ANATOMICAL RESEARCH

Anatomo-Radiological Comparison of the Cloward's Technique and Medial Facetectomy

Cloward Tekniği ve Medial Fasetektominin Anatomo-Radyolojik Olarak Karşılaştırılması

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Abstract: An evaluation of the advantages and limitations of both the anterior and posterior approaches was made in isolated cadaveric specimens of the cervical spine. During anterior decompressions, the Cloward drill with a diameter of 14 mm was used, and the vertebral borders of the interspace was dissected laterally with up-angled curettes. When decompressing via posteriorly, various sized medial facetectomies were performed. During each procedure, radiopaque markers were placed either for measuring the distances between the landmarks or x-ray evaluations. The mean length of the exposed nerve roots via anteriorly was 1.7 mm, and this could be increased to 3.8 mm when vigorous curettage was performed. The mean lengths of the the visible segments of the nerve roots in different cervical segments were in close relation with the extent of the facetectomies, and ranging between 5.0 and 7.2 mm. However, the risk of vertebral artery injury would seem to increase if the region of the uncovertebral joint was to be decompressed extensively via posteriorly. Because, not only the vertebral artery was closer to the most distal edge of the exposed nerve root segment than as it is in the anterior approach, but also the spinal cord and roots were hindering the exposure. We failed to demonstrate the actual extent of decompression on oblique x-ray views. Only the anteroposterior projections gave some information about the decompressive effect of facetectomy on the lateral wall of the neural foramen.

Key Words: Anterior surgery, cervical radiculopathy, neural foramen, posterior surgery, x-ray evaluation

Özet: Kadavra servikal omuga örnekleri üzerinde anterior ve posterior yaklaşımların yarar ve sınırlılıkları değerlendirildi. Anterior dekompresyonda 14 m çapında Cloward ucu kullanıldı ve disk mesafesine komşu omurga cismi kenarları yukarı doğru eğimli küretlerle alındı. Posterior dekompresyon sırasında değişik büyüklüklerde medial fasetektomiler yapıldı. Her işlemde radyografik değerlendirme ve mesafe ölçümü amacıyla radyoopak işaretler yerleştirildi. Anterior yaklaşımla serbestleştirilen sinir kökünün ortalama uzunluğu 1.7 mm idi ve bu mesafe iyi bir küretajla 3.8 mm'ye kadar çıkabiliyordu. Değişik servikal segmentlerde ortaya konabilen sinir kökü bölümünün uzunluğu fasetektominin büyüklüğüne başlıydı ve 5.0 ile 7.2 mm arasında değişiyordu. Ancak unkovertebral eklem bölgesinde geniş posterior dekompresyon vertebral arter yaralanması tehlikesini artırmaktadır. Çünkü bu yaklaşımda hem vertebral arter serbestleştirilen sinir kökü bölümüne anterior yaklaşımda olduğundan daha yakındır hem de omurilik ve kökler yaklaşımı zorlaştırır. Dekompresyonun gerçek boyutlarının oblik filmlerde gösterilemediğini saptadık. Fasetektominin nöral foramenin lateral duvarı üzerindeki dekompressif etkisi ancak ön-arka filmlerde kısmen saptanabilmektedir.

Anahtar Sözcükler: Anterior cerrahi, nöral foramen, posterior cerrahi, radyografik değerlendirme, servikal radikülopati

INTRODUCTION

Both the anterior and posterior approaches are used in the treatment of cervical radiculopathy (4, 9, 15, 18, 19, 22, 24). The removal of the intervertebral disc and parts of the adjacent vertebral bodies in the anterior approach (3), and the resection of the medial part of the facet joint in the posterior approach (22) are necessary to visualize the compressed nerve root. The anterior approach to central disc herniation has previously been shown to be superior to the posterior approach (5, 11, 14). But the management of anterolateral disc herniations or osseous compressions has remained controversial, and published series using posterior and anterior approaches have demonstrated similar results (6, 12, 17, 23). Neverthless, the surgeon should be aware of the advantages and limitations of each approach in order to choose the procedure that will best accomplish his objective. From this point of view, this cadaveric study was undertaken to find out the limits of the exposures of the nerve roots obtained by anterior and posterior decompression. The safety of each procedure was also assessed.

