의학석사 학위논문

자기공명영상에서의
C2 신경근의 형태와
후두부 신경통과의 관계

C2 Nerve Root on MR Imaging of Occipital Neuralgia

2013년 8월

서울대학교 대학원

임상의과학과

이 민 경

A thesis of the Master's Degree

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C2 Nerve Root on MR Imaging of Occipital Neuralgia

By

Min Kyung Yi

A thesis submitted to the Department of Clinical Medical Sciences in partial fulfillment of the requirements for the Degree of Master of Science at Seoul National University Graduate School

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Approved by Thesis Committee:

Professor ____________________ Chairman

Professor ____________________ Vice chairman

Professor ____________________

ABSTRACT

Introduction: The purpose of this study was to evaluate the feasibility of magnetic resonance imaging (MRI) for C1/2 neural foramen evaluation with a new grading system and to correlate the C1/2 neural foramen grade with occipital neuralgia (ON).

Materials and Methods: This study was approved by our institutional review board. The requirement for informed consent was waived. Among the registry of 124 patients who underwent C1/2 spinal surgery between July 2004 and May 2012 in our institute, we enrolled 109 patients who had information with regard to ON and a relevant preoperative cervical spine MR image. A total of 218 neural foramina were evaluated with our new C1/2 neural foramen grading system (Grade 0 to 3) using consensus reading by two experienced radiologists who were blinded to the clinical information. The relationship between the C1/2 grading system and ON was assessed using a chi-square test and Fisher's exact test.

Results: All C1/2 neural foramina were delineated on T2 parasagittal images. Among 218 C1/2 neural foramina, Grade 0 was found in 51 foramina (23.4%), Grade 1 in 105 (48.2%), Grade 2 in 31 (14.2%), and Grade 3 in 31(14.2%). The Grade 2 group had the most frequent prevalence of ON (41.9%), followed by Grade 3 (32.3%), Grade 0 (29.4%), and Grade 1 (26.7%). However, the relationship between the grade and ON was not statistically relevant.

Conclusion: C1/2 neural foramina can be depicted on MRI. However, the relationship between the new grading system for C1/2 neural foramina and ON was not statistically relevant.

Keywords: C2 nerve root

Cervicogenic headache

Occipital neuralgia

Cervical spine MRI

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INTRODUCTION

It is well recognized that abnormalities of the first three spinal nerve roots can be a source of headache (1-6). Among these abnormalities, the C2 nerve root, in particular, is implicated as the principal pain pathway in cervicogenic headache (CH), especially in occipital neuralgia (ON) (7-13). The C2 ganglion is considered vulnerable in its unique anatomical position by hyperextension, and rotatory motion of the head. It is also prone to degenerative changes, atlantoaxial instability, or congenital abnormalities.

The C2 ganglion lies in the atlantoaxial interlaminar space, which is bordered superiorly by the posterior arch of atlas, inferiorly by the lamina of the axis, anteriorly by the lateral atlantoaxial joint and its capsule, and posteriorly by the posteromedial corner between the arch of the atlas and the lamina of the axis with the atlantoepistrophic ligament (11, 13-15) (Fig. 1). An anatomical study by Lu and Ebraheim pointed out that the C2 nerve differs from other nerves in that the ganglion and the nerve root exit from the cord following a horizontal course; they also noted that the ganglion is predisposed to injuries because it is situated proximally (11).

Although a large number of case reports have been published describing the possible pathogenic significance of the C2 ganglion within the atlantoaxial interlaminar space in various settings, to the best of our knowledge, there have been no magnetic resonance imaging (MRI) studies of patients with and without ON in relation to C2 nerve root ganglion findings. In addition, there is no literature published on C1/2 neural foramen MR findings, and no grading system has been established.

In this study, we aimed to evaluate the feasibility of MRI for the assessment of the C2 nerve root ganglion and to suggest a new grading system for the C1/2 neural foramen. We also intended to correlate the C1/2 neural foraminal grade with ON.

