VIA MEDICA

ORIGINAL ARTICLE

Folia Morphol.
Vol. 74, No. 4, pp. 439–446
DOI: 10.5603/FM.2015.0105

ISSN 0015–5659
www.fm.viamedica.pl

Macro/micro observational studies of fibres maintaining the biceps brachii tendon in the bicipital groove: application to surgery, pathology and kinesiology

R. Singh[1], M. Singla[1], R.S. Tubbs[2]

[1]*Department of Anatomy, AIIMS, Rishikesh Uttrakhand, India*
[2]*Seattle Science Foundation, Seattle, WA, USA*

[Received 11 November 2014; Accepted 18 January 2015]

Background: *There is controversy over the nature of tissues covering the bicipital groove protecting the biceps brachii tendon from dislocation/subluxation causing shoulder pain. Recent researches on cadaveric dissection and histological studies have changed the old concept of the transverse humeral ligament covering the bicipital groove to tendinous fibres of the subscapularis or interdigitating fibres of the subscapularis and supraspinatus. The change has not been incorporated into standard text books of anatomy. Therefore, the aim of the study is to support the new or old concept.*

Materials and methods: *Eighteen embalmed shoulders were dissected to determine the nature of the tissues over the bicipital groove. Tissues from 4 shoulders were processed and 16 histological slides were examined for fibre types. Theoretical analysis of ligament and tendon has also been carried out.*

Results: *The dissection study revealed that the tissues over the bicipital groove were tendinous fibres of subscapularis/interdigitating fibres of the subscapularis and supraspinatus and fibrous expansions from the posterior lamina of the pectoralis major. This was supported by the histological slides which showed the signatures of collagen fibres with the characteristics of tendinous fibres.*

Conclusions: *No separate anatomical entity such as the transverse humeral ligament was detected in this study. Thus present study supports the view that the tissues covering the bicipital groove were formed by tendinous rather than ligamentous fibres.* (Folia Morphol 2015; 74, 4: 439–446)

Key words: bicipital groove, subscapularis, collagen fibres, subluxation, biceps tendon

INTRODUCTION

The bicipital groove lies between the lesser and greater tubercles of the humerus. The long head of the biceps brachii tendon passes through this groove in route to the supraglenoid tubercle of the scapula. There are two schools of thoughts regarding nature of the fibres covering this groove to maintain and protect the biceps brachii tendon from clinical complications such as dislocation and subluxation.

The transverse humeral ligament (THL), defined as a broad band of fibrous tissue passing from the lesser tuberosity to the greater tuberosity of the humerus. It maintains the position of the tendon of the long head of the biceps brachii within the bicipital groove [9].

Address for correspondence: Dr R. Singh, Additional Professor and Head, Department of Anatomy, AIIMS, Virbhadra Marg, Pashulok, Rishikesh 249201, Uttrakhand, India, tel: +919453193659, e-mail: nani_sahayal@rediffmail.com

The THL was described in humans by Brodie [2] as a broad band of fibrous tissue, trapezoidal in shape, passing between the lesser and greater tubercles of the humerus, converting the bicipital groove into a canal. Davis [5] wrote, "This [biceps] tendon is rarely luxated because it is firmly held in place by the transverse humeral ligament". Meyer [11] observed that in shoulders with biceps brachii tendon dislocations, the THL was actually intact. Snow et al. [16] described THL as anatomic region consisting of 2 layers of tissues, a thin superficial layer of fibres in distinct bundles and deep layer consisting of fibres from the rotator cuff tendons, the coracohumeral ligament, subscapularis and supraspinatus tendon. But none of these authors has isolated the THL as a separate anatomical entity.

Cash et al. [4] were the first to suggest that the THL might not be a distinct anatomical structure, after a study examining variations in the magnetic resonance imaging (MRI) appearance of the insertion of the tendon of the subscapularis. Subsequent dissection/ /histological studies by Boon et al. [1] revealed that a continuous band of tissues extending over the bicipital groove occupied by the biceps brachii tendon was neither separate from the tendon of the subscapularis medially nor the supraspinatous laterally.

In another view, there is no identifiable THL, rather the fibres covering the intertubercular groove are composed of a sling formed mainly by the fibres of the subscapularis tendon, with contributions from the supraspinatus tendon and the coracohumeral ligament [8]. Gleason et al. [8] also carried out a histological study of tissues covering the bicipital groove and detected only collagen fibres and no elastin fibres, characteristic of ligamentous fibres. According to MacDonald et al. [10], "In all 85 specimens observed, a fibrous expansion from the posterior lamina of the tendon of the pectoralis major overlay the long tendon of the biceps brachii and fused with the capsule of the shoulder joint. In no dissection activity, THL was identified." The recent work [16] again coined this term, THL so it has become a controversial matter.

