The Spiral Glenohumeral Ligament: An Open and Arthroscopic Anatomy Study

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Purpose: The purpose of this study was to visualize arthroscopically and to describe the micro- and macroscopic anatomy of the poorly known ligament of the anterior capsule of the glenohumeral joint: the so-called ligamentum glenohumerale spirale (spiral GHL). **Methods:** Twenty-two fresh shoulder joints were dissected, and the anatomy of the anterior capsular structures (the spiral GHL, the middle glenohumeral ligament [MGHL], and the anterior band as well as the axillary part of the inferior glenohumeral ligament [AIGHL and AxIGHL, respectively]) was investigated. For arthroscopic visualization, 30 prospective arthroscopic clinical cases and 19 retrospective video clips of the patients who had an arthroscopic shoulder procedure with a normal subscapularis tendon, labrum, and anterior joint capsule were evaluated. **Results:** The spiral GHL and the AxIGHL were present in all 22 shoulder specimens. The AIGHL was not recognizable on the extra-articular side of the joint capsule. The MGHL was absent in 3 shoulder specimens (13.6%). Arthroscopically, the spiral GHL was found in 22 (44.9%), the MGHL in 43 (87.8%), and the AIGHL in 46 (93.9%) of the cases. The spiral GHL arose from the infraglenoid tubercle and the triceps tendon and inserted together with subscapularis tendon onto the lesser tubercle of the humerus. **Conclusions:** Our results suggest that extra-articular structure of the spiral GHL is consistently recognizable, the upper part of which can be arthroscopically identified. **Clinical Relevance:** Advanced anatomic knowledge of the spiral GHL helps the clinician better understand the normal anatomy of the shoulder joint and also helps to differiantiate it from pathologic findings of the patient. The biomechanical importance of the spiral GHL and its connection with shoulder pathology remains to be determined in futher studies. **Key Words:** Anatomic study—Arthroscopy—Glenohumeral ligaments—Histology—Shoulder joint—Subscapularis tendon.

Advanced arthroscopic techniques have been increasingly used instead of open surgery to repair or reinforce injured anterior capsular ligaments as passive stabilizers of the glenohumeral joint.[1,2] Contemporary textbooks of anatomy describe three anterior capsular ligaments: the superior glenohumeral ligament (SGHL), the middle glenohumeral ligament (MGHL), and the inferior glenohumeral ligament (IGHL).[3,4] The IGHL has been divided into three parts: the anterior band (AIGHL), the posterior band, and the interposed axillary pouch (AxIGHL).[5] Clinical literature has described the variability and more detailed anatomic properties of these structures.[6-9]

Besides the classically shown anterior glenohumeral ligaments (GHLs),[5] the fasciculus obliquus[10] or "longitudinal oblique system"[11] has been described. Our recent anatomic studies[12,13] revealed it to be a distinct ligament that arose from the infraglenoid tubercle and the tendon of the long head of the triceps

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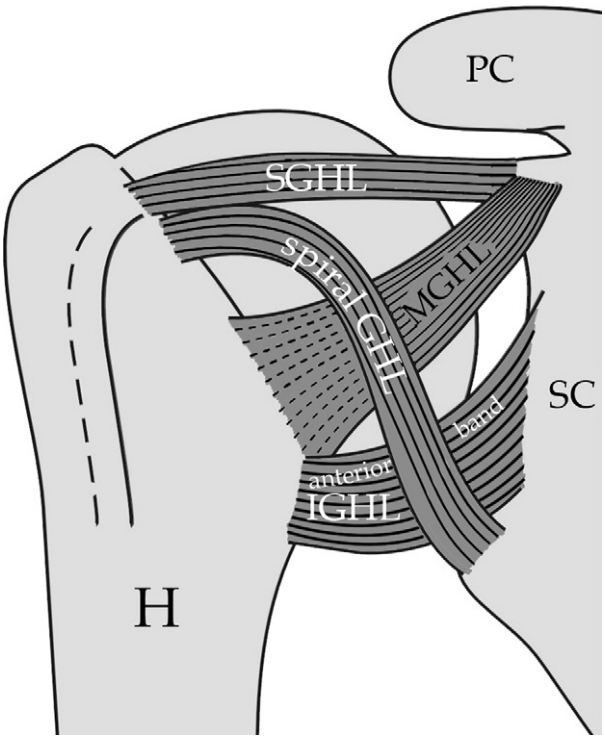