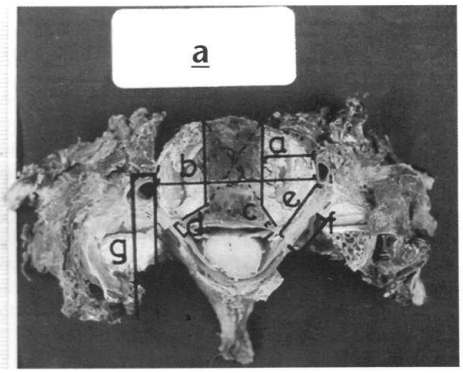
MATERIALS AND METHODS

Eight isolated cervical spine specimens were used. Each specimen was immobilized tightly between two vises which were fixed to the table. For anterior decompression, the Cloward's technique (3) was performed for C2-3, C3-4, C4-5, C5-6, and C6-7 disc spaces of each specimen. The Cloward drill with a diameter of 14 mm was chosen to remove the intervertebral disc, and parts of the adjacent vertebral bodies. The operative microscope was used when the procedure was extended laterally to achieve root exposure by removing more disc and bone with up-angled curettes from 000 to 0. Bilateral C3, C4, C5, C6, and C7 nerve roots were also exposed with facetectomy in the same specimens. A high-speed drill with various size diamond burrs was used for this task. An attempt was made to limit facet removal as follows; medial one-third, medial half and medial two-thirds of the structure.

When the dissection was complete a radiopaque clip was placed at the most lateral part of the exposed nerve segment, and a set of x-ray films of each specimen was made in order to compare the extent of lateral dissections.

Then the decompression of the uncovertebral joint via anteriorly had been pursued vigorously without directly seeing the cutting-edges of the curettes. The aim of this last procedure was to explore, whether vigorously pursued lateral dissection had increased the exposure of the root in the neural foramen.

Finally, axial anatomic sections through all disc spaces were made to measure the length of exposed segment of the roots and the distance from the dural tube to the ipsilateral vertebral artery. Also, the position of the vertebral artery was identified in every section. The sagittal planes, parallel with the medial, middle or lateral one-thirds of the ipsilateral facets were used to determine the vertebral artery position (Figure 1).



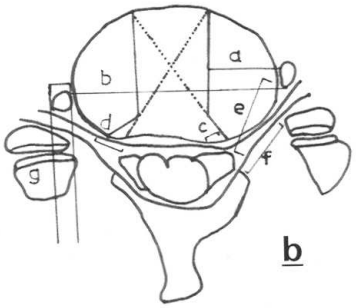


Figure 1, a) The measured parameters in each specimen **a:** (distance between the lateral edge of the burr-hole and the vertebral artery, **b**: distance between the two vertebral arteries, **c:** exposed root segment with normal curettage, **d:** exposed root segment with vigorous curettage, **e:** distance from the dural tube to the ipsilateral vertebral artery, **f:** exposed root segment after medial facetectomy, **g:** position of the vertebral artery according to the ipsilateral facet joint), b) The shematic drawing of figure 1a.

During the comparison of the procedures, the operated levels were divided into two groups. Group I (upper cervical segments) consisted of C2-3, C3-4, and C4-5 levels, and the lower cervical segments (C5-6 and C6-7 levels) were icluded in group II (Tables I and II).

After Kolmogorov Simirnov test revealed that the data obtained from the two groups, were normally distributed, Student's t-test was used to compare the two groups. One-way ANOVA was used to assess the effects of different sized facetectomies on the length of the exposed root segment. P-values less than 0.05 were accepted as statistically significant.

RESULTS

Exposure of the nerve root

Anterior decompression: Standing on the side opposite to the root to be decompressed gave maximal visualization. The mean lengths of exposed nerve root segments in the upper and lower cervical segments were 1.2 mm and 2.4 mm ($p<0.05$), respectively. If the lateral bone and disc removal was carried vigorously beyond the line of direct vision, mean lengths of the exposed nerve roots in the upper and lower cervical segments increased to 3.6 mm and 4.1 mm, respectively (Figures 2 and 3). Although this augmentation of the exposures seemed statistically

Table I: The Results of the Anterior Approaches.

