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The Quantitative Anatomy of the Cervical Nerve Root Groove and the Interverte Foramen

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Abstract

Study Design: The present study evaluated the cervical nerve groove and intervertebral foramen using dried vertebrae and cadaveric cervical spine.

Objectives: To measure the cervical nerve groove in eight linear and one angular dimensions and the intervertebral foramen in two linear diameters.

Summary of Background Data: Several anatomic studies of the cervical spine exist, but very little quantitative data have been reported on the cervical nerve groove.

Methods: Dried cervical vertebrae, C3-C7, from 41 complete vertebral sets (205 vertebrae) and 14 cadaveric cervical spine were obtained for the present study. Anatomic evaluation focused on the cervical nerve groove for dry specimens and intervertebral foramen for cadaveric specimens. Ten linear and one angular measurements were made bilaterally. The mean, range, and standard deviation were calculated for all of the specimens and for male and female specimens separately.

Results: Differences in dimensions of male and female specimens were not found to be statistically significant. The average lengths of the medial zone and distances from the midline of the vertebral body to the anterior border of the medial zone for male and female specimens consistently increased from C3 to C7. The width of the medial zone was larger in C3 than that of C4, C5, and C6 in male and female specimens. The minimum width for all levels ranged 1-2 mm. The medial zone depths gradually increased from C3 (3.2 mm for male and 2.3 mm for female specimens) to C7 (4.9 mm for male and 4.4 mm for female specimens). The smallest anteroposterior distances from the posterior midpoint of the lateral mass to the posterior border of the nerve groove were found in C7 (6.7 mm for male and 6.1 mm for female specimens). The general trend of the foraminal height and width increased from the cephalad to caudal except at C2-C3.

Conclusions: These data may enhance understanding of the important bony elements associated with the cervical spinal nerves and roots as they pass through the cervical groove and the intervertebral foramen.

As the dorsal and ventral roots of the C3-C7 nerves emerge from the vertebral canal via the intervertebral foramen, they are situated in a groove that extends from the medial border of the pedicle to the lateral end of the transverse process and associated costal process where it is bounded by the anterior and posterior tubercles. In the medial segment of the canal, the nerve roots are situated superior to the pedicle of the subjacent vertebra, posterolateral to the uncinate process, and anteromedial to the medial portion of the superior articular process. Further superiorly within the intervertebral foramen, the nerve roots are close to the intervertebral disc and the pedicle of the more superior vertebra. More laterally, after union of the roots, the spinal nerve and ventral primary ramus will still be situated within the groove and lie between the posterior surface of the vertebral artery as it ascends through the successive foramina transversarii and the anterior surface of the lateral portion of the superior articular process. The ventral ramus continues to lie in the groove more laterally and is bounded anteriorly and posteriorly by the ridges of the true transverse and costal processes and associated tubercles, respectively. Iatrogenic injury to the neural elements may result from use of improperly sized and poorly placed lateral mass screws. Compression of the cervical nerve root caused by either degenerative changes such as pathologic enlargement of the uncinate process or arthritic changes related to the facet joint remains a challenging clinical problem. In the lumbar region, anatomic and pathophysiologic changes within intervertebral foramen and nerve root have been well documented.[7,10-12,15,16] In the cervical spine, however, most studies have focused on the evaluation of the vertebral body, spinal canal, and spinal cord.[6,9,13,14] To better understand the bony elements that encompass the proximal portions of the cervical nerves, the authors thought it beneficial to create a set of quantitative data for the cervical nerve groove and intervertebral foramen. This anatomic study measured the cervical nerve groove in eight linear and one angular dimensions and intervertebral foramen in two linear diameters.

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[black small square] Materials and Methods

The present anatomic study consisted of two parts: the direct measurements of the cervical nerve groove in dry cervical vertebral specimens and the measurement of the intervertebral foramen in cadaveric specimens.

Direct dimensional measurements were performed on 41 cervical spines (22 male, 19 female) with an age range of 26-78 years for the first part of this study. The specimens were preserved dried specimens from the anatomy collection of Medical College of Ohio. Specimens having gross evidence of congenital or acquired vertebral pathology were excluded from the study. The cervical nerve groove was divided into three zones: medial zone (pedicle), middle zone (vertebral artery foramen), and lateral zone. Parameters measured on these zones from C3 to C7 involved lengths, widths of the medial and lateral zones, and depth of the medial zone (Figures 1A, 1B). The distances from the posterior midpoint of the lateral mass to the posterior border of the nerve groove in the sagittal plane, anteroposterior dimension, and from the midline of the vertebral body to the anterior border of the medial zone were also measured (Figures 1A, 1C). Angular measurement included the angle between the nerve groove axis and the midsagittal plane (Figure 1A).


