REVIEW

Anatomy and Clinical Significance of the Uncinate Process and Uncovertebral Joint: A Comprehensive Review

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Introduction: The uncinate process and its associated uncovertebral articulation are features unique to the cervical spine. This review examines the morphology of these unique structures with particular emphasis on the regional anatomy, development and clinical significance.
Materials and Methods: Five electronic databases were utilized in the literature search and additional relevant citations were retrieved from the references. A total of 74 citations were included for review.
Results: This literature review found that the uncinate processes and uncovertebral articulations are rudimentary at birth and develop and evolve with age. With degeneration they become clinically apparent with compression of related structures; most importantly affecting the spinal nerve root and vertebral artery. The articulations have also been found to precipitate torticollis when edematous and be acutely damaged in severe head and neck injuries. The uncinate processes are also important in providing stability and guiding the motion of the cervical spine.
Conclusion: This review is intended to re-examine an often overlooked region of the cervical spine as not only an interesting anatomical feature but also a clinically relevant one. Clin. Anat. 27:431–440, 2014.

Key words: uncinate process; uncovertebral joint; Luschka joint; cervical spine

INTRODUCTION

The uncinate process and its associated uncovertebral articulation are features unique to the cervical spine. In 1834, Rathke described the uncinate process as a prominence found on the posterior craniolateral edge of the vertebral body (Brismee et al., 2009). Von Luschka, in 1858, further described the uncinate process and went on to describe the uncovertebral joint which exists between the uncinate process and the vertebra above (Silberstein, 1965). Von Luschka originally described the uncinate process as "eminentia costaria" due to its resemblance to the head of a rudimentary rib (Ugur et al., 2000). The term "processes uncinatus" first appeared in 1893 when Trolard introduced it (Pait et al., 1996). Since these early descriptions the uncinate processes and the uncovertebral articulations have been studied anatomically, histologically, developmentally, radiologically, and biomechanically. The purpose of this review is to describe the anatomical features of the uncinate process and its relationship to the adjacent vertebrae as well as to describe their clinical significance.

METHODS

A review of the literature was conducted by searching the following databases from their earliest publication date until June 2012: Ovid MedLine, PubMed, Embase, AMED, and Web of Science. Figure 1 shows the search strategy. Articles retrieved were limited to the English language and duplicates were removed. The articles were

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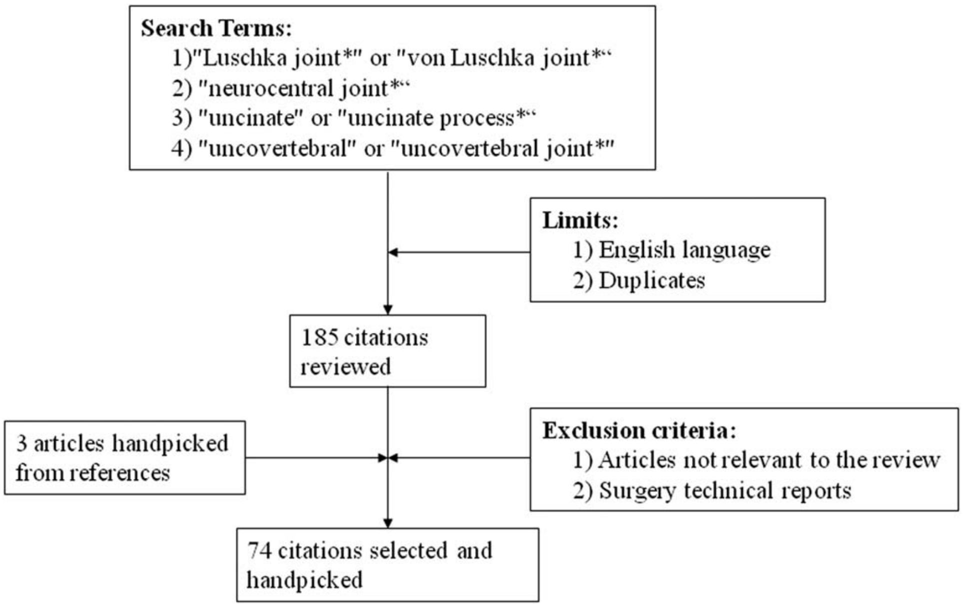

Fig. 1. Literature search strategy.

reviewed and excluded if they were not relevant to the purpose of this study or were limited to surgery technical reports. Additional citations were retrieved from the references of papers if they were deemed to be important to this review.v

