European Journal of Molecular & Clinical Medicine
ISSN 2515-8260 Volume 07, Issue 08, 2020

Ossification of the transverse atlantal ligament forming prominent osteophytes

Zygmunt Siedlecki[1], Maciej Śniegocki[2], Mariusz Baumgart[3], Michał Szpinda[4]

[1,2]*Department of Neurosurgery, Neurotraumatology and Pediatric Neurosurgery, The Ludwik Rydygier Collegium Medicum in Bydgoszcz, The Nicolaus Copernicus University in Toruń*
[3,4]*Department of Normal Anatomy, The Ludwik Rydygier Collegium Medicum in Bydgoszcz The Nicolaus Copernicus University in Toruń*

e-mail: siedlecki@cm.umk.pl

Abstract: The ossifications of the transverse atlantal ligament taking the form of prominent osteophytes within atlas occur rarely.A computed tomographyexamination of the head in a 57-year-old man revealedthesignificantossifications ofthe transverse atlantal ligamentattachments. In the present study, the Osirix 3.9 MD system was employed to perform the bilateral evaluation of linear dimensions, projection surface area and volume of the theseossifications-osteophytes. The sagittal and transverse diameters of examined ossifications were: on the right side 4.02 and 3.97 mm, respectively, and on the left side 3.62 and 3.14 mm, respectively. Furthermore, on the right side the projection surface area and volume were: 12.03 mm^2 and 27.66 mm^3, respectively, and on the left side – 9.78 mm^2 and 23.57 mm^3, respectively.Ossified attachments of the transverse ligament forming osteophytesseem to be casuistic.

Keywords: atlas, transverse atlantal ligament, ossification

1. BACKGROUND

In the course of the aging process, both syndesmoses and synchondroses within all segments of the spine may be involved in the ossification process.Both progressive ossification of vertebral ligaments and concomitant desiccation of intervertebral discs result in a gradual reduction in the spine flexibility with advanced age [10].
Ossification of the transverse atlantal ligament most frequently refers to elderly patients (1 in 1,000 cases) and to people with a subluxation of the atlantoaxial joint or hypertrophy of the axial dens [11,13]. Furthermore, as reported by some authors [7,12,13], ossification of the transverse atlantal ligament may be contributable to some metabolic disorders, i.e. phosphate–calcium disorders, dysmetabolic syndrome, diabetes mellitus, obesity, and as a result of injuries of the cervical spine, e.g. whiplash-associated disorder [1,7,9]. An understanding of the pathophysiology of ossification of the transverse atlantal ligament may be extremely useful for diagnostic purposes in radiology and neurology, for interventional treatment, i.e. neurosurgery, and conservative treatment in rehabilitation[4].

Massive osteophytes within the transverse atlantal ligament maycontact the dens axis surface and limit the mobility of the atlantoaxial joint causing neck and occiput pain [4,10,11].In patients with symptomatic ossification of the transverse atlantal ligament, a surgical procedure performed from the anterior, posterior or posterolateral accesses is to consider, so as to decompress and eliminate neurological symptoms [10].

2. CASE PRESENTATION

A male patient aged 57 years was admitted to the Clinic of Neurosurgery, Neurotraumatology and Pediatric Neurosurgery, Dr. A. Jurasz University Hospital no. 1, M. Skłodowskiej-Curie 9, Bydgoszcz, Poland after a traffic accident trauma. Due to the presence of a wound of the right frontal area, a head CT examination was performed. Head CT imaging revealed the ossification process within both attachments of the transverse atlantal ligamenthaving the character of osteophytes located on the medial surfaces of the lateral masses of atlas (C1) and posterolaterally located from the C2 dens(Fig. 1).In the described patient metabolic disorders and calcium phosphate disorders were excluded, the patient did not give any rheumatic diseases in medical anamnesis. No other features of bone hyperplasia or ostefitosis were found in the available CT examinations nor in skull neitherin spine. In the fronto-parietal cranial region, thinning of the skull bone was observed, coexisting with a small arachnoid cyst that was not clinically significant.The patient was in a good neurological condition, without any pathological symptoms in the neurological examination. He complained of a moderate headache. There was no significant pain of the cranio-vertebral junction and no restriction on active or passive mobility in the neck and cranio-spinal joints.The study consisted of analyzing CT images of this patient admitted to the Neurosurgery Department.The experiment was approved by the Bioethics Committee of the Ludwik Rydygier Collegium Medicum in Bydgoszcz (KB 34/2020). Written informed consent was obtained from the patient for publication of this case report and any accompanying images. With the use of the Discovery CT 750 HD GE scanner, CT scans in Digital Imaging and Communications in Medicine format (DICOM). Scans were acquired at 0.4 mm intervals (Fig. 1A, 1C). Measurements of the ossification center of the transverse atlantal ligament were conducted in a specific order (Fig. 2). The bilateral assessment of the linear dimensions, projection surface area and volume of the ossification center of the transverse atlantal ligament was performed in accordance with the diagram displayed in Fig. 2:

