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ORIGINAL ARTICLE

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Details of fibroligamentous structures in the cervical unco-vertebral region: an obscure corner

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Abstract Vertebral bone, joints and ligaments on the cervical spine are structures that maintain the stability of the spine and protect the neurovascular structures. Determining the detailed anatomical location of the intervertebral foramen and unco-vertebral (UV) region with respect to the vertebral bone, joint and ligaments is critical when choosing the safest surgical approach to the cervical spine. We studied the microscopic detailed anatomy of the dural covering and posterior longitudinal ligament (PLL) in eight cadaver specimens and the relevance of these structures in the UV region from C4 to C7. The uncinate process (UP) and its covering ligaments are mechanical barriers that prevent the nerve root and the vertebral artery against unintentional surgical damage. Dissection at the posterolateral surface of the UP revealed a separate perivascular fibroligamentous tissue (PVFLT) that originates from the PLL. The recognition of the PVFLT may provide for safe surgery by protecting the neural and vascular structures during decompression in the UV region.

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Description des structures fibroligamentaires de la région cervicale unco-vertébral: un coin obscur

Résumé L'os vertébral, les articulations et les ligaments de la colonne cervicale sont des structures qui maintiennent la stabilité de la colonne vertébrale et protègent les structures neuro-vasculaires. La reconnaissance de la localisation anatomique détaillée du foramen intervertébral et de la région unco-vertébrale, en fonction de l'os vertébral, de l'articulation et des ligaments, est délicate lorsque l'on choisit une voie chirurgicale sûre pour la colonne cervicale. Nous avons étudié l'anatomie microscopique détaillée de la couverture durale et du ligament longitudinal postérieur sur huit cadavres. L'aspect de ces structures dans la région unco-vertébrale a été étudié de C4 à C7. Le processus uncinatus ou uncus et ses ligaments qui le recouvrent sont des barrières naturelles qui préviennent la racine nerveuse et l'artère vertébrale d'une lésion chirurgicale non intentionnelle. La dissection de la surface postéro-latérale de l'uncus révèle un tissu fibro-ligamentaire péri-vasculaire distinct (PVFLT) qui prend son origine du ligament longitudinal postérieur (LLP). L'identification du PVFLT permet une chirurgie sûre en protégeant les structures neurologiques et vasculaires pendant la décompression de la région unco-vertébrale.

Keywords Cervical spine · Discectomy · Uncinate process · intervertebral foramen · Posterior longitudinal ligament

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Introduction

Detailed anatomical information about the cervical unco-vertebral (UV) corner is necessary for diagnostic

and surgical purposes concerning the lower cervical region. Cervical spondylodiscopathy can be managed surgically via an anterior or anterolateral approach and complete cervical disc and/or osteophyte resection are required for decompression [4, 7, 8, 11]. The anterior discectomy technique sufficiently exposes the midline spinal canal, but provides limited exposure to the lateral neural canal. If the problem is osteophyte and/or intraforaminal disc compression at the UV region, the standard anterior cervical approach is not sufficient with its limited exposure through the posterior part of the uncinate process (UP) [6, 7, 8, 10, 11, 16]. To better understand the ligamentous elements that encompass the UV region, it is beneficial to study morphological observations and to create a set of quantitative data for this ligamentous structures. This study was undertaken to accurately locate and specify the relationships of the neural, vascular and ligamentous structures in relation to the UP and the posterior longitudinal ligament (PLL) in anterior cervical spine surgery.