ANATOMY

Uncinate Process

In the vertebral column, the uncinate processes are found cranially at the level of the third cervical vertebra and extend caudally to as low as the second thoracic vertebra (Tulsi and Perrett, 1975). The most common vertebral segments to possess uncinate processes are C3 to C7 and are thus the most extensively studied (Bland and Boushey, 1990; Browne, 2010; Tubbs et al., 2012). Uncinate processes are variably absent on C7 and have been described to extend to T1 and T2 on occasion (Tulsi and Perrett, 1975). The uncinate processes are described as bony excrescences, protuberances, prominences, ridges, lips, or projecting edges situated on the lateral or posterolateral margins of the superior endplates (Lyon, 1945; Bland and Boushey, 1990; Del Sasso et al., 1991; Pait et al., 1996; Clausen et al., 1997; Kotani et al., 1998; Ugur et al., 2000; Yilmazlar et al., 2003a,b; Lee et al., 2006; Browne, 2010). They have an anterior slope, an apex, a posterior slope as well as a medial articular surface (Browne, 2010). The uncinate processes give the superior end plate of the vertebral body a concave appearance in the coronal plane (Lyon, 1945; Taylor et al., 2000). The uncinate processes are more anteriorly positioned in the upper cervical spine and become more posteriorly located in the lower vertebral segments (Tulsi and Perrett, 1975).

The height of the uncinate process (Fig. 2), as reported in 10 studies, tends to show an increase from C3 to the lower cervical spine. This trend was not observed in two studies where Civelek et al. (2007) and Pait et al. (1996) found C5 to be shorter than its neighboring C4 and C6 uncinate processes. Also, the height of the C7 uncinate process was found to be shorter than the adjacent C6 uncinate process in four of the 10 studies (Milne, 1991; Lu et al., 1998; Saringer et al., 2003; Civelek et al., 2007). The height of the uncinate processes ranged from the shortest measurement of 2 mm measured at C7 to the highest measurement of 10.5 mm at C6 (Russo et al., 2011; Tubbs et al., 2012). It is important to note that the morphometric data reported in the studies reviewed were obtained from different types of specimens, including fresh cadavers and dried disarticulated spines, which may account for the variability. Similar to the height of the uncinate process the width (Fig. 2) also tends to show an increase from C3 to C7. The average widths ranged from 4.6 mm at C3 to 7.4 mm at C7 (Lu et al., 1998; Civelek et al., 2007). In two of the six studies, the average width of the C5 uncinate process was narrower than its neighboring C4 uncinate processes and in one study the C5 uncinate process was found to be wider than its neighboring C6 processes. (Pait et al., 1996; Lu et al., 1998; Civelek et al., 2007). Yilmazlar et al. (2003) attributed the increased width of the uncinate process at C5 to spondylosis secondary to the increased cervical segmental motion at this level. Four studies assessed the anterior-to-posterior length (Fig. 2) of the uncinate process which also followed a general trend of increasing from C3 to C7. The average length ranged from 6.0 mm at C7 to 13.0 mm at C7 (Ugur et al., 2000; Tubbs et al., 2012). Two of the five studies however reported that the length of the C7 uncinate

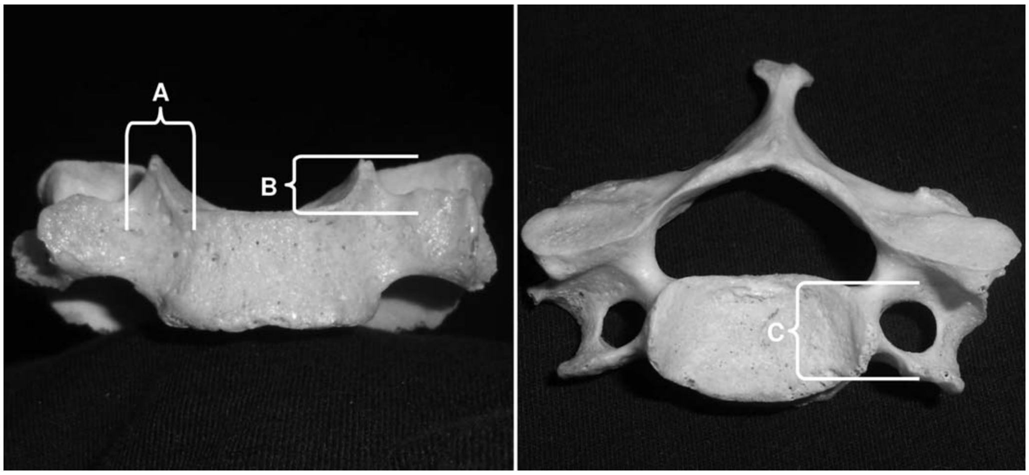

Fig. 2. Uncinate process width (A), height (B), and length (C).

