Anatomy of the glenohumeral ligaments

Alashkham, Abduelmenem; Alraddadi, Abdulrahman; Soames, Roger

Published in:
Italian Journal of Anatomy and Embryology

DOI:
10.13128/IJAE-24160

Publication date:
2018

Document Version
Peer reviewed version

Anatomy of the glenohumeral ligaments

Abduelmenem Alashkham[1,2,4], Abdulrahman Alraddadi[1,3], Roger Soames[1]

[1]Centre for Anatomy and Human Identification, University of Dundee, Dundee, UK.

[2]Human Anatomy Department, Faculty of Medicine, University of Zawia, Zawia, Libya.

[3]King Saud bin Abdulaziz University for Health Sciences, Riyadh, Saudi Arabia

[4]Centre for Human Anatomy, School of Biomedical Sciences, University of Edinburgh, Edinburgh, UK

Running title: glenohumeral ligament

Corresponding author:

Dr Abduelmenem Alashkham (PhD, MSc (distinction), MBBCH)

Teaching Fellow in Human Anatomy, University of Edinburgh

Old Medical School

Teviot Place

EH8 9AG

Edinburgh, United Kingdom

E-mail: { HYPERLINK "mailto:Abduelmenem.alashkham@ed.ac.uk" }

Abstract

For many years, there has been controversy regarding the presence of the glenohumeral ligaments, the aim of the present study was to evaluate the detailed anatomy of these ligaments. 140 shoulders were dissected and examined. The detailed anatomy of glenohumeral ligaments were recorded. Data were doubled-entered into the Statistical Package for Social Sciences version 21. Kruskal-Wallis and one way analysis for variance on ranks tests were used: statistical significance was set at $p<0.05$. The superior glenohumeral ligament was present in all specimens originating from the glenoid labrum anterosuperior aspect, inserting into the lesser tubercle (mean thickness 5.06 mm). The middle glenohumeral ligament was present in 98.57% of specimens arising from the glenoid labrum anterior aspect, inserting into the lesser tubercle (mean thickness 5.97 mm). The inferior glenohumeral ligament anterior band was present in all specimens arising from the glenoid labrum anteroinferior aspect, inserting into the humeral neck anteroinferior aspect (mean thickness 4.41 mm). The inferior glenohumeral ligament posterior band was observed in 79.28% of specimens arising from the posteroinferior aspect of the glenoid labrum, inserting into the humeral neck posteroinferior aspect: its mean thickness was 3.45 mm. this study concludes that the superior glenohumeral ligament was observed in all specimens. The middle glenohumeral ligament was seen in 98.57%. An anterior band of the inferior glenohumeral ligament was present in all specimens, while a posterior band was present in 79.28%. A tuberculohumeral ligament was seen in 54.83% of specimens. The present observations should encourage evaluation of the function of this ligament.

Keywords: Fibrous capsule; Inferior glenohumeral ligament; Middle glenohumeral ligament, Superior glenohumeral ligament; Shoulder joint;

Introduction

Even though the glenohumeral (superior, middle and inferior) ligaments were described by Flood (1829), controversy regarding their anatomy still exists. The superior glenohumeral ligament has been described as a slender ligament arising from the superior margin of the glenoid cavity and adjacent glenoid labrum and inserting into a small depressive area on the humeral articular surface (Di Giacomo et al. 2008; Robinson 1922; Gray et al. 1946). Williams (1995) stated that it arose from the coracoid process base and the superior aspect of the glenoid labrum and inserted into an area located between the lesser tubercle and the articular margin. Kolts et al. (2001) observed that the superior glenohumeral ligament arose from the supraglenoid tubercle and inserted into the lesser tuberosity. Lately, Kask et al. (2010) reported that the superior glenohumeral ligament divides into direct and oblique fibres, with the oblique fibres arising as a common origin with the middle glenohumeral ligament from the supraglenoid tubercle inserting in the semicircular humeral ligament while the direct fibres arose directly from the glenoid labrum between 11 and 1 o'clock inserting mainly into the floor of the bicipital groove and partly into the lesser tubercle.

Contemporary anatomy textbooks and atlases report the middle glenohumeral ligament originating proximally just inferior to the superior ligament from a wide area along the anterior margin of the glenoid as far inferiorly as the inferior third of the rim and inserting into the anterior surface of the lesser tubercle of the humerus (Williams 1995; Palastanga et al. 2006; Sinnatamby 2006). In contrast, the middle glenohumeral ligament has been reported as arising from the superior neck of the scapula and anterosuperior aspect of the glenoid labrum, fusing with the lateral aspect of the anterior region of the fibrous capsule (Merila et al. 2008). Kolts et al. (2001) reported that the middle glenohumeral ligament arose from the supraglenoid tubercle, anterosuperior aspect of the glenoid neck of the scapula and the base of the coracoid

process inserting into the lesser tuberosity, while Gray et al. (1946) stated that it inserts into the inferior aspect of the lesser tubercle.

Robinson (1922), Gray et al. (1946) Palastanga et al. (2006) and Williams (1995) describe the inferior glenohumeral ligament as being more prominent, ambiguous, longer and stronger proximally compared to the superior and middle glenohumeral ligaments, originating from the anterior margin of the glenoid cavity inferior to the glenoid notch and the anterior border of the glenoid labrum: it then passes inferolaterally to attach to the anteroinferior or inferomedial aspect of the anatomical neck of the humerus distally. In contrast, Kolts et al. (2001) reported that it originates from the scapular neck and base of the coracoid process inserting into the surgical neck of the humerus, while Cooper et al. (1992) revealed that the inferior glenohumeral ligament was firmly attached to the glenoid rim as well as the anteroinferior aspect of the glenoid labrum at 4 o'clock.