Materials and methods

This study was based on the dissection of eight formalin-fixed human cadaveric spines from C4 to C7. All cadavers were in the sixth decade of age; six of them were male and two were female. The dissection was performed under magnification with an operating microscope (Opmi 6, Zeiss, Germany). The cervical cadaveric column was approached anteriorly. The longus colli was dissected and the usual anterior cervical discectomy was performed. With the aid of an air drill, complete discectomy, partial and then complete resection of the UP (uncusectomy) and partial vertebrectomy were performed in all the specimens. The posterolateral portion of the vertebral body edge and the UPs were drilled for an anterolateral approach to expose the UV areas. The PLL was exposed at the posterolateral turn on the vertebrae. The PLL was carefully dissected anteriorly and partially excised to study its relation to the nerve root and ligaments of the UV. Subsequently the PLL and its extension were completely opened to explore the spinal epidural space, nerve root and vascular structures. The vertebral artery and venous plexus were then displayed (Fig. 1). At the end of the dissections, all the specimens were cut axially and photographed at the level of the disc space. Indirect photographic measurements of the PLL and ligamentous structures at the UV region were performed in eight formalin-fixed human cadaver cervical spines using the 3D-Doctor Software. Parameters measured on the UV region involved only width of the ligamentous structures from the axial sections. Using a paired *t*-test, measurement results were statistically compared between right and left sides. One of the specimens was examined histologically after Masson trichrome staining, which stains fibroligamentous and collagen tissue in blue.

Results

The anatomical relationships among the UP, neural foramen and ligaments from C4 to C7 were analyzed in eight cadaveric specimens. In all the specimens, the anterior elements of the spine were approached anteriorly under microscopic magnification. Neural root, vascular structures and ligamentous tissue were exposed with fine dissections.

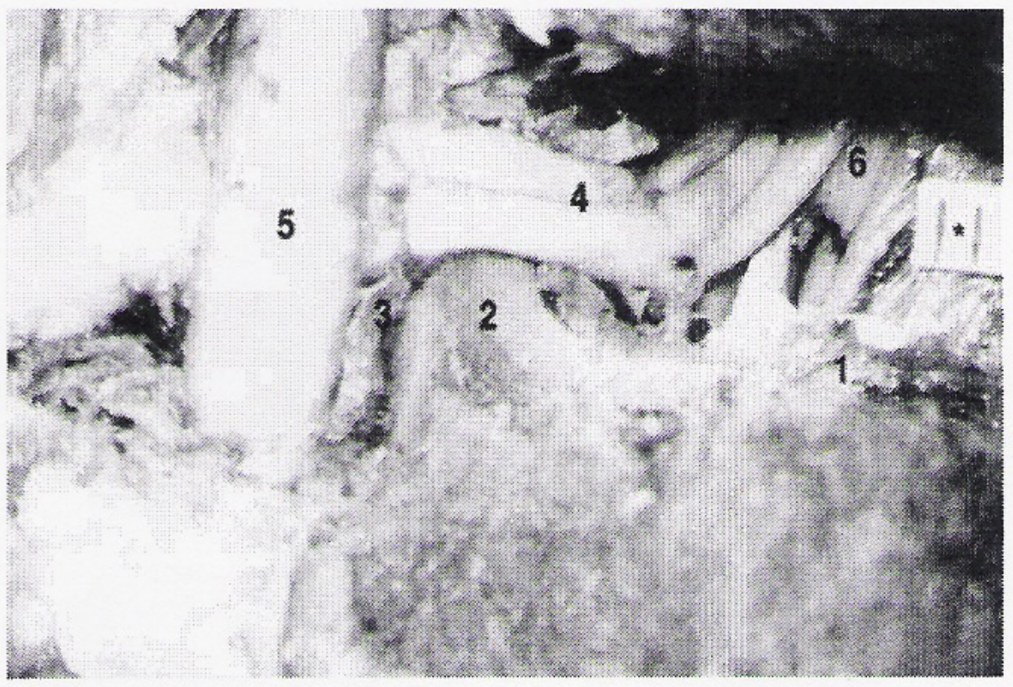

Fig. 1 Anterolateral exposure of the unco-vertebral corner after discectomy; partial uncusectomy reveals neurovascular and fibroligamentous relations; posterior longitudinal ligament (PLL) and dural sheaths are sectioned for exposure of the neural root. *1*, PLL; *2*, uncinate process; *3*, perivascular fibroligamentous tissue (PVFLT); *4*, neural root (with motor and sensory components); *5*, vertebral artery; *6*, cervical spinal cord; *, a millimeter ruler is placed on the anterior surface of the spinal cord