process was less than the adjacent C6 uncinate process (Lu et al., 1998; Tubbs et al., 2012). Panjabi et al. (1991) measured the inclination angle of the uncinate process relative to the sagittal plane (Fig. 3) and found it to be relatively constant with C7 having the largest angle. The average angle was 40.3° and the range was 34.5–47.3°. They also assessed the angle between the long axis of the uncinate process and the frontal plane (Fig. 3) and found the angle to increase significantly from C5 to C7. The average angle was 91.02° and the range was 76.2–115.6°. Saringer et al. (2003) measured the angle between the long axis of the uncinate process and the sagittal plane (Fig. 3) and found a similar trend of an increasing angle towards the lower cervical spine. The average measurement was 5.06° and the range was 0.4–11.6°. Ugur et al. (2000) and Bozbuga et al. (1999) assessed the angle between the medial surface of the uncinate process and the superior surface of the vertebra (Fig. 3). They found this angle to vary greatly ranging from 90° to 162°.

Uncovertebral Articulation

In the adult, the uncinate processes on the vertebrae below articulate with the corresponding bevelled surfaces on the inferior aspect of the vertebrae above (Fig. 4) (Lyon, 1945; Francois et al., 1985; Kotani et al., 1998; Sizer et al., 2002; Yilmazlar et al., 2003a). The distance between the cranial tip of the uncinate process and the vertebra above ranges from 0 to 3 mm (Pait et al., 1996). The surface area of the articular surface of the uncinate process is on average 23.4 mm^2 which is nearly half the area of the articular

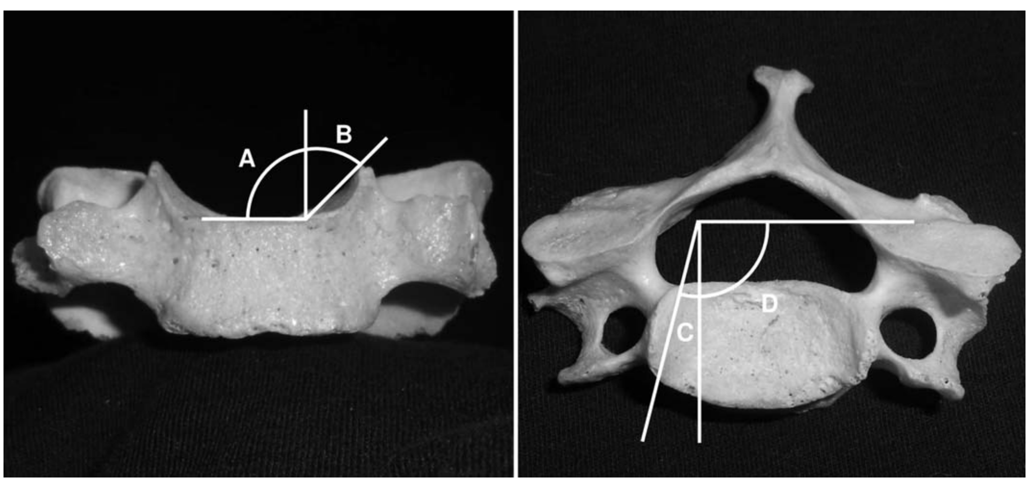

Fig. 3. Inclination angle of the uncinate process relative to the sagittal plane (B), angle between the medial surface of the uncinate process and the superior surface of the vertebra (A + B), angle between the long axis of the uncinate process and the frontal plane (C + D), angle between the long axis of the uncinate process and the sagittal plane (C).

Fig. 4. *Left:* Anterior view of the cervical spine segments C3–C7. The uncinate processes can be observed on the lateral margins of the superior endplates projecting superiorly to articulate with the corresponding inferior endplate. *Right:* Oblique view of the cervical spine segments C3–C7. The uncovertebral articulation (arrow) can be seen contributing to the anteromedial boundary of the intervertebral foramen (star).