ANTERIOR APPROACH	Group I (n=24)	Group II (n=16)	Total (n=40)
	mean±SD	mean±SD	mean±SD
Exposed root segment			
-with regular curettage	1.2±1.2mm	2.4±1.3mm●	1.6±1.4mm
-with vigorous curettage	3.6±1.2mm◆	4.1±0.8mm◆	3.8±1.1mm
Distance between the two vertebral arteries	28.2±2.2mm	34.0±3.2mm●	30.5±3.9mm
Distance between the lateral edge of the burr-hole and the vertebral artery	7.1±1.1mm	10.0±1.6mm●	8.3±2.0mm

●: data that differs between the two groups; ◆: data that differs in a group. SD:standard deviation.

Table II: The Results of the Posterior Approaches.

POSTERIOR APPROACH	Group I (n=24)	Group II (n=16)	Total (n=40)
	mean±SD	mean±SD	mean±SD
Exposed root segment after			
- 1/3 medial facetectomy	5.3±2.2mm	4.5±1.6mm	5.0±2.0mm
- 1/2 " "	6.0±2.0mm	5.3±1.2mm	5.7±1.5mm
- 2/3 " "	6.7±1.8mm	8.3±2.1mm◆	7.2±1.9mm◆
Distance from the dural tube to the vertebral artery	8.2±1.1mm	11.5±2.4mm●	9.5±2.4mm
Vertebral artery position on the same sagittal line with			
- 1/3 medial facet joint	20 (83 %)	8 (50 %)	28 (70 %)◆
- 1/3 middle " "	4 (17 %)	8 (50 %)	12 (30 %)
- 1/3 lateral " "	-	-	-

●: data that differs between the two groups; ◆: data that differs in a group. SD:standard deviation.

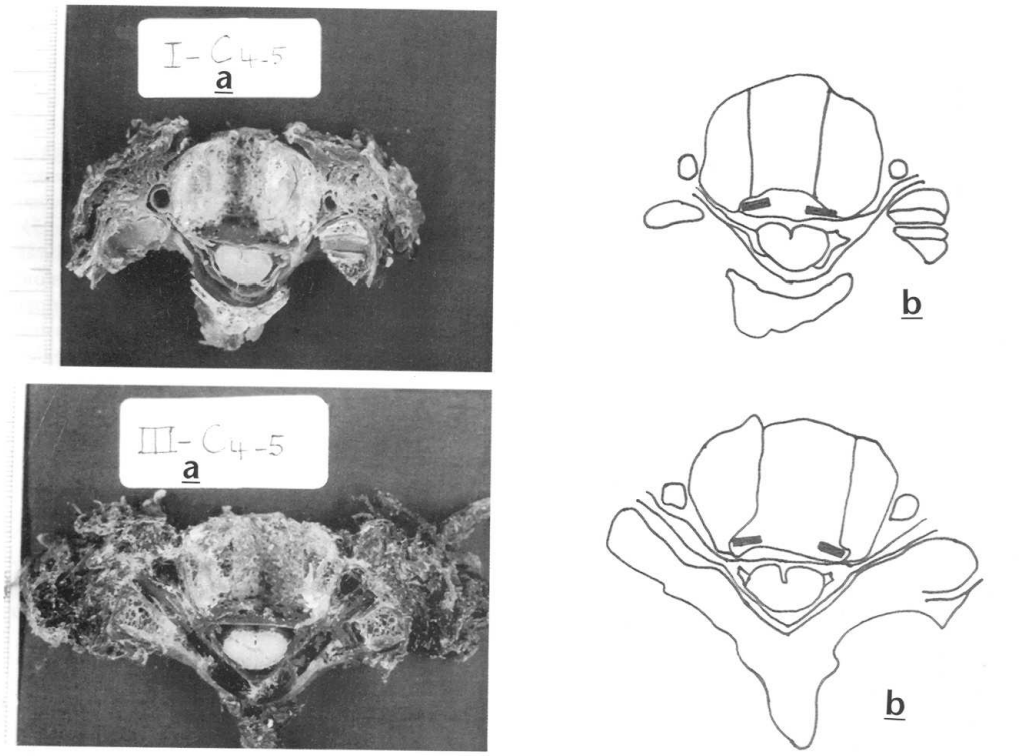


Figure 2, a) Dural tube could be decompressed almost totally with the removal of the posterior longitudinal ligament via anteriorly. But the resection of the uncovertebral joint was limited and the mean length of the exposed root segment was 1.2 mm in the upper cervical segments, b) The shematic drawing of figure 2a, c) When vigorous curettage was attempted, the mean length of the decompressed root segment was increasing two-folds and the vertebral arteries which were located on the same sagital plane with the medial one-third of the facets, were still far away from the lateral limit of the dissection, d) The shematic drawing of figure 2c.