FIGURE 1. Anterior capsular ligaments. (Abbreviations: H, humerus; IGHL, inferior glenohumeral ligament with projection of the anterior band; MGHL, middle glenohumeral ligament; PC, processus coracoideus; SC, scapula; SGHL, superior glenohumeral ligament; spiral GHL, spiral glenohumeral ligament.)

brachii muscle, coursed obliquely upwards and inserted together with the subscapularis tendon onto the lesser tubercle of the humerus (Fig 1). Based on the course, shape, and position of this ligament, the name ligamentum glenohumerale spirale (spiral GHL) was proposed.

Even though arthroscopy allows a precise intra-articular visualization of the anatomy of the glenohumeral joint, we could not find any previous arthroscopic descriptions of the fasciculus obliquus or spiral GHL in the current literature. The aim of this study was to describe the gross and histologic anatomy of the spiral GHL and to visualize it arthroscopically.

METHODS

Gross Anatomic Dissection and Histology

Twenty-two fresh shoulder joints with intact joint structures (11 right and 11 left shoulders; 12 male and 10 female; age range, 61 to 90 years) were investigated. Soft tissues, clavicle, and shoulder girdle muscles were removed from the shoulder specimens. The extra-articular part of the long head of the biceps tendon within the intertubercular groove was preserved. The muscles and tendons of the rotator cuff were separated from the joint capsule with scissors by blunt and sharp dissection. The ligaments of the anterior joint capsule were identified by fine dissection according to the direction of the bundles of the collagen fibers. The subscapularis bursa was carefully opened with scissors along the rotator interval to visualize the inner side of the subscapularis tendon and latero-superior part of the anterior capsule. Holding the scapula fixed and moving the humerus manually, the macroscopic appearance and tensioning of the spiral GHL were observed throughout the range of glenohumeral joint motion.

Histology: Approximately 1.5- $\times$ 1-cm pieces of the spiral GHL from all shoulder specimens were taken from three different capsular regions: the origin, crossing with the MGHL, and insertion on to the lesser tubercle of the humerus. The material was fixed in 10% neutral buffered formalin and embedded in paraffin. Sections with a thickness of 10 μm were stained with H&E, and were examined by light microscopy.

Arthroscopic Evaluation

For arthroscopic visualization of the spiral GHL, two independent, experienced shoulder surgeons analyzed 49 clinical cases (video clips of 19 patients retrospectively, and 30 prospective arthroscopic clinical reports; 20 left and 29 right shoulders; 29 male and 20 female; age range, 28 to 65 years). The surgeons were shown a cadaveric dissection of the spiral GHL before clinical cases and were then asked to identify the structure at arthroscopy. When the surgeons' opinion differed, these cases were evaluated together. If the arthroscopic appearance remained questionable or unclear, it was evaluated negatively; otherwise, it was positive result.

All patients had a pre- and intraoperative diagnosis of impingement syndrome or rotator cuff disease with a normal labrum, anterior capsular ligaments, and subscapularis tendon.

Standard shoulder arthroscopy was performed under general endotracheal anaesthesia. The patients were positioned in the lateral decubitus position and the arm was held in 70° of abduction and in 10° of forward flexion. The glenohumeral joints were distended with Ringer's solution. An arthroscope was inserted 30°

obliquely through the standard posterior portal; the anterior capsule, ligaments, and subscapularis tendon were examined in different shoulder joint positions.

RESULTS

Gross Anatomy

The oblique ascending capsular ligament in the superficial layer of the anterior shoulder joint capsule—the spiral GHL—was clearly visible in all 22 shoulder specimens. It arose as a distinct band from the infraglenoid tubercle and from the long head of the triceps brachii muscle tendon (Fig 2A). After crossing the underlying IGHL and establishing a tight connection with the MGHL, it fused laterally with the postero-cranial surface of the subscapularis tendon. The spiral GHL and the subscapularis tendon inserted together onto the lesser tubercle of the humerus (Figs 2A and 2B). Looking through the opened subscapularis bursa on the inner side of the anterior capsule, the spiral GHL was not macroscopically recognizable. The spiral shape of the obliquely ascending capsular ligament became taut and clearly visible with the humerus in abduction and in external rotation (Fig 2B).

