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The anterior glenohumeral joint capsule: macroscopic and MRI anatomy of the *fasciculus obliquus* or so-called *ligamentum glenohumerale spirale*

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Abstract The purpose of this study was to demonstrate the macroscopic and MRI anatomy of the *fasciculus obliquus*, otherwise known as the *ligamentum glenohumerale spirale* or spiral GHL of the anterior shoulder joint capsule. Conventional and MR arthrography (1.5-T device Somatom Symphony, Siemens with shoulder coil) images in standard planes were compared with gross anatomic dissection findings in six fresh shoulder specimens from three cadavers. The MR imaging protocol included T1, PD and DESS 3D WI sequences. The macroscopically

recognisable band—the spiral GHL—was identified by anatomic dissection and MRI in all the specimens. It was best visualised by MR arthrography on axial and oblique sagittal planes (T1; PD WI) and appeared as a low signal intensity stripe within the superficial layer of the anterior joint capsule. The absence of the variable middle glenohumeral ligament did not influence the anatomic properties and the MR imaging of the spiral GHL. Diagnostic visualisation of the normal anatomic structures is a prerequisite to distinguish between normal and pathologic conditions. Anatomy of the spiral GHL can be used by radiologists for more detailed interpretation of the anterior shoulder joint capsule ligaments on MR images.

Keywords Shoulder · MRI · MR arthrography · Ligaments

Introduction

Anterior shoulder instability is a common clinical problem in orthopaedic practice. Since an aim of the orthopaedic operation is to restore the anatomy of the joint or to reinforce the injured joint structures, a preliminary detailed anatomy-based diagnosis is required [1–8].

In the official *Terminologia Anatomica*, the three ligaments of the anterior shoulder joint capsule are mentioned together as *Ligg. glenohumeralia* [9]. As such, contemporary anatomy textbooks and atlases do not demonstrate the detailed anatomy of these ligaments [10–12].

In the clinical literature, the three anterior capsular ligaments classically have been described as the superior, middle and inferior glenohumeral ligaments (SGHL, MGHL and IGHL) [13]. The IGHL has been divided into three parts—an anterior band, a posterior band and an interposed axillary pouch [14]. In addition to the SGHL, MGHL and IGHL, a bundle of fibres historically called the *fasciculus obliquus* or “longitudinal oblique system” has been described in the superficial layer of the anterior shoulder joint capsule [15–17].

A recent anatomic study on embalmed shoulder joints revealed more detailed anatomy of the *fasciculus obliquus* that made it possible to recognise it as a distinct anterior

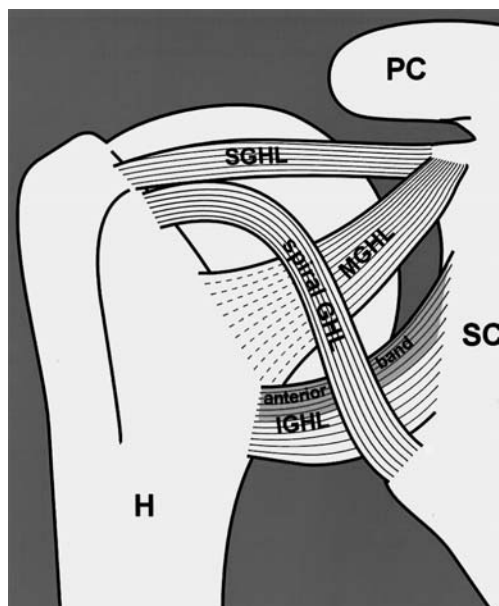


Fig. 1 Schematic drawing of the anterior capsular ligaments. *H* humerus, *PC* processus coracoideus, *SC* scapula, *SGHL* superior glenohumeral ligament, *MGHL* middle glenohumeral ligament, *IGHL* inferior glenohumeral ligament with projection of the anterior band; *spiral GHL* spiral glenohumeral ligament (*fasciculus obliquus*)

capsular ligament. Because of its macroscopic appearance during external rotation and abduction, it was named the *Ligg. glenohumerale spirale* (Fig. 1). Despite the tight connection with the MGHL and IGHL, its significance in the shoulder joint biomechanics and involvement in different pathologic conditions has not been investigated [18].

MR imaging has proved to be a valuable method in identifying the normal anatomy of the shoulder joint and in the diagnostic evaluation of labrum and glenohumeral ligaments [19–24]. The aim of this study was to repeat the previous anatomic dissections on fresh shoulder joint specimens and to attempt to visualise the *fasciculus obliquus*, or *Ligg. glenohumerale spirale* (spiral GHL), on conventional and contrast-enhanced MR images.

