The Anterior Atlantodental Ligament: Its Anatomy and Potential Functional Significance

R. Shane Tubbs1, Martin M. Mortazavi1, Robert G. Louis2,3, Marios Loukas2, Mohammadali M. Shoja4, Joshua J. Chern1, Brion Benninger5, Aaron A. Cohen-Gadol6

INTRODUCTION

Stability of the craniocervical junction is of vital importance because instability at this anatomical site can have life-altering results. This joint is one of the most complex of the human spine; therefore, an understanding of each and every connective tissue in this region is important to the clinician who deals with patients with injury or pathology here (2, 6, 7, 18). Most of the ligaments of the craniocervical junction have been well described in the literature (4, 5, 8, 13-17). However, one ligament binding the anterior aspect of the dens to the posterior aspect of the atlas is the anterior atlanto-axial membranes. atlanto-axial ligaments were reflected superiorly and inferiorly, respectively, to expose the interval between the anterior foramen magnum and inferior aspect of C2.

OBJECTIVE: Knowledge of the anatomy of the ligaments that unite the head to the neck is important to the clinician who treats patients with lesions in this region. Although the anatomy and function of the majority of these ligaments have been well described, some are relatively unknown. One of these includes the anterior atlantodental ligament (AADL). Our goal was to increase knowledge about the AADL.

METHODS: We dissected the craniocervical junction in sixteen adult cadavers and paid special attention to the presence and anatomy of the AADL.

RESULTS: The AADL was found in 81.3% of specimens. The attachment of each ligament was consistent and traveled between the base of the anterior dens to the posterior aspect of the anterior arch of the atlas in the midline and just inferior to the fovea dentis. In 38.5% of specimens, there was some connection between the AADL and the anterior atlanto-occipital membrane. The ligament was roughly 4 × 4 × 4 mm in all specimens. With transection of the transverse ligament, the AADL could be made taut with posterior distraction of the dens. In addition, with left and right rotation of the atlantoaxial joint, the AADL became taut (less than 10°) before any tautness of the alar ligaments in all specimens.

CONCLUSIONS: The AADL appears to resist posterior displacement of the dens and, with the alar ligaments, resists rotation. When present, the AADL contributes to the predental space. Knowledge of this ligament may aid in further understanding craniocervical stability and help in differentiating normal anatomy from pathology via imaging modalities.

Key words
- Anatomy
- Craniocervical
- Stability

Abbreviations and Acronyms
AADL: Anterior atlantodental ligament
shape of the AADL were more or less congruous among all ligaments examined. The ligament was found to be a horizontal band attaching onto the anterior base of the dens and continuing anteriorly to attach onto the internal aspect of the anterior arch of the atlas just inferior to the fovea dentis (the articular surface for the anterior dens on the posterior aspect of the anterior arch of the atlas; Figures 1 and 2). In five specimens (38.5%), there was some connection between the AADL and the more anteriorly placed anterior atlanto-occipital membrane. In these connections, the attachment was primarily in the midline. No connections were found to the nearby alar ligaments. The average width, length, and thickness of the AADL was 4 mm (range, 3.2-4.4 mm), 4 mm (range, 3.8-4.6 mm), and 4 mm (range, 3-4.7 mm), respectively.

With ranges of motion of the craniocervical junction, the AADL became taut with axial rotation to the left and right of between 7 and 10° (mean 9°). After transection of the transverse ligament, minimal posterior distraction (approximately 3 mm) resulted in tautness of the AADL. Statistical analysis revealed no significant differences in width, length, and thickness of the ligaments between genders.

**DISCUSSION**

In 1987, Dvorak (3) found that in three of seven (43%) specimens, there were fibers connecting the anterior dens to the posterior aspect of the anterior arch of C1 and termed this the AADL with the posterior atlantoaxial ligament being another term for the transverse ligament (12). Anatomically, the AADL was found in the majority of our specimens and was noted to travel from just inferior to the fovea dentis to the anterior odontoid process. The dimensions were fairly consistent among the specimens.

The exact incidence of the AADL remains undetermined. Our findings suggest an occurrence rate of greater than 80% because the ligament was present in the majority of the specimens examined. The difference in our incidence compared with the incidence of the study of Dvorak (3) may be attributable to the dissection technique as this is a challenging anatomical area to examine. Moreover, our study was prospective in nature in contrast to the study of Dvorak that found these ligaments only incidentally (3). More recently, Möller et al. (8) studied the alar and transverse ligaments. Incidentally, these authors found tissue between the dens and anterior arch of C1 consistent with the AADL in at least 4 of 13 (31%) specimens.

We did not find a connection between the AADL and surrounding ligaments other than in specimens where it connected anteriorly to the anterior atlanto-occipital membrane. The AADL became taut at an average of 9° of axial rotation and resisted posterior dislocation of the dens following transection of the transverse ligament. Cervical injuries, which may cause disruption of other ligaments (cruciform ligaments), most likely prevent the AADL from providing craniocervical instability alone. Rojas et al. (11) stated that an increased predental space suggests disruption of the transverse and atlantodental ligaments. Bertozzi et al. (1) added that the predental space is maintained by the presence of the transverse, alar, and atlantodental ligaments. These comments are supported by our findings.

At the atlantoaxial joint, reported ranges for flexion/extension, lateral flexion, and axial rotation have ranged from 0–30°, 0–10°, and 14–50°, respectively (10). Dvorak et al. (4) found axial rotation at this joint to have a mean of 31°. We found that the AADL became taut at approximately 9° of axial rotation. Interestingly, the alar ligaments, which primarily limit rotation at the atlantoaxial joint, are lax in the neutral position (8) and the transverse ligament primarily becomes taut in flex-
ion of the atlantoaxial joint to resist posterior displacement of the dens. Therefore, and on the basis of our findings, the AADL would appear to resist rotation before the alar ligaments and posterior movement of the dens prior to or at least at the same time as limitation by the transverse ligament. Moreover, some studies have found that in some specimens, the alar ligaments are too lax to restrict axial rotation (3). In such cases, the AADL would be the structure primarily responsible for this restriction. Individuals without the AADL (approximately 20%, on the basis of our study) may, therefore, be at greater risk for rotatory subluxation.

Surgically, the AADL may be encountered in anterior transoral procedures, which require resection of lesions along the anterior craniocervical junction. This ligament would be encountered in the predental space and may be a sentinel structure to the surgeon alerting to the nearby presence of the dens and alar ligaments.

CONCLUSIONS
When present, the AADL appears to resist posterior displacement of the dens and may be synergistic to the transverse ligament. In addition, this ligament resists rotation of the atlantoaxial joint and therefore assists the alar ligaments in restricting this movement. Furthermore, individuals without this ligament may be predisposed to posterior dislocation of the dens with injuries to the transverse ligament. Because many of the accessory ligaments of the craniocervical junction can be identified on magnetic resonance imaging (9), future studies aimed at identifying this structure on imaging may better elucidate its function and involvement in disease processes of the craniocervical juncture. In addition, studies in which the transverse ligament is removed to better appreciate the AADL’s function after such injury are necessary to elucidate its true function in craniocervical stability.

REFERENCES