1) sagittal diameter, based on the determined distance between the anterior and posterior borderlines of the ossification center of the transverse atlantal ligament in the transverse plane (Fig. 2);
2) transverse diameter, based on the determined distance between the lateral and medial borderlines of the ossification center of the transverse atlantal ligament in the transverse plane (Fig. 2);
3) projection surface area, based on the contoured area occupied by the ossification center of the transverse atlantal ligament in the transverse plane (Fig. 2);
4) volume, calculated using innovative diagnostic imaging tools for 3D reconstruction, taking into account both the position and absorption of radiation by bone tissue (Fig. 1D).

Since the numerical data achieved could not be subjected to a statistical analysis, all individual measurements have been included in Table 1.

Table 1 Sagittal and transverse diameters, projection surface area and volume of the right and left ossified parts of the transverse atlantal ligament.

Side	Ossification center of the transverse atlantal ligament			
	sagittal diameter (mm)	transverse diameter (mm)	projection surface area (mm^2)	volume (mm^3)
Right	4.02	3.97	12.03	27.66
Left	3.62	3.14	9.78	23.57

We found the sagittal and transverse diameters of the ossified part of the transverse atlantal ligament to be: 4.02 and 3.97 mm, respectively on the right side, and 3.62 and 3.14 mm, respectively on the left side. The projection surface area and volume established for the ossified part of the transverse atlantal ligament were: 12.03 mm^2 and 27.66 mm^3, respectively on the right side, and 9.78 mm^2 and 23.57 mm^3, respectively on the left side.

3. DISCUSSION

The transverse atlantal ligament plays a significant stabilizing role at the atlantoaxial joint by holding the axial dens in its correct position. This flattend ligament is concave anteriorly and convex posteriorly, and is approx. 2 cm in length and 2 mm in thickness [7]. It symmetrically originates from the medial surfaces of the lateral parts of the atlas, thus stabilizing the posterior aspect of the axial dens. At the intersection of the transverse atlantal ligament with the axial dens, some elongated fibers arise, continuing both upwards and downwards to produce the so-called longitudinal fasciculi. The upper section of the longitudinal fasciculi inserts onto the anterior border of the foramen magnum of the occipital bone, whereas the lower section inserts onto the posterior surface of the axial body. The horizontal section, i.e. the transverse atlantal ligament and the longitudinal fasciculi together form the cruciform ligament of the atlas. The transverse atlantal ligament separates the vertebral foramen of the atlas into two unequal parts: the greater posterior part for the spinal cord and its meninges, and the smaller anterior part for the axial dens [4]. The transverse atlantal ligament is the strongest craniovertebral ligament which can withstand loads of 220–1590 N [6, 8, 9].

The ossification process of the transverse atlantal ligament usually commences in its marginal parts, while calcification starts with its central section [13]. In our case, a CT examination clearly displayed ossification which must have started in the marginal parts of the transverse atlantal ligament (Fig. 1).

