Capped Dens Sign in Cervical Spondylotic Myelopathy

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ABSTRACT

Background: The calcification of the inter-atlanto-occipital ligament is called capped dens sign. This study aimed to investigate the prevalence of capped dens sign in patients with cervical spondylotic myelopathy (CSM) and to explore the potential association between these two conditions.

Methods: A retrospective review was conducted of 60 patients who underwent surgery for CSM between 2019 and 2023. 44 of 60 of patients were male and 16 were female with 61.4 average of age. The patients were examined for inter-atlanto-occipital ligament calcification based on available radiographic data.

Results: Our findings revealed a high incidence of capped dens sign among patients diagnosed with CSM, with calcification of the inter-atlanto-occipital ligament observed in 43 of the 60 patients (71.7%). The remaining 17 patients (28.3%) showed no evidence of such calcification

Conclusion: The study reveals a noteworthy association between capped dens sign and CSM, suggesting that the calcification of the inter-atlanto-occipital ligament may play a significant role in the pathophysiology of CSM. Further studies are needed to confirm these findings and to delve deeper into the potential clinical implications of inter-atlanto-occipital ligament calcification in the management and prognosis of patients with CSM

ORIGINAL ARTICLE

INTRODUCTION

Cervical spondylotic myelopathy (CSM) is the most common spinal cord disorder affecting adults globally. This condition, resulting from degenerative cervical spine disease, leads to spinal cord compression and subsequent neurological dysfunction [1]. The clinical manifestations of CSM are diverse, reflecting the complex interplay of factors contributing to its pathogenesis, including the direct mechanical compression of the spinal cord, spinal cord ischemia, and changes in the spinal canal [2,3].

The craniocervical junction (CCJ) is a complex anatomical and functional unit, representing the transition point between the skull and the cervical spine. The CCJ comprises multiple ligaments and membranes, which play vital roles in maintaining the stability and function of the cervical spine [4-6] One of these is the inter-atlanto-occipital ligament is first described by Wu et al [7].

The pathological calcification or ossification of the ligaments in the CCJ can lead to various clinical syndromes. For example, ossification of the posterior longitudinal ligament has been widely studied and is known to contribute to spinal stenosis and myelopathy [8]. Moreover, calcification of the inter-atlanto-occipital ligament can lead to a radiodiagnostic cue known as the "capped dens sign," which is distinct from the "crowned dens sign," characterized by calcification around the odontoid process and diffuse idiopathic skeletal hyperostosis (DISH) [9,10].

Recent studies have presented novel imaging findings of atlantooccipital ligament calcification. These studies showed associations with pediatric rotational vertebral artery occlusion, hinting at the potential pathological implications of ligament calcification in the CCJ [11]. Further, research by Wang et al. has demonstrated a correlation between the ossification of the nuchal ligament and pathological changes in patients with cervical spondylosis [12]. These findings further underscore

the potential role of ligament ossification in the pathogenesis of cervical spine disorders.

Despite these insights, the specific role and clinical implications of capped dens sign in the pathogenesis of CSM remain unclear. The current study aims to explore this potential link, offering a more comprehensive understanding of the association between inter-atlanto-occipital ligament calcification that known as capped dens sign, and CSM. According to our investigations this would be the first study to lay out the association between CSM and capped dens sign. Furthermore, we aim to shed light on this association's potential diagnostic and therapeutic implications in clinical practice.

MATERIALS AND METHODS

Study Population and Data Collection

This retrospective study included 60 patients, 44 (73.3%) men and 16 (26.7%) women, with an average age of 61.4 (± SD, 10.5) years, were included in the study patients diagnosed with cervical spondylotic myelopathy (CSM) who underwent surgery between 2019 and 2023. The inclusion criteria were:

- A confirmed diagnosis of CSM.
- Surgical intervention during the specified time frame.
- Availability of complete radiological data.

Patients with cervical or craniocervical tumors, deformity, infection, fracture, dislocation, and incomplete radiological data were excluded from the study.

A total of 60 patients met the inclusion criteria.

Radiological Evaluation

All patients underwent cervical spine imaging as part of their pre-operative workup, including computed tomography (CT) scans and magnetic resonance imaging (MRI). Inter-atlanto-occipital ligament calcification, indicating capped dens sign, were evaluated retrospectively by independent one radiologist and one neurosurgeon blinded to the clinical data.

Furthermore, the degree of calcification was classified based on the classification system proposed by Wu et al. [13] which provides a reliable grading system for the extent of ligament calcification.