The UP is a bony projecting edge from the posterolateral aspect of each cervical vertebral body. The posteroinferior side of the upper cervical body articulates with the UP of the lower vertebral body. This articulation is covered by ligamentous tissue originating from the PLL that lies on the posterior part of the vertebral bodies at the level of the neural foramen. The PLL lies on the posterior aspect of the vertebral bodies and has two loosely connected layers named the anterior layer (which covers annulus fibrosus) and the posterior layer (which covers directly the dura mater of the spinal cord) [1, 9]. Laterally, the PLL was attached to the posterior end of the UP from its base.

The results of width of the ligamentous structures taken from the specimens are shown in Table 1. The average width of the ligamentous structures at the UV region for male and female specimens consistently increased from C4 to C6. The mean width of the PLL for al levels ranged from 1.84 ± 0.40 mm to1.95 ± 0.39 mm (Table 1).

Table 1 Anatomical parameters:posterior longitudinal ligament (PLL) and perivascular fibroligamentous tissue (PVFLT) measurements. All parameters are in millimeters and presented as mean ± standard deviation. Female cervical cadaver columns were included in male groups. *A*, width of the PLL at the unco-vertebral region in axial sections; *B*, width of the anterior layer of PVFLT in axial sections; *R*, right; *L*, left

Variable		C4	C5	C6
A	R	1.89 ± 0.41	1.92 ± 0.40*	1.95 ± 0.39
	L	1.84 ± 0.40	1.88 ± 0.38*	1.92 ± 0.38
B	R	1.60 ± 0.33	1.62 ± 0.37*	1.64 ± 0.28
	L	1.56 ± 0.31	1.58 ± 0.32*	1.61 ± 0.25

*Paired *t*-test *P* value 0.05 in comparison between right and left sides

The PLL was also found to separate into two fibroligamentous bundles at the posterior corner of the UP that we called the perivascular fibroligamentous tissue (PVFLT). It covers the lateral aspect of the UP and the vascular content of the foramen transversarium. We identified a venous plexus between the two layers of the PLL at the transition from PLL to the PVFLT. After removal of the thick anterior layer of the PLL, a vertebral venous plexus was seen consistently between the layers of the PLL laterally just at the posterior part of the UP in all our specimens. At the UV region, thin posterior bundles of the PVFLT covered the outer side of the vertebral vasculature and passed in front of the dural sheath. Anterior bundles of the PVFLT covered the lateral side of the UV region and inner side of the vertebral vasculature. The average width of the anterior layer of the PVFLT for all levels ranged from 1.56 ± 0.31 mm to 1.64 ± 0.28 mm (Table 1). Posterior and anterior bundles reunited loosely after surrounding the vertebral vasculature that was continuous with the periosteum over the anterolateral aspect of the vertebral body to join the anterior longitudinal ligament (ALL). At the site of the UP region, the ligamentous and osseous contents of the specimen were greatly increased and this fibroligamentous structure continued to the vascular contents (Fig. 2). Excision of the PVFLT after removal of the UP can expose the vertebral artery/veins and neural root (Fig. 1). The ventral roots are adjacent to the UP anteriorly and to the pedicle inferiorly. At the level of the caudal end of the foramina, exploration disclosed ventral nerve roots and dorsal nerve root ganglia completely. The vertebral artery resides in a lateral position with respect to the UP and is covered by veins that are located in the lateral aspect of the artery. As a result, all these vascular contents were covered by a fibroligamentous sheath originating from the PVFLT.

