Anatomical analysis of medial branches of the dorsal rami of cervical nerves for radiofrequency thermocoagulation

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Directed by Professor Youn-Woo Lee

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Tae Dong Kweon

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This certifies that the Doctoral Dissertation of Tae Dong Kweon is approved.

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<TABLE OF CONTENTS>

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

Anatomical analysis of medial branches of the dorsal rami of cervical nerves for radiofrequency thermocoagulation

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Objective: Blocking of the cervical medial branches has been used to successfully treat patients with chronic neck pain. The aim of this study was to clarify the anatomical aspects of the cervical medial branches to improve the accuracy and safety of thermocoagulation denervation.

Methods: Forty cervical spine specimens (20 right and 20 left specimens) were harvested from 20 cadavers and dissected. Therein, the anatomical parameters of the C4 – C7 cervical medial branches from the dissected specimens were measured. Three-dimensional computed tomography (3D-CT) reconstruction images were then obtained after coating the nerve with barium. The parameters were measured using the electronic calipers provided by Picture Archiving Communication System (PACS).

Results: Based on cadaveric analysis, most of the cervical dorsal rami gave off one medial branch; however, the cervical dorsal rami gave off two medial branches in 27 % at the vertebral level C4, in 15% at level C5, in 2 % at level C6, and in 0 % at level C7. The diameters of the medial branches varied from 1.0 to 1.2 mm, and the average distance from the notch of inferior articular process to the medial branches was about 2 mm.

The averaged contact lengths of the medial branches with a straight electrode needle under a parasagittal approach and a 30-degree angular approach at levels C4 – C6 were 4.9±2.1 mm and 2.7±0.9 mm, respectively.

Lateral branches emerged from the dorsal rami at the medial portion of the posterior tubercle in more than 80% of all 40 specimens at all vertebral levels, while bifurcation sites on the upper portion of the posterior tubercle were observed in six, six, four and zero specimens at vertebral levels C4, C5, C6 and C7, respectively.

On the analysis of three-dimensional computed tomography reconstruction images, cervical medial branches (C4 to C7) passed through the upper 49% – 53% of a line between the tips of two consecutive superior articular processes (anterior line). Also, cervical medial branches passed through the upper 28% – 35% of a line between the midpoint of two consecutive facet joints (midline).

Conclusions: The present study demonstrated that cervical medial branches run dorsally along a line that passes through the midpoint of the anterior line and through the upper one third of the midline of the facet column at vertebral levels C4 – C6, respectively. The results of the present study indicate that needle tip placement at the middle of the anterior line and the upper one third of the midline, respectively, in cervical radiofrequency thermocoagulation may be superior to conventional approaches.

Key words: anatomy, cervical nerve, chronic neck pain, medial branches of the dorsal rami, thermocoagulation.

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I. INTRODUCTION

Chronic neck and shoulder pain, as a referred pain, commonly originate at cervical facet joints.[1] Fifty-five percent of patients with chronic neck pain exhibit a cervical facet joint problem.[2] Notwithstanding, chronic neck pain in nearly 60% of patients with whiplash injury can be alleviated by facet joint block.[3]

Encapsulated and free nerve endings have previously been identified in cervical facet joints, and have been shown to characteristically express substance P and calcitonin gene-related peptides.[4-5] Additionally, previous biomechanical study demonstrated that overstretching of the cervical facet joint capsule can be a source of cervical pain.[6] Accordingly, radiofrequency thermocoagulation of the medial branch has been successfully applied to denervate the facet joint in an effort to treat cervical facet joint pain.[7-8]

The technical aspects of thermocoagulation have been validated through anatomical analysis of cervical medial branches.[1, 9-10] To perform thermocoagulation, two electrodes are introduced to each nerve via both a parasagittal and oblique approach. A previous study recommended placing a straight radiofrequency electrode needle parallel to the nerve for more effective denervation, but they did not show such placement in relation to bony landmarks of the cumulative pathways of the cervical medial branches.[11] Another group of studies have, however, targeted the cervical medial nerve with a single curved needle, performing the procedure in slightly different ways in terms of the lesion size, number of punctures and the numbers of lesion made.[11-15] Although these modified techniques have been developed based on previous anatomical research, they have yet to be validated by anatomical analysis. Anatomical awareness of cervical medial branches would also be important to spine surgeons to prevent nerve injury when performing lateral mass screw insertion.[16-17]

Presumptively, radiofrequency thermocoagulation could be more efficiently applied upon further assessment of the pathways of cervical medial branches in a more precise manner based on specific anatomic landmarks. Under fluoroscopic or computed tomography guidance, bony landmarks serve as the best indicators for placing an electrode needle near a targeted nerve. Therefore, this study was designed to analyze the pathways of cervical medial branches via anatomical dissection, in addition to three-dimensional computed tomography (3D-CT) reconstruction images of the bone, to indentify bony landmarks that may prove useful in radiofrequency thermocoagulation of cervical medial branches.

II. MATERIALS AND METHODS

1. Materials

A total of 40 specimens were harvested from 20 adult cadavers (10 males, 10 females, age range 38 – 90 years), in which the atlanto-occipital joint was separated via dissection and the area of the C8 nerve root was separated with an electric saw to obtain more workable cervical neck specimens.

2. Dissection technique

Careful dissection proceeded from the intervertebral foramen area until the lateral branches of the spinal nerves of C4 – C7 were exposed. The scalenus muscle was dissected to the intervertebral canal to identify bifurcation sites of the medial and lateral branches. To expose the medial branch, dissection was directed along the medial branch toward the posterior direction. All of the muscles and soft tissue around the nerve and pillar were removed after the cervical medial branch was exposed beyond the facet joint boundary (Figure 1A).