The capped dens sign was graded on a scale from 1 to 3 based on the relationship between the length of ossification of interest and the distance from the posterosuperior rim of the anterior arch of the atlas to the inferior margin of the foramen magnum on mid-sagittal cervical spine CT images. Grade 1 was assigned when the length of ossification of interest in relation to the length of foramen magnum was less than one-third (Group A, Figure 1A-B), Grade 2 was assigned when this length was between one-third and two-thirds (Group B, Figure 1C-D), and Grade 3 was assigned when the length exceeded two-thirds (Group C, Figure 1E-F). Grade 3 was specifically defined as the typical capped dens sign.

Statistical Analysis

Qualitative variables were presented as frequency (n, %), and continuous variables were presented as mean and standard deviation. Whether the scores obtained from each continuous variable were normally distributed or not was examined using descriptive, graphical, and statistical methods. Shapiro-Wilk test was used to test the normality of scores obtained from a continuous variable with the statistical method. Quantitative comparisons between groups were made with the Independent sample t test and One-way ANOVA analysis. Tukey post hoc analysis was used to determine which groups caused the differences in multiple quantitative comparisons. Comparisons between groups in qualitative variables were made with Fisher's exact test. Results; Significance within the 95% confidence interval was evaluated below $p<0.05$. All statistical calculations were performed with SPSS software version 26 (IBM Corp., Armonk, NY, USA) and GraphPad Prism Version 8 Software (GraphPad Software San Diego, California, USA).

RESULTS

Cervical region ligament calcification was detected in 43 (71.7%) of the patients. Calcification classification was grade A in 13 patients, grade B in 16, and grade C in 14 (Table 1).

The average age of patients with ligament calcification was statistically significantly higher ($p = 0.002$). Additionally, when ligament calcification was examined in a broader spectrum, it was determined that there was a statistically significant difference in the average age of the patients according to the calcification classification ($p = 0.015$). In the subgroup analysis, it was determined that this difference was between the patient group without ligament calcification and the patients with grade B and C ligament calcification ($p <0.05$). There was no statistically significant difference in the presence of ligament calcification in patients according to gender (Tables 2 and 3).

DISCUSSION

This study examined the association between the calcification of the inter-atlanto-occipital ligament, indicative of capped dens sign, and cervical spondylotic myelopathy (CSM) in a cohort of 60 patients. The study's results provided a unique contribution to the existing body of literature, particularly in identifying the prevalence and role of the calcified ligament in the clinical presentation and prognosis of CSM.

In this retrospective analysis, inter-atlanto-occipital ligament calcification was present in most patients (71.7%). This high prevalence underscores the need to understand the impact of this radiological finding on the clinical course and outcomes of patients diagnosed with CSM. As observed in our study, the calcification of this ligament could serve as a predictive marker for disease progression or a determinant of surgical outcomes. However, further studies are warranted to confirm this hypothesis.

It is crucial to differentiate capped dens sign from its clinical analog, crowned dens sign. Despite similarities, these two conditions stem from calcifying different ligaments in the cervical region. Crowned dens sign is characterized by the calcification of the transverse ligament of the atlas, whereas capped dens sign involves the inter-atlanto-occipital ligament [9]. The differing anatomical locations might implicate divergent clinical consequences, hence the importance of accurate diagnosis and understanding of their distinct clinical courses.

Furthermore, it is crucial to note the impact of ligament calcification on the stability and biomechanics of the cervical spine [13]. Calcified ligaments could alter spinal strength and flexibility, leading to spinal cord compression and resultant myelopathy [8,9,14]. As our study shows, this interplay could explain the association between ligament calcification and CSM.

Interestingly, the extent of ligament calcification, graded using the system proposed by Wu et al. [7], was not assessed about the severity of myelopathy symptoms in this study. Future research could consider this aspect to provide more detailed insights into the correlation between ligament calcification and disease severity in CSM.

This study contributes to the growing literature on the potential implications of inter-atlanto-occipital ligament calcification in CSM patients. The high prevalence of capped dens sign among the CSM population underlines the necessity of further investigation to understand its clinical significance better. The potential impact of this ligament calcification on the stability and biomechanics of the cervical spine and its role in the development and progression of CSM forms a valuable premise for future research.

CONCLUSION

this study highlights the high prevalence of inter-atlanto-occipital ligament calcification among CSM patients and draws attention to its potential role in the disease process. Further prospective, multicentric studies with larger sample sizes are needed to confirm these findings and to delve deeper into the potential clinical implications of inter-atlanto-occipital ligament calcification in patients with CSM.

TEACHING POINT

If inter-ligament calcification is seen or reported in cervical computed tomography, patient must be evaluated for CSM. According to classification of ligament calcification patient should be follow up for surgery or further clinical diagnosis.