Material and methods

Six fresh shoulder joints (three right and three left) from three cadavers (two male and one female; ages 73, 81 and 91 years) were investigated by MR imaging and subsequent gross anatomic dissection.

MR imaging of the shoulder specimens

Shoulder specimens were examined by MRI on a 1.5 Tesla device [Somatom Symphony (R), Siemens, Erlangen, Germany]. The shoulder coil was used in all cases. Three shoulders were investi-

gated without contrast medium. MR arthrography was performed on all the six shoulder specimens. The MR arthrography was done under fluoroscopic control with injection of 15–20 ml of a contrast solution (1 ml of Omniscan in 100 ml of saline). We used standard axial, oblique sagittal and oblique coronal fat saturated views PDW WI [TR 3,000 ms, TE 36 ms, SL 3 mm, Matrix (M) 224×512, number of acquisitions (NA) 2, TA (min) axial 3.18, oblique sagittal/coronal 3.54], axial and oblique sagittal T1 W1 [TR 632 ms, TE 14 ms, SL 3 mm, M 256×512, NA 3, TA (min) axial 4.32, oblique sagittal 3.46] and DESS 3D W1 [TR 21.5 ms, TE 6.5 ms, SL 1.5 mm, M 217×256, NA 1, TA (min) 5.14].

Gross anatomic dissection

After MRI examination, the soft tissues, clavicle and shoulder girdle muscles were removed from the shoulder specimens. The extra-articular part of the long head biceps tendon within the inter-tubercular groove was preserved. The acromion was separated from the scapular spine and turned anteriorly together with the acromioclavicular ligament. Muscles and tendons of the rotator cuff were cleaned from the rests of the subacromial bursa and separated from the joint capsule. The ligaments of the anterior joint capsule were identified by fine dissection according to the direction of the bundles of collagen fibres. The subscapularis bursa was opened to visualise the glenoid labrum and its relation to the capsular ligaments. To avoid confusing recognition of capsular folds as ligaments, the anatomically identified structures were examined through the total range of shoulder joint motions.

Comparison of the MR images with gross anatomic specimens

On MR images we specifically evaluated the MGHL, the spiral GHL and the anterior band as well as the axillary part of the IGHL complex. Because of the separate position of the SGHL and posterior band of the IGHL complex from the spiral GHL, these structures were not evaluated in MR images and during gross anatomic dissection of the shoulder joints.

Since the spiral GHL has not been previously described in the radiology literature, two experienced specialists in musculoskeletal radiology read the first two MR images after they saw the cadaver specimens and learned the pertinent anatomy. Having become familiar with the expected location of the spiral GHL, the remaining four shoulder MR images were interpreted prior to the anatomic dissection. Different evaluations were resolved by consensus.

Results

Gross anatomic dissection

The glenohumeral ligaments of the anterior shoulder joint capsule were clearly recognisable structures (Figs. 2d–f, 3c). The spiral GHL was present in all the six dissected shoulder joint specimens. It arose from the region of the infraglenoid tubercle and the long head of the triceps muscle as a separate band (Fig. 2e,f). The ligament coursed cranially in the superficial layer of the anterior shoulder joint capsule, crossing and fusing with the underlying IGHL. After establishing a tight connection with the MGHL, it fused with the postero-cranial surface of the subscapularis tendon. The ligament and the tendon inserted together on the lesser tubercle of the