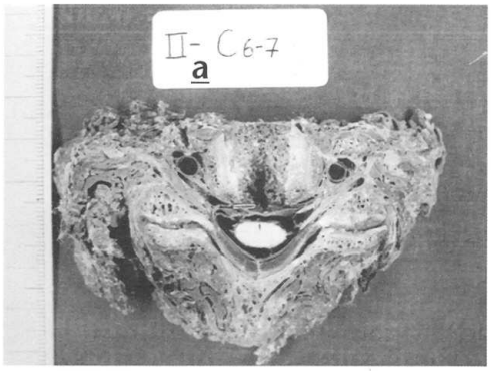
significant ($p<0.05$), no difference was observed between the upper and lower segments.

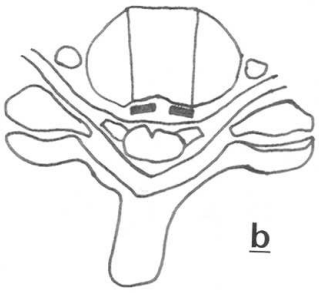
Facetectomy: Longer segments of the nerve roots were easily seen via the posterior approaches, as would be expected since the roots were under direct vision. The mean lengths of the exposed roots in the upper and lower cervical levels were 5.3 mm and 4.5 mm, respectively, when medial one-third of the facets had been removed (Figure 3). The resection of medial one-half of the facets resulted in the visualization of 6.0 mm of nerve root in group I, and 5.3 mm in group II segments. The removal of medial two-thirds of the facet joints enabled us to visualize 6.7 mm and 8.3 mm of the nerve roots in the upper and lower cervical segments, respectively (Figure 4).

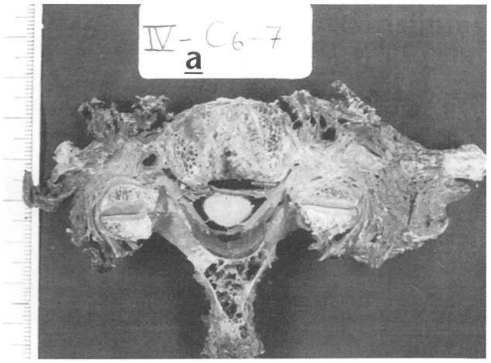
The amount of medial facet resection seemed to be a determinant for the length of the exposed root segment, especially the resection of the medial two-thirds of the facet ($p<0.05$). But the two groups did not exhibit any statistical significant difference.

Position of vertebral artery

Anterior decompression: The mean distances between the two vertebral arteries in the upper and lower cervical levels were 28.2 mm and 34 mm ($p<0.01$), respectively. The mean distance between the vertebral artery and the lateral edges of the burr-holes with a diameter of 14 mm, was 7.1 mm in the upper and 10.0 mm in the lower cervical segments ($p<0.01$), respectively.







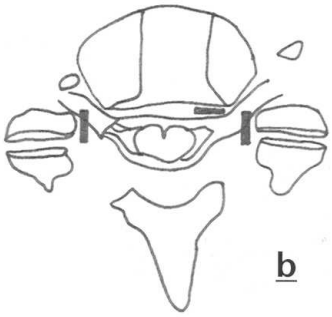
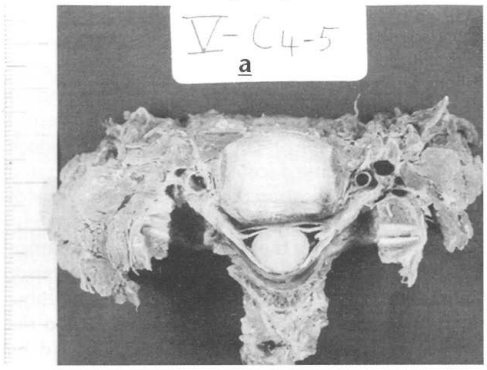


Figure 3, a) The vertebral arteries located more anteriorly, but they were still on the same sagittal plane with the medial or middle one-third of the facet joints in the lower cervical segments. Although the anterior decompression of the dural tube was maintained, the medial wall of the neural foraminae, were intact with regular curettage, b) The shematic drawing of figure 3a, c) The mean length of the exposed root segments increased to 4.1 mm, when the lateral dissections were carried out vigorously. Even the removal of the medial one-third of the facet joint, was superior to the anterior decompression in the visualization of the nerve root at the neural foramen, d) The shematic drawing of figure 3c.