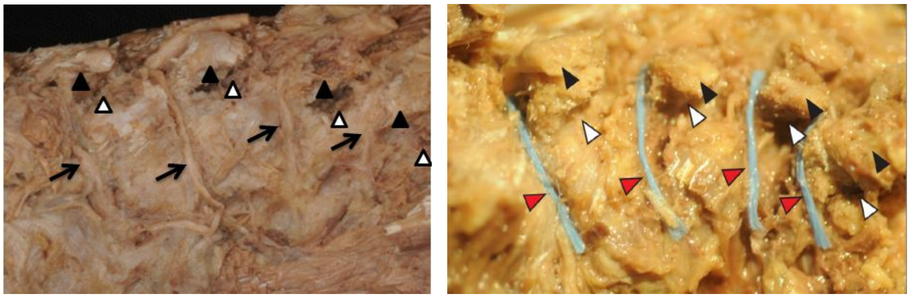


Figure 1. Photography of the cervical spine showing medial branches

A. Lateral aspect of dissected cervical medial branches, B. Barium coated threads attached to the medial branches

Arrow: medial branch

Black arrow head: posterior tubercle

White arrow head: notch of the inferior articular process

Red arrow head: barium coated thread along the medial branch

3. Measurement of anatomical parameters from the dissected specimens

As anatomical parameters, the distance between the origin of the dorsal rami and bifurcation site and the distance from the notch of the inferior articular process to medial branch were measured (Figure 2). The diameter of the medial branch was measured at 3 mm behind the notch of the inferior articular process (Figure 2).

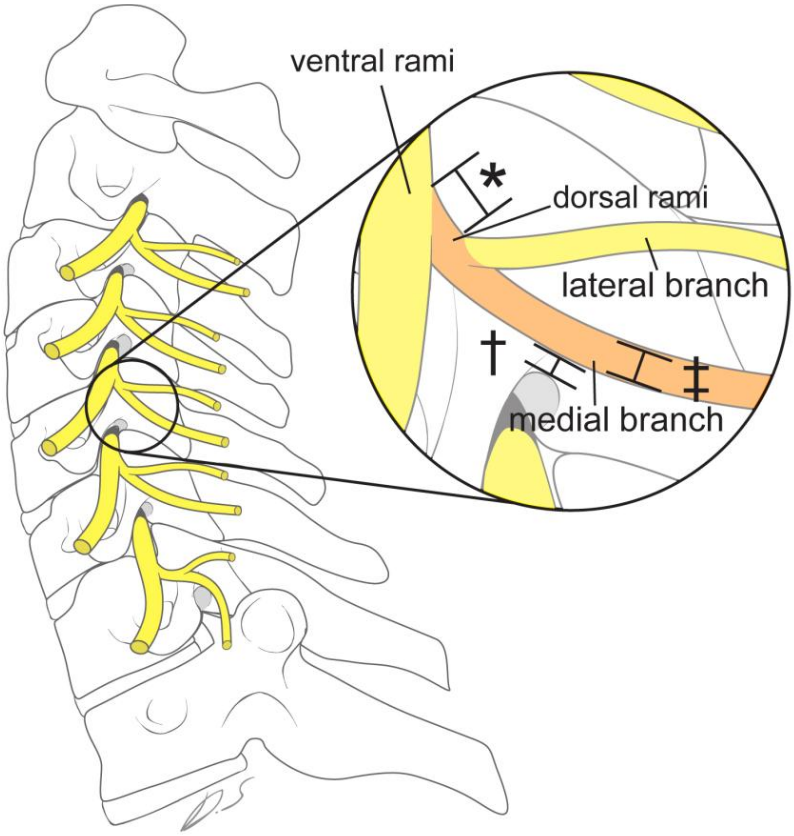


Figure 2. Illustration of the measurement of anatomical parameters of the cadaveric cervical medial branches of the posterior rami

*. Distance between the origin of the dorsal rami and the bifurcation site

†. Distance from the notch of inferior articular process to the medial branch

‡. Diameter of the medial branch at 3 mm behind notch of inferior articular process

Assuming that a straight needle would be inserted on a parasagittal plane with the needle tip placed at 3 mm behind the posterior tubercle or on an oblique plane with the needle tip placed just behind the posterior tubercle during radiofrequency thermocoagulation, the present author measured the contact lengths of the tip of a straight needle with the medial branch in the parasagittal plane and a 30-degree oblique plane (Figure 3). At the vertebral level C7, only the contact length of the needle tip with the medial branch in the parasagittal plane was measured; contact length in the oblique plane was not measured because of the flat shape of the pillar in all specimens. The contact length of the needle tip with the medial branch (medial branch-needle tip contact length) was also measured for curved needles in the same manner.