Both Ticker et al. (2006) and Fealy et al. (2000) reported that the inferior glenohumeral ligament consists of anterior and posterior bands, with an intervening axillary pouch. According to Fealy et al. (2006) the anterior and posterior bands arise from the glenoid labrum between 2 - 4 o'clock and 8 - 9 o'clock respectively, while Ruiz et al. (2012) reported the anterior band arising from the anterosuperior glenoid labrum at 3 o'clock or above in 40% (n=4) of shoulders, from the middle glenohumeral ligament in 10% (n=1) and from the anteroinferior glenoid labrum in 50% (n=5). Gelber et al. (2006), in contrast, reported that proximally the bands originated from the glenoid rim midway along the anterior and posterior borders, attaching distally to the humeral neck in the form of a collar in 41% (n=25), to the humerus with an inferior angulation giving rise to a V-shaped axillary pouch in 36% (n=22), while in 23% (n=14) the distal attachment was not well defined.

The superior glenohumeral ligament has been consistently reported by Delorme (1910), Welcker (1877) and Fick (1904: cited in Di Giacomo et al. 2008)). Park et al. (2000) report the

presence of the superior and inferior glenohumeral ligaments in 99% (n=107) of specimens, with the middle glenohumeral ligament being observed in only 79% (n=85) of specimens. Wilson et al. (2012) observed the superior glenohumeral ligament has been observed in all shoulders examined (Wilson et al., 2012) and 88% (n=43) (Merila et al. 2008), with the middle glenohumeral ligament present in 88% (n=91) (Wilson et al. 2012) and 94% (n=46) (Merila et al. 2008). Furthermore, Merila et al. (2008) observed a spiral glenohumeral ligament arising from the infraglenoid tubercle and tendon of the long head of triceps brachii, passing superoanterolaterally anterior to the middle and inferior glenohumeral ligaments fusing with the tendon of subscapularis to insert together in the lesser tuberosity of the humerus: this was observed in all fresh frozen specimens, but in only 45% of arthroscopic shoulders. Dewan et al. (2012) reported variations of the superior glenohumeral ligament in 7.84% (n=4), the middle glenohumeral ligament in 9.8% (n=5) and the inferior glenohumeral ligament in 17.64% (n=9) of individuals.

In contrast to the foregoing, Longo et al. (1996) reported the presence of a superior glenohumeral ligament in 10% (n=1), a middle glenohumeral ligament in 30% (n=3) and an inferior glenohumeral ligament in 40% (n=4) of specimens.

The aim of the present study was to determine and evaluate the detailed anatomy of the glenohumeral ligaments.

Materials and Methods:

One hundred and forty formaldehyde-embalmed shoulders from 30 males and 40 females, average age 81.5 years (range 53-101 years), were examined. All muscles around the glenohumeral joint were removed allowing a full exposure of the fibrous capsule. An incision was made through the lateral part of the posterior aspect of the fibrous capsule and posterior dislocation of the humeral head was performed, following which the long head of biceps brachii was released from the fibrous capsule superiorly. The interior anterior aspect of the fibrous

capsule was carefully manipulated and observed to identify and distinguish the glenohumeral ligaments. Stretching of the fibrous capsule with some degree of humeral flexion helped in exposing the presence of the glenohumeral ligaments. The site of origin and thickness of the superior, middle and inferior glenohumeral ligaments, using digital callipers, were examined and recorded. Data were doubled-entered into the Statistical Package for Social Sciences (SPSS, version 21). Kruskal-Wallis and one-way analysis of variance on ranks tests were used: statistical significance was set as $p<0.05$. The repeatability and reliability of the measurements taken was determined by randomly selecting shoulders from the study cohort and taking three measurements of each on three separate occasions by the researcher and by two other individuals on two separate occasions.

Results:

Kruskal-Wallis One-Way Analysis of Variance on Ranks revealed no difference for a single observer between the same measurements taken on separate occasions ($P<0.504$); nor was there any difference in measurements taken by different observers ($P<0.759$). These results indicate that the measurement methodology used was reliable and repeatable.

Superior glenohumeral ligament:

The superior glenohumeral ligament was present in all specimens (N=140) arising from the anterosuperior aspect of the glenoid labrum between the attachment of the long head of the biceps and the middle glenohumeral ligament (Figure 1) passing laterally to attach to the anterior aspect of the lesser tubercle of the humerus. The mean thickness at its origin of 5.06 mm, with no significant difference between males and females ($P=0.223$), although mean thickness was greater in males that females. In both males and females the left side was thicker than the right (Table 1); however this difference was not significant.

Middle glenohumeral ligament:

The middle glenohumeral ligament was observed in 98.6% (n=138) of specimens arising from both the anterior aspect of the glenoid labrum immediately inferior to the superior glenohumeral ligament and the anterior aspect of the glenoid neck of the scapula (Figures 1 and 2). It first ran inferiorly then laterally to attach to the anterior aspect of the lesser tubercle humerus just inferior to the superior glenohumeral ligament. The overall mean thickness of the middle glenohumeral ligament at its origin was 5.97 mm: a significant difference (P=0.003) between males and females was observed with the mean thickness being greater in males than females. In both genders, the right middle glenohumeral ligament was thicker than the left, but the difference was not significant (Table 1). The middle glenohumeral ligament was absent in one (1.4%) female cadaver on both sides.