A symptomatic ossification process of the transverse atlantal ligament issporadic, especially in patients at their thirties and forties. Autopsy studies demonstrated calcifications within the transverse atlantal ligament in 1 in 1,000 cases [13]. Desai et al. [4] studied posthumously 125 human skulls and found ossification of the transverse atlantal ligament in two specimens. In one individual, the length of the ossified section of the transverse atlantal ligament was 18 mm, and its thickness was 4 mm. In the second case, the authors did not report the dimensions of the ossification center at all, focusing only on the presence of an ossified section between the occipital condyles on the anterior border of the foramen magnum of the occipital bone. In our study, the sagittal diameter of the ossified section of the transverse atlantal ligament was 4.02 mm on the right side and 3.62 mm on the left side, while the transverse diameter was 3.97 and 3.14 mm, respectively. Furthermore, the projection surface area and volume were: 12.03 mm^2 and 27.66 mm^3, respectively on the right side, and 9.78 mm^2 and 23.57 mm^3, respectively on the left side.

Constantin et al. [3] examined 21 patientsat the age of 69 to 89 years, admitted to a rheumatology unit due to joint chondrocalcinosis. Their CT examinations demonstrated ossification of the transverse atlantal ligament in 66% of the patients with calcification positioned behind the axial dens.

Sasaji et al. [11] suggested that ossification of the transverse atlantal ligament was preceded by hypertrophy of the axial dens and abnormalities at the atlanto-occipital joint, which consequently resulted in a forward translocation of the atlas and subluxation at the atlantoaxial joint. A permanent overload of the transverse atlantal ligament causes hypertrophy and ossification, further leading to the spinal cord compression. Moreover, a long-term overload of the cervical segment causes injuries to ligaments, their hypertrophy and ossification, which may lead to the formation of large bone masses, thereby causing myelopathy [2].

Spinal stenosis within the atlas is very rare due to the unique anatomy of this region, which considerably protects the spinal cord from compression. The size of the vertebral foramen of the atlas is 21.3 mm [10, the diameter of the spinal canal at the retrodental level varies between 17 and 25 mm, whereas the transverse diameter of the spinal cord at this level is 10 to 12 mm [1, 2, 10]. In view of the above, secondary spinal compression can be suspected when the transverse diameter of the spinal canal is lower than 14 mm [1, 10]. In this case, the patient had no neurological symptoms, while described osteophyteswere an incidentally detected anatomical variant.

CT examinations allow for the assessment of dimensions of the spinal canal and the detection of coexisting anomalies or pathologies of the spine at the C1 level or below [2]. According to Constantin et al. [3], only a CT examination of the atlantoaxial joint is able to exactly visualizecalcifications and the ossification process of the transverse atlantal ligament. Furthermore, magnetic resonance imaging (MRI) is useful in finding the site of nerve compression and signal changed, as well as the evaluation of degenerative changes in the cervical spine, all of which may change the diagnostic process not only in radiology and neurology, but also in surgical strategies in neurosurgery [2].

A diagnosis of calcification of the transverse atlantal ligament ismostly based on CT imaging, which allows for the visualizationof a calcified retro-odontoidal mass following the contour of the transverse atlantal ligament. Of note, MRI allows for the visualization of not only nerve compression, but also non-calcified ligament sections. Contrast is usually dispensable, but its use can reveal inflammation, particularly when linked to gout [2].

Having used MRI to visualize the transverse atlantal ligament, Dickman et al. [5] suggested that MRI accurately shows the anatomical integrity of this ligament.

ISSN 2515-8260 Volume 07, Issue 08, 2020

4. CONCLUSIONS

Ossified attachments of the transverse atlantal ligament forming prominent osteophytes of C1 appear to be casuistic. Therefore, the authors of this manuscript decided to describe this case. Osseous processes of vertebral ligaments and osteophytes formation are characteristic for the elderlybut even in geriatric patients such prominent C1 osteophytes are rarely observed. They have clinical implications due to changes in the biomechanics of the spine and that they can compress the nerve structures. An understanding of the pathophysiology of ossification of the transverse atlantal ligament may be extremely useful for diagnostic purposes in radiology and neurology, for interventional treatment, i.e. neurosurgery, and conservative treatment in rehabilitation.

Abbreviations

- C1 – altas, first cervical vertebra
- CT – computed tomography
- DICOM - Digital Imaging and Communications in Medicine
- MRI - Magnetic resonance imaging

5. DECLARATIONS

• Ethics approval and consent to participate: The experiment was approved by the Bioethics Committee of the Ludwik Rydygier Collegium Medicum in Bydgoszcz (KB 34/2020). Written informed consent was obtained from the patient for publication of this case report and any accompanying images. A copy of the written consent is available for review by the Editor of this journal.