Figure 1

The second part involved measurements of cadaveric spines. Fourteen cervical spines (nine male, five female; aged 62-78 years) from C1 to T8 were harvested from embalmed cadavers. All of the specimens were stripped of muscle on the posterior and lateral aspects. The associated ligaments and joint capsules were retained to more adequately preserve the anatomic relationships and stability of the spinal segments. To directly visualize the intervertebral foramina, the transverse processes, vertebral arteries, and cervical nerve roots were removed. The maximum height and width of the isolated vertebral column, with intact ligamentous structures, was positioned so that a cervicothoracic lordotic curvature, or Cobb angle, of approximately 30° was maintained. Strong flexion, extension, or distraction forces were not placed on the specimens during removal or subsequent handling (Figure 2).


Figure 2

All linear distances were measured using calipers and a standard rule with 1-mm increments, and angular measurement was made with a standard goniometer accurate to 1°. The measurements between male and female specimens for each parameter in the first part of this study were compared with a Student's *t* test. Significant difference was determined as $P < 0.05$.

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[black small square] Results

The results of nerve groove measurements taken from the dried bone specimens are shown in Table 1 and 2. Differences between male and female specimens, including linear and angular measurements, were not statistically significant. The average lengths of the medial zone and distances from the midline of the vertebral body to the anterior border of the medial zone for male and female specimens consistently increased from C3 to C7. The width of the medial zone of C3 was larger


Table 1


Table 2

than that of C4, C5, and C6 for male and female specimens, respectively. The minimum width for all levels ranged from 1-2 mm. The mean medial zone depths gradually increased from C3 (3.2 mm for male and 2.3 mm for female specimens) to C7 (4.9 mm for male and 4.4 mm for female specimens). The smallest anteroposterior distances from the posterior midpoint of the lateral mass to the posterior border of the nerve groove were found in C7 (6.7 mm for male and 6.1 mm for female specimens).

The anatomic parameters measured in the second part of this study are shown in Table 3. The general trend of the foraminal height and width increased from the cephalad to caudal except at C2-C3.

Table 3

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[black small square] Discussion

A detailed set of data regarding the anatomy of the cervical nerve groove and the intervertebral foramen is reported. Unfortunately, no previous data are comparable because few quantitative studies relative to the specific area exist.

Veleanu 17 initially described the morphology of the unciform and transverse processes and the pedicle and articular facet of the cervical vertebrae, which was termed the *uncotransceroarticular complex*. Based on the observation of 120 cadaveric spines, he stated that the spinal nerve groove was from the vertebral orifice (vertebral foramen or canal) to the tip of the transverse process and had a length of 1.5-2 cm. In addition, the nerve groove was divided into two portions: radicular portion and portion of the anterior ramus of the transverse process. A length of 1 cm of the radicular portion was also reported. He did not quantitate the dimensions of the nerve groove in detail.

To describe the cervical nerve groove according to the different anatomic features along its length, it was divided into three zones: medial (pedicle), middle (vertebral artery), and lateral. When compared with the other two zones, the medial zone was believed to play an important role in the etiology of cervical radiculopathy 3,4 because it is bounded by the uncinate process anteriorly, the superior facet posteriorly, and the adjacent pedicles superiorly and inferiorly. Narrowing of the distance between the superior facet and uncinate process, as seen in degenerative conditions such as spondylosis, may result in nerve root compression. The minimum anteroposterior diameter (width) measured on dry bone specimens in the present study ranged of 1-2 mm from C3 to C7. This observation may suggest that severe degenerative changes occurred in these specimens because the age of some of the specimens was more than 60 years, but the maceration process involved in the cleaning of the bones removed all nonmineralized tissues, making the appreciation of the total extent of regional pathology difficult to appreciate. Likewise, a medical history is not available to correlate possible neurologic problems with the measured size of the specimen. It was found that the width of the medial zone in C3 was larger than those of C4, C5, and C6, but smaller than C7.