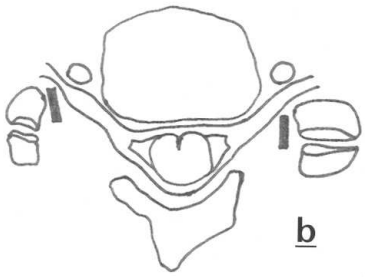


Figure 4, a) The medial half of the right and medial two-thirds of the left facet joints were removed. The length of the exposed root segment increased parallel to the extent of the facetectomy. Since the vertebral arteries were very close, they would be prone to injury, when the decompression of the uncovertebral joint and the intervertebral disc was attempted via posteriorly, b) The shematic drawing of figure 4a.

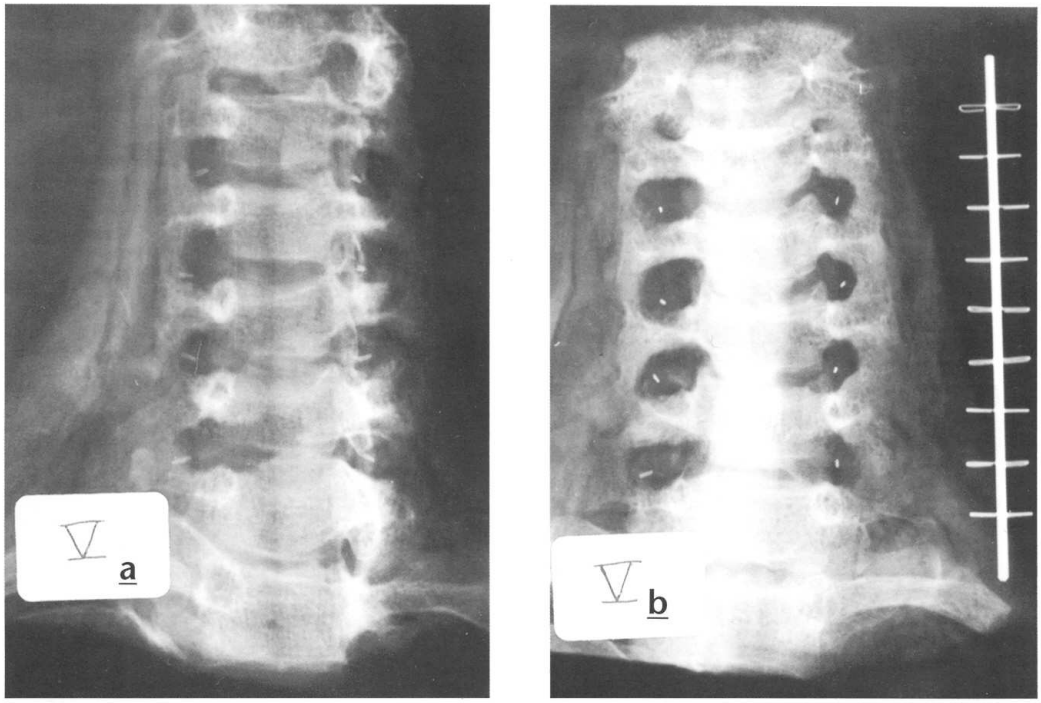


Figure 5, a) Oblique, and b) A/P views. The medial one-third of the left and medial two-thirds of the right facet joints are removed. On oblique views, we couldn't observe any change in the sizes of the neural foraminae, even after large facetectomies. The extent of decompression was more prominent on A/P projections, especially after facetectomies, and this finding was supported by the position of the radiopaque clips.