The MGHL originated from the superior neck of the scapula and the antero-superior labrum. After crossing the spiral GHL, the MGHL lost its clear macroscopic appearance and the fibers fused with the lateral part of the anterior joint capsule. The MGHL was absent in three shoulder specimens (Fig 2B).

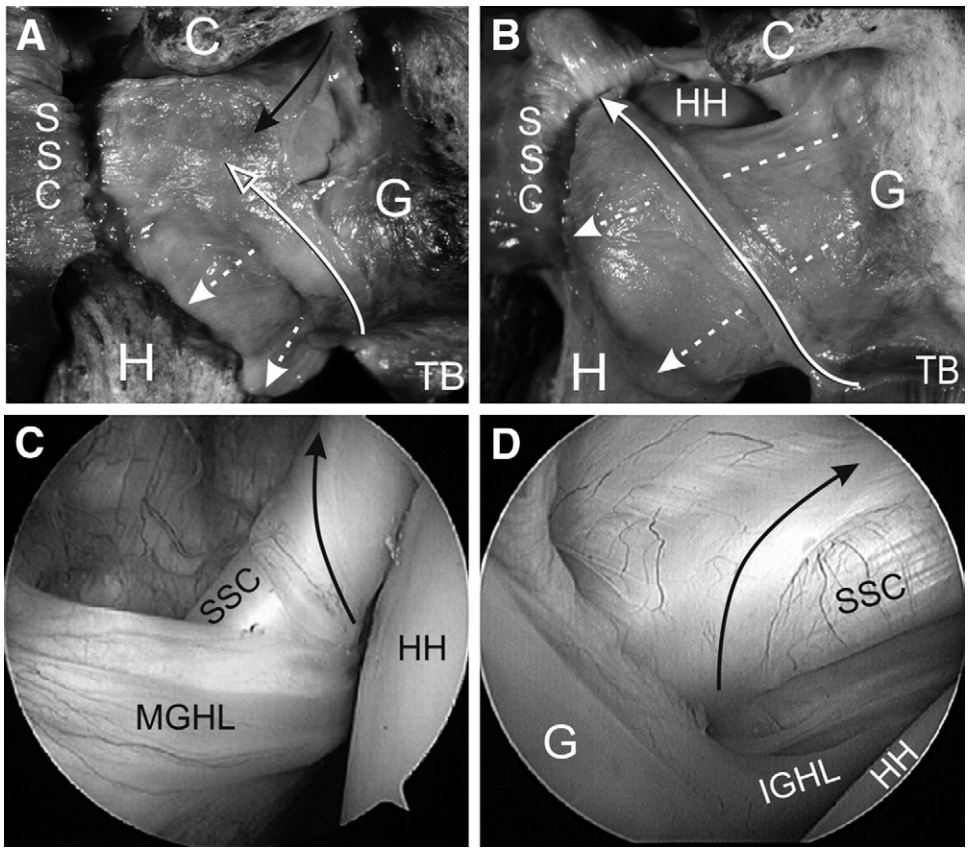

FIGURE 2. Anatomic dissection and clinical arthroscopic procedures on the right shoulder joint with MGHL (A and C) and without MGHL (B and D). (A) Visible capsular thickening: the spiral GHL (white arrow) and MGHL (black arrow) fuse within the anterior capsule, which has been separated from the subscapularis tendon (SSC). The IGHL runs deep to the spiral GHL (white dotted arrows). (B) The course of the spiral GHL from the infraglenoid tubercle to the lesser tubercule of the humerus is clearly visible under tension in abduction and in external rotation. The absence of the MGHL does not influence the basic anatomic properties of the spiral GHL. (C) Intra-articular view through a standard posterior arthroscopy portal shows the spiral GHL (black arrow) as an ascending bundle of fibers overlapping the cranio-lateral margin of the subscapularis tendon, which is partially veiled by the MGHL. (D) In absence of the MGHL, the anterior band of the IGHL and a relatively more pronounced part of the spiral GHL are visible. (Abbreviations: C, coracoid process; HH, humeral head; SSC, subscapularis tendon; G, glenoid; H, humerus; TB, tendon of the triceps brachii muscle.)