Clinically, dimensions of foramina are important in the diagnosis of foraminal stenosis and radiculopathy. Several dynamic anatomic studies on the intervertebral foramen and nerve root have been reported. Yoo et al 18 studied the effect of cervical spine motion on the foraminal dimension. They found that flexion of the cervical spine increased the dimensions of the foramen. Conversely, extension decreased the dimensions of the foramen. Recently, another study regarding nerve pressure with changing head and arm positions was reported by Farmer and Wisnesli.[5] Results showed that a significant increase of pressure on C5, C6, and C7 nerves was seen in extension of the cervical spine, whereas a significant decrease of pressure was found with moving the arm from the neutral to abducted position. The present study was designed to establish baseline data of the foramen in a neutral position, with a cervicothoracic lordotic angle, Cobb angle, of 30° being maintained during measurements of isolated cervicothoracic segments of the vertebral column. To make the direct caliper measurements as accurate as possible, the transverse process of the cervical spine was removed, and the foramen was completely cleaned. The measurements showed that the trend of the foraminal dimension of width and height consistently increased from cephalad to caudal, except at C2-C3 foramina.

Posterior plate-screw fixation for the management of unstable cervical spine, which requires the placement of screw into the lateral mass of the cervical spine, has become popular worldwide. Injury of the nerve root by misplaced, misdirected, or improper length of screw still is a potential concern. A series of anatomic studies with respect to safer screw placement in the lateral mass has been reported.[1,2,8] No previous study, however, measured the distance in the sagittal plane from the midpoint of the lateral mass to the posterior wall of the cervical nerve groove in that An et al [1] measured the depth of drill holes places obliquely (anterolaterally) through the lateral mass. The measurements from the present study showed that the smallest diameter was found in C7; this may contribute to the relative small anteroposterior diameter of C7 lateral mass.[1]

In summary, based on observation of 41 cervical spines (205 vertebrae) and 14 cadaveric cervical spines, a detailed set of anatomic data of the cervical nerve groove and intervertebral foramen has been presented. This information may enhance understanding of the unique anatomy of this specific region and its attendant natural and iatrogenic alterations that may lead to neurologic compression or impingement.

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Key words: cervical nerve canal; cervical spine; intervertebral foramen

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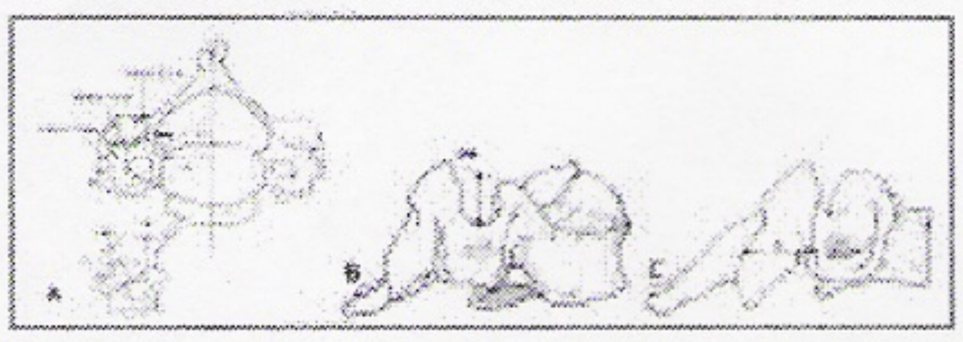