Figure 1: C2 ganglion situated in the atlantoaxial interlaminar space. T2-weighted sagittal image of a 25-year-old man without structural pathology, showing the C2 ganglion (arrow) within a normal C1/2 neural foramen. This space is bordered superiorly by the posterior arch of atlas, inferiorly by the lamina of the axis, anteriorly by the lateral atlantoaxial joint and its capsule, and posteriorly by the posteromedial corner between the arch of the atlas and the lamina of the axis with the atlantoepistrophic ligament.

MATERIALS AND METHODS

This study was approved by our institutional review board. The requirement for informed consent was waived.

Study Populations

The medical records of 124 consecutive patients who were referred to our hospital (the National Tertiary Medical Center) for a cervical spine operation, including the C1–2 level, between July 2004 and May 2012 were retrospectively reviewed by one radiologist. Among this population, we excluded 15 patients who had not undergone preoperative cervical spine MRI (n=2), who had no information with respect to ON (n=8), who had suboptimal MR images (n=3), or who had a history of metal instrumentation of the C1–2 level that hampered proper evaluation (n=2). The diagnosis of ON was made by an orthopedic surgeon in our hospital according to the criteria described by the International Headache Society (16). As a result, a total of 109 patients finally participated in the study. The patients' ages ranged from 4 to 86 years (mean age 48.7). Forty patients were male, and 69 were female. The final diagnoses of the patients were: os odontoideum (n=34), dens fracture malunion (n=20), rheumatoid arthritis (n=17), congenital anomaly (n=15), idiopathic atlantoaxial instability (n=10), osteoarthritis (n=8), and others, including metastatic tumors (n=5). The presence of ON was recorded with its sidedness.

Image Acquisition

In our institute, the MRI scans were performed with either a 1.5-T scanner (Gyroscan, Philips Healthcare) or a 3-T scanner (Intera Achieva, Philips Healthcare) using a 16-channel neurovascular coil for the 3-T scanner or a head-and-neck coil for the 1.5-T scanner, with the patient in the supine position. The imaging protocol included sagittal T2-weighted images acquired with the following parameters: repetition time msec/echo time msec, 1200–4378/100–120; field of view, 250–270 mm; and section thickness, 1.5–3 mm. Eleven cases had imported MRI scans performed at diverse hospitals with various MRI scanners. The T2-weighted sagittal images were selected for grading. All the images were deidentified before the analysis and were randomly numbered from 1 to 109.

MRI Grading System for C1/2 foraminal stenosis

The C1/2 neural foramen of the C2 nerve root was evaluated on the T2-weighted parasagittal images on the plane where it was bordered superiorly by the lateral mass and part of the posterior arch of atlas, inferiorly by the vertebral arch of axis, anteriorly by the C1/2 facet joint, and posteriorly by the obliqus capitis inferior muscle (cervical paravertebral muscle) (Fig. 2). An MRI grading system for the C1/2 neural foramen was developed by two experienced musculoskeletal radiologists who had 15 years' and 5 years' experience, respectively, following a consensus after the first session of imaging reviews of the included cases without clinical information.

Grade 0 refers to the definite absence of stenosis: the C2 nerve root is, whether it is round or oval in shape, clearly demarcated by surrounding perineural fat (Fig 3). Grade 1 (probable absence of stenosis) was given to the cases showing an unclear margin of the C2 nerve root. Nerve roots with relatively sufficient perineural fat but having ill-defined margins were classified as Grade 1. Margin blurring etiologies were considered as unknown microstructures, such as capillary vessels. There was no evidence of flattening of the margin of the nerve root at any portion. No bony structures obliterated perineural fat (Fig. 4). Grade 2 (probable presence of stenosis) was given to the cases showing perineural fat obliteration by bony structures, with mild flattening of the margin of the C2 nerve root. In Grade 2, the C2 nerve root could be traced, and there was no evidence of definite collapse of the nerve root (Fig. 5). Grade 3 refers to the definite presence of stenosis, with nerve root collapse or missing nerve roots on serial sagittal images. Missing nerve roots on the serial sagittal images means that the nerve roots show cut-off due to severe adjacent structural deformities, making it impossible to trace the C2 nerve root on the serial sagittal images (Fig. 6). The aforementioned grading system is summarized in Table 1.