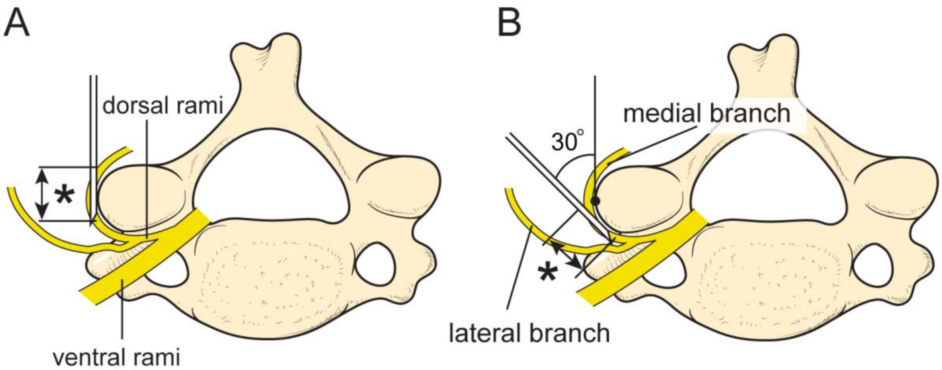


Figure 3. Illustration of measurement of medial branch-needle tip contact length

A) Contact length assuming that the needle is advanced parasagittally and placed parallel along the cervical medial branches. B) Contact length assuming that the needle is advanced on a 30-degree oblique plane and placed parallel along the cervical medial branches.

*. Contact length of a needle with the medial branches in the parasagittal plane or a 30-degree oblique plane

4. Measurement of parameters from three dimensional computed tomography (3D-CT) reconstruction images.

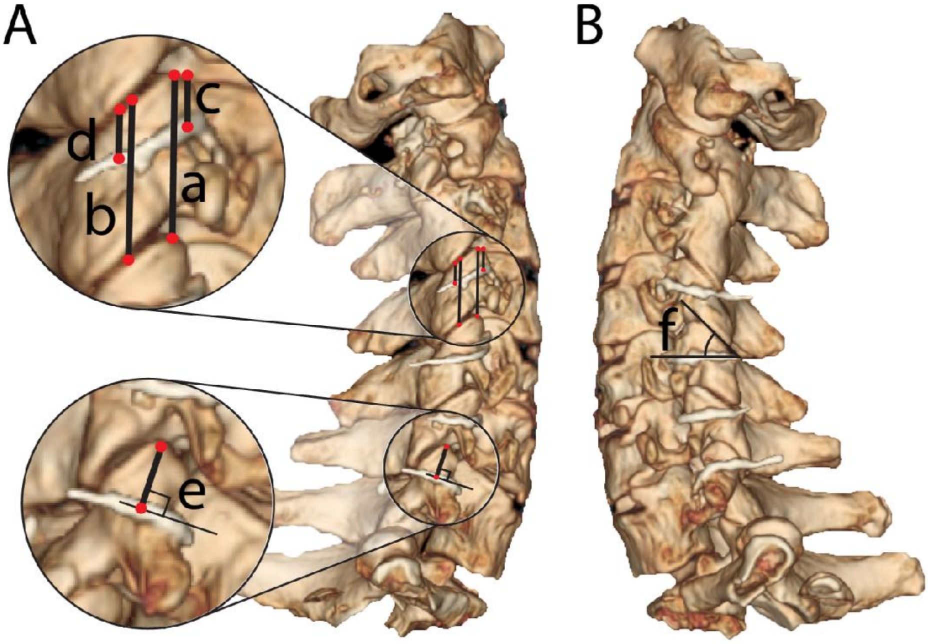
Dissected medial branches were fixed with barium-coated threads along the nerve pathways (Figure 1B). CT scans were performed with a 64 multidetector row CT scanner (Somatom Sensation 64; Siemens, Erlangen, Germany). CT images were obtained in a craniocaudal direction with a collimation of 64 x 0.6 mm and a pitch of 0.9. The tube rotation time was 1,000 ms, and the tube voltage and mAs were 120 kVp and 250 mAs, respectively. Using a dedicated 3D workstation and software, axial, coronal, and sagittal images were reformatted with a 1.0-mm slice thickness, and a total of approximately 650 slices were obtained. Imaging data were digitally stored and displayed using the Picture Archiving Communication System (PACS) (Centricity; GE Healthcare, Milwaukee, WI). The parameters were measured using the electronic calipers provided by PACS.

The anterior line was defined as the line connecting the tips of two consecutive superior articular processes (Figure 4). The midline was defined as the line between the midpoint of the upper facet joint and the lower facet joint (Figure 4). The angle of the medial branch was defined as the angle between the upper facet joint line and the medial branch pathway (Figure 4).

The locations of the medial branches were described as the percent of the anterior line and midline at which the medial branches crossed. As shown in

Figure 4, the percent of the anterior line at which medial branches crossed was calculated as c/a*100, while the percent of the midline was calculated as d/b*100. At level C7, the perpendicular distance between the tip of the superior articular process and the medial branch was measured; the percent at which medial branches crossed the anterior line and midline could not be measured because all of the medial branches at vertebral level C7 ran through the base of the posterior tubercle and obscured the lower facet line of the C7 vertebra. Also, the author did not measure the contact distance for the 30-degree oblique needle approach because of the flat shape of the pillar in all C7 specimens.

The pathways of all medial branches at each level were marked on a schematic drawing of the cervical spine according to the percentage of the anterior line and midline at which each nerve crossed, and then, averaged pathways were calculated as the mean values thereof. Postulated coagulation area was delineated on the assumption that the maximum radius of a lesion made by a radiofrequency needle is around 1.2 mm.



A. Right cervical spine **B. Left cervical spine**

Figure 4. Three-dimensional CT reconstruction images of the cervical spine and schematic illustration of the measurement parameters

a. Anterior line: the line between the tips of two superior articular processes at levels C4-C6

b. Midline: the line between the midpoint of the upper facet joint and the lower facet joint

c. Distance between the tip of the superior articular process and the pathway of the medial branch

d. Distance between the midpoint of the upper facet joint line and the pathway of the medial branch.

e. Perpendicular distance between the tip of the C7 superior articular process and the medial branch.

f. Angle between the upper facet joint line and the pathway of the medial branch at levels C4-C7.

