

A Comprehensive Review of the Superficial Anterior Atlanto-Occipital Ligament of the Craniocervical Junction

SHOGO KIKUTA*, JOE IWANAGA*^{***‡}, BASEM ISHAK[†],
AARON S. DUMONT[‡] AND R. SHANE TUBBS^{‡.§. §§. #}

* Dental and Oral Medical Center, ** Division of Gross and Clinical Anatomy, Department of Anatomy, Kurume University School of Medicine, Kurume 830-0011, Japan, † Department of Neurosurgery, Heidelberg University Hospital, Heidelberg 69120, Germany, ‡ Department of Neurosurgery, Tulane Center for Clinical Neurosciences, Tulane University School of Medicine, New Orleans, LA 70112,

§ Department of Neurosurgery and Ochsner Neuroscience Institute, Ochsner Health System, New Orleans, LA 70121,

§§ Department of Structural & Cellular Biology, Tulane University School of Medicine, New Orleans, LA 70112, USA,

Department of Anatomical Sciences, St. George's University, University Centre, Grenada, West Indies

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Summary: This paper aimed to better describe the anatomy of the superficial anterior atlanto-occipital ligament of the craniocervical junction and discuss this ligament's potential function and clinical implications. A broad literature review on the anatomical features and findings of the superficial anterior atlanto-occipital ligament was performed. The superficial anterior atlanto-occipital ligament is located anterior to the anterior atlanto-occipital membrane. However, the physiological role of the superficial anterior atlanto-occipital ligament is still unclear due to a lack of anatomical and biomechanical studies although one study has suggested that this ligament is a secondary stabilizer of the craniocervical junction. Further studies are needed to clarify the function and anatomy of the superficial anterior atlanto-occipital ligament.

Keywords craniocervical joint, ligaments, anatomy, cadaver, cervical vertebra

INTRODUCTION

The craniocervical junction (CCJ) consists of the occipital bone, atlas, and axis and includes the complicated transition from the skull to the spine [1]. The CCJ contains the spinal cord, lower cranial nerves, and many blood vessels supplying the head and neck [2,3]. The CCJ forms several joints including the atlantooccipital joint, atlantoaxial joint, and atlantodental joint. These joints allow for rotation, flexion, and extension at the junction between the head and neck [4–6]. The atlantooccipital joint plays a role in flexion and extension of the neck, while the atlantoaxial joint

mainly supports axial rotation. The biomechanics of movement and stability of the CCJ are unique and complex. Therefore, a better understanding of its anatomy and biomechanics is essential to effectively to diagnosis and treat the various pathological conditions in this region [7].

The CCJ contains a variety of ligaments and membranes [8]. The most essential ligaments of the CCJ are the transverse and alar ligaments, which have been well studied [9–13]. Tubbs et al. [3] reviewed the literature on the ligaments and membranes of the CCJ. One of these ligaments, the central or superficial anterior atlanto-occipital ligament (SAAOL), has received

Corresponding Author: Joe Iwanaga, D.D.S., Ph.D., Department of Neurosurgery, Tulane Center for Clinical Neurosciences, Tulane University School of Medicine, 131 S. Robertson St. Suite 1300, New Orleans, LA 70112, USA. Tel: +1-504-988-5565, Fax: +1-504-988-5793, E-mail: iwanagajoea@gmail.com

Abbreviations: AAAL, anterior atlanto-axial ligament; AAOM, anterior atlanto-occipital membrane; ALL, anterior longitudinal ligament; CCJ, craniocervical junction; LAOL, lateral atlanto-occipital ligament; SAAOL, superficial anterior atlanto-occipital ligament.

very little attention (Figs. 1 and 2) [14]. It is located anterior to the anterior atlanto-occipital membrane (AAOM) and runs vertically from the anterior tubercle of the atlas to the pharyngeal tubercle of the occipital bone [14–16]. It should be distinguished from the deeper fibers of the anterior atlanto-occipital membrane (AAOM). The superficial anterior atlanto-occipital ligament (SAAOL) has most often been depicted as the superior-most part of the anterior longitudinal ligament [2,3,8,17]. With few descriptions in the literature, the goal of this paper is to better describe the anatomy of the SAAOL and discuss its potential function and clinical implications.

ANATOMY OF THE SAAOL

In the frontal view of the CCJ, the ligamentous connections from the anterior margin of the foramen magnum to the anterior arch of the atlas may appear as only one broad membrane. However, the continuity of both these structures is achieved by several ligaments: the AAOM, SAAOL, atlanto-occipital articular capsular ligaments, and the lateral atlanto-occipital ligament (LAOL) [14,16,18]. The AAOM is generally defined as a thin fibrous structure that connects the anterior margin of the foramen magnum to the upper border of the anterior arch of the atlas, located just posterior to

the prevertebral muscles and anterior to Barkow's ligament [3,17,19].

The SAAOL exists in a more superficial layer anterior to the AAOM. In 1879, Morris [14] defined the considerable thickened central fibers of the midline as a separate ligament, "central or superficial anterior atlanto-occipital ligament." The author described the AAOM as consisting of dense fibers located posterior to the SAAOL. The AAOM is less than 2 cm wide and ascends slightly outward from the anterior surface and upper margin of the atlas to the anterior border of the foramen magnum [14,16]. The SAAOL runs radially from the anterior tubercle of the atlas to the pharyngeal tubercle, which is located on the lower surface of the basilar part of occipital bone [14,16]. The SAAOL is thicker than the AAOM, is located anterior to it, courses vertically from the anterior tubercle of the atlas to the pharyngeal tubercle, and continues to the superficial part of the anterior atlanto-axial ligament (AAAL) followed by the anterior longitudinal ligament (ALL) of the vertebral column [14,16,20].