• Consent for publication: Written informed consent was obtained from the patient for publication of this case report and any accompanying images.

• Availability of data and materials: All relevant data are within the paper.

• Competing Interests: The authors declare that they have no conflict of interest.

• Funding: The study was financed from own funds of the Neurosurgery Department and the Anatomy Department of Collegium Medicum in Bydgoszcz. The authors received no specific founding for this work.

• Authors' contributions: ZS treated this patient, noted the presence of ossification, therefore he came up with the idea of describing a case. ZS analyzed and interpreted the patient's data. ZS and MB performed measurements of ossification. ZS wascontributor in writing the manuscript. ZS andreviewed the literature about similar ossification. MŚ and MSz checked the written manuscript in formal terms.

• Acknowledgements: The authors thank computed tomography technicians and doctors of the radiology department for professional and perfect imaging of the images analyzed in this case report.

6. REFERENCES

[1] Baqai MWS, Javed G, Baig MZ (2019) Ossification of the cruciform ligament of atlas; a rare cause of cervical myelopathy: case report and review of literature. Asian J Neurosurg 14(3): 999–1003

[2] Bokhari R, Baeesa S (2012) Atlas hypoplasia and ossification of the transverse atlantal ligament: a rare cause of cervical myelopathy. Case Rep Neurol Med 893284

[3] Constantin A, Marin F, Bon E, Fedele M, Lagarrigue B, Bouteiller G (1996) Calcification of the transverse ligament of the atlas in chondrocalcinosis: computed tomography study. Ann Rheum Dis 55(2): 137–139

[4] Desai SD, Shaik HS, Shepur MP, Thomas ST, Mavishettar GF, Haseena S (2012) Ossification of transverse ligament of atlas. Indian J Med Healthcare 1(4): 82–84

[5] Dickman CA, Mamourian A, Sonntag VK, Drayer BP (1991) Magnetic resonance imaging of the transverse atlantalligament for the evaluation of atlantoaxial instability. J Neurosurg 75: 221–227

[6] Dvorak J, Schneider E, Saldinger P, Rahm B (1988) Biomechanicsof the craniocervical region: the alar and transverse ligaments. J Orthop Res 6: 452–461

[7] Hayashi T, Hirose Y, Sagoh M, Murakami H (1998) Ossification of transverse ligament of the atlas associated with atlanto-axial dislocation - case report. Neurol Med Chir 38(7):425–428

[8] Heller JG, Amrani J, Hutton WC (1993) Transverse ligamentfailure; a biomechanical study. J Spinal Disord 6: 162–165

[9] Krakenes J, Kaale BR, Nordli H, Moen G, Rorvik J, Gilhus NE (2003) MR analysis of the transverse ligament in the late stage of whiplash injury. Acta Radiol 44(6): 637–644

[10] Proietti L, Scaramuzzo L, Sessa S, Schirò GR, Logroscino CA (2012) Cervical myelopathy due to ossification of the transverse atlantal ligament: a Caucasian case report operated on and literature analysis. Orthop Traumatol Surg Res 98(4): 470–474

[11] Sasaji T, Kawahara Ch, Matsumoto F (2011) Ossification of transverse ligament of atlas causing cervical myelopathy: A Case Report and Review of the Literature. Case Rep Med. 2011: 238748

[12] Tang JG, Hou SX, Shang WL, Wu WW (2010) Cervical myelopathy causedby anomalies at level of the atlas. Spine 35: E77–79

[13] Tsuruta W, Yanaka K, Okazaki M, Matsumura A, Nose T (2003) Cervical myelopathy caused by hypoplasia of the atlas and ossification of the transverse ligament – case report. Neurol Med Chir 43(1): 55–59

Figure legends

Figure 1. CT of the cervical spine in the transverse plane (A), diagram illustrating the location of the ossification center of the transverse atlantal ligament (B), bone reconstruction of the atlas and axis (C), 3D reconstruction of the volume of the transverse atlantal ligament using Osirix 3.9 MD (D).

Figure 2. Measurements taken for the ossification center of the transverse atlantal ligament of in the transverse plane: 1—sagittal diameter, 2—transverse diameter, 3—projection surface area.