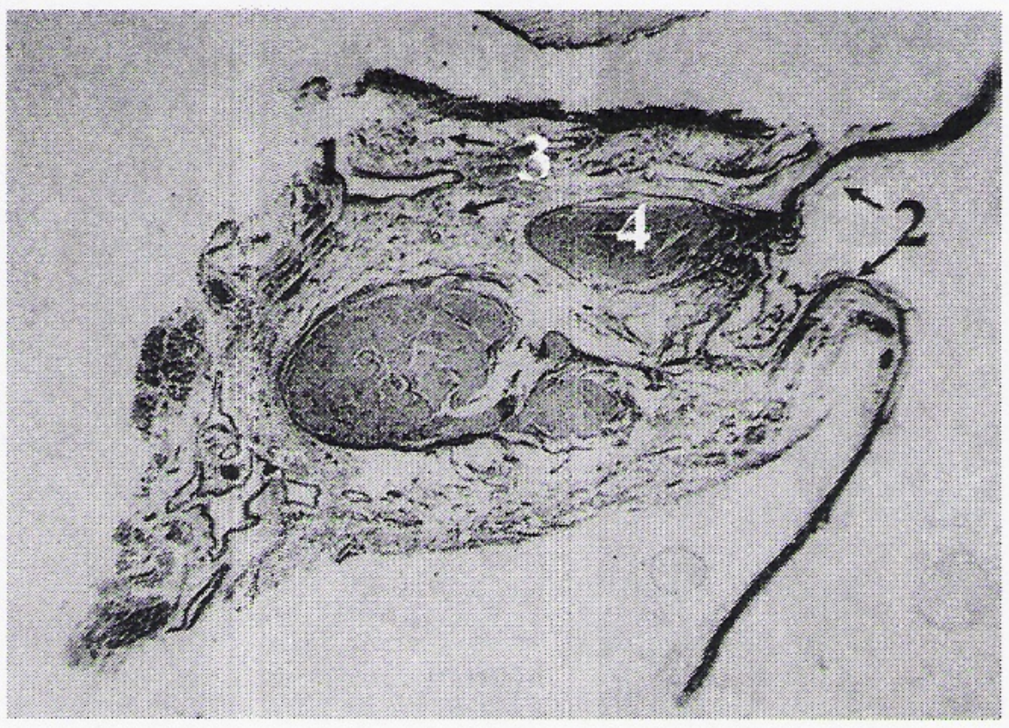

Fig. 2 Axial transsection of the soft tissue specimen at the level of C6; the UVF region is stained by the Masson trichrome stain technique (×6 magnification). *1*, Vascular structures; *2*, dural membranes; *3*, PVFLT including collagen fibers on the ventral and dorsal sides (*arrows*); *4*, neural root

Discussion

Approaches to the cervical spine are basically anterior and posterior [4, 13, 14]. Anterior cervical discectomy has generally been an accepted approach for cervical spondylodiscopathies [2, 4]. Surgeons should be familiar with the detailed microsurgical anatomy of the UV region for safe and sufficient decompression [15]. The present study revealed that in the anterolateral portion of the spinal canal, the posterior and anterior layers of the PLL form a protection for the periradicular and perivascular sheath and are attached firmly to the pedicle as a broad wrap, whereas the thick anterior layer of the PLL becomes part of the annulus fibrosus also and sends fibers to it as we have seen in histopathological specimens of the PVFLT.

During an anterior approach to the cervical spine, the surgeon can open both layers of the PLL with good hemostasis and can achieve complete decompression of the nerve root. During surgery, the PLL is a protective layer for the spinal cord and nerve roots. This study suggests that the anterior cervical discectomy procedure is safe in the medial part of the spinal canal, but during resection of the UP it carries the risks of vertebral arterial/venous bleeding, dural tear and neural injury. The vertebral vasculature is surrounded by a fibroligamentous sheath originating from the PVFLT (Fig. 3). The compressive effect of these fibroligamentous bands has been incriminated in symptomatic vertebral artery stenosis, and surgical release has been reported as a means