The AAAL is a strong, narrow ligament that runs vertically from the lower border of the anterior arch of the atlas to the front of the body of the axis [16]. It is continuous with the SAAOL and ALL and is sometimes separated from the deeper ligaments. The superficial part of the AAAL is often described as "the superficial atlanto-axial ligament" [16]. Quain [15] previously described the AAOM as being reinforced by an "accessory ligament" that is thick, round, and has vertical fibers; this refers to the commencement of the ALL and covers the AAOM. A small band of 5 to

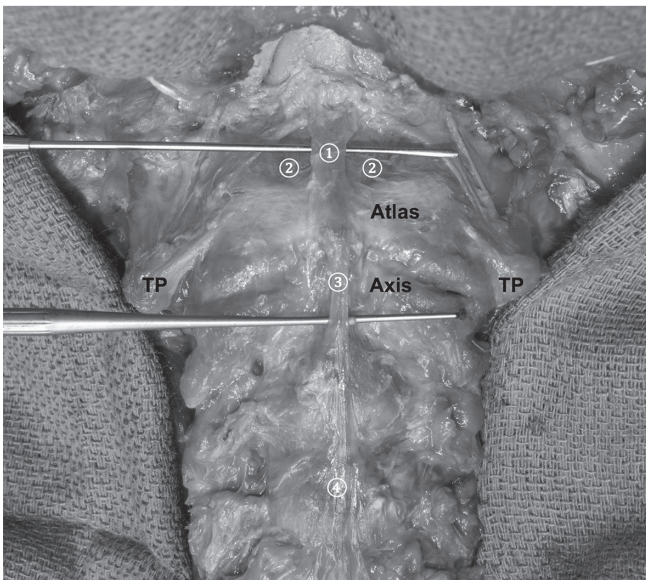


Fig. 1. Photograph of the anterior craniocervical junction in a cadaver after removing the longus capitis, rectus capitis anterior, and longus colli muscles. 1. Superficial anterior atlanto-occipital ligament; 2. Anterior atlanto-occipital membrane; 3. Anterior atlanto-axial membrane; 4. Anterior longitudinal ligament. TP, transverse process of C1.

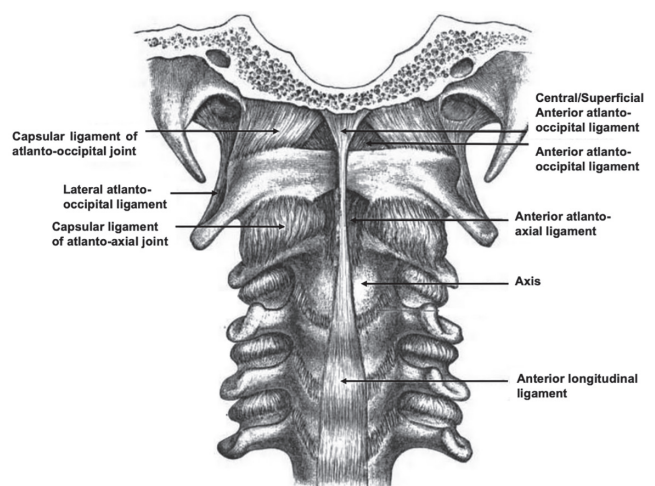


Fig. 2. Schematic view of the anterior craniocervical junction.

(Reproduced from Morris, Morris' Human Anatomy: A Complete Systematic Treatise, Part 1. 5th ed. 1914, Blakiston with modifications.)

6 mm in width is observed in the midline of the AAOM, and according to Testut [21], may be the origin of the anterior longitudinal ligament.

The SAAOL, AAL, and ALL may be considered as a series of the same ligament—distinctly—since each ligament has different sizes, thicknesses, and strengths. Kikuta et al. [22] investigated the SAAOL using fresh-frozen cadavers. The SAAOL ran vertically as central thick fibers between the basilar part of the occipital bone and the anterior tubercle of the atlas and was located anterior to the AAOM [22].

BIOMECHANICS

Few studies have examined the biomechanical function of the SAAOL. A previous author stated that the SAAOL had considerable strength and plays a role in limiting extension of the head [14]. Kikuta et al. [22] concluded the SAAOL might be a secondary stabilizer of the CCJ since its tensile strength was only 38.8 N and it was relatively frail. On the other hand, the AAOM and ALL located on the anterior side of the CCJ function in preventing hyperextension of the cervical spine [3,14]. Tubbs et al. [19] stated that the AAOM may work synergistically with Barkow's ligament, which is a horizontal band adhering to the occipital condyles anterior to the attachment of the alar ligaments. Although the vertical ligaments and membranes of the CCJ are believed to prevent hyperextension, in general, each ligament might have different biomechanics since each has intrinsically different features, e.g., size, length, strength. Some of these ligaments might be remnants and other mammals could have variable ligaments [23].

CONCLUSION

The SAAOL is a distinct ligament, located anterior to the AAOM and may or may not be continuous with the ALL. However, the physiological role of the SAAOL in the CCJ is still unclear due to a lack of anatomical and biomechanical studies. Further studies are required to clarify the function and anatomy of the SAAOL, especially as related to trauma of the craniocervical junction.

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