Although, it can be concluded from the foregoing studies that the earlier concept of the THL is a primitive misnomer. Since the THL does not exist as a separate anatomical entity, the editors and authors of standard anatomy text books continue to use the same old conventional name as THL in its original definition, covering the intertubercular groove. The THL has already been customised so it is in normal use. This transmits a wrong message in medical education.

Therefore the aim of the present study is to analyse and support one of the concepts by examining the definition of the term, THL analytically, meticulous dissection and histological examination of tissues covering the bicipital groove in the shoulders of human cadavers.

MATERIALS AND METHODS

Eighteen matched embalmed upper limbs from 9 human cadavers fixed in 10% formalin were used as study material. There were 3 females and 6 male cadavers with a mean age 75 years at death (range 70–80 years). No specimen was found to have previous surgery or pathology of the regions dissected. The pectoralis major muscle was reflected laterally to expose the posterior lamina of its tendon and the fibrous expansion arising from it. This expansion was incised longitudinally towards the shoulder joint capsule in the line of the bicipital groove. The bicipital groove region was carefully dissected for the presence of the THL. The tendon of the subscapularis and all structures attached to or in close proximity of the lesser and greater tuberosities and bicipital groove were dissected under a magnifying glass. The outcomes of dissection of each shoulder were recorded and relevant photographs of variant cases were taken. Eight tissue samples from 4 cadavers, 2 from each cadaver and 1 from each shoulder, were processed and 16 histological slides were prepared. Eight slides were stained with haematoxylin and eosin (H&E). The remaining 8 slides were stained with Verhoeff's stain in the Department of Anatomy. Ligaments/tendon/muscle fibre tissues were distinguished by standard signatures of elastin/collagen/muscle fibres. All 16 slides were assessed for these fibres but only the 4 best (2 stained with H&E and 2 with Verhoeff's stain) were presented in this article. The theoretical analysis of THL was also carried out.

RESULTS

In 1 of the 18 shoulders, the biceps brachii tendon was dislocated medially. The biceps brachii tendon was clearly visible coursing over the humeral head and within the bicipital groove in the other 17. The histories of pathological conditions and symptoms were not known as this was a cadaveric study. The results are presented in two parts, (1) from the dissection study and (2) from examination of the histological slides.

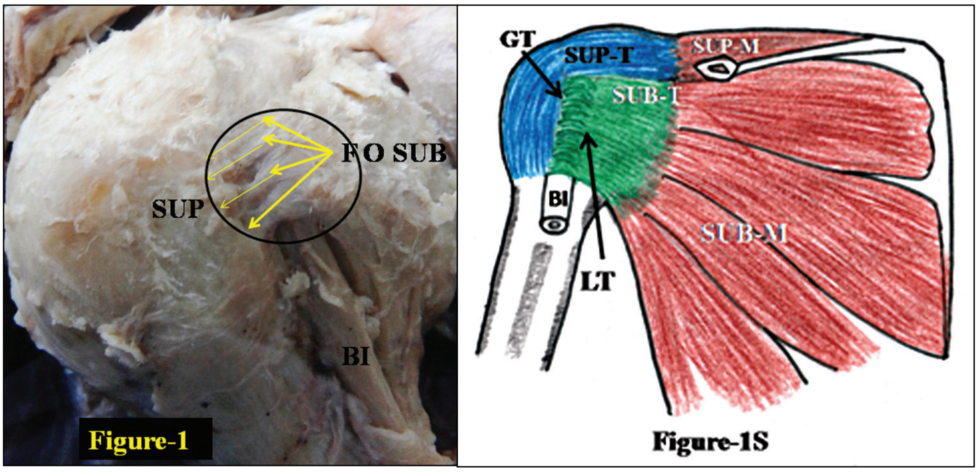

Figure 1. Fibres of the subscapularis tendon passing over the bicipital groove. Fibres of the subscapularis are shown by yellow arrows; **1S.** Schematic diagram showing tendinous fibres of the subscapularis passing over the bicipital groove; F O SUB — fibres of the subscapularis; SUP — supraspinatus; Bi — biceps brachii tendon; SUP-M — supraspinatus muscle fibres; SUP-T — tendinous fibres of supraspinatus; LT — lesser tubercle; GT — greater tubercle.