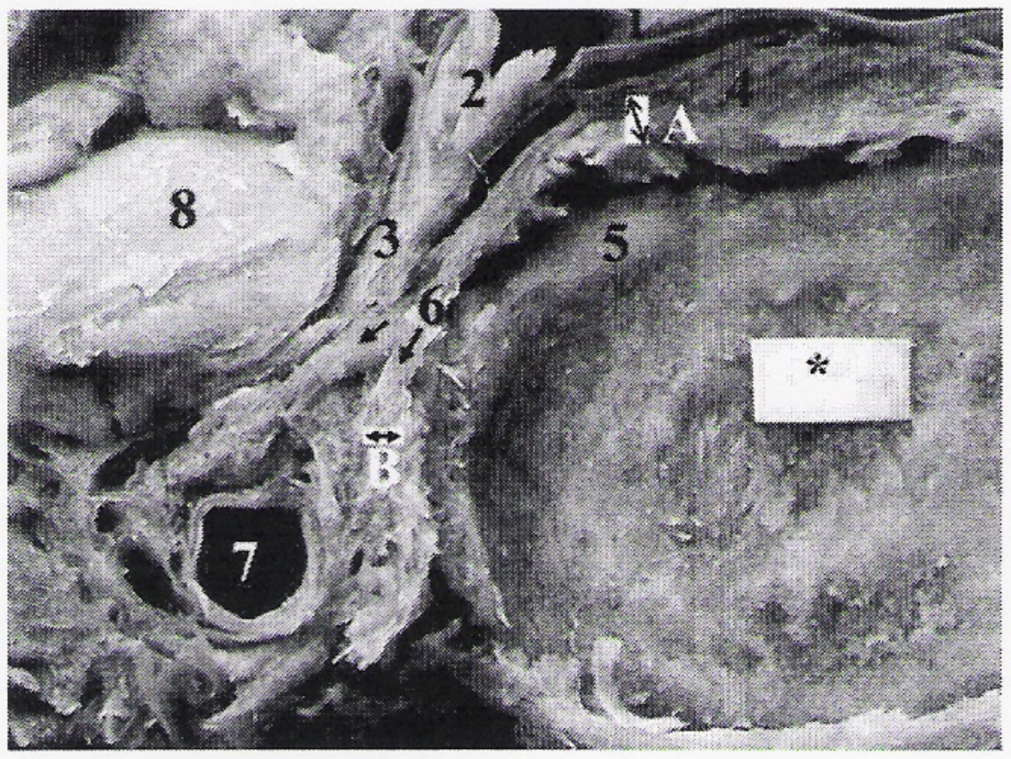

Fig. 3 In axial section at the unco-vertebral level, the PLL makes an angle at the posterior part of the uncinate process (UP), which divides into two separate bundles (PVFLT). This structures covers the lateral aspect of the UP and vascular contents (vertebral artery and veins) of the foramen transversarium. *1*, Spinal cord; *2*, neural root with motor and sensory components in oblique section; *3*, periradicular dural sheath over the neural root; *4*, PLL; *5*, uncinate process; *6*, PVFLT including anterior and posterior bundles (*arrows*); *7*, vertebral artery; *8*, superior articulate facet; *, millimeter ruler on the vertebral body; *A*, width of the PLL; *B*, width of the anterior bundle of the PVFLT

for the artery to regain its normal caliber [3, 17]. Based on cadaveric observation, protection of the anterior bundles of the PVFLT eliminates risks of injury to the neural root and vertebral artery. It is important to follow the covering if the normal anatomical plane is to be safely dissected during decompression of the neural root. Drilling and curettage of the posterior part of the UP creates sufficient space to explore sequestrated disc fragments and direct decompression of the nerve root. In the case of severe foraminal disc sequestration, which can occur due to defective fibroligamentous structures or broad-based unco-vertebral osteophyte formation, further removal is performed through the space obtained by drilling the UP with or without excision of the PVFLT. Careless resection of the UP for the decompression causes injury to the vascular and neural structures in the UV region [5, 12, 18, 19, 20].

Conclusion

To determine the exact location of the UP, neural root and vertebral artery connected with the PLL and PVFLT is wise before surgery. This study revealed that the UP is covered posterolaterally by a separate layer of fibroligamentous tissue that originates from the PLL, which we called the PVFLT. Protection of the PVFLT is pivotal in avoiding injury during decompression of the neural root. If the vertebral artery or nerve root is to be exposed then resection of the UP and section of the PVFLT are necessary, which are identified as an "entrance gate".

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