surface on the vertebrae above which averages 44.2 mm^2 (Panjabi et al., 1991). The articulation is enclosed laterally by unorganized connective tissue creating a pseudocapsule (Prescher, 1998; Mercer and Bogduk, 1999; Taylor et al., 2000). Mercer and Bogduk (1999) termed this connective tissue structure “periosteofascial tissue.” It was described as arising from deep to the lateral edge of the posterior longitudinal ligament and passing anteriorly to enclose the lateral uncovertebral articulation. The periosteofascial tissue continues anterior passing deep to the lateral portion of the anterior longitudinal ligament to blend with the outer fibres of the anulus fibrosus. Yilmazlar et al. (2003) termed this connective tissue structure “perivascular ligamentous tissue (PVLT)” and “perivascular fibroligamentous tissue (PVFLT)” (Yilmazlar et al., 2003a,b). This structure was described to arise from the posterior longitudinal ligament and divide into anterior and posterior bundles. The anterior bundle encloses the lateral aspect of the uncovertebral articulation before passing to the medial aspect of the vessels transmitted by the transverse foramen. The posterior bundle passes from the posterior longitudinal ligament to the lateral aspect of the vessels, meeting anteriorly with the anterior bundle to surround the vertebral artery and venous plexus. After uniting anteriorly the bundles join the anterior longitudinal ligament. It is not entirely clear if the anterior bundle of the PVLT is a distinct structure or is analogous to the periosteofascial tissue described by Mercer and Bogduk.

Fig. 5. Superior view of a cervical vertebra. The uncinate process (asterisk) is found on the lateral margin of the superior endplate in close proximity to the intervertebral foramen (double-headed arrow) and foramen transversarium (star).

The uncovertebral articulation has an intimate relationship with the cervical intervertebral disc. The anterior anulus fibrosus in the median plane is thick but progressively tapers to reach the uncinate process and enclose the anterior aspect of the uncovertebral joint space (Mercer and Bogduk, 1999). The posterior anulus fibrosus is thin throughout and arises from the bases of the uncinate processes. In the region of the uncinate process the anulus fibrosus is absent. Medially the uncovertebral joint space is not enclosed by a capsule-like structure. The joint space is formed by a fissure into the fibrocartilaginous core of the intervertebral disc (Payne and Spillane, 1957; Wilkinson, 1960; Silberstein, 1965; Pesch et al., 1984; Bland and Boushey, 1990; Milne, 1993; Pait et al., 1996; Clausen et al., 1997; Prescher, 1998; Yoganandan et al., 2001; Sizer et al., 2002; Brismee et al., 2009). This space extends medially in the posterior aspect of the disc for a variable distance and often unites with the fissure of the opposite joint space (Bland and Boushey, 1990; Prescher, 1998; Yoganandan et al., 2001). The presence of synovial tissue within the uncovertebral articulation has been debated. Von Luschka originally described the uncovertebral articulations as true joints containing synovial fluid and lined with a synovial membrane exhibiting papillary processes. Payne and Spillane (1957) disagreed with Von Luschka's assessment as they failed to observe synovial membrane on histological examination. Others including Silberstein (1965) found synovial tissue in adult specimens but not in younger spines and attributed this finding to a metaplasia. Most recently Brismée et al. (2009) identified conclusively that synoviocytes were present in the lateral joint capsule tissue of elderly uncovertebral articulations. Brismée et al. (2009) also investigated the innervation of the uncovertebral articulation with immunohistochemical methods. They demonstrated that the uncovertebral articulation receives nerve fibres from the somatic and autonomic nervous system and that the articulation is a potential pain generator in the cervical spine. Research to date has not identified the peripheral nerve source and spinal segments of origin of these nerve fibres.