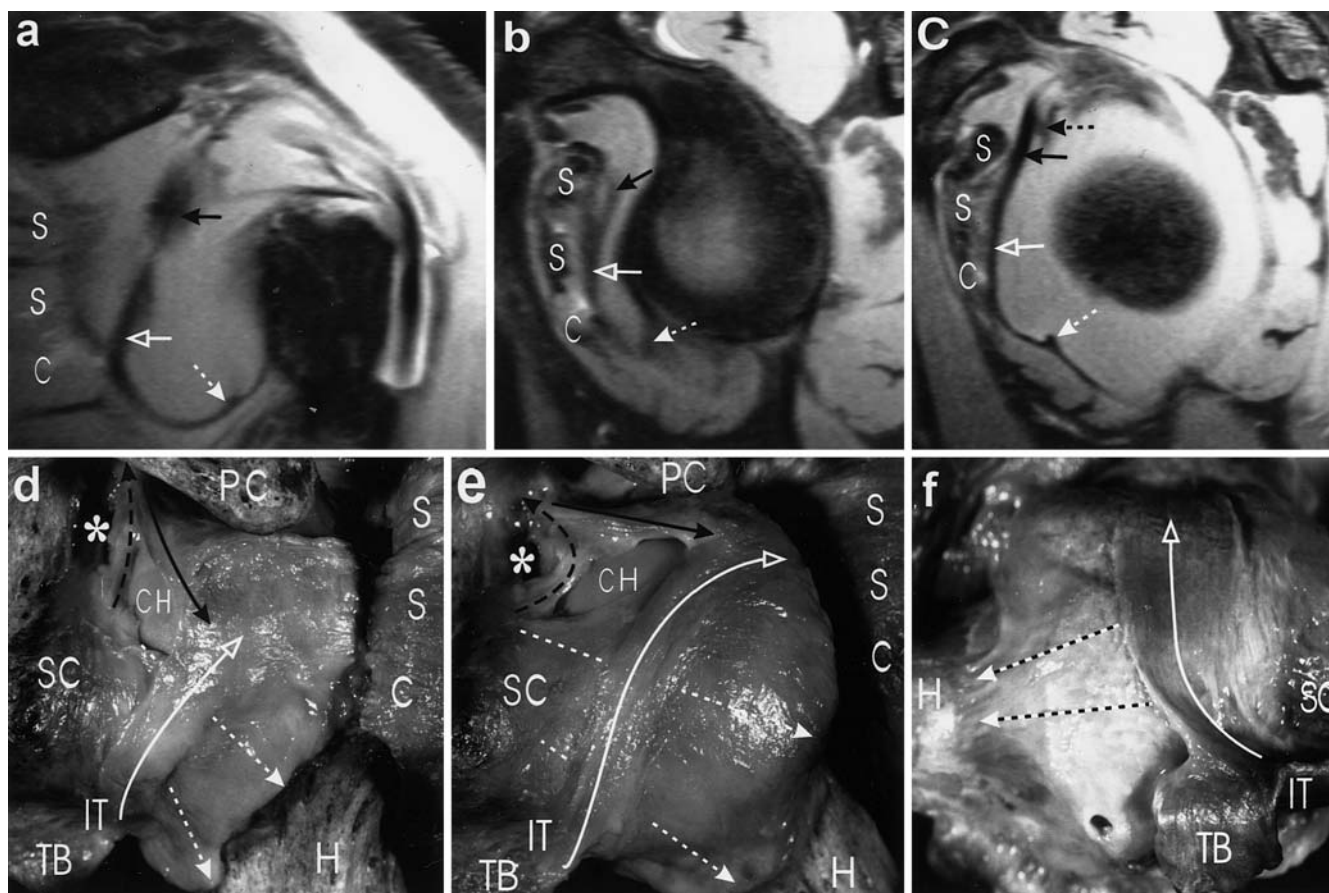


Fig. 2 a–c MR arthrograms of a left shoulder with MGHL. PD-WI fat-saturated (fs); TR/TE=3,000/36 ms. **a** Oblique coronal image shows the MGHL (black arrow), an anterior capsular folding corresponding to the location of the spiral GHL (white arrow) and the axillary part of the IGHL (dotted white arrow). **b, c** Subsequent oblique sagittal images show anterosuperior labrum (dotted black arrow), the MGHL (black arrow), the anterior capsular section with spiral GHL (white arrow) and the anterior band of the IGHL (dotted white arrow). **d–f** Photograph of an anatomic dissection of a left shoulder specimen with MGHL. **d, e** The MGHL (black arrow) and visible capsular thickening—the spiral GHL (white arrow)—fuse with the anterior capsule, which has been separated from the subscapularis muscle (SSC). The IGHL (dotted white arrows) pass deep to the spiral GHL. A normal variation of the anterosuperior labrum (dotted black arrow) with sublateral foramen (asterisk) is noted. **e** In abduction and external rotation, the anterior capsular structures come under tension. The course of the spiral GHL and its fusion with MGHL is clearly demonstrated. **f** Photograph of an axillary view of a right shoulder specimen in abduction demonstrates the spiral GHL (white arrow) origin from the infraglenoid tubercle and its superficial course over the taut IGHL (dotted white arrows). PC processus coracoideus, CH caput humeri, SSC subscapularis muscle, SC scapula, H humerus, IT infraglenoid tubercle, TB tendon of the triceps brachii muscle

humerus (Figs. 2d,e, 3c). The spiral appearance of the oblique, ascending capsular ligament was clearly visible with the humerus in abduction and external rotation (Fig. 2e).