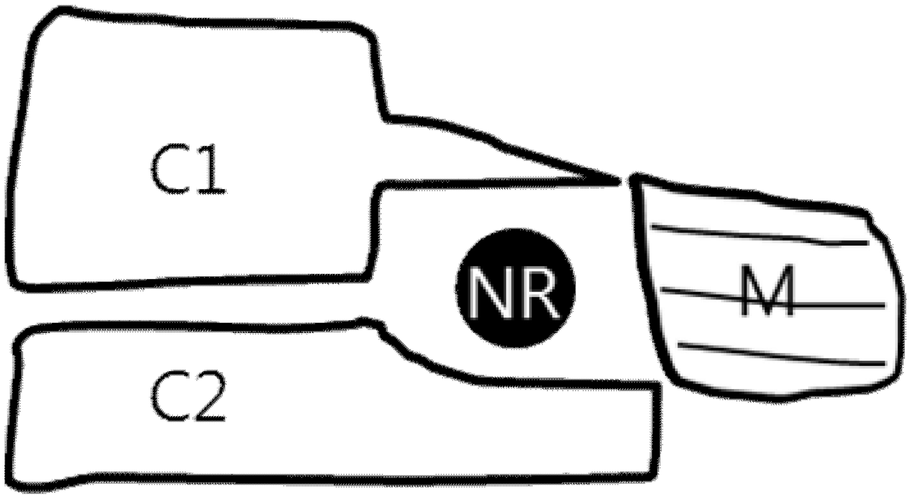

Figure 2: Schematic illustration of the parasagittal plane appropriate for evaluation of the C2 nerve root. The C1/2 neural foramen is bordered superiorly by the lateral mass and part of the posterior arch of atlas, inferiorly by the vertebral arch of axis, anteriorly by the C1/2 facet joint, and posteriorly by the obliqus capitis inferior muscle (cervical paravertebral muscle). NR = nerve root, M = muscle.