Figure 1

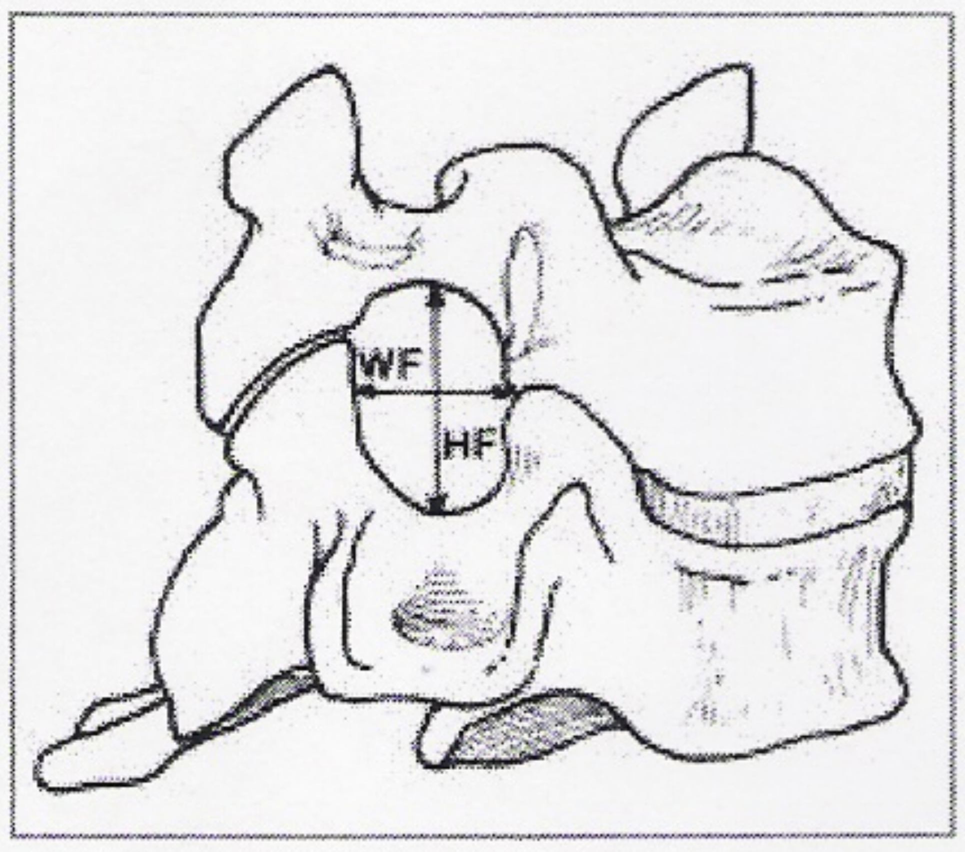

Figure 2

	Medial Zone Length		Middle Zone Length		Lateral Zone Length		Midline to Anterior Border of Medial Zone	
	M	F	M	F	M	F	M	F
C3								
Average	4.8	4.6	5.5	5.4	4.9	4.3	8.7	8.0
Range	3-6	3-6	3-8	4-8	3-7	2-6	3-10	7-10
SD	0.8	0.8	1.2	1.3	1.1	1.0	1.0	1.0
C4								
Average	4.7	4.5	5.4	5.4	5.1	5.4	9.0	8.9
Range	3-6	4-6	4-7	4-8	4-7	4-8	8-11	7-11
SD	0.5	0.6	0.8	0.7	1.1	1.4	1.1	1.3
C5								
Average	5.5	5.1	4.6	5.4	4.5	4.8	9.1	9.0
Range	4-7	4-7	2-7	4-7	3-7	3-7	8-10	8-10
SD	1.0	0.9	1.4	0.6	1.3	1.3	0.8	0.9
C6								
Average	5.9	5.6	5.6	5.3	3.5	4.2	9.3	9.8
Range	4-8	4-7	1-7	3-7	2-7	3-8	8-11	9-11
SD	1.4	0.9	1.5	1.3	1.2	1.3	1.0	0.9
C7								
Average	6.2	5.9	4.6	4.6	5.1	5.8	9.3	10.1
Range	5-8	4-8	3-7	4-8	1-11	2-12	8-11	8-1[illegible]
SD	0.8	1.0	0.9	1.2	2.4	2.5	0.9	1.3

Distances measured in millimeters.
M = male, F = female; SD = standard deviation.

Table 1

Table 2

	Foramen Height	Foramen Width
C2-C3		
Average	8.1	5.2
Range	5-8	3-6
SD	1.2	0.9
C3-C4		
Average	7.4	4.5
Range	5-8	2-8
SD	1.1	0.8
C4-C5		
Average	7.4	5.2
Range	5-9	2-7
SD	1.1	1.4
C5-C6		
Average	8.3	5.9
Range	6-10	4-8
SD	0.9	0.9
C6-C7		
Average	8.6	6
Range	6-11	4-8
SD	1.4	0.9
C7-T1		
Average	8.8	7.0
Range	7-11	5-9
SD	1.8	1.1

Distances measured in millimeters.
SD = standard deviation.

Table 3

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