Development

The uncinate process is a phylogenetic remnant of the costovertebral joint in reptiles and birds (Bland and Boushey, 1990). This feature was apparent to Von Luschka as he named the process "eminentia costaria" due to its resemblance to the head of a rudimentary rib. The uncinate process begins its development inutero and is apparent by three to four months of fetal development (Orofino et al., 1960). Once the fetus reaches full term the interspace between the uncinate process and vertebrae above is devoid of synovial tissue; rather it is filled with loose fibrous tissue and many blood vessels (Orofino et al., 1960). This is in contrast to other joints which show synovial tissue formation around 10–11 weeks and by the time the fetus is full term they exhibit well formed joints with a clear synovial lining (Orofino et al., 1960). The uncinate process grows upward from the age of 4 and continues to enlarge from age 9 to 14 years (Bland and Boushey, 1990; Taylor et al., 2000). As the uncinate processes enlarge, fissures begin to form in the lateral and posterolateral intervertebral discs between the age of 8 or 10 years (Pesch et al., 1984; Bland and Boushey, 1990; Taylor et al., 2000). These fissures give rise to the joint space of the uncovertebral articulation. Between the ages of 20 and 35 years the clefts continue to bisect the disc towards the midline where eventually they unite with the fissure of the opposite side by 45 years of age (Bland and Boushey, 1990; Taylor et al., 2000). Therefore, the fissure formation proceeds from the periphery towards the centre of the disc (Maigne et al., 2003). In older spines, these fissures transect the posterior two thirds of the intervertebral disc (Mercer and Bogduk, 1999). Anterior to the fissure remains the fibrocartilaginous core of the intervertebral disc (Mercer and Bogduk, 1999). Prescher (1998) attributed the formation of the uncovertebral fissures to loads experienced by the cervical spine secondary to cervical motion and the development of the cervical lordosis. He noted that the loads placed on cervical segments C3 through to C5 as increasing as a consequence of the development of the cervical lordosis. These segments were also the first to demonstrate the formation of the clefts. Fissure formation was also believed to be a consequence of shear forces experienced by the intervertebral disc during rotation and lateral flexion of the cervical spine. Mercer and Bogduk (1999) state that during axial rotation the uncovertebral clefts are necessary to allow the posterior corners of the vertebral body to swing laterally as the vertebrae pivots around its axis of rotation (Mercer and Bogduk, 1999). With age, the uncovertebral articulation continues to evolve. The once erect uncinate process with its sharp tapered tip begins to enlarge and flatten (Pait et al., 1996). With time, the uncinate process develops osteophytic lipping where the tip turns laterally (Taylor et al., 2000). The conformational change in the architecture of the uncinate process is believed to occur in part to the age related changes in the intervertebral disc. Dehydration and narrowing of the cervical intervertebral discs begin to occur in the fourth and fifth decades of life (Dvorak, 1998). With narrowing of the intervertebral discs the uncinate processes bear a greater load to support the weight of the head. The vertebra above comes to rest on the uncinate processes below which results in remodeling to the flattened and laterally directed configuration (Resnick, 1985; Dvorak, 1998; Prescher, 1998; Dvorak et al., 2003).

Regional Relationships

The intervertebral foramina in the cervical spine extend anteriorly from the vertebral canal at an angle of 45° relative to the coronal plane (Pech, 1988; Ebraheim et al., 1997). The anteromedial boundary of the intervertebral foramen (Fig. 4) is formed by the posterolateral aspect of the uncovertebral joint (Lyon, 1945; Cave et al., 1955; Boreadis and Gershon-Cohen, 1956; Raynor, 1983; Kotani et al., 1998;Tanaka et al., 2000; Shen et al., 2004). The posterior aspect of the uncovertebral joint is related to the anterior aspect of the axilla of the ventral nerve root and the lateral portion of the spinal cord (Ebraheim et al., 1997). As the nerve roots pass through the intervertebral foramen they are found in the lower third of the space with the apex of the uncinate process being above each root (Pech, 1988; Ebraheim et al., 1997). The more anterior portion of the uncovertebral joint has its lateral surface being in proximity to the vertebral artery and its accompanying venous plexus (Yilmazlar et al., 2003b). The distance between the medial margin of the foramen transversarium (Fig. 5), in which the vertebral artery and veins travel, and the uncinate process increases in size from C3 to C7 (Ebraheim et al., 1996; Oh et al., 1996; Ebraheim et al., 1997; Ugur et al., 2000). The segment of the vertebral artery that is related to the uncinate process is the portion that is located between the transverse processes of adjacent vertebrae. Nourbakhsh et al. (2010) demonstrated that these intertransverse segments demonstrate tortuosity in 13.4% of all intertransverse segments. Tortuosity was greatest at the third to fifth intertransverse spaces and was more likely to be present in segments demonstrating degeneration. Nourbakhsh et al. explained the tortuosity in part due to the loss of disc height and fixation of the vertebral artery to the vertebra at the level of the transverse foramen. Of the intertransverse segments that showed tortuosity, 9.7% showed inward looping becoming more closely related to the uncinate process. Measurements of the distance between the tip of the uncinate process and the medial aspect of the vertebral artery have been attempted by a number of investigators; their results have shown variable measurements. This is likely due to the tortuosity described by Nourbakhsh et al. Therefore, using the distance from the uncinate process to the foramen transversarium as a surrogate measurement for the distance to the vertebral artery may be misleading due to the presence of tortuosity.