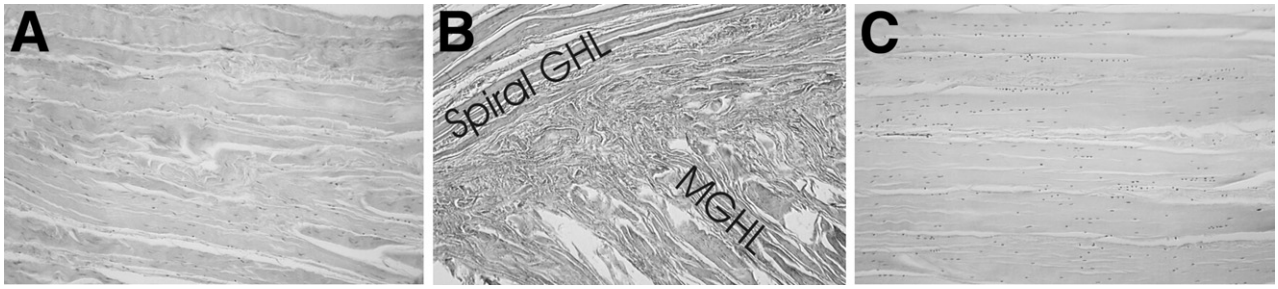

FIGURE 3. Histologic appearance of the spiral glenohumeral ligament at the insertion onto the lesser tubercle of the humerus (A), crossing with the middle glenohumeral ligament (B) and at the origin (C). In all parts, the spiral glenohumeral ligament displays features of the dense connective tissue with the parallel-oriented bundles of collagen fibers, which is typical of a ligamentous structure.

The AxIGHL was present in all investigated shoulder specimens. It originated from the anterior and inferior margins of the scapular neck and labrum, coursed obliquely under the spiral GHL, and inserted onto the anatomic and surgical necks of the humerus. The AIGHL was not detectable on the extra-articular side of the joint capsule (Figs 2A and 2B).

Microscopic Anatomy

In all shoulder specimens, the three investigated parts (caudal, middle, and cranial) of the spiral GHL showed typical features of the dense connective tissue with the parallel-oriented bundles of collagen fibers, which is typical of a ligamentous structure (Fig 3).

Arthroscopic Anatomy

The spiral GHL was identified in 22 of the 49 evaluated cases (44.9%). The major caudal and inferior parts of the spiral GHL were concealed by the MGHL, AIGHL, and AxIGHL. After crossing the MGHL, a subtle, obliquely ascending capsular thickening became visible on the upper cranial margin of the subscapularis tendon (Figs 2C and 4). The craniolateral part of the spiral GHL inserted together with the fibers of the subscapularis tendon onto the upper medial part of the lesser tubercle of the humerus. External or internal rotation of the patient's arm did not affect visualization of the spiral GHL. The MGHL was tightly connected with the antero-superior labrum, blended with the spiral GHL, and fused with the lateral joint capsule (Fig 2C). The MGHL was absent in 6 of 49 (12.2%) shoulders (Fig 2D). In these cases, a relatively more pronounced appearance of the spiral GHL was noted (Fig 2D). The AIGHL originated from the area between the 2 and 4 o'clock positions and inserted at the anatomic neck of the humerus. It was found in 46 of 49 cases (93.9%).

DISCUSSION

Our study describes the arthroscopic appearance as well as gross and microscopic anatomy of the relatively unknown glenohumeral joint structure, the so-called spiral GHL.