Facetectomy: The distance from the dural tube to the ipsilateral vertebral artery was statistically longer in the lower cervical segments. Mean distances were measured as 8.2 mm in group I and 11.5 mm in group II segments. In the upper segments, the vertebral artery was located on the same sagittal plane with medial one-third of the ipsilateral facet in 20 (83.3 %) and with middle one-third in 4 (16.7 %) sides (Figures 2 and 4). But in the lower cervical segments, the vertebral artery was positioned more anterolaterally. While eight (50 %) of them were on the same sagittal plane with medial one-third of facets, the rest eight (50 %) were located parallel with the middle one third (Figure 3).

X-ray evaluation

We tried to visualize the so-called neural foramen with oblique roentgenograms. But, we observed little changes on the medial and lateral walls of the foraminae on oblique projections after performing the operative procedures (Figure 5). However, the anteroposterior projections gave the impression of larger decompression of the lateral walls of the neural foraminae after medial facetectomies (Figure 5). The radiopaque clips, which were placed during facetectomies, were situated more laterally, indicating the extended exposures of the the nerve roots via posteriorly. Unfortunately, the decompression of the medial wall of the foramen was again not clearly visible on anteroposterior projections (Figure 6). In a few levels, some widening of the medial walls of the foraminae due to the resection of the uncovertebral joint, could be observed on anteroposterior views only when the lateral decompression had been pursued very vigorously (Figure 6).

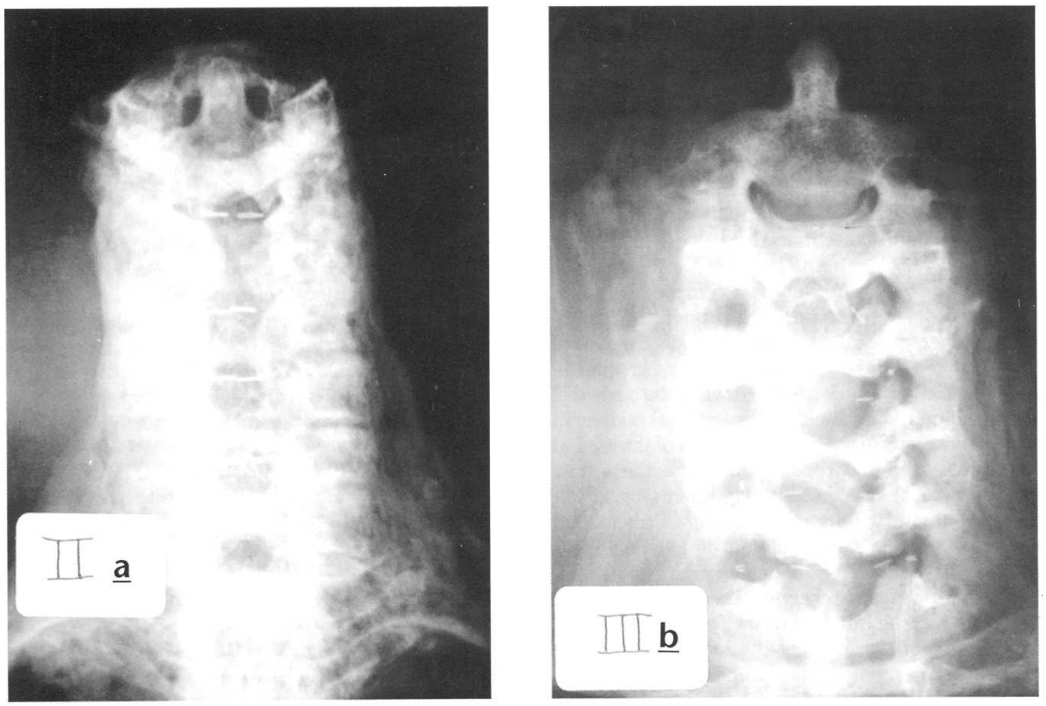


Figure 6, A/P views. a) Unless the lateral dissection was completed satisfactoraly, the decompression obtained via anteriorly, would be very limited. The radiopaque clips indicating the lateral extent of exposures via anteriorly, located at the lateral edges of the burr-holes, b) The fact that the exposed root segments were longer after facetectomies, could be confirmed on A/P views. The radiopaque markers, which were placed after vigorous curettage, were seen more laterally, but they were still quite medial to the others, which were placed after the resection of the medial one-third of the facets(left side).