Fig. 3a

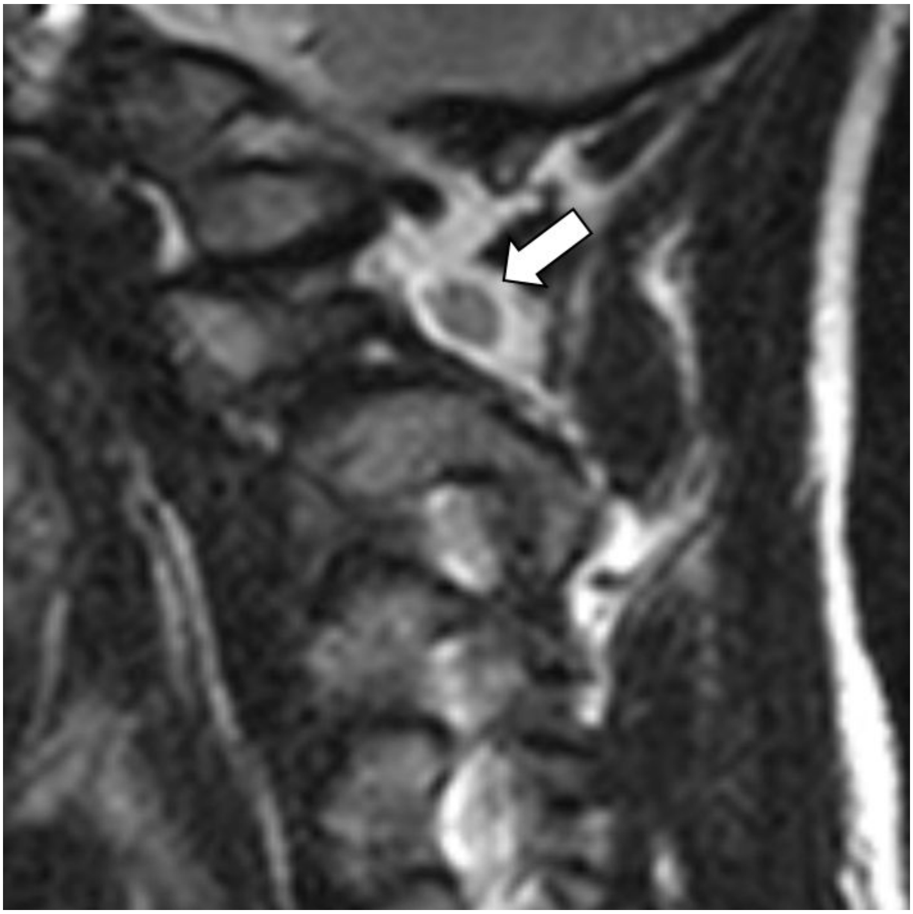

Fig. 3b

Figure 3: Cases of Grade 0 foraminal stenosis. (a) T2-weighted sagittal image of a 41-year-old man with idiopathic atlantoaxial instability, showing a round-shaped nerve root (arrow) clearly demarcated by surrounding perineural fat. (b) T2-weighted sagittal image of a 7-year-old boy with os odontoideum, showing an oval-shaped nerve root (arrow) clearly demarcated by surrounding perineural fat.

Fig. 4a

Fig. 4b

Figure 4: Cases of grade 1 foraminal stenosis. (a) T2-weighted sagittal image of 69-year-old woman with idiopathic atlantoaxial instability shows blurred margin of C2 nerve root. (b) T2-weighted sagittal image of 67-year-old woman with idiopathic atlantoaxial instability shows relatively sufficient perineural fat but less than grade 0 neural foramen. No evidence of nerve margin flattening or any bony structures obliterating the perineural fat is noted.

