dorsal ramus of C1 and C2 near their posterior elements was found on 12 sides (15%).

Some interesting descriptions in textbooks can also provide important information for our review. Williams, Warwick, Dyson et al. (1995) have reported that the dorsal root of C1 is absent in 8% of individuals. According to Burt (1995), the spinal cord throughout its length presents an ordered pattern and target of 31 pairs of spinal nerves. Each spinal nerve is formed by dorsal and ventral roots. However, the C1 may be an exception, only to have ventral roots in 50% of cases. Likewise, Moore, Dalley and Agur (2011) claimed that the first cervical nerves lack dorsal root in 50% of people, and the coccygeal nerve may be completely absent.

Erhart (1974) described that the C1 is essentially motor. According to Butera (2003), the dorsal branch of first

cervical pair is exclusively motor and it is responsible for the innervation of deep muscles of the upper neck.

It is reported that often the C1 does not present dorsal root, the nerve in such cases usually anastomoses with the accessory nerve. Even if the dorsal root is present, the dorsal branch, often presents no cutaneous (GARDNER, GRAY and O'RAHILLY, 1988).

Machado (1998) described that with the exception of the first three cervical nerves, the dorsal branches of spinal nerves are smaller than the corresponding ventral.

According to Martini, Timmons and Tallitsch (2009), each spinal nerve is formed by the fusion of the nerve roots, dorsal and ventral, the only exceptions are C1 and coccygeal nerve that in some people, have no dorsal root.

Citow and Macdonald (2004) reported that there is no C1 dorsal root. Thus, there is no sensitive to C1 dermatome. Moreover, it is generally agreed that C1 normally has no clinically detectable cutaneous sensory distribution (HAYMAKER and WOODHALL, 1953; POLETTI, 1991; LOESER, BUTLER, CHAPMAN et al., 2001). These informations have great importance as it explains why C1 is not shown in the figures of dermatomes of the head and neck in many Neuroscience textbooks.

Kandel, Schwartz and Jessell (2000) showed a schematic representation of the distribution of dermatomes in the absence of C1, and also commented that this absence is due to the fact that the C1 has no dorsal root. On the other hand, other authors (BRODAL, 1984; GUYTON, 1993; MARTIN, 1998; PURVES, AUGUSTINE, FITZPATRICK et al., 2004; GUYTON and HALL, 2006; BEAR, CONNORS and PARADISO, 2008) presented only in the absence of C1 schematic figures, however, does not explain the reason for the absence of C1 in figures illustrative. Finally, we believe that the omission of information may generate doubts and confusion in the understanding of the issue of great clinical importance.

#### 4 Conclusion

This review shall be useful for clinicians, surgeons and academics that manipulate and keep particular interest for this anatomical site. Specifically, this knowledge may be helpful in procedures involving C1 rhizotomy, including peripheral denervation procedures for occipital and cervical neuralgia.

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