DISCUSSION

Cervical radiculopathies may be treated with various techniques performed either anteriorly (3, 7, 15, 18, 24) or posteriorly (1, 9, 22). But the controversy is still largely unsettled, and in most instances satisfactory results are obtained with both approaches (6, 10, 12, 16, 17, 23). However, the lesion leading to radiculopathy should dictate which approach to be used (1, 2). If the surgeon knows the advantages and risks of each procedure, he or she will be able to choose the best and safest procedure for a particular case (20).

Since the posterior longitudinal ligament and the uncovertebral joints are relatively easy to be approached via anteriorly, the Cloward's technique is widely accepted for the surgical management of the cervical disc diseases (10, 12, 13, 16, 17, 25). However, the actual area of nerve root compression at the neural foramen may sometimes be missed in cases with anterolateral disc herniations or osteophytes (20), because in our study, only 3.6 mm of nerve root could be exposed in the upper, and 4.1 mm in the lower cervical segments, even when the lateral dissections were vigorously pursued. Another procedure that can be preferred in those cases is the Smith-Robinson technique, in which more resection of the medial uncovertebral joint with the high speed drill is possible when the two adjacent vertebral bodies are distracted (24). In such cases, the possibility of a posterior approach should also be searched (1, 12), because the mean lengths of the exposed nerve roots after the resection of medial one-third or two-thirds of facets were ranging between 4.5 and 6.0 mm in this study, and they were longer than those obtained via anteriorly.

An attempt to achieve an extended exposure should always remind some probable risks. In the anterior approach, this extended exposure could only be accomplished by lateral and upward blind curettage. At this stage, the vertebral artery is the limiting factor for any further dissection, and the surgeon should remember how far the vertebral artery is from the lateral edge of the decompressed bone. We measured the distance from the dural tube to the ipsilateral vertebral artery as 8.2 mm in the upper and 11.5 mm in the lower cervical segments. Even a vigorous curettage is attempted, a safety distance of 4.6 mm remains in the upper and 7.4 mm in the lower cervical segments. In fact, the risk of vertebral artery injury is less than one percent (8), and practically it may be avoided when the burr-hole is opened on the midline of the vertebral bodies. In the posterior approach, more resection of the medial facet is required for exposing the root axilla and its lateral extension into the neural foramen (1, 9, 20). In the present study, only the resection of the medial two-thirds of the facet enabled us to visualize a statistically significant extended exposure of the root. But this amount of resection inevitably leads to defficiency in the function of the facet joint (21). So, the amount of resection of the facet joint did not exceed fifty percent in many reports (1, 9, 14, 20). Another difficulty observed during posterior approach is the decompression of the area of the uncovertebral joint. Not only it is usually hard to resect any significant amount of bone ventral to the intervening spinal cord and root, but this also increases the risk of vertebral artery injury (1, 20). Our cadaveric study confirmed this, since the vertebral artery was located on the sagittal plane parallel with the medial one-third of the ipsilateral facet in 70 % of the operated sides and with the middle one-third in 30 %. In addition, there were very short safety distances beyond the most lateral edge of the exposed root to the vertebral artery. A more extended facetectomy for a safe operative trajectory between the dural tube and the vertebral artery might be expected. But this operative corridor would be very narrow, and the length of the exposed root would not significantly increase. Moreover, it might result with a destabilized cervical spine.

On oblique x-ray projections, we could not show any decompression on either the medial or lateral walls of the neural foraminae. Raynor et al. reported a similar observation pointing out the inefficacy of oblique views in demonstrating the decompreesion at the neural foramen (20). Contrary to this, a comparison between the two operative procedures was more easy on anteroposterior views. The radiopaque markers which were placed to identify the most lateral exposed edges of the roots determined a better exposure facility of facetectomy. Also, the decompression on the lateral wall of the foramen with medial facetectomy was more prominent than the decompression on the medial wall observed after the classical Cloward's technique.

Both approaches have some advantages, disadvantages, risks and limitations. The nature of the lesion (soft disc or osteophyte), and its location (medial or lateral, dorsal or ventral) should be considered in each case. The decision must be made after a careful evaluation of the clinical and neuroradiological features of the patients to alleviate the nerve root compression satisfactorily.

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