Fig. 5a

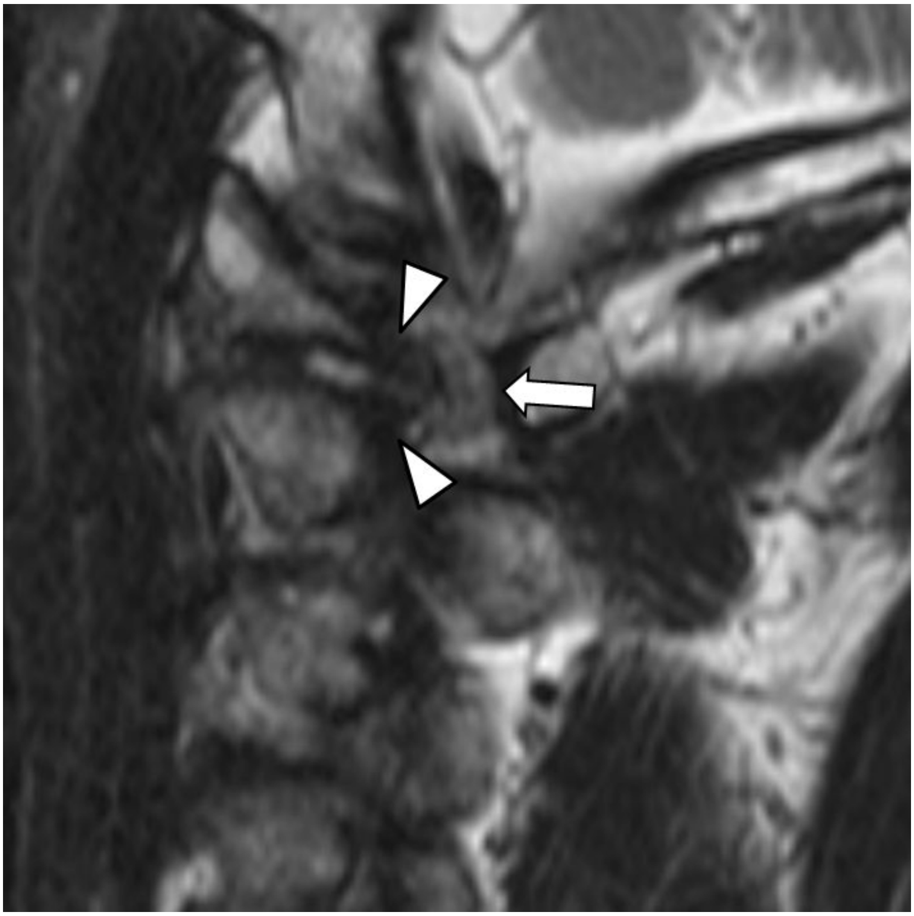

Fig. 5b

Figure 5: Cases of Grade 2 foraminal stenosis. (a) T2-weighted image of a 32-year-old woman with dens nonunion, showing mild flattening of the C2 nerve root (arrows). (b) T2-weighted image of a 63-year old man with dens nonunion, showing perineural fat obliteration by the bony structure and osteophytes (arrow heads) of the atlantoaxial facet joint. (arrow; C2 nerve root) (a) and (b) showed no evidence of nerve root collapse, and both nerve roots were traceable.

Fig. 6a

Fig. 6b

Figure 6: Cases of Grade 3 foraminal stenosis. (a) T2-weighted sagittal image of a 49-year-old man with severe C1/2 degenerative change of the atlantoaxial joint and (b) an 86-year-old woman with dens erosion of unknown etiology, showing a nearly collapsed C2 nerve root, which was not traceable.(arrows; C2 nerve root)

MR Imaging Analysis

In the second session after devising the grading system, the two musculoskeletal radiologists, blinded to the clinical information, evaluated the C1/2 neural foramen on the MR. The C1/2 neural foramina were reviewed bilaterally, and a total of 218 neural foramina were qualitatively analyzed. The two radiologists conducted a consensus reading with regard to the degree of compromise of the C2 nerve root according to the new grading system proposed above.

Statistical Analysis

The relationship between a given C1/2 neural foramen grade and the presence of ON was assessed using the chi-square test and Fisher's exact test. The Statistical Package for the Social Sciences for Windows (version 8) was used for statistical analyses.

Table 1 Summary of the C1/2 neural foramen grading system

Grade 0	Definite absence of stenosis	Round or oval shaped nerve root clearly demarcated by surrounding perineural fat
Grade 1	Probable absence of stenosis	Unclear margin of the C2 nerve root No nerve margin flattening No bony structure obliterating perineural fat
Grade 2	Probable presence of stenosis	Perineural fat obliteration by bony structure Mild flattening of margin of the C2 nerve root Traceable nerve root No evidence of collapse
Grade 3	Definite presence of stenosis	Nerve root collapse Not traceable

RESULTS

The feasibility of the C1/2 neural foramen evaluation with the T2-weighted parasagittal images was reasonable in that all the C1/2 neural foramina were delineated on those images. Among 218 C1/2 neural foramina, Grade 0 was found in 51 foramina (23.4%), Grade 1 in 105 (48.2%), Grade 2 in 31 (14.2%), and Grade 3 in 31(14.2%). Grade 1 stenosis was most frequently noted.

ON was present in 66 of 218 sides in 109 patients (30.3%). Bilateral ON was noted in 20 patients, and unilateral was noted in 26 patients. The incidence of ON according to the grade of C1/2 foraminal stenosis is shown in Table 2. The Grade 2 group shows the most frequent prevalence of ON (41.9%), followed by Grade 3 (32.3%), Grade 0 (29.4%), and Grade 1 (26.7%). However, the relationship between the grade and ON was not statistically relevant. When we compared the Grade 0 and 1 groups with the Grade 2 and 3 groups in relation to ON, the Grade 2 and 3 groups showed a higher proportion of ON than the Grade 0 and 1 groups (37.1% versus 27.6%, respectively) (Table 3), although this was not statistically significant ($p=0.112$).