Function

The uncovertebral articulation contributes to the spinal motion segments mobility and stability as well as functions to protect the intervertebral foramen contents from herniated disc material. The spinal segments' mobility throughout flexion, extension, lateral flexion, and rotation is influenced by the structure of the uncinate processes and their articulation with the vertebra above. Milne (1991) agreed with the hypothesis of Ecklin that the uncinate processes serve as guide rails to control the anteroposterior translation that occurs during flexion and extension in the sagittal plane (Milne, 1991). The height of the uncinate processes at the posterolateral aspects of the superior endplate limit the coronal plane motion as the vertebra above translates on the vertebra below during flexion and extension. Motion in the coronal plane that occurs during lateral flexion is coupled with axial rotation. Penning and Wilmink (1987) described the coupled motion as being a function of the shape of the superior endplate including the uncinate processes. With the uncinate processes being located posterior on the superior endplate they abut the posterior part of the vertebra above during lateral flexion. As a result the uncinate process forces the posterior part of the vertebra in the opposite direction of lateral bending while the anterior portion continues to translate towards the direction of bending. This opposite translation of the anterior and posterior aspect of the vertebra induces rotation. Clausen et al. (1997) investigated the biomechanical role of the uncovertebral articulation and were in agreement with Penning and Wilmink that the uncovertebral articulation was a significant contributor to coupled motion. It is important to note that although the uncovertebral articulations contribute to the observed coupled motion between lateral flexion and axial rotation the zygapophysial joints also play a significant, if not more important, role in dictating the pattern (Chen et al., 2001; Yoganandan et al., 2001).

In addition to influencing the mobility of the spinal segments the uncinate processes provide stability. Kotani et al. (1998) and Snyder et al. (2007) demonstrated that the posterior part of the uncinate process provides more stability than the anterior part. They believed this finding was due to the wider and taller morphology of the posterior part compared to the anterior part of the uncinate process. The uncinate processes function to limit lateral flexion and posterior translation (Kotani et al., 1998). The stability provided by the uncovertebral articulations in lateral flexion was believed to be due to the abutment of the ipsilateral uncinate process on the vertebra above and tension on the contralateral capsule-like structure (Kotani et al., 1998). The uncovertebral articulation was found to contribute in excess of 60% of the stability of the spinal motion segment in extension at C3-C4 (Kotani et al., 1998). The uncinate process also provided stability during axial rotation but it was only the most posterior portion which is related to the intervertebral foramen that was responsible for the stability (Kotani et al., 1998). An additional function of the uncinate process is that of bearing the load of the vertebra above (Yamazaki et al., 2003). With age the intervertebral disc dehydrates and thins leading to an increased load being supported by the uncinate processes (Dvorak, 1998; Dvorak et al., 2003). In assuming greater load, the uncinate processes stabilize the vertebra above on the vertebra below.

Another proposed function of the uncinate process is that of a barrier to herniation at the posterolateral margin of the intervertebral disc (Bland and Boushey, 1990; Taylor et al., 2000). Yamazaki et al. (2003) assessed 200 computed tomographic discograms of patients with myelopathy or radiculopathy secondary to intervertebral disc herniation. Of the 200 herniations observed, 198 were median or paramedian with the remaining two being lateral. The two observed lateral herniations causing radiculopathy occurred at C7-T1 where the uncovertebral articulation is rudimentary or absent. It was concluded that the uncovertebral articulations prevent lateral herniations. Post et al. (2006) investigated intervertebral disc herniations at C7-T1 and concluded that lateral herniations were more common at this level than other cervical segments (Post et al., 2006). They attributed this to the lack of barrier provided by the uncinate processes as well as the increased stresses experienced by the lateral anulus at this level. These stresses were postulated to be due to altered biomechanics secondary to the lack of uncovertebral articulation and fixation of T1 to the thoracic spine. With the barrier function of the uncinate process acting at the posterolateral aspect of the intervertebral disc the intervertebral foramen and its contents are protected against herniated discal material.

CLINICAL SIGNIFICANCE

The uncovertebral articulations are common sites for osteoarthritic changes. These changes manifest as pitting and eburnation of the articular surfaces and distortion of the uncinate process as it develops osteophytic spurring (Cave et al., 1955). Houser et al. (1993) showed that osteophyte formation from the uncinate process follows the typical development of a cartilaginous cap that undergoes progressive ossification to become a mature bony osteophyte. The observed osteoarthritic changes often begin in the fourth decade and progress to involve more uncovertebral articulations and become more distorted with age (Cave et al., 1955; Pesch et al., 1984). These changes are believed to be related to the dehydration and shrinkage of the intervertebral disc which leads to increased load and contact between the vertebra above and the uncinate processes below (Lyon, 1945; Cave et al., 1955; Pesch et al., 1984; Taylor et al., 2000). The uncovertebral articulations preferentially show osteoarthritic changes in the lower cervical spine secondary to the relatively higher loads and stress experienced at these levels (Pesch et al., 1984; Prescher, 1998). The osteophytic spurring from the uncinate processes project laterally and thus can impinge on anatomical structures within the vicinity (Pesch et al., 1984). Structures reported to be affected include the spinal nerve root, vertebral artery, radicular (medullary) artery, cervical spinal cord, and cervical sympathetic trunk (Ebraheim et al., 1997; Houser et al., 1994).