According to a currently accepted opinion, the GHLs are constant and discrete thickenings of the joint capsule.[14] As such, the anterior capsular ligaments are best visible from the inside of the shoulder joint, as shown in contemporary anatomy textbooks[3,4] and clinical studies.[5-7] Besides this well known de-

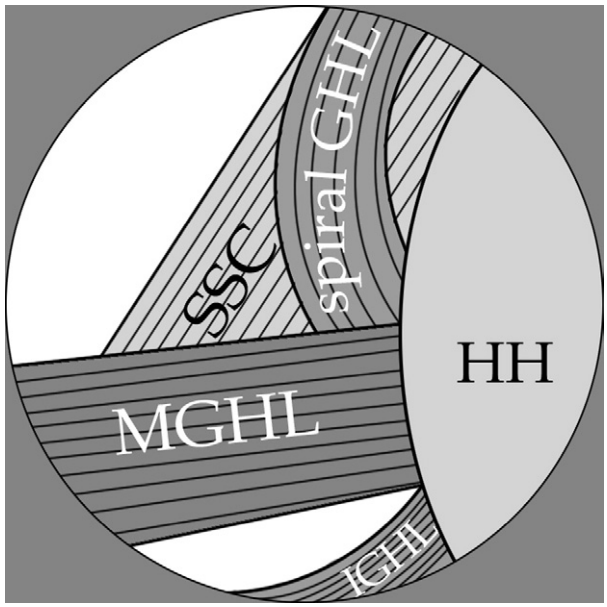

FIGURE 4. Arthroscopic view of the anterior capsular structures. (Abbreviations: HH, humeral head; IGHL, inferior glenohumeral ligament [anterior band]; MGHL, middle glenohumeral ligament; SSC, subscapularis tendon, ligament; spiral GHL, spiral glenohumeral ligament.)

scription, a bundle of fibers, originally called fasciculus obliquus[10] or "longitudinal oblique system,"[11] has been found on the extra-articular side of the joint capsule. Landsmeer and Meyers[11] described it as part of the subscapularis muscle fascia within the inferior superficial capsular layer. Further anatomic investigations[15,16] have only confirmed the existence of the fasciculus obliquus without providing a more detailed gross anatomic description of this structure.

The basic structure and the histologic appearance of the normal shoulder joint capsule have been already shown in previous studies.[5,17] In addition, thorough histologic investigations have confirmed the existence of the obliquely arising bundles of collagen fibers of the fasciculus obliquus, and the approximate position of the structure has been seen on schematic drawings.[16] Our study supports the previous histologic findings[5] and proves the existence of parallel-oriented bundles of collagen fibers throughout the entire course of the spiral GHL.

The macroscopic appearance of these capsular fibers that form a distinct capsular ligament on the extra-articular side of the anterior joint capsule has been shown in recent studies[12,13] and is consistent with the findings of the present investigation. As shown in anatomic investigations, the bundle of the upper lateral fibers, in contrast to the strong inferior medial part, became much thinner and was not clearly visible from the inside of the joint. However, nearly half of our clinical arthroscopic evaluations revealed a subtle thickening in the anterior capsule, ascending upon the lateral border of the subscapularis tendon.

The variable absence of the MGHL in shoulder specimens and in patients studied (13.6% and 12.2%, respectively) is similar to previous anatomic reports that have shown its absence in 12% to 37% of cases.[6,9] The presence and intra-articular appearance of the anterior band of the IGHL also coincide with the findings of other studies.[5,7]

Despite impressive previous gross anatomic and arthroscopic investigations of the anterior shoulder joint capsule and, particularly, the subscapularis tendon,[5-7,9,15,18-21] we found no descriptions corresponding to the intra-articular fibers of the spiral GHL. This can be explained by the fact that approximately 25% of the entire subscapularis tendon can be seen arthroscopically.[20] Even if noted previously, because of the limited field of vision, this fine bundle of fibers upon the subscapularis tendon has not been identified as an intra-articular part of the ascending fibers of the spiral GHL, because the structure is still relatively unknown.

Our study was limited by the small number and high age of the investigated shoulder specimens and by the limited number of clinical cases. For this reason, the anatomic variability of the spiral GHL was not recorded.

CONCLUSIONS

The results of this anatomic study suggest that extra-articular structure of the spiral GHL is consistently recognizable and the upper part of the spiral GHL can be arthroscopically identified. Further biomechanical and clinical studies are needed to clarify its clinical importance.

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