Percent of the anterior line was calculated as c/a*100, and percent of the midline was calculated as d/b*100

5. Statistics

All data were presented as mean ± standard deviation or number (percentage). Statistical parameters were obtained using SPSS ver. 13.0[R] (SPSS Inc. Chicago, IL). Normal distribution of all parameters was tested by the Kolmogorov-Smirnov test.

Comparisons of the anatomical parameters between the left and right sides of the specimens were analyzed by Paired t-test and McNemar test for numerical and categorical variables, respectively. ANOVA and two pairwise comparison tests among cervical vertebral levels were conducted with *P*-values adjusted by Bonferroni correction for multiple tests. *P*-values less than 0.05 were regarded as statistically significant.

III. RESULTS

In this study, a total of 20 cadavers were dissected and analyzed.

1. Anatomical parameters from the dissected specimens

The diameters of the medial branches varied from 1.0 to 1.2 mm and decreased at lower cervical levels (Table 1). Most of the medial branches were single; however, 27% of the medial branches at C4 exhibited double branches that separated near the inferior articular notch, compared to 15% (6/40) at C5 and 2.5% (1/40) at C6 (Table 1). All of the double branches ran parallel throughout the pathway, and the distance between two medial branches was less than 0.2 mm. There were no differences in anatomical parameters between the left and right sides. The diameters and numbers of double branches were higher at the vertebral level C4 than at vertebral levels C6 and C7 (Table 1).

Table 1. Anatomical parameters of the cervical medial branches

	Nerve diameter (mm)			Bifurcation site (mm)[1]			No. of double branches (%)[2]		
	Right	Left	Total*	Right	Left	Total	Right	Left	Total†
C4	1.2±0.3	1.2±0.3	1.2±0.3	2.4±1.4	2.1±1.0	2.2±1.2	4(20)	7(35)	11(27)
C5	1.1±0.3	1.3±0.4	1.2±0.3	1.8±1.1	2.0±1.6	1.9±1.3	4(20)	2(10)	6(15)
C6	1.0±0.2	1.0±0.2	1.0±0.2	1.9±1.2	1.8±1.1	1.8±1.2	0(0)	1(5)	1(2.5)
C7	1.1±0.3	1.0±0.3	1.0±0.3	1.8±1.2	1.8±1.1	1.8±1.1	0(0)	0(0)	0(0)

Values are mean ± standard deviation or number (percent)
[1] Distance between the origin of dorsal rami and the bifurcation site
[2] No. of double branches: number of double medial branches at each level
* $p < 0.05$, C4 vs. C6 and C4 vs. C7: Comparison of diameter according to vertebral level
† $p < 0.01$, C4 vs. C6 and C4 vs. C7: Comparison of the number of double branches among vertebral levels

A distance between the notch of the inferior articular process and the cervical medial branch of less than 2 or 2 – 4 mm was most frequently recorded at all vertebral levels on the both sides (Figure 5).

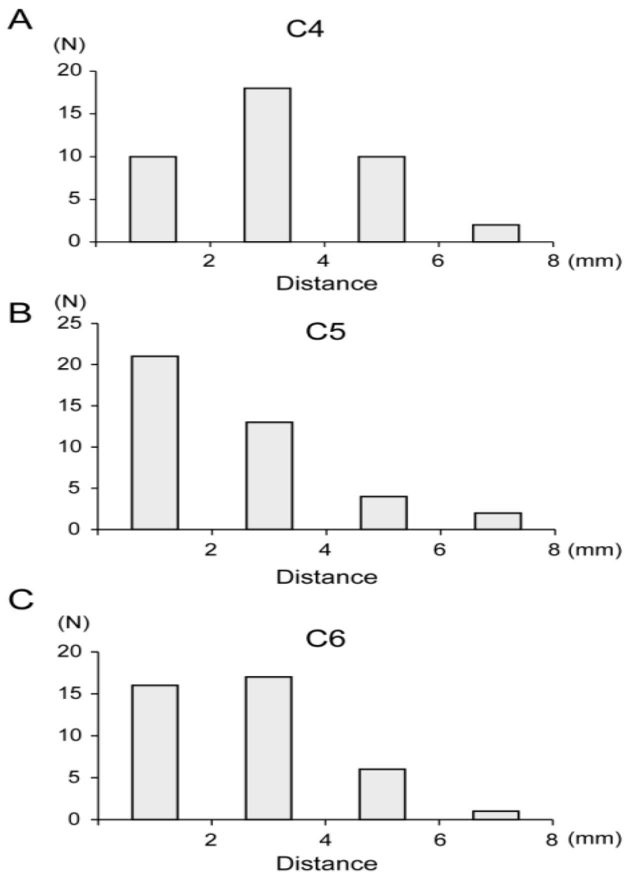


Figure 5. Distribution of distances between the notch of the inferior articular process and the cervical medial branch

A) C4 level, B) C5 level, C) C6 level

$p > 0.05$ comparison among cervical levels

$p > 0.05$ comparison between right and left sides

Bifurcation sites of the dorsal rami were classified into three types: Type I was defined as a bifurcation site located at the medial side of the posterior tubercle. Type II was defined as a bifurcation site located at the upper side of the posterior tubercle. Type III was defined as a bifurcation site located behind the posterior tubercle (Figure 6). In total, 82.5% (33/40), 85% (34/40), 90% (36/40) and 100% (40/40) of all 40 specimens were type I at the vertebral level C4-C7, respectively, while 15%(6/40) of the 40 specimens at both C4 and C5 were type II; only 10%(4/40)at C6 were type II. All specimens at C7 were classified as type I (Table 2). Only one specimen on the right side at level C4 showed emergence of a lateral branch beyond the notch of the inferior articular process. The width of the posterior tubercle was around 2 mm at all vertebral levels.