Inferior glenohumeral ligament anterior band

The inferior glenohumeral ligament anterior band was present in all specimens arising from the anteroinferior aspect of the glenoid labrum between 3 and 5 o'clock and ran laterally to attach to the anteroinferior aspect of the humeral neck (Figure 2). The overall mean thickness of the inferior glenohumeral ligament anterior band at its origin was 4.41 mm, there being no significant difference (P=0.052) between males and females although the thickness was greater in males than females. Although thicker on the left than the right in both genders, the differences were not significant Table (1).

Inferior glenohumeral ligament posterior band

An inferior glenohumeral ligament posterior band was present in 79.28% (n=111) of specimens arising from the posteroinferior aspect of the glenoid labrum between 7 and 9 o'clock, passing laterally to attach to the posteroinferior aspect of the humeral neck to form, with the anterior band of the inferior glenohumeral ligament, an axillary pouch (Figure 3). The overall mean thickness of the inferior glenohumeral ligament posterior band at its origin was less than the anterior band, being 3.45 mm, with the mean thickness being significantly (P=0.004) greater

in males than females. In males, the right side was thicker than the left, while in females the left side was thicker than the right: however, these differences were not significant (Table 1). In females, the posterior band was absent in 13 (16.25%) specimens, 6 (7.5%) on the right and 7 (8.75%) on the left, whereas in males it was absent in 16 (26.76%) specimens, 9 (15%) on the right and 7 (11.7%) on the left. It was less common in males, especially on the right side.

Please insert table 1 here

Extra-glenohumeral ligament (tuberculohumeral):

Extending from the inferior glenoid tubercle to the posterior aspect of the surgical neck of the humerus an additional ligament was observed, here named the tuberculohumeral ligament (Figure 3). During the dissection and examination of 62 specimens (17 females, 14 males), the tuberculohumeral ligament was present in 54.83% (n=34/62) (Table 2). Based on gender and side, the thickness and length of the tuberculohumeral ligament were variable, being thicker in females and longer in males: however, only the length between males and females was significant (P=0.052). In females, it was more common on the left, whereas in males it was more common on the right. The overall mean length and thickness in both genders were 28.3 mm and 4.29 mm. In females, the left side was thicker and longer, while in males the right side was thicker and longer; however, in both genders these differences were not significant.

Please insert table 2 here

Discussion

A number of studies have reported on the attachment of the superior glenohumeral ligament. Some are of the view that it arises from the base of the coracoid process and superior aspect of the glenoid labrum inserting into the anterior area located between the lesser tubercle and articular margin of the humeral head (Williams 1995), while others are of the opinion that it originates from the glenoid neck close to the origin of the long head of biceps tendon (Di Giacomo et al. 2008). Robinson (1922) and Gray et al. (1946) have described it as a slender

band originating proximally from the superior margin of the glenoid cavity and adjacent glenoid labrum, while Di Giacomo et al. (2008) reported that the superior glenohumeral ligament arises from the supraglenoid tubercle anterior to the origin of the long head of biceps tendon with some fibres from the long head of biceps brachii and inserts into a small depression on the humeral articular surface. In contrast Kolts et al. (2001) observed the superior glenohumeral ligament arising from the supraglenoid tubercle inserting into the lesser tuberosity. More recently Kask et al. (2010) observed that the superior glenohumeral ligament was divided into direct fibres originating from the superior glenoid labrum inserting into the floor of the bicipital groove and lesser tubercle and oblique fibres arising as a common origin with the middle glenohumeral ligament from the supraglenoid tubercle inserting into the semicircular humeral ligament. The current study found that the superior glenohumeral ligament was a single band arising from the anterosuperior aspect of the glenoid labrum between the attachment of the long head of biceps and the middle glenohumeral ligament, thus partly agreeing with Kask et al. (2010), passing laterally to attach to the anterior aspect of the humerus in agreement with both Palastanga et al. (2006) and Di Giacomo et al. (2008). These observations do not support the findings of Kolts et al. (2001) and Di Giacomo et al. (2008) of the origin extending to the glenoid neck, base of the coracoid process or supraglenoid tubercle. Furthermore, the current study adds, for the first time, the thickness of the superior glenohumeral ligament at its origin, with no difference in thicknesses noted between males and females or side. No other variations were observed.

Reports of the absence of a superior glenohumeral ligament is variable ranging from 1% (Longo et al. 1996) to 90% (Park et al., 2000), while others have reported its presence in all shoulders (Wilson et al. 2012; Delorme 1910; Welcker 1877; Fick 1904 - cited in Di Giacomo et al. 2008). The present study disagrees with Longo et al. (1996) and Park et al. (2000) thereby

supporting Wilson et al. (2012), Delorme (1910), Welcker (1877) and Fick, (1904) (cited in Di Giacomo et al. 2008) by observing the superior glenohumeral ligament in all specimens.