Table 2 Incidence of occipital neuralgia according to the C1/2 foraminal stenosis grading system

	Grade				Total
	0	1	2	3	
Presence of occipital neuralgia	15 (29.4%)	28 (26.7%)	13 (41.9%)	10 (32.3%)	66
Absence of occipital neuralgia	36 (70.6%)	77 (73.3%)	18 (58.1%)	21 (67.7%)	152
Total	51	105	31	31	218

P=0.230

Table 3 Incidence of occipital neuralgia according to Grade 0–1 vs. Grade 2–3 of C1/2 foraminal stenosis

	Grade		Total
	0, 1	2, 3	
Presence of occipital neuralgia	43 (27.6%)	23 (37.1%)	66
Absence of occipital neuralgia	113 (72.4%)	39 (62.9%)	152
Total	156	62	218

P=0.112

DISCUSSION

In this study, when the new suggested grading system for the C1/2 neural foramen was applied, although the high grade groups (Grade 2 and 3) showed ON more commonly than the low grade groups (Group 0 and 1), there was no statistically significant difference. The Grade 0 foramina where the nerve roots were clearly demarcated with intact perineural fat showed symptoms not uncommonly. This study depicted the C2 nerve root ganglion on MRI, something that has been usually overlooked, and proposed a grading system for the C1/2 neural foramen.

CH is pain perceived in the head but originates from the cervical spine. It is currently understood that the convergence of two topographically separate regions of the body cause nociceptive activity along one of the afferents to be perceived as pain from the other afferent (17). Laboratory animal studies revealed that the upper three cervical nerves overlap extensively and that among these the C2 nerve, in particular, shows substantial convergence with the C1 or the C3 segment (18). A branch of C2 dorsal ramus becomes the greater occipital nerve, which supplies the cutaneous sensory to the occiput area. From this perspective, ON, as a subset of CH, originates not only from the C2 nerve root but also from other convergent nerves or ganglions. In addition, studies have suggested that uncovertebral joints, intervertebral joints, muscles, vessels, and ligaments may also contribute to ON (19, 20). As various structures are implicated in CH, and the symptoms overlap with tension-type or migraine headache, intense controversy has surrounded the development of diagnostic criteria for CH.

So far, no specific pathology has been noted on imaging that correlates with CH (4). Although the International Headache Society included radiological abnormalities in its diagnostic criteria in 1988, radiographic abnormalities specific to CH have not been identified in the literature (16). Pfafferath et al. investigated cervical spine plain radiographs and dynamic radiographs of 15 patients who had CH (21). This study, however, showed no difference between the patients and control subjects. In a study by Fredrikten et al., the imaging findings of cervical plain radiographs and computer tomography of 11 patients with CH also demonstrated no typical characteristic pathology in the group (22). Cervical plain radiographs of 132 CH patients were reviewed by Antonaci et al., and 49.1% of the subjects showed normal findings, suggesting that an ordinary cervical spine plain radiograph is not a sensitive method for a diagnosis of CH (3). There was an attempt to correlate MRI findings with CH as well. Coskun et al. performed cervical spine MRI on 22 patients with CH and compared the imaging findings with those of 20 controls (23). They focused on disc bulgings and the prevalence of positive findings and found no statistically significant difference between the two groups.

In the present study, we investigated the MRI findings of a larger group of 109 patients with ON, focusing on the C2 nerve roots. We noted a higher prevalence of ON among the higher grade C1/2 neural foramen group than the lower grade group, but the difference was statistically insignificant. This implies that the degree of C2 nerve root compression is not necessarily related to the symptoms. Therefore, not all symptomatic individuals may require decompression surgery. ON patients who have a Grade 0 C1/2 neural foramen may obtain benefits from instability fixation rather than decompression surgery.

Our data also support the previous notion that there appears to be no discernible correlation between positive radiological findings and radiculopathy symptoms. Myriad reports on MRI findings of asymptomatic individuals have been published. In a study by Fish et al., the negative predictive value of MRI for cervical radiculopathy was only 25% (24). Disc protrusions are common findings in the cervical MRIs of asymptomatic patients (25), and mild cervical stenoses are also very common (26). A lumbar study reported that while MRI exhibits high sensitivity for radicular disorders, it has a relatively low specificity and negative predictive value (27).