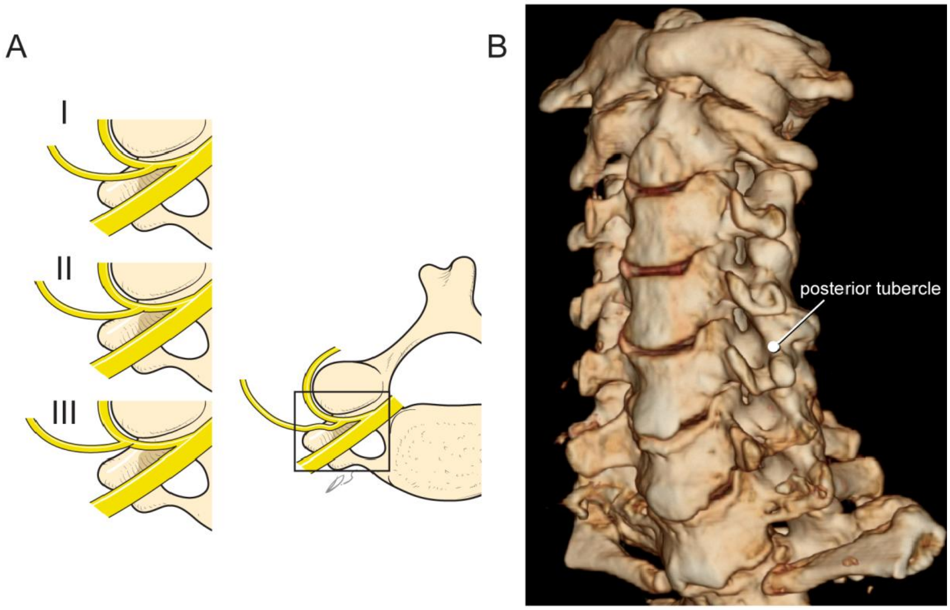


Figure 6. Pattern of bifurcation sites of the dorsal rami of the cervical nerves
A) Three types of bifurcation sites from a transverse view. B) Bifurcation site from the oblique view.
Type Ⅰ: bifurcated at the medial side of the posterior tubercle
Type Ⅱ: bifurcated at the upper portion of the posterior tubercle
Type Ⅲ: bifurcated behind the posterior tubercle

Table 2. Pattern of the bifurcation sites of the dorsal rami of the cervical nerve at each vertebral level

Vertebral level	C4 (N=20)			C5 (N=20)			C6 (N=20)			C7 (N=20)		
side	Rt	Lt	total*	Rt	Lt	total†	Rt	Lt	total	Rt	Lt	total
Type Ⅰ[1]	85	80	82.5	85	85	85	90	90	90	100	100	100
Type Ⅱ[2]	10	20	15	15	15	15	10	10	10	0	0	0
Type Ⅲ[3]	5	0	2.5	0	0	0	0	5	2.5	0	0	0

Values are expressed as percent
[1] Bifurcated at the medial side of the posterior tubercle
[2] Bifurcated at the upper side of the posterior tubercle
[3] Bifurcated behind the posterior tubercle
* $p < 0.01$, C4 vs.C6 and C4 vs. C7: Comparison among vertebral levels.
† $p < 0.01$, C5 vs. C6 and C5 vs. C7: Comparison among vertebral levels

Contact lengths with the medial branch varied from 3.4 to 5.8 mm at levels C4 – C7, assuming the needle tip was positioned 3 mm behind the posterior tubercle via a parasagittal approach (Table 3). Assuming that the needle tip was positioned just behind the posterior tubercle in the 30-degree oblique plane, the contact lengths with the medial branch ranged from 2.3 to 2.9 mm (Table 3).

The contact lengths of a straight needle with the cervical medial branches were longer at vertebral levels C4 and C5 than at C6 and C7 for both the parasagittal and 30-degree angular approach (Table 3). The overall average of possible contact lengths were 4.9±2.1 mm in the parasagittal plane and 2.7±0.9 mm in the 30-degree oblique plane.

Table 3. Contact lengths of a straight needle with the cervical medial branches

	Parasagittal[1](mm)			30-degree[2] (mm)		
side	Right	Left	Total	Right	Left	Total
C4	5.5±2.4	6.2±2.5	5.9±2.4	3.0 ±1.1	2.8 ±0.9	2.9±1.0
C5	5.6 ±2.2	5.8 ±1.8	5.7±2.0	3.1 ±1.1	2.8 ±0.7	2.9±0.9
C6	4.3 ±1.4	4.7 ±1.9	4.5±1.6	2.3 ±0.8	2.4 ±0.8	2.3±0.8
C7	3.2 ±1.5	3.6 ±1.2	3.4±1.4	No data	No data	

Values are expressed as mean ± standard deviation

[1] Parasagittal: Contact length of a straight needle with the medial branch with a perpendicular approach

[2] 30 degree: Contact length of a straight needle with the medial branch with a 30-degree angular approach

[*] $p < 0.05$, C4 & C5 vs. C6 vs. C7: Comparison among vertebral levels

[†] $p < 0.05$, C4 & C5 vs. C6: Comparison among vertebral levels

Using a curved needle (a curve of 9 – 10 degrees), the contact lengths of the curved thermocoagulation electrode with the cervical medial branches was 5.7±1.7 mm at C4, 5.5±1.7 mm at C5, and 3.8±1.4 mm at C6. However, the curved needle tip could not touch the proximal portion of the medial branch in 40% of the C4 medial branches, 25% of the C5 medial branches, and 15% of the C6 medial branches when the curved needle tip was placed at the anterior border of the pillar.