There is some disagreement concerning the attachment and indeed presence of the middle glenohumeral ligament. The contribution of the glenoid labrum in its attachment has only been cited by Merila et al. (2008). Both Williams (1995) and Palastanga et al. (2006) report it arising from the anterior margin of the glenoid as far inferiorly as the inferior third of the rim inserting into the anterior surface of the lesser tubercle of the humerus. Kolts et al. (2001) disagrees with the proximal attachment, but agrees about the distal one stating that the middle glenohumeral ligament arises from the supraglenoid tubercle, the anterosuperior aspect of the glenoid neck and base of the coracoid process. Gray et al. (1946) were more precise in the distal attachment disagreeing with Williams (1995) and Palastanga et al. (2006) stating that the humeral attachment is to the inferior aspect of the lesser tubercle of the humerus. Merila et al. (2008) observed the middle glenohumeral ligament to arise from the superior neck of the scapula and anterosuperior glenoid labrum fusing with the lateral aspect of the anterior region of the fibrous capsule. The present observations support Williams (1995), Palastanga et al. (2006) and Merila et al. (2008) in that middle glenohumeral ligament arises from the anterior aspect of the glenoid labrum immediately inferior to the superior glenohumeral ligament: less frequently it arises more medially along the neck of the scapula passing laterally to attach to the anterior aspect of the humerus just inferior to the superior glenohumeral ligament. Furthermore, the current study found that the middle glenohumeral ligament is the thickest of the glenohumeral ligaments, with a significant difference ($P=0.003$) being observed between males and females.

Absence of the middle glenohumeral ligament ranges from 12% to 70% (Longo et al. 1996; Merila et al. 2008; Park et al. 2000; Dewan et al. 2012). In the present study the middle

glenohumeral ligament was present in 98.6% (n=138) of specimens examined, being higher than that reported in other studies (Longo et al. 1996; Merila et al. 2008; Park et al. 2000; Dewan et al. 2012). This difference could be due to fewer specimens being examined than in the current study, as well as the method employed to identify the ligament. The middle glenohumeral ligament may run slightly inferior before passing laterally and as such cannot be detected unless the fibrous capsule is invaginated posteriorly and stretched laterally to enable it to be hooked onto the probe: it is therefore not easy to approach arthroscopically.

There are a number of inconsistencies in the literature regarding the inferior glenohumeral ligament in terms of its attachments, number of bands and presence. The inferior glenohumeral ligament is more prominent, ambiguous, longer and stronger than the middle glenohumeral ligament: it has been reported to be absent in 6% to 60% of specimens examined (Robinson 1922; Gray et al. 1946; Palastanga et al. 2006; Longo et al. 1996; Merila et al. 2008). The current study revealed that the inferior glenohumeral ligament is prominent, but thinner than the middle and superior glenohumeral ligaments, being 4.41 mm thick.

Robinson (1922), Gray et al. (1946) and Palastanga et al. (2006) state that proximally the inferior glenohumeral ligament originates from the anterior margin of the glenoid cavity and anterior border of the glenoid labrum inserting into the anteroinferior aspect of the anatomical neck of the humerus and inferomedial aspect of the humeral neck. However, Kolts et al. (2001) reported it to originate from the scapular neck and base of the coracoid process just inferior to the middle glenohumeral ligament inserting into the surgical neck of the humerus. Williams (1995) reported it arising from the anterior, middle and posterior margins of the glenoid labrum only, with Cooper et al. (1992) observing that the inferior glenohumeral ligament is attached firmly to the glenoid rim as well as the anteroinferior aspect of the glenoid labrum (at 4 o'clock). There is disagreement concerning the proximal and distal bony attachments of the middle glenohumeral ligament in the literature; however many studies agree that the glenoid labrum

shares in its origin, nevertheless controversy exists regarding the attachment site. The current study observed that the inferior glenohumeral ligament arises from the anteroinferior glenoid labrum between 3 – 5 o'clock and passes laterally to attach to the anteroinferior aspect of the humerus.

Few studies agree that the inferior glenohumeral ligament consists of anterior and posterior bands with an intervening axillary pouch, as well as there being disagreement about their attachments. Distinct anterior and posterior inferior glenohumeral ligament bands with an axillary pouch between have been observed, with the anterior band attaching to the glenoid labrum between 2 - 4 o'clock and the posterior band between 8 and 9 o'clock (Fealy et al. 2000; Ticker et al. 2006). Furthermore, Gelber et al. (2006) reported that the anterior band arose from the glenoid rim midway along the anterior border attaching distally either to the humeral neck or the humerus. In contrast, Ruiz et al. (2012) reported the anterior band arising from the anterosuperior glenoid labrum at 3 o'clock or above in only 33.3% of shoulders, from the middle glenohumeral ligament in 8.3%, and from the anteroinferior glenoid labrum in 41.7%. Based on its attachment the current study disagrees with Ruiz et al. (2012), but supports the observations of Fealy et al. (2000) and Ticker et al. (2006) and confirms that the inferior glenohumeral ligament anterior band was present in all specimens examined arising from the anteroinferior aspect of the glenoid labrum between 3 – 5 o'clock passing laterally to attach to the anteroinferior aspect of the humerus. The current study observed the anterior band thickness to be 4.41 mm, with a significant difference noted between males and females.

Gelber et al. (2006) found that the inferior glenohumeral ligament posterior band was present in only 41% of shoulders. The current study observed its presence in 79.3% of specimens arising from the posteroinferior aspect of the glenoid labrum between 7 and 9 o'clock, passing laterally to attach to the posteroinferior aspect of the humerus to form, together with the anterior band, an axillary pouch, thereby agreeing with Fealy et al. (2000) and Ticker et al. (2006).

Furthermore, the current study found that there was a significant difference in thickness of the posterior band of the inferior glenohumeral ligament between males and females.