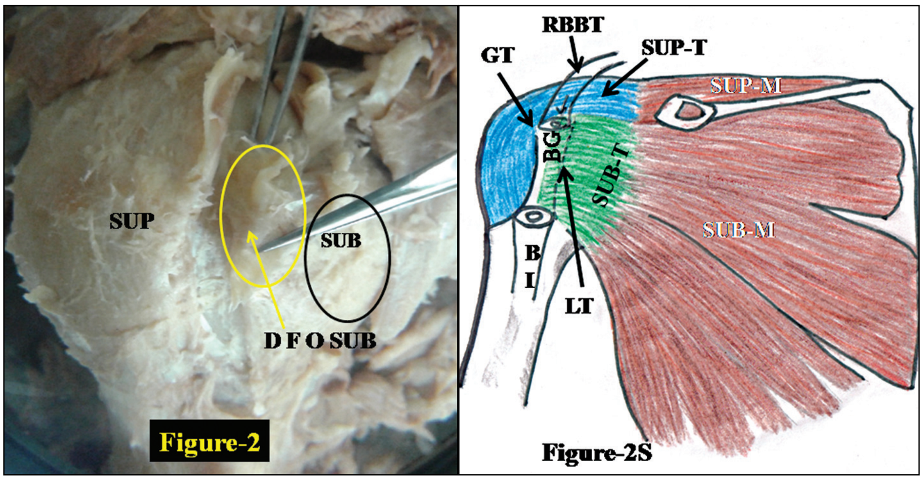

Figure 2. Fibres of the subscapularis inserting into floor of the bicipital groove; **2S.** Schematic diagram showing fibres of the subscapularis inserting into floor of the bicipital groove; D FO SUB — deep fibres of the subscapularis; SUP — supraspinatus; BG — floor of bicipital groove; LT — lesser tubercle; GT — greater tubercle; BI — biceps brachii tendon; SUP-M — supraspinatus muscle; SUP-T — tendon of supraspinatus; SUB-M — subscapularis muscle; SUB-T — tendon of subscapularis; RBBT — reflected biceps brachii tendon.

Dissection study

In 10 shoulders (10/18 = 55.56%) 5 left and 5 right sides, fibres over the bicipital groove were tendinous fibres of the subscapularis muscle extending from the lesser to the greater tubercle at the level of the intertubercular sulcus superficial to the biceps brachii tendon as seen by dissection (Fig. 1 and 1S).

In 5 shoulders (5/18 = 27.76%), 3 left and 2 right sides, superficial tendinous fibres of the subscapularis extended from the lesser to the greater tubercle interdigitating with tendinous fibres from the supraspinatus. Deep subscapularis fibres passed under the biceps brachii tendon and inserted into the floor of the bicipital groove (Fig. 2 and 2S). The interdigitating fibres of subscapularis and supraspinatus formed the covering of the bicipital groove (Fig. 3 and 3S).

In 2 shoulders (2/18 = 11.11%), both of the left side, the subscapularis inserted exclusively into the lesser tubercle (Fig. 4 and 4S). The fibrous expansion of the posterior lamina of the pectoralis major muscle passed over the bicipital groove superficially so, maintaining the biceps brachii tendon.

In 1 shoulder (right side) the biceps brachii tendon was dislocated medially. The fibres of the subscapularis

