The Empty Bicipital Groove – A Pictorial Essay on the Congenital Absence of Long Head of Biceps Tendon and other Biceps Tendon Pathologies

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ABSTRACT

An empty bicipital groove may be congenital or post-surgical. Congenital absence of long head of biceps tendon is rare and often missed on MRI unless the radiologist has a high index of suspicion. Surgical treatment such as biceps tenotomy or tenodesis will also demonstrate an empty bicipital groove. Long head of biceps tendon pathology is a common cause of anterior shoulder pain as it faces both intra-articular and extra-articular constraints resulting in tendinopathy, tenosynovitis, tear or subluxation. However, the proximity to other structures such as the coracohumeral ligament, superior glenohumeral ligament, rotator cuff muscles and glenoid labrum gives rise to a diagnostic challenge in patients with anterior shoulder pain. We present a rare case series of congenital and post-surgical empty bicipital groove and other long head of biceps tendon pathologies in the context of an empty bicipital groove. Radiologists should be mindful of such an entity as they may be the first to encounter the imaging features and clinical scenario.

INTRODUCTION

An empty bicipital groove may be congenital or post-surgical. Congenital absence of long head of biceps tendon is rare and often missed on MRI unless the radiologist has a high index of suspicion. Surgical treatment such as biceps tenotomy or tenodesis will also demonstrate an empty bicipital groove. Long head of biceps tendon pathology is a common cause of anterior shoulder pain as it faces both intra-articular and extra-articular constraints resulting in tendinopathy, tenosynovitis, tear or subluxation. However, the proximity to other structures such as the coracohumeral ligament, superior glenohumeral ligament, rotator cuff muscles and glenoid labrum gives rise to a diagnostic challenge in patients with anterior shoulder pain. We present a rare case series of congenital and post-surgical empty bicipital groove and other long head of biceps tendon pathologies in the context of an empty bicipital groove.

CASE DESCRIPTION

Case 1- Congenital absence of LHBT

Non-visualization of the intra-articular portion of the long head of biceps tendon (LHBT) raises the possibility of LHBT pathologies such as tears, subluxation or dislocation. However in the absence of features such as tendon stump, tendon degeneration, and retracted distal tendon, radiologists should be cognizant of anatomical variants [1]. We present a case of bilateral congenital absence of LHBT, a rare phenomenon with only a few case reports in the literature [2-8]. The LHBT can be absent in the intra-articular segment of both intra and extra-articular segments [5]. Most cases of LHBT absence were diagnosed incidentally during MRI or shoulder arthroscopy [3]. The hallmark on MRI would be shallow/flat bicipital groove with absent LHBT (Figure 1a-1d) [2]. In addition, Dierickx et al. reported a large case series of anatomical variants of the biceps tendon, of which 2 types of variants can give rise to the appearance of an absence of LHBT on MRI or arthroscopy – These are the ADH-CL (complete adherence to labrum) and ADH-CO (complete adherence to supraspinatus) [3]. Kumar et al described an association of LHBT absence with shoulder pain (85.7% or patients) and shoulder instability (37.1% of patients) [3]. The majority of patients do not require active surgical treatment for congenital absence of LHBT unless there is associated rotator cuff pathology [3]. In addition, given that the LHBT is developed at 6-7 weeks of gestation [9] and there have been case reports of associated birth defects such as vertebral defects, undescended testis and intestinal anomalies [6], clinicians should be cognizant of the evaluation for other congenital anomalies.

Case 2 – Subluxation of LHBT

Subluxation of the LHBT is often due to trauma and is often associated with rotator cuff injury, especially the subscapularis [10, 11]. The LHBT tendon angles laterally from its origin to the bicipital groove and a medially directed force, often seen in throwing movements, may cause subluxation/dislocation towards the lesser tuberosity [12]. Patients often report a snap at a certain point in the range of motion and a reducible pop can be reproduced on clinical examination. On MRI, the bicipital groove appears to be empty with the LHBT subluxated anteromedially due to the anteromedial location of the biceps brachii muscle (Figure 2a-2d) [11]. Rotator cuff repair with tenodesis of the LHBT is often performed to restore stability [11].