An additional glenohumeral ligament in the anterior layer of the fibrous capsule arising from the axillary pouch of the inferior glenohumeral ligament and inserting into the superolateral aspect of the tendon of subscapularis has been reported by Kolts et al. (2001). Merila et al. (2008) also observed a spiral glenohumeral ligament passing from the infraglenoid tubercle and tendon of the long head of triceps brachii inserting into the lesser tuberosity of the humerus, which was observed in all specimens. The current study observed a new ligament, the "tuberculohumeral ligament", extending from the inferior glenoid tubercle to the posterior aspect of the surgical neck of the humerus: it was present in 54.8% (n=34/62) of specimens examined. While it was thicker in females it was significantly longer in males. In females, it was more common on the left, while in males it was more common on the right. The mean thickness of the tuberculohumeral ligament was similar to that of the glenohumeral ligament, being 4.29 mm. The difference in incidence between sides and gender remains unexplored. The function of the tubeculohumeral ligament is as yet unknown, however due to its location it could provide inferior and inferoposterior support to the glenohumeral joint.

Conclusion:

The superior glenohumeral ligament was observed in all specimens examined arising as a single band from the anterosuperior aspect of the glenoid labrum between the long head of the biceps attachment and the middle glenohumeral ligament. The middle glenohumeral ligament was seen in 98.6% of specimens having a mean thickness significantly greater in males than females. An inferior glenohumeral ligament anterior band was found in all specimens arising from the anteroinferior aspect of the glenoid labrum between 3 and 5 o'clock, with its mean thickness being significantly greater in males than females. An inferior glenohumeral ligament

posterior band was present in 79.3% specimens examined arising from the posteroinferior aspect of the glenoid labrum between 7 and 9 o'clock: its mean thickness was significantly greater in males than females. A tuberculohumeral ligament was observed in 54.8% of 62 specimens extending from the inferior glenoid tubercle to the posterior aspect of the surgical neck of the humerus, with its length between males and females being significantly different. The observations regarding the tuberculohumeral ligament should encourage future studies to evaluate its function and histological composition.

Acknowledgment:

The authors express their thanks to donors and their families: without them this study would not have been possible. Special thanks to both: Centre of Anatomy and Human Identification, University of Dundee and Centre of Anatomy, University of Zawia.

Conflict of interest: None of the authors has any conflict of interest.

Ethical Approval, Informed Consent: all the cadavers were approved by Human tissue (Scotland) Act 2006

Reference

Cooper D.E, Arnoczky S.P, O'Brien S.J, Warren R.F, DiCarlo E, Allen A.A (1992) Anatomy, histology, and vascularity of the glenoid labrum. Journal of Bone and Joint Surgery 74(1):46-52.

Delorme D.H.D (1910) Die Hemmungsbander des Schultergelenks und ihre bedeutung fuer die schulterluxationen. Archives der Klinikum Chirurgie 92:72-101.

Dewan A.K, Garzon-Muvdi J, Petersen S.A, Jia X, McFarland E.G (2012) Intraarticular abnormalities in overhead athletes are variable. Clinical Orthopaedics and Related Research 470:1552–1557.

Di Giacomo G, Pouliart N, Costantini A, De Vita A (2008) Atlas of Functional Shoulder Anatomy. New York, Springer.

Fealy S, Rodeo S.A, Dicarlo E.F, O'Brien S.J (2000) The developmental anatomy of the neonatal glenohumeral joint. Journal of Shoulder and Elbow Surgery 9(3):217-222.

Fick R (1904) Handbuch der Anatomie und Mechanik der Gelenke unter Berucksichtigung der bewegenden Muskeln. Part 1.Anatomie der Gelenke. Gustav Fischer, Jena, pp 163-187.

Flood V (1829) Discovery of a new ligament of the shoulder joint. Lancet I:672-673

Gelber P.E, Reina F, Monllau J.C, Yema P, Rodriguez A, Caceres E (2006) Innervation patterns of the inferior glenohumeral ligament: anatomical and biomechanical relevance. Clinical Anatomy 19:304–311.

Gray H, Johnston T.B, Whillis J (1946). Anatomy: Descriptive and applied. London: Longman.

Kask K, Poldoja E, Lont T, Norit R, Merila M, Busch L.C, Kolts I (2010) Anatomy of the superior glenohumeral ligament. Journal of Shoulder Elbow Surgery 19: 908-916.

Kolts I, Busch L.C, Tomusk H, Rajavee E, Eller A, Russlies M, Kühnel W (2001) Anatomical composition of the anterior shoulder joint capsule. A cadaver study on 12 glenohumeral joints. Annals of Anatomy 183:53-59.

Longo C, Loredo R, Yu.J, Salonen D, Haghighi P, Trudell D, Clopton P, Resnick D (1996) Pictorial essay. MRI of the glenoid labrum with gross anatomic correlation. Journal of Computer Assisted Tomography 20(3):487-495.

Merila M, Helio H, Busch L.C, Tomusk H, Poldoja E, Eller A, Kask K, Haviko T, Kolts I (2008) The spiral glenohumeral ligament: an open and arthroscopic anatomy study. Journal of Arthroscopic and Related Surgery 24(11):1271-1276.

Palastanga N, Field D, Soames R (2006) Anatomy and Human Movement: structure and function, Edinburgh, Butterworth Heinemann Elsevier.

