Craniocervical junction ossification

In the craniocervical junction, the ligaments between the anterior foramen magnum and the anterior arch of the atlas are not well defined, and ossification of the ligaments in this region has rarely been reported. Characterizing the anatomy and ossification of these ligaments may help in the diagnosis and treatment of disorders in this region.

What is the prevalence of an unrecognized craniocervical junction ossification in patients with cervical spine disorders ?

What are the patient characteristics associated with this ossification?

Do patients with this ossification have a greater risk of ossification of other structures at the craniocervical junction or cervical spine?

Is there an unreported ligament at this ossified site?

Wu et al. conducted a retrospective study of 578 hospitalized patients who underwent cervical spine CT for cervical spine disorders between January 2016 and July 2020. Based on the inclusion criteria, 11% (66 of 578) were excluded because of a cervical or craniocervical tumor, deformity, infection, fracture or dislocation, or prior surgery, leaving 89% (512 of 578) for analysis. These 512 patients had diagnoses of cervical radiculopathy, cervical myelopathy, cervical spondylotic amyotrophy, cervical spinal cord injury without a radiographic abnormality, or axial neck pain. Their mean age was 57 years (range 22-90 years), and 60% of the patients were men. Patient characteristics including age, gender, and diagnosis were retrieved from a longitudinally maintained institutional database. CT images were used to assess the presence of a previously unrecognized ossification and ossification of other structures in the craniocervical junction and cervical spine, including the posterior longitudinal ligament, anterior longitudinal ligament, nuchal ligament, ligamentum flavum, transverse ligament, and apical ligament, as well as diffuse idiopathic skeletal hyperostosis (DISH). The association between these structures was also assessed. This unreported ossification was called the capped dens sign. It was defined and graded from 1 to 3. Grade 3 was defined as the typical capped dens sign. Cervical spine MRI was used to assess whether there was an unreported structure in the same region as where the capped dens sign was detected on CT images. In the database of a recent study, there were 33 patients younger than 41 years. Nine percent (three of 33) were excluded because they did not have cervical spine MRI. MRIs of the remaining 30 patients were assessed. Their mean age was 35 years (range 22-40 years), and 58% were men. All cervical spine CT images and MRIs were reviewed by one senior spine surgeon and one junior spine surgeon twice with a 2-week interval. Blinding was accomplished by removing identifying information from the radiographs and randomly assigning them to each examiner. Any discrepancy with respect to the grade of the capped dens sign was adjudicated by a third blinded senior spine surgeon. Intrarater and interrater reliabilities were assessed by calculating weighted kappa statistics. No ligament or membrane was reported at this site. MRI is not sensitive to identify thin tissue in this region, especially when severe degeneration has occurred. A cadaveric study was conducted to discover a potential ligament between the inferior margin of the foramen magnum and the anterior arch of the atlas, as prompted by the newly discovered ossification in the clinical analysis of this study. Six embalmed human cadaveric craniocervical regions (three male and three female cadavers; median age 56 years, range 45-78 years) were dissected by a senior anatomist and a senior anatomy technician. A mid-sagittal section of the craniocervical junction was created, allowing us to explore the interval between the anterior foramen magnum and anterior arch

of the atlas. A histologic analysis was conducted in two of the six cadavers (a male cadaver, 45 years; and a female cadaver, 51 years). Slides were made with 4-µm sections and stained with hematoxylin and eosin.

Results: A novel capped dens sign was detected in 39% (198 of 512) of the patients and the most typical capped dens sign was detected in 19% (96 of 512) of patients. The prevalence of this sign was the highest in patients with cervical spondylotic amyotrophy (12 of 25 patients). The prevalence of ossification of the anterior longitudinal ligament, ligamentum nuchae, and apical ligament, as well as DISH, was higher in patients with a capped dens sign than in those without ($p = 0.04$, $p < 0.001$, $p < 0.001$, and $p = 0.001$, respectively). The capped dens sign was identified in 69% (18 of 26) of the patients with DISH. A thin and short band-like structure or osteophyte was detected on MRI in 87% (26 of 30), in the same region as the capped dens sign. In the cadaveric study, an unreported, distinct ligamentous structure was identified at this ossified site. It originated from the posterosuperior rim of the anterior arch of the atlas to the inferior margin of the foramen magnum, which we called the inter-atlanto-occipital ligament. It was found in all six dissected craniocervical junctions. The histologic analysis revealed dense connective tissue.

Conclusion: More than one-third of the patients in this series demonstrated CT evidence of a previously unrecognized ossification in the craniocervical junction, which we called the capped dens sign. Anatomic evidence of this sign, which was a previously unidentified ligament, was also newly discovered in this region. This study was conducted among Asian patients and specimens. Further studies among diverse ethnic groups may be needed to generalize the results. An additional well-designed prospective study will be needed to provide further evidence regarding the potential pathophysiology and clinical relevance of the capped dens sign. Furthermore, the cadaveric analysis in this study was only a preliminary report of the ligament; further biomechanical research is needed to investigate its function.

Clinical relevance: Knowledge of this novel ligament may improve the diagnosis and treatment of craniocervical stability and dislocation. Ossification of this ligament is correlated with age, cervical spondylotic amyotrophy, and DISH. We wonder whether patients with cervical degenerative disorders who also have a capped dens sign may be at risk for the formation of osteophytes of an uncovertebral joint, which may result in palsy of the upper limb muscles. The capped dens sign may be the craniocervical manifestation of DISH. This possible association between the capped dens sign and DISH should be considered when performing surgery on patients with the capped dens sign [1)]

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Wu B, Yi X, Cui W, Rong T, Sang D, Xiao B, Zhao S, Wang D, Zhang J, Liu B. An Unrecognized Ligament and its Ossification in the Craniocervical Junction: Prevalence, Patient Characteristics, and Anatomic Evidence. Clin Orthop Relat Res. 2021 Mar 15. doi: 10.1097/CORR.0000000000001719. Epub ahead of print. PMID: 33739308.