Cases 3 and 4 – Torn LHBT

Tears of the LHBT with retraction can cause non-visualization of the intra-articular portion of the LHBT [1]. LHBT tears can be incomplete or complete. It is often associated with rotator cuff tears, especially the supraspinatus [1, 11]. Other associated pathologies include SLAP tear and biceps pulley injuries (superior glenohumeral ligament (SGHL), coracohumeral ligament (CHL) and subscapularis) [1]. LHBT tear is often located at the origin of the superior glenoid labrum or myotendinous junction at the distal aspect of the bicipital groove. In a complete tear, MRI demonstrates a retracted tendon. There will be an absent tendon in the bicipital groove in a myotendinous tear (Figure 3a-3e) [11]. On MR Arthrography, extension of intra-articular contrast into the subcoracoid space has been associated with complete rotator interval tears [13]. In an incomplete tear, MRI demonstrates an intratendinous fluid-filled cleft on fluid-sensitive sequence (Figure 4a-4b) [11].

Fluid-filled tendon sheaths are commonly associated with LHBT tears. Notwithstanding, radiologists should also be cognizant of anatomical variants such as duplicated intra-articular LHBT (bifurcate or Y-shaped) that will mimic a “fluid cleft” in incomplete LHBT tears [1]. The “magic angle” phenomenon on MRI makes it more difficult to accurately evaluate the LHBT [14]. This can be improved with longer echo times or with abducted external rotation (ABER) positioning [14]. Surgical treatment includes tenotomy or tenodesis, usually for complete tears [15].

Case 5, 6 and 7 – Superior Labral from Anterior to Posterior (SLAP) tears

SLAP tears are usually caused by trauma to the shoulder joint associated with instability thereafter. Patients often present with a deep sensation of joint pain associated with locking, popping or clicking sensations with activity. Risk factors include overhead sports, especially those with repeated throwing actions [16]. Calvi et al. reported an association between LHBT variants (mesotenon, adherent and split types) and SLAP tears [17]. There was no case of absent LHBT in that case series. This was postulated to be due to the adherence of LHBT to the supraspinatus causing limited excursion and higher chance of SLAP tears [17].

The original classification of SLAP tear by Synder et al included 4 main types of SLAP tears, with further extensions by Morgan et al. and Maffet et al. to include up to a total of 10 types [18]. However, these classifications have been shown to only have mixed reproducibility and should be used with caution [18, 19]. Rather than classifying the type of SLAP tear, it is more crucial to accurately describe the location, morphology, extent of the SLAP tear and associated injuries (rotator cuff, glenohumeral ligaments, cartilage and bony injuries) [20]. Of note, SLAP tears that extend into the anteroinferior labrum and MGHL suggest glenohumeral instability and are an indication for surgery [20].

- Type 1 SLAP tear describes degenerative fraying of the superior labrum with intact biceps anchor.
- Type 2 SLAP tear describes degenerative fraying with the detachment of the superior labrum and biceps from the glenoid.
- Type 3 SLAP lesion consists of a bucket-handle tear of the superior labrum with an intact biceps tendon anchor (Figures 5a-5e).
- Type 4 SLAP tear consists of a type III tear with extension into the biceps tendon anchor (Figures 6a-6c,Figures 7a-7d).
- Types 5 to 10 SLAP tears involve variations of Type II SLAP tears.
    - Type 5 describes a Bankart-type labral disruption continuous with a Type II SLAP lesion.
    - Type 6 describes an unstable flap tear of the labrum associated with a Type II SLAP lesion (Figure 6d).
    - Type 7 describes a Type II SLAP tear that extends anteriorly through the capsule through the middle glenohumeral ligament.
    - Type 8 describes a Type II SLAP tear with extension into the posterior labrum.
    - Type 9 describes a Type II SLAP tear with circumferential labral disruption.
    - Type 10 describes a Type II SLAP tear with posteroinferior labral disruption.

On MRI, it is a common diagnostic challenge to differentiate SLAP tear from sublabral sulcus. The sublabral recess is generally less than 2 mm in width with smooth margins [14]. A SLAP tear is demonstrated by an irregular fluid cleft separating the labrum from the glenoid which follows the glenoid contour medially [14]. Both MR arthrography and 3T MRI have been reported to be superior to conventional 1.5T MRI for diagnosis of SLAP tears [17, 21].In terms of surgical repair, there have been mixed outcomes in athletes and is most suitable for patients under age 40 years old [16].