Park Y.H, Lee J.Y, Moon S.H, Mo J.H, Yang B.K, Hahn S.H, Resnick D (2000) MR arthrography of the labral capsular ligamentous complex in the shoulder: imaging variations and pitfalls. American Journal of Roentgenology 175(3):667-672.

Robinson A (1922) Cunningham's Textbook of Anatomy, London, Henry Frowde Hodder & Stoughton.

Ruiz F.A.R, Baranski Kaniak B.C, Haghighi P, Trudell D, Resnick D.L (2012) High origin of the anterior band of the inferior glenohumeral ligament: MR arthrography with anatomic and histologic correlation in cadavers. Skeletal Radiology 41:525–530.

Sinnatamby C.S (2006) Last's Anatomy: regional and applied, Edinburgh, New York, Elsevier/ Churchill Livingstone.

Ticker J.B, Flatow E.L, Pawluk R.J, Soslowsky L.J, Ratcliffe A, Arnoczky S.P, Mow V.C, Bigliani L.U (2006) The inferior glenohumeral ligament: a correlative investigation. Journal of Shoulder and Elbow Surgery 15(6):665-674.

Welcker H (1877) Nachweis eines Ligamentum interarticulare ("teres") humeri, sowie eines Lig. sessile femoris. Zeitschrift fur Anatomie Entwicklungsgeschaft 2:98-107.

Williams P.L (1995) Gray's Anatomy: The Anatomical Basis of Medicine and Surgery 38th ed, Churchill Livingstone.

Wilson W.R, Magnussen R.A, Irribarra L.A, Taylor D.C (2012) Variability of the capsular anatomy in the rotator interval region of the shoulder. Journal of Shoulder and Elbow Surgery 22(6): 856-861.

Figure 1: Right shoulder showing the superior (SGHL) and middle glenohumeral (MGHL) ligaments; LHBT: long head of biceps tendon.

Figure 2: Right shoulder showing the superior (SGHL), middle (MGHL) and inferior glenohumeral anterior band (IGHL-A) ligaments; LHBT: long head of biceps tendon.

Figure 3: Right shoulder inferior view showing the inferior glenohumeral ligament posterior band (IGHLP) and the tuberculo-humeral ligament.

Figure 1: Right shoulder showing the superior (SGHL) and middle glenohumeral (MGHL) ligaments; LHBT: long head of biceps tendon.

Figure 2: Right shoulder showing the superior (SGHL), middle (MGHL) and inferior glenohumeral anterior band (IGHL-A) ligaments; LHBT: long head of biceps tendon.

Figure 3: Right shoulder inferior view showing the inferior glenohumeral ligament posterior band (IGHLP) and the tuberculo-humeral ligament.

Table 1: Thickness of the superior glenohumeral humeral ligament (SGHL), middle glenohumeral ligament (MGHL), inferior glenohumeral ligament anterior band (IGHL-A) and inferior glenohumeral ligament posterior band (IGHL-P) in both genders.