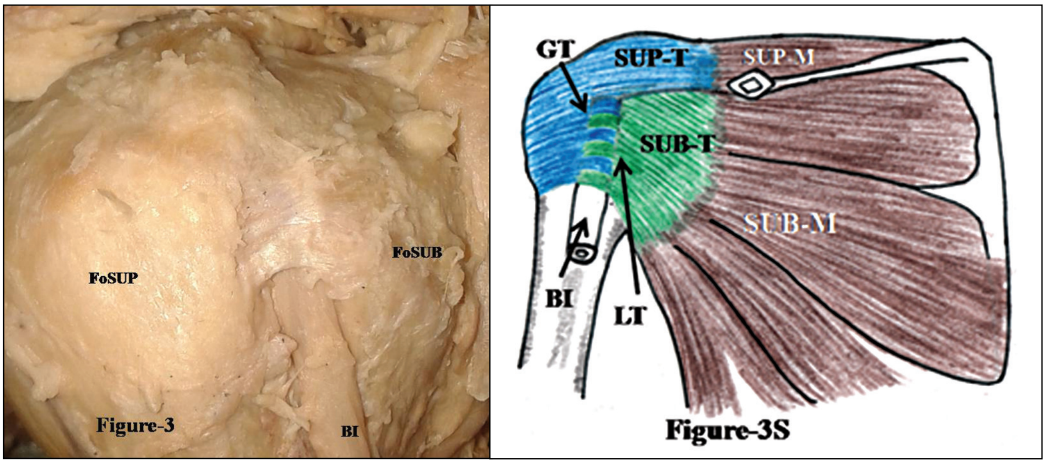

Figure 3. Interdigitating fibres of the subscapularis and supraspinatus bridging the groove; **3S.** Schematic diagram showing interdigitating fibres of the subscapularis and supraspinatus over the bicipital groove; FoSUP — fibres of the supraspinatus; FoSUB — fibres of the subscapularis SUP-M — supraspinatus muscle; SUP-T — tendon of supraspinatus; SUB-M — subscapularis muscle; SUB-T — tendon of subscapularis; LT — lesser tubercle; GT — greater tubercle; BI — biceps brachii tendon.

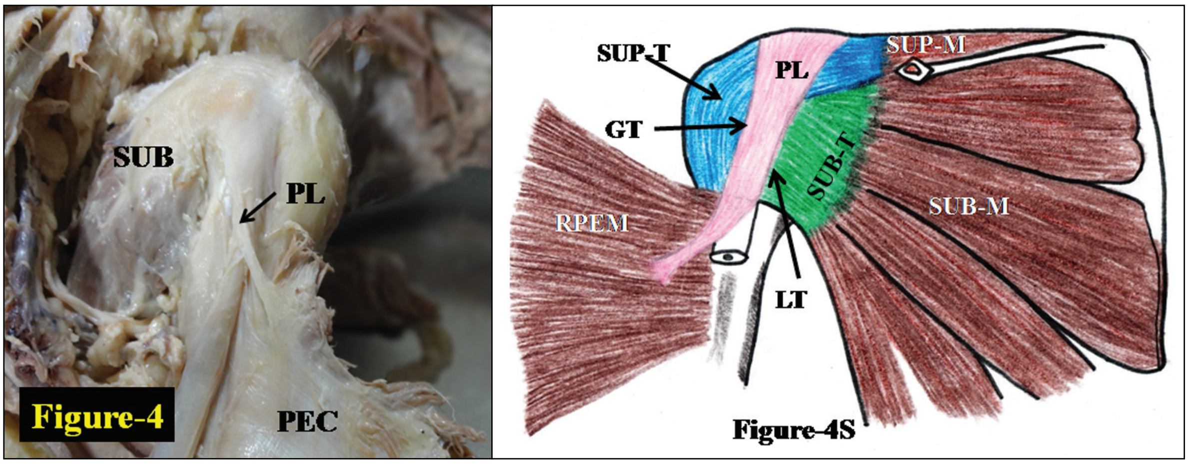

Figure 4. Fibres of the subscapularis inserting exclusively in the lesser tubercle; **4S.** Schematic diagram showing fibres of the subscapularis inserting exclusively in the lesser tubercle; SUB — subscapularis; PEC — pectoralis major muscle; PL — fibrous expansion from posterior lamina of pectoralis major; SUP-M — supraspinatus muscle; SUP-T — tendon of supraspinatus; SUB-M — subscapularis muscle; SUB-T — tendon of subscapularis; RPEM — reflected pectoralis major muscle; PL — fibrous expansion from posterior lamina of pectoralis major muscle.

and supraspinatus were intact. This is because the fibrous expansion from the posterior lamina of the pectoralis major muscle covered the bicipital groove. The fibrous expansion from the posterior lamina of the pectoralis major muscle was deformed.

No distinct entity resembling a THL was found during dissection in any of the shoulders.

In all shoulders the posterior lamina of the pectoralis major overlay the biceps brachii tendon and merged into the capsule of the shoulder joint.

Histological study

Eight slides were stained with H&E. Another 8 slides were treated with Verhoeff's stain. Photographs of the histological slides, stained with H&E, showed collagen fibres characteristic of tendinous fibres in all the slides, of which the two best are presented (Figs. 5, 6).

Photographs of histological slides stained with Verhoeff's stain showed no elastin fibres, which appear black with this stain but all the slides showed collagen fibres (stained red) (Figs. 7, 8).

These tendinous fibres belong to the subscapularis and supraspinatus or occasionally the fibrous expansion from the posterior lamina of the pectoralis major muscle.