2. Measured parameters from three-dimensional computed tomography (3D-CT) reconstruction images

On the right side, medial branches passed through the upper 49% – 53% of the anterior line at levels C4 – C6. On the left side, medial branches passed through the upper 46% – 53% at levels C4 – C6 (Table 4). At level C7, the distance from the tip of the superior articular process to the cervical medial nerve was measured to characterize the position of the nerve. This distance was 4.5 ± 1.4 mm on the right side and 4.2 ± 1.1 mm on the left (Table 4). In view of the midline, medial branches on the left side passed through the upper 27% to 39% of the midline at levels C4 – C6 (Table 4). On the right side, medial branches passed through the upper 28% to 35% of the midline at levels C4 – C6 (Table 4). Medial branches at vertebral level C6 crossed at higher point along the midline than those at C4 and C5 (Table 4).

Table 4. Parameters measured from three-dimensional CT reconstruction images

	Percent of the anterior line[1]			Percent of the midline[2]			Angle		
side	Right	Left	Total	Right	Left	Total*	Right	Left	Total†
C4	53 ± 8	53 ± 10	53±9	35 ± 9	39 ± 7	A	31 ±11	27 ± 9	A
C5	52 ± 10	53 ± 11	52±11	34 ± 11	36 ± 12	A	29 ± 9	30 ± 12	A
C6	49 ± 13	46 ± 14	48±14	28 ±14	27 ±14	B	34 ± 10	38 ±14	B
C7	4.5±1.4[3]	4.2±1.1[3]		No	data		No	data	

Values are expressed as mean ± standard deviation.

[1] The point where medial branches crossed the anterior line

[2] The point where medial branches crossed the midline

[3]Distance from the tip of the superior articular process to the cervical medial nerve (mm)

* $p<0.01$, C4 & C5 vs. C6: Comparison among vertebral levels

† $p<0.01$, C4 & C5 vs. C6: Comparison among vertebral levels

Figure 7 shows the cumulative pathways (Figure 7A) and averaged pathways (Figure 7B) of all medial branches at each level. Figure 7C outlines the postulated coagulation areas for needle placement along the averaged pathways. According to this figure (Figure 7C), most of the nerves at C4 and C5 could be coagulated with a needle placed along the averaged pathways, while some of the medial branches at C6 would be spared from coagulation. (Figure 7D).

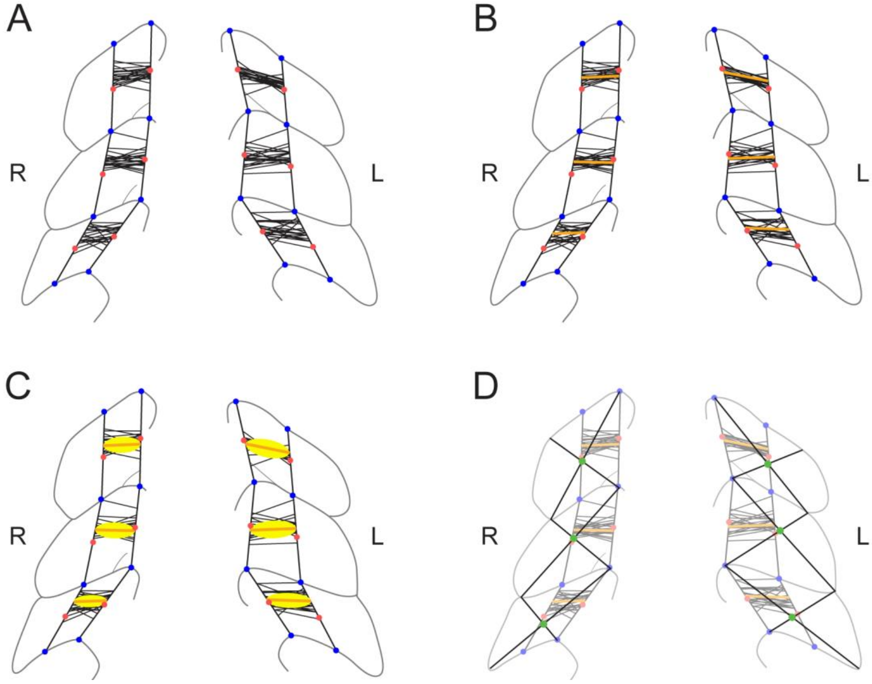


Figure 7. Schematic view of the cumulative and averaged pathways of the cervical medial branches

A) Cumulative pathways of the medical branches (black horizontal lines), B) Averaged pathways of the medial branches (orange line), C) Postulated coagulation areas (yellow elliptical area), D) Recommended target sites for medial branch block (green dot)

Red dot: midpoints of the anterior line and midline.

IV. DISCUSSION

As the procedural technique of radiofrequency neurotomy for cervical facet joint pain can influence the efficacy of the intended neurotomy, the technique should be based upon identification of the neural pathway of the medial nerve. The radiofrequency neurotomy technique, similar to that described by Lord et al., is considered optimal for treatment of the cervical spine.[11] The technique involves making multiple lesions with large-bore electrodes at each vertebral level, under both a parasagittal and oblique approach with caudal angulation, by placing the electrode parallel to the nerve for optimal coverage. The technique is based upon the traditional description that the medial branches travel parallel along the central area of the upper and lower facet joint line. Nevertheless, clarification of the neural pathway of medial branches is required to optimize radiofrequency neurotomy.