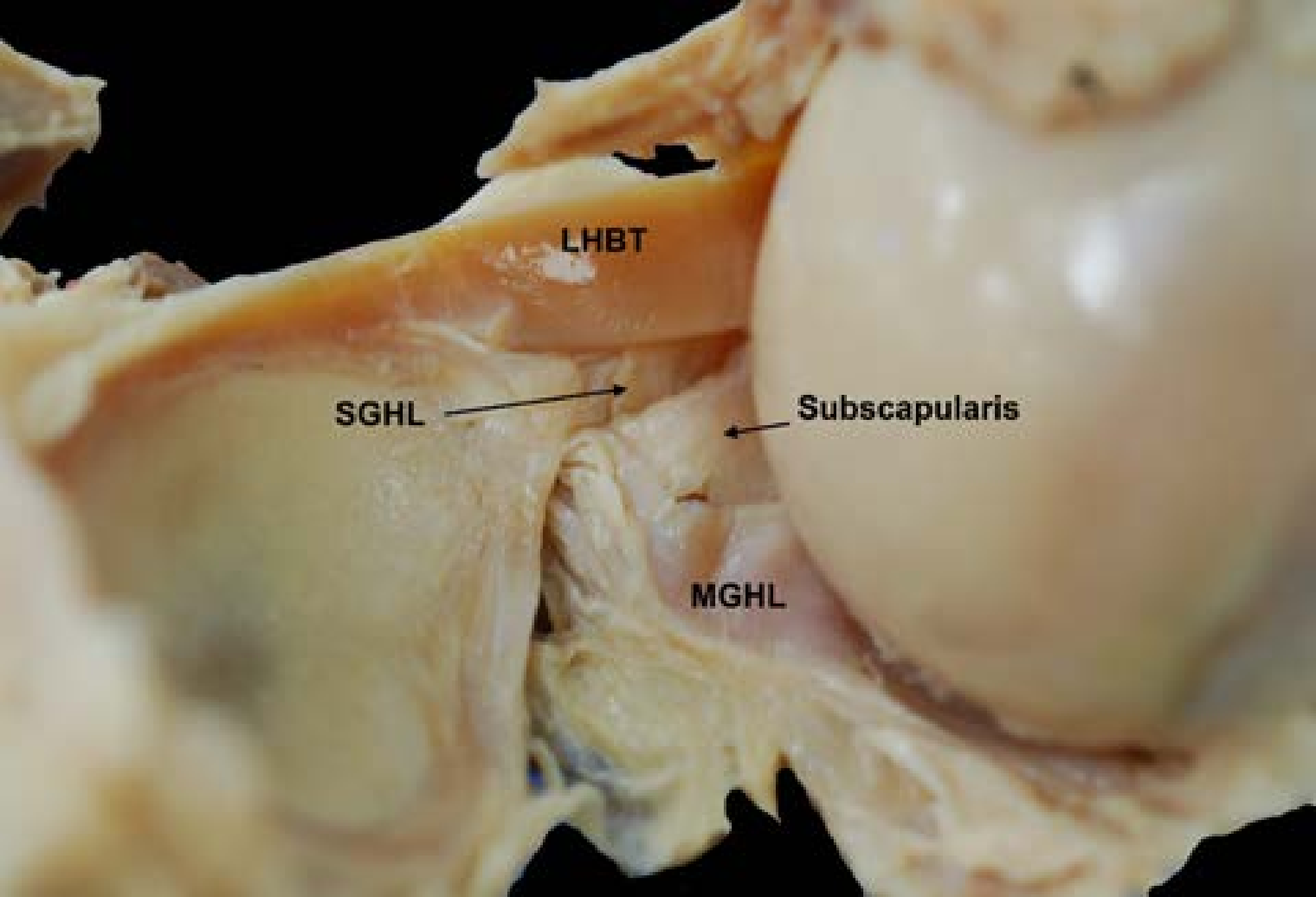
Descriptive statistics	Mean (mm)	Range (mm)	Standard deviation (mm)
SGHL thickness			
Both genders	5.06	2.52 – 8.89	0.93
Females both sides	4.97	2.89 – 8.89	0.93
Right side females	4.82	2.89 – 6.69	0.76
Left side females	5.12	3.26 – 8.89	1.06
Males both sides	5.17	2.52 – 7.84	1.02
Right side males	5.02	3.25 – 6.5	0.83
Left side males	5.33	2.52 – 7.84	1.17
MGHL thickness			
Both genders	5.97	1.75 – 11.17	1.35
Females both sides	5.67	3.09 – 7.58	1.15
Right side females	5.74	3.09 – 7.58	1.23
Left side females	5.6	3.2 – 7.45	1.08
Males both sides	6.36	1.75 – 11.17	1.50
Right side males	6.40	3.49 – 8.4	1.27
Left side males	6.32	1.75 – 11.17	1.72
IGHL-A thickness			
Both genders	4.41	1.54 – 8.1	1.33
Females both sides	4.23	1.54 – 8.1	1.23
Right side females	4.08	2.01 – 6.85	1.13
Left side females	4.37	1.54 – 8.1	1.32
Males both sides	4.67	1.76 – 8.05	1.42
Right side males	4.60	1.76 – 7.25	1.45
Left side males	4.73	1.88 – 8.05	1.41
IGHL-P thickness			
Both genders	3.45	1.3 – 5.84	0.83
Females both sides	3.27	1.43 – 4.77	0.77
Right side females	3.17	1.84 – 4.48	0.71
Left side females	3.38	1.43 – 4.77	0.82
Males both sides	3.72	1.3 – 5.84	1.3
Right side males	3.78	2.36 – 5.22	2.36
Left side males	3.66	1.3 – 5.84	1.3