Figure 5. Histological slides stained with haematoxylin and eosin showing collagen fibres in transverse section with magnification of 40×.

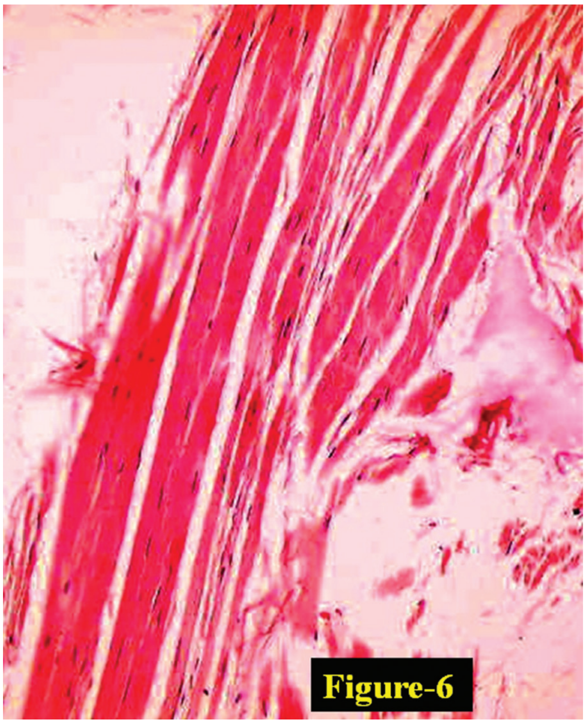

Figure 6. Histological slides stained with haematoxylin and eosin showing collagen fibres in longitudinal section with magnification of 40×.

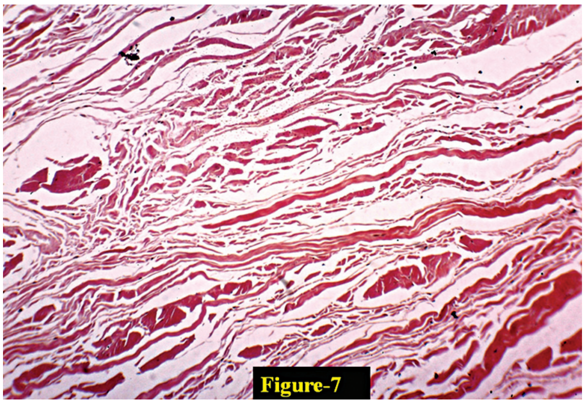

Figure 7. Histological slides stained with Verhoeff's stain showing collagen fibres in red colour in longitudinal section with magnification 40×.

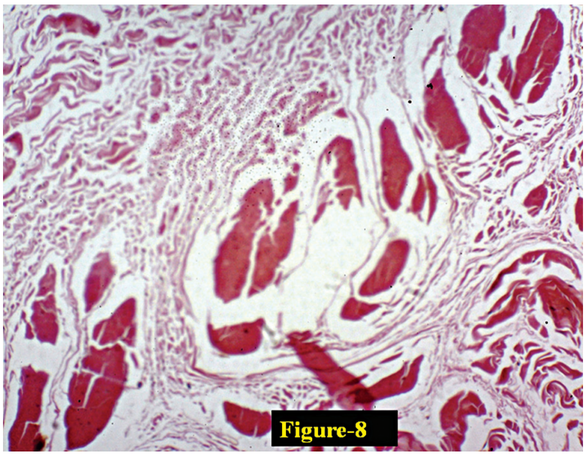

Figure 8. Histological slides stained with Verhoeff's stain showing collagen fibres in red colour in transverse section with magnification of 40×.

DISCUSSION

Analysis of THL by cadaveric dissection

Several authors [7, 12–14, 18] suggested that fibres from the tendon of the subscapularis inserted on to areas other than the lesser tubercle. Cash et al. [4] in his MRI studies demonstrated that fibres of the subscapularis inserted in the region of the bicipital groove (66%) and the greater tubercle in 14% of cases, but these fibres appeared to insert exclusively on to the lesser tubercle in 20% of cases.