QUESTIONS

1. What is the name of complex anatomical and functional unit, representing the transition point between the skull and the cervical spine?

a) Ligamentum flavum
b) Dentate ligament
c) Alar ligament
d) Transver ligament
e) ***Caniocervical junction***

Explanation

a) Ligamentum flavum [Found in posterior spine]
b) Dentate ligament [It is on the spinal cord attached to roots]
c) Alar ligament [Ligament on atlanto-axial joint]
d) Transver ligament [Ligament on atlantoaxial joint]
e) ***Caniocervical junction***

2. Which radiodiagnostic tool is used for classification of atlanto-occipital ligament?

a) ***Computed tomography***
b) Magnetic resonance imaging
c) X-ray
d) Ultrasound
e) Floroscopy

Explanation

a) ***Computed tomography*** [Best radiodiagnostic tool for bone and calcifications]
b) Magnetic resonance imaging [It is used for imaging spinal cord and soft tissues]
c) X-ray [It could not show details]
d) Ultrasound [Not used in cervical spine calcifications]
e) Floroscopy [Used in OR not for detailed imaging]

3. Which radiodiagnotic tool is used to evaluate the atlato-occipital ligament injury?

a) Computed tomography
b) ***Magnetic resonance imaging***
c) X-ray
d) Ultrasound
e) Floroscopy

Explanation

♋◑ Computed tomography [Best radiodiagnostic tool for bone and calcifications]
♌◑ ***Magnetic resonance imaging*** [It is used for imaging spinal cord and soft tissues]
♍◑ X-ray [It could not show details]
♎◑ Ultrasound [Not used in cervical spine calcifications]
♏◑ Floroscopy [Used in OR not for detailed imaging]

4. Where is ‘Capped dens sign’ seen?

a) Kranium
b) Lower cervical spine
c) Upper thoracal spine
d) ***Craniovertebral junction***
e) Lumbar spina

Explanation

a) Kranium
b) Lower cervical spine

c) Upper thoracal spine

d) Craniovertebral junction [Capped dens sign is the calcification of atlanto-occipital ligament in craniovertebral junction]

e) Lumbar spina

5. Where is 'Crowned dens sign' located?

a) Ligamentum flavum

b) Dentate ligament

c) Alar ligament

d) Transvers ligament

e) Caniocervical junction

Explanation

a) Ligamentum flavum [Found in posterior spine]

b) Dentate ligament [It is on the spinal cord attached to roots]

c) Alar ligament [Ligament on atlanto-axial joint]

d) ***Transvers ligament*** [Crowned dens sign is the calcification of transvers ligament of atlas in cervical spine]

e) Caniocervical junction

Author contributions

Luay Serifoglu - Supervision, Data collection, Formal analysis, Article writing, Final revision.

Hanife Gulden Duzkalir, MD - Supervision, Data collection, Formal analysis, Article writing.

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Conflict of interest

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Disclosures

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Consent

Yes

Human and animal rights

There are no experiments on human or animal subjects.