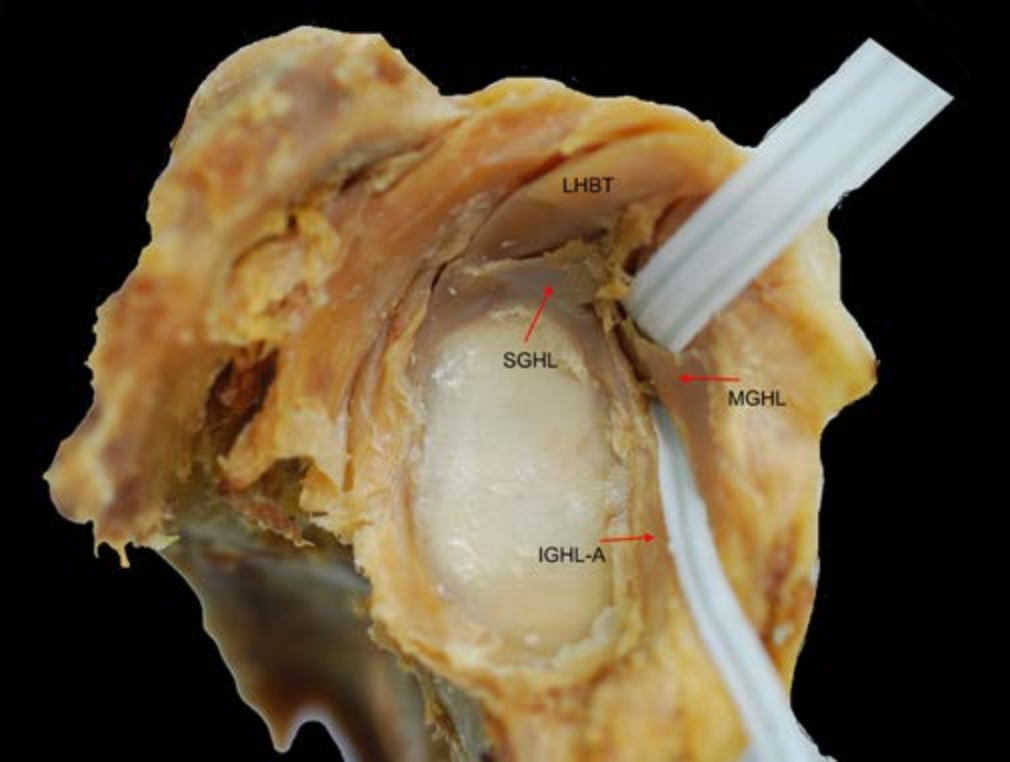
SD: standard deviation

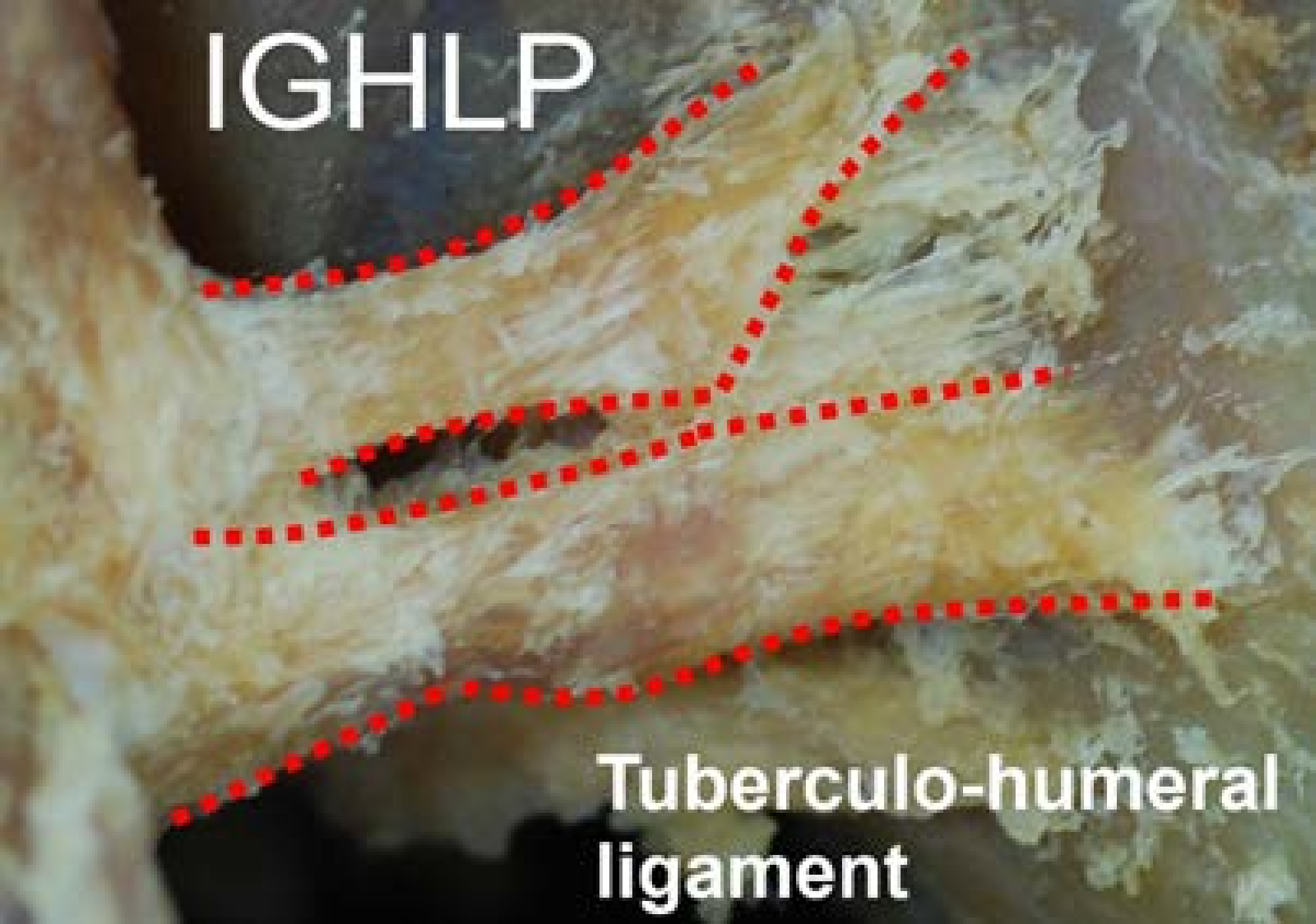
Table 2: Comparison of the tuberculohumeral ligament in both genders.

Descriptive statistics	Availability (%)	Mean (mm)	Range (mm)	SD (mm)
Both genders	54.83			
Thickness		4.29	2.68 – 6.63	0.95
Length		28.30	20.32 – 36.49	4.19
Female both side	61.76			
Thickness		4.31	2.68 – 6.36	1.10
Length		27.21	20.32 – 36.49	4.22
Female right side	29.41			
Thickness		4.2	2.77 – 6.2	0.98
Length		26.20	22.46 – 33.85	3.28
Female left side	32.35			
Thickness		4.41	2.68 – 6.63	1.24
Length		28.12	20.32 – 36.49	4.89
Male both sides	46.42			
Thickness		4.25	3.24 – 5.33	0.67
Length		30.07	25.33 – 35.39	3.63
Male right side	25			
Thickness		4.42	3.33 – 5.33	0.71
Length		30.7	25.33 – 35.39	3.94
Male left side	21.42			
Thickness		4.06	3.24 – 5.01	0.63
Length		39.33	25.89 – 34.5	3.42

SD: standard deviation


LHBT
SGHL
Subscapularis
MGHL


LHBT
SGHL
MGHL
IGHL-A


IGHLP
Tuberculo-humeral
ligament