Macroscopically (dissection study), the fibres from the subscapularis interdigitated with fibres of the supraspinatus passing over the bicipital groove from the lesser to the greater tubercle and vice versa [1]. Gleason et al. [8] found tendinous fibres of the subscapularis splitting into deep and superficial fibres. The deep fibres were inserted into the lesser tubercle and the floor of the bicipital groove. The superficial fibres traversed the bicipital groove overlying the long tendon of the biceps brachii and inserted in to the greater tubercle. In addition, these authors reported that the superficial fibres

of the subscapularis, which overlay the biceps brachii tendon interdigitated with fibres of the supraspinatus. This type of arrangement of fibres was observed in all 14 shoulders. MacDonald et al. [10] classified the pattern of fibres covering the bicipital groove into four types:
— type I: fibres from the tendon of the subscapularis insert on to the lesser tubercle only;
— type II: fibres insert on to the lesser tubercle and additional fibres pass deep to the long tendon of the biceps brachii and insert either on to the floor of the bicipital groove or the greater tubercle;
— type III: fibres insert on to the lesser tubercle with additional fibres passing superficial to the long tendon of the biceps brachii and inserted on to the greater tubercle;
— type IV: fibres insert onto the lesser tubercle with additional fibres passing both deep and superficial to the long tendon of the biceps brachii to insert on to the greater tubercle ensheathing the biceps brachii tendon.

A similar pattern of fibres, with some variations, was also observed in the present study and details of the comparison with the MacDonald's classification are appended below.

Type I fibres of MacDonald's classification were detected in 2 shoulders of the 18 in our study. Such a pattern was also observed by Cash et al. [4] but not by Gleason et al. [8] or Boon et al. [1].

The type II configuration was not seen in the present study, or by Gleason et al. [8] or Boon et al. [1]. Such an arrangement of fibres was observed only by MacDonald et al. [10].

The most common pattern in the MacDonald [10] study was type III and was also observed in 10 of the 18 shoulders in the present study. This pattern of fibres was not observed by Gleason et al. [8] or Boon et al. [1].

The type IV pattern in MacDonald's classification was not observed in the present study, or by Gleason et al. [8] or Boon et al. [1]. In the present study, the pattern observed was a variant of the type IV fibres. Thus, MacDonald's classification can be extended to type V to include this variant, in which the superficial fibres of the subscapularis interdigitate with fibres of the supraspinatus. Such interdigitation of the fibres was also observed by Gleason et al. [8] and Boon et al. [1]. The pattern was not observed by MacDonald et al. [10].

Cash et al. [4] stated that "A distinct but not necessarily separate THL was seen in only 36% of shoulders". This statement is confusing as according to the author [4], "in the identification of a THL on MRI, no relationship with image grade was found". This clearly manifest that the presence of ligament is subjective in his study. The presence of ligament is disagreeable to the author.

Snow et al. [16] observed the fibres of coracohumeral ligament blended with the rotator cuff tendons at the proximal superior edge of the groove. But the ligament (coracohumeral) constrained by its definition for insertion in the bone so this would be inserted into either the lesser or the greater tubercles without spanning over the bicipital groove. Therefore this ligament did not contribute to the tissues covering the bicipital groove. Distally, the fibres of the subscapularis muscle which might be covering the bicipital groove, were predominant. So this study too supported the presence of tendinous fibres covering bicipital groove. Therefore, all the above cadaveric dissection studies undoubtedly established that the tissues overlying the bicipital groove were tendinous.

Histological analysis

Boon et al. [1] histologically found sheet of collagen fibres in all their slides. Gleason et al. [8] in their histological studies did not find the elastin fibres characterising the ligament. Snow et al. [16] reported flat sheets of collagen fibres and free nerve endings as pain generators consisting of myelinated and unmyelinated nerves based on his histologic studies. The sheets of collagen fibres are deterministic representative of tendinous fibres. The free nerve ending did occur in tendons. Mechanoreceptors detected in glenohumeral ligament were also not observed in tissues over the bicipital groove by Snow et al. [16]. So these tissues covering bicipital groove were tendinous fibres. In the present study all the 16 slides were found to have collagen fibres. No slide was observed to contain elastin fibres, the characteristic of ligament. This clearly reveals that the fibres covering the bicipital groove were tendinous. Therefore, it is result of all the histological studies that the tissues covering bicipital groove were tendinous fibres.

Theoretical analysis of THL

In continuation, it is pertinent to analyse the controversial THL theoretically. The definitions of ligament can be consolidated as "ligament is defined as a broad band or sheet of tough/elastic fibres of connective tissues between bones (limited extent) at a joint serving to support and strengthen (to stabilise) these bones during relative biomechanical moment."

First, the greater and lesser tubercles are not the part of the joint as per the definition of ligament rather these bones are fused with the proximal part of the humerus without involvement of biomechanical movements. Therefore, development of this ligament itself is doubtful.