The present study revealed that medial branches travel from near the midpoint of the anterior line toward the upper one third of the midline of the facet column at vertebral levels C4 – C6. Moreover, the present cadaveric analysis generated anatomical data that would be of use in clinical applications of radiofrequency thermocoagulation.

Based on the results of the present study, the author suggests that diagnostic block needles should be placed at points higher than target sites recommended in previous studies. Thereby, one may be able to more accurately and more safely confirm cervical facet joint syndrome through diagnostic block with less of a need for local anesthetics than previously recommended. In fact, no serious complications, such as systemic toxicity or paralysis, have been reported for use of less than 0.2 ml of any local anesthetics at each level.

In a previous report by Lord et al.[9], the diameter of cervical medial branches was less than 0.9 mm below the C4 vertebral level; Ebraheim et al.[18] reported diameters of around 1.2 mm – 1.6 mm, which were similar to the results of the present study. This discrepancy in nerve diameter may be partially due to differences in the anatomical locations of where the diameter of the nerves were measured, as well as differences in ethnicity. The present author measured the diameter of medial branches at 3 mm behind the notch of the inferior articular process because this site is located within the target point for radiofrequency thermocoagulation denervation.

In the present study, most of the medial branches were singular; however, the cervical medial branch gave off double branches in about 20% of all specimens at vertebral levels C4 – C5 and in less than 5% at levels C6 – C7. Accordingly, double lesioning may be required at both levels C4 and C5 in order to destroy the entire width of the double branches given that, according to the results of the present study, 1) 27% of all specimens at level C4 and 15% of all specimens at C5 had double branches, 2) the diameter of each branch was around 1 mm and the distance between the double branches was less than 0.2

mm in most cases (which means that the total diameter of the double branches was approximately 2 mm), and 3) the maximal effective radius of a neurotomy lesion induced by a needle was 1.2 ± 0.2 mm. Nevertheless, despite that only one out of 40 medial branches at C6 comprised double branches, the range of the cumulative pathway was too wide to cover the entire nerve pathway with a single lesion; therefore, two lesions would be still required to increase the success rate of the denervation. Additionally, considering that all of the lateral branches at level C7 originated at the medial portion of the posterior tubercle and the diameter of the nerve was 1.0±0.3 mm, one lesion may be enough to coagulate medial branches at level C7. Moreover, at C7, although a straight needle may be enough to sufficiently coagulate medial branches, it may be better to use a curved needle for medial branch thermocoagulation as it may enlarge the lesion size in comparison to that with a straight needle.

At the vertebral levels C4 – C6, 10 – 15 % of the specimens had bifurcation sites of the dorsal rami that were located along the upper portion of the posterior tubercle. Taking a parasagittal and 30-degree angular approach, respectively, the medial nerve-needle contact size for a straight needle would be around 5 and 2 – 3 mm. In the parasagittal approach, lesioning of medial branches larger than 5 mm at level C4 – C5 and 3.5 mm at C6 could be made by placing a straight electrode needle with a 5-mm active tip at the lateral border of the pedicle. By placing an additional straight needle at a 30-degree angle, a larger lesion of more than 2 – 3 mm could be made. Needle tip localization at the point at 2 – 3 mm behind the anterior border of the pedicle in the lateral view in the parasagittal approach seems safe because most of the lateral branches in this study emerged before the lateral border of the posterior tubercle, except for one case at level C4 on the right side. An oblique view would be helpful in positioning the needle tip at the outside of the posterior tubercle. The diameter of the upper part of the posterior tubercle is around 1.5 – 2 mm, and advancing the needle to a point 2 mm behind the posterior margin of the intervertebral foramen under an oblique view of the C-arm may be recommended. Although taking an oblique approach may be helpful to making a larger lesion, a lesion of about 5 mm in size via the parasagittal approach may be enough to alleviate cervical facet joint pain. Although potentially improving the effectiveness of the denervation, additional lesioning may lead to an increase in complications, and warrants further evaluation.

Using a curved needle to denervate medial branches, lesions larger than 5 mm at the vertebral levels C4 – C5 and 3.7 mm at C6 can be made. However, in the present study, much of the proximal portion of the medial branches were not in contact with the curved needle tip for a length of around 2 – 3 mm; only the distal portion of the medial branches could be coagulated with a curved needle, while the proximal portion of the medial branches remained intact and were incidentally not coagulated. Therefore, to prevent injury to lateral branches, placement of a curved needle tip at a point about 3 mm behind the posterior margin of the intervertebral foramen in an oblique view or 2 – 3 mm behind the lateral margin of the posterior tubercle is recommended. This is in accordance with the needle endpoint of the posterolateral technique first described by Sluijter, which is in close proximity to the origin of the dorsal ramus.[19] The advantage of this location is that there is less interindividual anatomical variation in the dorsal ramus as it is close to the segmental nerve.[20] At this point, the distance between the dorsal ramus and the superior articular process varies by < 2 mm.[18]

Notwithstanding, consideration of the anatomy of the articular pillar is required during placement of a needle. The anatomy of the cervical articular pillars, to which the cervical medial branches are related, predicates how an electrode should be inserted. Because the concavity of the articular pillar slopes caudally and posteriorly, electrodes directed to nerves over the lateral aspect off the pillar should be inserted along a cephalad-anterior slope. If a direct postero-anterior parasagittal approach is used, the lateral flange of the superior articular process of the target pillar and any osteophytes stemming from it, may prevent the electrode from being placed correctly on targeted nerves located along the upper half of the pillar; this also applies to the oblique approach.