The MGHL originated from the superior neck of scapula and was connected to the antero-superior labrum. It coursed in a caudal direction under the subscapularis tendon and crossed with the ascending fibres of the spiral GHL. With the humerus in abduction and external rotation, the spiral GHL tensed and turned the MGHL from the vertical to a nearly horizontal position (Fig. 2d,e). After the crossing with the spiral GHL, the MGHL fused with the lateral joint capsule, and its course towards the lesser tubercle of the humerus was not clearly detectable macroscopically. The MGHL was absent in two glenohumeral joints. The absence of the MGHL in two glenohumeral specimens did not influence the anatomic position or the main course of fibres of the spiral GHL (Fig. 3c).

The IGHL complex was present in all the six investigated shoulders. It originated from the antero-inferior neck of the scapula, coursed under the spiral GHL in the latero-caudal direction and inserted on the anatomic neck of the humerus. The anterior thickening of the IGHL complex was not recognisable on the extra-articular side of the joint capsule (Figs. 2d–f, 3c).

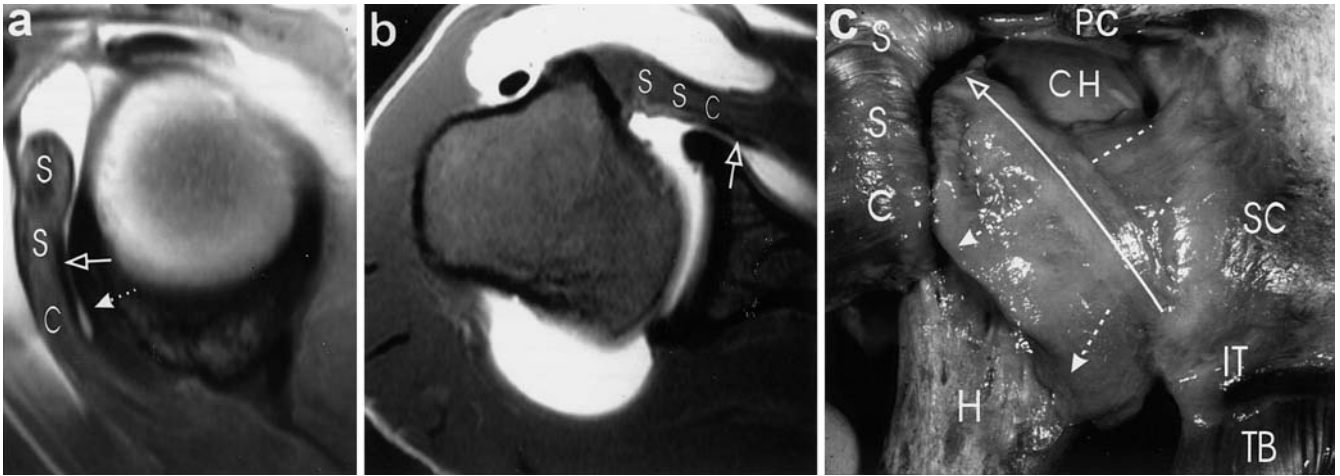


Fig. 3 MR arthrograms of a left shoulder without MGHL. **a** Oblique sagittal PD-WI; fs; TR/TE=3,000/36 MR arthrogram of a left shoulder demonstrates the anterior band of the IGHL (dotted white arrow) in the deep layer and the spiral GHL (white arrow) in the superficial layer of the shoulder joint capsule. **b** Axial T1-WI; fs; TR/TE=632/14 ms scan—the spiral GHL runs perpendicular to the plane of imaging and is seen as a low signal intensity stripe (white arrow) within the anterior capsule. The MGHL is absent on both images. **c** Photograph of a right shoulder specimen without the MGHL. The IGHL complex (dotted white arrows) is visible together with the spiral GHL (white arrow). PC processus coracoideus, CH caput humeri, SSC subscapularis muscle, SC scapula, H humerus, IT infraglenoid tubercle, TB tendon of the triceps brachii muscle

In addition, we observed the sublabral foramen as a complete separation between the antero-superior labrum and the underlying glenoid rim in two specimens. Its anatomical appearance depended on the position of the MGHL (Fig. 2d,e).

MRI findings

The ligaments of the anterior shoulder joint capsule were best seen on axial (T1 WI, PDW WI, DESS) and oblique sagittal (T1 WI and PDW WI) oriented images after MR arthrography (Figs. 2b,c, 3a,b). In one of six shoulders, the oblique coronal sections were useful for detecting MGHL and spiral GHL (Fig. 2a).

The spiral GHL was detectable as a low signal intensity stripe on MR images along its course within the anterior joint capsule in all the six specimens (Figs. 2a–c, 3a,b). The ligament could not be detected in two of three shoulder MR images without arthrography.