Secondly, the THL as defined in Gray's anatomy [9] should have its origin at one of the tuberosities, greater/lesser and insertion at the other. This will form a separate anatomical entity/structure restricted between greater/lesser tubercle. This separate anatomical entity has not been demarcated by any researcher rather the description of the THL by all authors presented the fibrous tissues pertaining to tendon of subscapularis/supraspinatus, fibrous expansion of posterior lamina of pectoralis major covering the intertubercular groove. This clearly delivers a message that THL is a misnomer.

Thirdly, from a histological point of view, THL should contain collagen and elastin fibres both. No study could establish the presence of elastin fibres in the analysis of histological slides of this tissue. But it is well established fact that the presence of collagen fibres without elastin fibres as detected by all authors is characteristic of tendinous fibres. Though Snow et al. [16] have reported the presence of blended fibres of coracohumeral ligament and rotator cuff tendons in one extremity of bicipital groove cover yet the histological study did not reveal the deterministic indicators of ligament. Therefore again the name THL for these fibres is a misnomer.

Fourthly, as regards nerve endings as pain generators, these neural elements are present in tendon also so again it casts a doubt whether the fibres are tendinous or ligamentous. Besides, a study brought out that ligament of the shoulder joint possess mechanoreceptors but these were reported absent by Snow et al. [16] in this tissue. This again casts a doubt that these are ligamentous fibres rather enrich the conviction that these are tendinous fibres.

All the 4 theoretical aspects, dissection and histological studies establish the concept that the tissues overlying the bicipital groove are tendinous fibres rather than ligamentous. Therefore, the name THL is unfit to be used rather it needs to be modified.

Clinical significance

The tendon of the subscapularis retains the long head of biceps brachii in the bicipital groove, a function similar to that previously described for the indiscernible THL [10]. Similarly interdigitating fibres of the subscapularis and supraspinatus forming the covering over the bicipital groove perform the same function of retaining the biceps brachii tendon in the bicipital groove. In cases where there is no extension of fibres of the subscapularis/supraspinatus over the bicipital groove, the fibrous expansion from the posterior lamina of the pectoralis major over lays the bicipital groove. One would thus expect tears in the tendon of the subscapularis/subscapularis and the supraspinatus or fibrous expansion from the posterior lamina of the pectoralis major to be associated with subluxation of the long tendon of the biceps brachii. In one case in the present study, the tendon of biceps brachii was dislocated medially but none of the fibres of the subscapularis/subscapularis and the supraspinatus was torn; rather the fibrous expansion from the posterior lamina of pectoralis major was ruptured. As these fibres covered the bicipital groove and retained the biceps tendon in this groove, they were damaged because the biceps brachii tendon was dislocated.

Meyer [11] in 1928 stated that dislocations of the long head of the biceps brachii tendon occurred either deep to or within the substance of the subscapularis. Moreover, Deutsch et al. [6] observed that 6 out of 13 patients with full thickness subscapularis tears on MRI had an apparent medial subluxation/dislocation of the tendon of the long head of the biceps brachii. In addition, at arthroscopy, all tendon subluxations/ /dislocations occurred medial and deep to the tendon of the subscapularis [15]. Macdonald et al. [10] explained that this was because the tear involved the deep fibres of the subscapularis being avulsed off the lesser tubercle and the floor of the bicipital groove, allowing the tendon of the long head of the biceps brachii to slip underneath the subscapularis and dislocate medially. Thus if the tendon of the long head of the biceps brachii is subluxed or dislocated on imaging or at arthroscopy, a tear in the tendon of the subscapularis should be suspected. If this is not apparent, the clinician should consider whether the tear is hidden, involving only the deeper fibres inserting on to the lesser tubercle and/or bicipital **groove** [10]. In cases where the fibrous expansion from the posterior lamina of the pectoralis major covers the structure, the biceps brachii tendon is retained in the bicipital groove by this fibrous expansion. The expansion can act as a retinaculum to the long head of the biceps brachii distal to the coracohumeral ligament preventing it from "bowstringing" [3]. In such cases, dislocation of the long head of the biceps brachii tendon can disrupt the fibres of the fibrous expansion from the posterior lamina of the pectoralis major, keeping the subscapularis fibres intact; in 1 case in the present study the biceps brachii tendon was dislocated medially with intact subscapularis and supraspinatus fibres and the fibrous expansion was deformed. Thus if 1 reports shoulder pain or signs and symptoms of dislocation of the biceps brachii tendon, the clinician should inspect for rupture of the subscapularis/supraspinatus/fibrous expansion from the posterior lamina of the pectoralis major. A case has been reported in which a vertical tendon arising from upper horizontal fibres of pectoralis major muscle and travelling lateral to long head of the biceps brachii tendon, fused with fibrous capsule of shoulder joint. Mechanical traction of the humeral attachment of the pectoralis major muscle results in tautness of this tendon causing anteroinferior displacement of the shoulder joint capsule [17]. This may also be one of the causes of shoulder pain.