The anatomical descriptions provided herein may be helpful in performing ultrasound guided medial branch block, allowing us to focus on the predicted sites of medial branches and to discriminate artifacts with greater accuracy.[21-22] Pillar shape estimation with ultrasound may be helpful in making an oblique needle approach or when using a curved needle. In addition, visualization of medial branches with ultrasound before performing radiofrequency thermocoagulation may be helpful in positioning the needle correctly under C-arm guidance. Validation of clinical outcomes and the efficacy of thermocoagulation denervation using this new anatomical guideline are also needed as the efficacy of cervical neurotomy has been challenged in a few reports.[23-24]

There are two limitations to this study that warrant consideration. First, vascular pathways should be considered in order to reduce hematoma formation. However, this study did not analyze vascular pathways because there were no clinically significant vessels located along the pathways of medial branches, and all vessels were removed for clear exposure of the nerve. Secondly, barium coated threads did not fit the nerves exactly, although effort was given to cover the entire area of the nerve. However, any errors this discrepancy may cause would be negligible in regards to measuring the parameters on 3D reconstruction images in view of clinical aspects.

In terms of thermocoagulation of cervical medial branches, the clinical implications of the results of this study are as follows: Two lesions should be made, especially at C4 and C5 level, to cover the total diameter of double nerve branches and placing a needle at the midpoint of the anterior line and at the upper one third of the midline may increase the accuracy of the denervation. Furthermore, parasagittal needle insertion may be safe for an active tip of 5 mm, and even though insertion of a straight needle at a 30-degree angle can lengthen the lesion size, we need further clinical studies to evaluate the efficacy and safety. For avoiding neural damage on lateral branches, the needle tip should not pass the posterior tubercle on a lateral view or 2 – 3 mm behind to posterior margin of the intervertebral foramen on an oblique view.

V. CONCLUSION

The present study revealed that medial branches run dorsally along a line that intersects the midpoint of the anterior line and the upper one third of the midline of the facet column. The results of the present study indicate that needle tip placement at the middle of the anterior line and the upper one third of the midline, respectively, in cervical radiofrequency thermocoagulation may be superior to conventional approaches. This study did not present data of functional improvement or pain relief for radiofrequency thermocoagulation as the intent of this study was to access the pathways of cervical medial branches based on anatomical landmarks. Future study comparing the effectiveness of radiofrequency thermocoagulation based upon the present study with that of conventional approaches is warranted.

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ABSTRACT (IN KOREAN)

경추신경 후지내측지 고주파열응고술 시행을 위한 해부학적 분석

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목적: 경추부 후지내측지의 차단은 만성 경추부통증 환자에서 효과적으로 사용되어져 왔다. 본 연구는 경추부 후지내측지의 해부학적 및 영상학적 분석을 통하여 고주파 열응고술 시행의 해부학적 가이드라인을 제공하고자 한다.

방법: 20구의 사체에서 경추부를 획득하여 경추부의 후지내측지 부위를 해부한다. 해부된 경추부 조직으로 해부학적 분석을 시행하였다. 해부된 신경을 barium으로 덮고 3차원 콤퓨터 단층촬영을 시행하였으며 PACS에서 제공하는 계측자를 통하여 영상이미지를 분석하였다.

결과: 해부학적 분석을 한 결과 대부분의 후지내측지는 한가닥이었으며, 후지내측지가 두가닥으로 이루어져 있는 경우는 4번째 경추부에서는 27%, 5번째 경추부에서는 15%, 6번째 경추부에서는 2%, 7번째 경추부에서는 없었다. 경추신경

후지내측지의 직경은 1.0 mm에서 1.2mm사이에 위치해 있었으며, 하척추절흔에서 후지내측지까지의 거리는 평균 2.0 mm 이었다.

직선 바늘을 뼈에 수직으로 삽입하는 경우와 30도 경사면으로 삽입하는 경우에 바늘과 후지내측지와 접촉하는 면의 길이는 각각 5.7±2.1 mm 와 2.7±0.9 mm 로 측정되었다.

대부분의 경우 후결절에서 외측가지가 기시하였으나, 4번째와 5번째 경추부에서 각각 40개 가운데 6개씩에서 후결절 후부에서 외측가지가 기시하였으며, 6번째 경추부에서는 40개 가운데 4개에서 외측가지가 후결절 상부에서 기시하였다.

콤퓨터단층촬영을 통한 분석에서, 4번째에서 6번째 후지내측지의 주행은 아래위 상관절돌기 첨부를 잇는 선의 상위 49 – 53 %부위를 지나가고 후관절 중간면을 잇는 선의 상위 28 –35 %부위를 지나간다.

결론: 해부학적 고찰을 통하여 임상에서 적용할 수 있는 많은 정보를 얻을 수 있었으며 특히 과거연구의 경우와 상이한 점은 4번째와 5번째 경추부 후지내측지의 경우에 고주파열응고술을 2부위 이상 시행하는 것이 권장된다.

후지내측지의 경로는 상관절 돌기를 잇는 선에서는 중간부위, 후관절 중간부위를 지나는 선에서는 상위 삼분의 일 정도에 바늘을

거치하는 것이 추천된다.

핵심되는 말 : 경추 후지내측지, 해부학, 만성 경부통, 고주파열 응고술,