The MGHL was absent on MR images in two shoulder specimens. This was confirmed during the anatomic dissections.

The IGHL was seen on all MR arthrograms as a continuous low signal intensity band with an origin on the anterior and inferior parts of the scapular neck and an in-

sertion on the neck of humerus. On the oblique sagittal plane images, the anterior band of the IGHL complex became clearly recognisable (Figs. 2b,c, 3a).

Discussion

The results of the present investigation confirm the existence of an additional glenohumeral ligament within the superficial layer of the anterior shoulder joint capsule. Its oblique course through the midline of the anterior joint capsule was recognisable in all the investigated fresh cadaver shoulder joint specimens and on MR images with arthrography.

A superficial oblique course of collagen fibres within the superficial layer of the anterior shoulder joint capsule, the *fasciculus obliquus*, was first described by Delorme in 1910. This finding was confirmed by Landsmeer and Meyers in 1959. According to their description, the inferior superficial capsular layer formed a bundle of fibres that was recognised as a part of the *M. subscapularis* fascia. This *fasciculus obliquus* intermingled cranio-laterally with the MGHL and the subscapularis tendon, lost its macroscopic appearance and fused with the superior part of the anterior joint capsule. Later anatomic investigations have confirmed the existence of the *fasciculus obliquus* with no additional gross anatomic description of this capsular structure [13, 17, 25].

Our findings on six fresh shoulder joint specimens support the previous, more detailed macroscopic description that rediscovered the existence of the oblique capsular fibres in the form of a separate ligament—the *Ligg. glenohumerale spirale* [18]. The spiral GHL originates from the infraglenoid tubercle and the long head triceps tendon and is tightly connected with the IGHL and MGHL. Cranially, it fuses with the subscapularis tendon and inserts together with it on the lesser tubercle of the humerus, which has not been found in the previous in-

vestigations describing the *fasciculus obliquus* of the anterior shoulder joint capsule [15, 16].

The anatomic knowledge of the existence of the spiral GHL and its connection with the MGHL could be used during the interpretation of the MR images. Because the fibres of the spiral and MGHL ligaments are close to the oblique coronal plane, the partial volume effect within the anterior joint capsule interferes with visualisation of these ligaments. Despite this, these structures can be identified on oblique coronal images (Fig. 2a). In the oblique sagittal plane, a nearly vertical position of the spiral GHL and the MGHL is visualised as one or two low signal intensity vertical stripes (Fig. 2b,c). In those cases when the MGHL exists, one could follow its course to identify the spiral GHL at the point of fusion (Fig. 2b). However, the MGHL can be absent in 12–27% of cases [26–28]. In our series, it was not found in two of six specimens (both shoulders in one cadaver), which confirms the previous results concerning the variability of the MGHL. When the MGHL is absent, the low signal intensity stripe of the spiral GHL is detectable on the posterior, articular side of the subscapularis muscle (Fig. 3a). The clear visualisation of the spiral GHL on axial MR images might be explained with the cross-sectional view of the separate anatomic structure (Fig. 3b).

The anatomic and MRI appearance of the IGHL complex and the absence of the anterior band on the extra-articular side of the shoulder joint capsule (Figs. 2c–f, 3c) are consistent with previous anatomic findings [14, 18, 27] and MR arthrography results [20, 21, 23].

Direct MR arthrography has proven to be a useful method in the evaluation of the normal anatomy as well as pathologies of the shoulder joint [22, 23, 29–31]. The

enhanced soft tissue contrast and controlled distension of the joint cavity provides better delineation and assessment of the glenohumeral intra-articular structures. Our results support the positive experience of the previous studies. Without injection of the contrast medium, the spiral GHL could be recognised only in one of the three shoulder joints.

The small number and old age of the investigated shoulder specimens limited the present study. We obtained the MR images with the shoulder in the neutral position, but the anatomic dissection showed that the spiral GHL is the best visualised with the shoulder in abduction and external rotation. Therefore, MR imaging of the spiral GHL may be improved if the shoulder is placed within the coil with the spiral GHL in the tensioned position.

The macroscopic appearance of the spiral GHL and its tension during abduction and external rotation suggests that its role in shoulder joint function might be underestimated. During motion, the spiral GHL influences the position of the MGHL that plays an important role in maintaining the shoulder joint stability. As the diagnostic visualisation of the normal anatomic structures is a prerequisite to distinguish between normal and pathologic conditions, MRI anatomy of the spiral GHL can be used by the radiologist for more detailed interpretation of the anterior shoulder joint capsule ligaments on MR images.

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