CONCLUSIONS

Thus, this study, both macroscopically and microscopically, confirms the finding of Gleason et al. [8], MacDonald et al. [10] and partly Snow et al. [16] that the tissues covering the bicipital groove is not a separate entity. Rather, the tissues covering the bicipital groove are formed by tendinous fibres of the subscapularis or both the subscapularis and supraspinatus or fibrous expansion of posterior lamina of pectoralis major muscle. Standard text books should be altered based on these findings.

ACKNOWLEDGEMENTS

The paper is dedicated to the father of author, Mr. Man Singh — a retired scientist. The authors are thankful to Dr Raj Kumar — the director of the institute for permitting to carry out the work in the department. The authors also acknowledge Mr. Sandeep, the modeller in the department of anatomy for preparing schematic diagrams. The authors gratefully thank to Dr R. Shane Tubbs for critically reviewing the manuscript.

REFERENCES

1. Boon JM, de Beer MA, Botha D, Maritz NG, Fouche AA (2004) The anatomy of the subscapularis tendon insertion as applied to rotator cuff repair. J Shoulder Elbow Surg, 13: 165–169.
2. Brodie CG (1889) Note on the transverse-humeral, coraco-acromial and coraco-humeral ligaments. J Anat, 4: 247–252.
3. Burkhead WZ Jr. (1996) Rotator cuff disorders. Williams and Wilkins, London.
4. Cash CJC, MacDonald KJ, Dixon AK, Bearcroft PWP, Constant CR (2009) Variations in the MRI appearance of the insertion of the tendon of subscapularis. Clin Anat, 22: 489–494.
5. Davis GG (1910) Applied anatomy. J.B. Lippincott Co., Philadelphia, PA.
6. Deutsch A, Altchek DW, Veltri DM, Potter HG, Warren RF (1997) Traumatic tears of the subscapularis tendon. Am J Sports Med, 25: 13–22.
7. Erickson SJ, Fitzgerald SW, Quinn SF, Carrera GF, Black KP, Lawson TL (1992) Long bicipital tendon of the shoulder: Normal anatomy and pathologic findings on MR Imaging. Am J Rad, 158: 1091–1996.
8. Gleason PD, Beall DP, Sanders TG, Bond JL, Ly JQ, Holland LL, Pasque CB (2006) The transverse humeral ligament: a separate anatomical structure or a continuation of the osseous attachment of the rotator cuff? Am J Sports Med, 34: 1–6.
9. Gray H, Pick TP, Howden R (1997) Gray's anatomy: the classic collector's edition. 15th Ed. Bounty Books, New York, NK.
10. MacDonald K, Bridger J, Cash C, Parkin I (2007) The transverse humeral ligament: does it exist? Clin Anat, 20: 663–667.
11. Meyer AW (1928) Spontaneous dislocation and destruction of tendon of the long head of biceps brachii. Arch Surg, 17: 493–506.
12. Nidecker A, Guckel C, Von Hochstetter A (1997) Imaging the long head of biceps tendon. A pictorial essay emphasizing magnetic resonance. Eur J Radiol, 25: 177–187.
13. Peterson CJ (1986) Spontaneous medial dislocation of the tendon of the long biceps brachii. Clin Orthop Rel Res, 211: 224–227.
14. Rokito AS, Bilgen OF, Zuckerman JD, Cuomo F (1996) Medial dislocation of the long head of the biceps tendon. Am J Orthop, 25: 314–323.
15. Slatis P, Aalto K (1979) Medial dislocation of the tendon of the long head of the biceps brachii. Acta Orthop Scand, 50: 73–77.
16. Snow BJ, Navy SJ, Omid R, Atkinson RD, Vangsness CT Jr. (2013) Anatomy and histology of transverse humeral ligament. Orthopedics, 36:1295–1298.
17. Tubbs RS, Shola MM, Shokouhi G, Loukas M, Oakes WJ (2007) Insertion of the pectoralis major into the shoulser joint capsule. Anat Sci Int, 83: 291–293.
18. Wood JF (1946) Buchanan's manual of anatomy. 7th Ed. Balliere, Tindall and Cox, London.