Intervertebral Foramen Stenosis

Osteophytes that arise from the posterior aspect of the uncinate process project into the intervertebral foramen and encroach on its contents (Philip, 1950; Cave et al., 1955; Boreadis and Gershon-Cohen, 1956; Mcginnis and Eisenbrey, 1964; Houser et al., 1993; Prescher, 1998; Giles, 2000). The cervical nerve roots are closely related to the uncovertebral articulations and can become angulated and mechanically irritated by the intruding uncovertebral osteophyte (Cave et al., 1955; Kiwerski, 1991; Dvorak et al., 2003). In cervical spondylosis, the uncovertebral osteophytes are the most common cause of nerve root compression (Lyon, 1945; Raynor, 1983; Lu et al., 1998; Bozbuga et al., 1999; Ugur et al., 2000; Civelek et al., 2007). Further narrowing of the intervertebral foramen can result from posterior encroachment secondary to zygapophysial joint degeneration, ligamenta flava, and periradicular fibrous tissue thickening in addition to further anterior encroachment from protruded discs and a bulging posterior longitudinal ligament (Cave et al., 1955; Prescher, 1998; Tanaka et al., 2000; Shen et al., 2004). In cases where intervertebral disc height is lost due to degeneration the intervertebral foramen can be narrowed in superior–inferior height and anterior–posterior width (Shen et al., 2004). The clinical picture resulting from cervical nerve root compression is one of pain, paraesthesia, diminished sensation to pinprick, diminished reflexes, muscle weakness, and, rarely, muscle wasting in the neck and ipsilateral upper extremity (Cave et al., 1955; Kiwerski, 1991). Ebraheim et al. (1997) reported a higher incidence of nerve root compression secondary to uncovertebral osteophytes in the lower cervical spine at the C4–C6 vertebral levels (Ebraheim et al., 1997). They proposed that this observation was a result of higher uncinate processes, smaller anteroposterior diameter of the intervertebral foramen, and longer course of nerve roots at the C4–C6 level. Although less common, intervertebral foramen stenosis can occur in the upper cervical spine. Poletti (1996) described six cases of C3 nerve root and ganglion compression secondary to uncovertebral and zygapophysial joint osteophytes (Poletti, 1996). The radicular artery is another structure located in the intervertebral foramen that can be compressed by uncovertebral osteophytes (Kiwerski, 1991; Civelek et al., 2007). The reduced blood flow through the radicular artery from external compression is a contributing factor to the development of cervical spondylotic myelopathy (Breig et al., 1966; Manabe et al., 1988; Lu et al., 1998; Civelek et al., 2007).

Vertebral Artery Compression

Uncovertebral osteophytes that arise from the anterior aspect of the uncinate process curl laterally and, combined with overlying fibroligamentous thickening, may compress the anteromedial wall of the second portion of the vertebral artery (Lyon, 1945; Virtama and Kivalo, 1957; Dvorak, 1998; Citow and Macdonald, 1999; Yilmazlar et al., 2003b). The uncovertebral osteophytes that project into the path of the vertebral artery cause it to meander around the obstruction to continue on its path to enter the superior foramen transversarium (Taylor et al., 2000; Cagnie et al., 2005). As opposed to nerve root compression which occurs at the lower cervical spine, vertebral artery compression due to uncovertebral osteophytes tends to occur at the level of the mid-cervical spine (Ebraheim et al., 1997). Ebraheim et al. (1997) hypothesized that one contributing factor to the predilection for the mid-cervical spine was the decreasing distance between the uncinate process and the foramen transversarium in the cephalad direction. When the vertebral artery is compressed it usually occurs at the level of the inferior border of the superior vertebra where the uncovertebral osteophyte curls lateral (Ebraheim et al., 1997). Additional sources of external vertebral artery compression reported in the literature include zygapophysial joint osteophytes, fascial bands, spinal fracture/dislocation, cervical disc herniation, longus colli and anterior scalene muscle compression and tendon thickening, transverse process hyperrotation and zygapophysial joint subluxation, hyperrotation of the atlanto-axial joint, axial rotation instability of the uncovertebral joint, neoplasm, and infection (Kawaguchi et al., 1997;