As previously mentioned, the C2 nerve root pathology is not the only etiology implicated in ON: Various other structures may be involved. However, all the patients included in our study had C1–2 structural pathology, which needed to be surgically corrected. Hence, the assumption that the C2 nerve root is the culprit in ON is more plausible than in other ON patient populations without structural abnormalities. For subjects who have anatomical deformities, including the C1–2 level, the use of our grading system can aid the assessment of C1/2 foraminal stenosis and surgical decision making.

There are some limitations in this study. First, the validation process for the C1/2 neural foraminal stenosis grading system was not included in the present study. Our study focused on the feasibility of MRI to delineate the C2 nerve root, as well the development of a new grading system to assess its relationship with ON. The reproducibility of this new grading system should be evaluated in further studies involving interobserver and intraobserver agreement analyses. Second, we only included patients who were planned to undergo cervical operation including the C1-2. Further study of the general population will be needed.

In conclusion, although ON is not directly related to the degree of C1/2 neural foraminal stenosis, for those who have mechanical pathology, including pathology of the C1–2 vertebral body and associated structures, the assessment of the C2 nerve root ganglion with our MRI grading system might be helpful in deciding upon surgical options.

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국문초록

목적: 자기공명영상 상에서 C2 신경근을 보는 것과 새롭게 제시하는 C1/2 신경공의 등급체계로 분석하는 것의 타당성을 검토하고 나아가 이러한 C1/2 신경공의 등급과 후두부 신경통과의 관계를 알아보고자 한다.

대상과 방법: 후향적 연구로서 이 연구는 기관윤리위원회의 승인을 받았다. 2004 년 7 월부터 2012 년 12 월까지 우리 병원에서 C1/2 를 포함한 척추수술을 받은 124 명의 대상자 중, 후두부 신경통 여부에 대한 정보가 있고 판독 가능한 수술 전 경추 자기공명영상이 있는 109 명을 등록하였다. 총 218 개의 신경공이 우리가 제시하는 새로운 C1/2 등급체계에 의거하여 평가되었고 이러한 평가는 환자의 임상적 정보에 대해 알지 못하는 두 명의 경험있는 영상의학과 의사들의 합의에 의해 이루어졌다. C1/2 등급과 후두부 신경통과의 관계는 Chi−squre test 와 Fischer exact test 로 분석하였다.

결과: 모든 C2 신경공은 자기공명영상 T2 parasagittal image 에서 잘 구별되었다. 218 개의 C2 신경근 중 grade 0 은 51 개의 신경공에서 (23.4%), grade 1 은 105 개의 신경공에서 (48.2%), grade2 는 31 개의 신경공에서 (14.2%), 그리고 grade 3 는 31 개의 신경공에서 (14.2%) 관찰되었다. Grade 1 의 협착이 가장 많았다. Grade 2 군에서 후두부 신경통이 가장 많이 발견되었으며 (41.9%), 그 뒤로는 grade 3 (32.3%), grade 0(29.45), 그리고 grade 1(26.7%)등이 뒤따랐다. 그러나 C1/2

신경공의 grade 와 후두부 신경통과의 관계는 통계학적으로 유의하지 않았다. Grade 0 과 1 을 합한 군을 grade 2 와 3 을 합한 군과 비교하였을 때 grade 2 와 3 군에서 후두부 신경통의 비율이 높았지만 (각각 37.1% vs. 27.6%)이 역시 통계학적으로 유의하지 않았다. (p=0.112)

결론: 본 연구에서 새롭게 제시한 C1/2 신경공의 등급체계를 적용하였을 때 고등급 군 (grade 2 와 3)에서 후두부 신경통이 저등급 군 (grade 0 와 1)보다 높았지만 통계학적인 차이는 없었다. Grade 0 의 신경공에서도 증상이 적지 않게 나타나는 것을 볼 수 있었다. 이 연구의 또 다른 의미는 자기공명영상에서 종종 간과되었던 C2 신경근을 잘 볼 수 있다는 것과 C1/2 신경공의 등급체계를 새롭게 제시하였다는 것을 들 수 있겠다.