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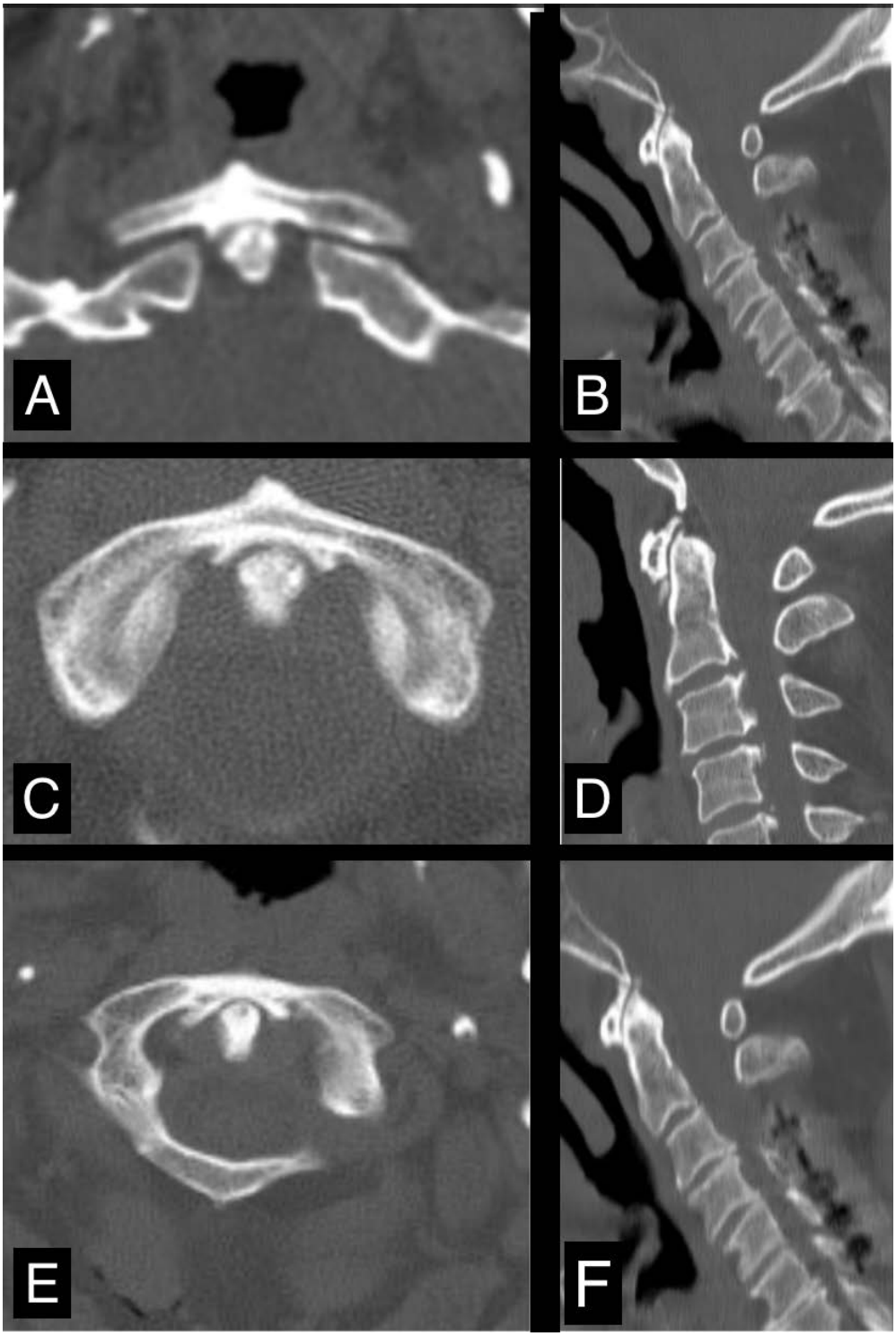
FIGURES



Mid-sagittal cervical spine CT images.

Figure 1A,1B: Grade A was assigned when the length of ossification of interest in relation to the length of foramen magnum was less than one-third

Figure 1C,1D: Group B was assigned when this length was between one-third and two-thirds **Figure 1E,1F**: Grade C was assigned when the length exceeded two-thirds. Grade C was specifically defined as the typical capped dens sign.

TABLES

Table 1: Patient demographics and ligament calcification groups

Variables(N=60)	**n(%)**
Age, mean(±Sd)	61.48(10.51)
Gender	
Man	44(73.3)
Woman	16(26.7)
Ligament calcification	
Yes	43(71.7)
No	17(28.3)
Ligament calcification group	
A	13(21.7)
B	16(26.7)
C	14(23.3)
No	17(28.3)

SD = Standard Deviation

Table 2: Ligament calcification according to patient demographics

	Ligament calcification		
Variables	**Yes (n=43)**	**No (n=17)**	***P*-value**
Age, yr	64.00(9.28)	55.12(11.02)	**0.002[a]***
Gender			0.756[b]
Male	32(72.7)	12(27.3)	
Female	11(68.8)	5(31.3)	

Table 3: Ligament calcification grades according to patient demographics.

	Ligament calcification					
Variables	**A (n=13)**	**B (n=16)**	**C (n=14)**	**No (n=17)**	**P-value**	**Difference****
Age, yr[#]	61.31(8.05)	65.19(9.16)	65.14(10.56)	55.12(11.02)	**0.015[a]***	*No<B,C*
Gender, n(%)					0.791[b]	
Male	10(22.7)	13(29.5)	9(20.5)	12(27.3)		
Female	3(18.8)	3(18.8)	5(31.3)	5(31.3)		

*p<0.05, a: One way ANOVA test, b: Fisher's exact test, **: Tukey post hoc analysis

KEYWORDS

Capped Dens Syndrome, Cervical Spondylotic Myelopathy, Inter-Atlanto-Occipital Ligament, Ligament Calcification

ABBREVIATIONS

CSM = Cervical Spondylotic Myelopathy
CCJ = Craniocervical Junction
CT = Computed Tomography
MRI = Magnetic Resonance Imaging

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