Citow and Macdonald, 1999; Ogino et al., 2001; Cagnie et al., 2005; Miele et al., 2008; Yoshimura et al., 2011; Choi et al., 2012). Klaassen et al. (2011) concluded that when the vertebral artery was compressed by osteophytes they are more likely to be derived from the uncinate process than from the zygapophysial joints. Vertebral artery compression due to uncovertebral osteophytes can lead to clinical symptoms of vertebrobasilar insufficiency (Brismee et al., 2009). In most cases, vertebral artery compression significant enough to cause symptoms occurs dynamically with various head positions (Klaassen et al., 2011; Choi et al., 2012). Uncovertebral osteophyte mediated rotational occlusion of the vertebral artery is a reported mechanism for intermittent symptomatic vertebrobasilar insufficiency (Kawaguchi et al., 1997; Citow and Macdonald, 1999; Cagnie et al., 2005). Due to the collateral circulation provided by the contralateral vertebral artery and the posterior communicating arteries, occlusion of a single vertebral artery will not produce vertebrobasilar insufficiency (Kawaguchi et al., 1997; Ogino et al., 2001; Cagnie et al., 2005). In cases where the collateral circulation is compromised due to hypoplasia, aplasia or occlusion, compression of a single vertebral artery during head rotation can cause ischemia and symptoms (Kawaguchi et al., 1997; Citow and Macdonald, 1999; Ogino et al., 2001). The direction of head rotation is usually ipsilateral but can be contralateral to the side of uncovertebral osteophyte mediated vertebral artery compression (Kawaguchi et al., 1997).

Trauma

The uncovertebral articulation is commonly disrupted in severe head and neck injuries. Jonsson et al. (1991) investigated the cervical spine injuries sustained by traffic accident victims who suffered skull fractures. Of the 22 subjects studied, 77 uncovertebral cleft hematomas were identified, most of which were bilateral and at multiple levels. They concluded that uncovertebral injuries were common findings in this population and that they most commonly occurred in isolation but occasionally were associated with disc rupture. Yetkin et al. (1985) assessed the computed tomography (CT) scans of patients who suffered cervical spine articular pillar fracture or dislocation and found the uncovertebral joint to be subluxed in all cases. These patients were found to have articular pillar fractures as well as perched, locked, and distracted zygapophysial joints. It was advised that CT evidence of uncovertebral subluxation should prompt further evaluation for fracture or dislocation of the articular pillars. Further to the uncovertebral hematomas and subluxations, uncinate process fractures have been reported in the literature. Huang (1982) described a case report of a 26-year-old female who suffered a severe head injury and a fracture of the C3 uncinate process following a traffic accident.

Torticollis

Maigne et al. (2003) reported a case of a 15-year-old male who presented with acute torticollis lacking the ability to rotate or laterally flex to the right. Investigation with magnetic resonance imaging (MRI) identified a fluid containing lesion at the right C2–C3 uncovertebral articulation. The authors postulated that the uncovertebral cleft that normally fissures gradually towards the midline, acutely fissured leading to edema, tension, and reflex muscle spasm causing an atlantoaxial rotary fixation. Gubin et al. (2009) investigated 10 children who had acute stiff necks which were tilted and rotated away from the side of pain. These patients received MRI within 12 hours of symptoms and all were found to have high-intensity lesions identified in the uncovertebral region of C2–C3 or C3–C4 on the side opposite of head rotation and tilting. The authors disagreed with Maigne et al. as they believed rapid or gradual strangulation of vascular tissue in the uncovertebral region creates a “wedge” of hydropic tissue that irritates the posterior longitudinal ligament causing an antalgic position.

SUMMARY

The uncinate processes and the uncovertebral articulations are distinct features unique to the cervical spine. The uncinate processes are consistently found on the posterolateral aspect of the superior end plate of the third to seventh cervical vertebrae. They have been identified as important structures in guiding and dictating vertebral motion with head and neck movement. They do so through their interaction with the inferior aspect of the vertebra above where they form the uncovertebral articulation. This uncovertebral articulation develops and evolves throughout life from a rudimentary articulation to a mature joint that becomes degenerated with time. In some instances, the diseased articulation becomes clinically apparent due to the compressive effects of the uncinate osteophyte. The compressive effects manifest as nerve root compression with encroachment on the intervertebral foramen as well as vertebral artery compression with lateral lipping of osteophytes. In acute cases, the uncinate processes and uncovertebral articulations have been implicated in torticollis in the young as well as a site of injury in the severely head and neck injured patient. Although often overlooked due to their relatively small size the uncovertebral articulation has been shown to contribute to the stability of the cervical spine. This comprehensive review has described the anatomical features of the uncinate processes and uncovertebral joints and their importance in clinical conditions. It is hoped that clinicians will be mindful of these structures when assessing and treating their patients and that researchers will be stimulated to investigate these entities further.

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