Case 8 – Empty bicipital groove due to biceps tenodesis attachment site within the proximal humerus

As radiologists, we must also be cognizant of post-operative changes and keep updated with the new surgical techniques involving the pathology of concern. Tenotomy involves incising the tendon away from the biceps labral complex while tenodesis involves an additional step of anchoring the LHBT into the upper humerus [10, 15, 22]. LHBT tenodesis can be performed open or arthroscopically. Different techniques exist such as suprapectoral tenodesis, subpectoral tenodesis, interference screw and cortical buttons, most common being the interference screw and cortical button techniques [15]. Indications for LHBT tenodesis include instability, tear and SLAP lesions when conservative management fails [10, 15]. In addition to the nature and extent of injury, the patient's premorbid functional status and occupation are important factors to consider for surgery [15].

We describe a case of iatrogenic cause of empty bicipital groove post biceps tenodesis (Figures 8a-8d). Both tenotomy and tenodesis demonstrate an empty bicipital groove, but tissue anchors in the proximal humerus are seen in patients post-tenodesis [22]. Tissue anchors are radiographically occult where only a round lucency is seen and should not be mistaken for a lytic lesion [11, 22]. Complications of LHBT tenodesis include failed fixation, biceps fatigue and decreased power in elbow flexion/supination strength, periprosthetic fracture, neurovascular injury and cosmetic deformity from "popeye" lesion [15].

DISCUSSION

We present a case series of LHBT pathologies and their imaging features. An empty bicipital groove is a rare entity. Congenital absence of LHBT is perhaps even rarer and often missed on MRI unless the radiologist has a high index of suspicion. Kumar et al. reported that 60% of absent LHBT missed on the initial MRI [3]. The LHBT has been described to have many variations, from different attachment sites and morphology [1,2,10,13,23]. Classically, it inserts onto the supraglenoid tubercle of the scapula and superior labrum, with several variations previously reported [10,12]. LHBT is a common cause of anterior shoulder pain as it faces both intra-articular and extra-articular constraints resulting in tendinopathy, tenosynovitis, tear or subluxation [10]. However, the proximity to other structures such as the coracohumeral ligament, superior glenohumeral ligament, rotator cuff muscles and glenoid labrum gives rise to a diagnostic challenge in patients with anterior shoulder pain [1]. The rotator interval serves to stabilize the biceps tendon as it moves from its extra to intraarticular position, therefore injuries of the supraspinatus, subscapularis, coracohumeral ligament or superior glenohumeral (also known as "pulley lesions") may result in injury of the long head of the biceps tendon [1, 11]. Tear of the LHBT is often associated with supraspinatus injury and subluxation of the LHBT is associated with subscapularis injury [1,10,11]. In addition, due to LHBT attachment to the superior labrum, superior labral anterior posterior tear (SLAP) lesions are often associated with LHBT injury.

MRI is the radiological gold standard for accurately diagnosing LHBT pathologies and its associated injuries [23-25]. Ultrasound is an acceptable alternative imaging modality, though less accurate in diagnosing partial thickness tears, tendinosis and tenosynovitis [26]. As it may be difficult to diagnose the LHBT pathologies clinically, radiologists should be proficient in utilizing these modalities.

CONCLUSION

An empty bicipital groove raises the possibility of congenital absence of LHBT or an acquired cause. Acquired causes can be further divided into traumatic (LHBT/SLAP tear, LHBT subluxation/dislocation) or iatrogenic (tenotomy/tenodesis). Congenital absence of LHBT is rare and may be associated with pain or instability. Treatment is only warranted in the presence of other related injuries. Radiologists should be mindful of such an entity as they may be the first to encounter the imaging features and clinical scenario.

TEACHING POINT

An empty bicipital groove raises the possibility of congenital absence of LHBT or an acquired cause such as traumatic (LHBT/SLAP tear, LHBT subluxation/dislocation) or iatrogenic (tenotomy/tenodesis). Radiologists should be mindful of such an entity as they may be the first to encounter the imaging features and clinical scenario.

COMPLIANCE WITH ETHICAL STANDARDS

The authors do not have any conflict of interest, financial or non-financial disclosures.

QUESTION AND ANSWER

Which of the following is/are false about the long head of biceps tendon (LHBT)?

1. LHBT absence is common (applies)
2. LHBT has many anatomical variants
3. LHBT absence may be associated with pain or instability
4. LHBT absence with no other injury does not require surgery
5. LHBT absence may be bilateral

Which of the following may be a cause for an empty bicipital groove in relation to the long head of biceps tendon (LHBT)?

1. LHBT absence (applies)
2. LHBT subluxation (applies)
3. LHBT complete rupture (applies)
4. LHBT tenodesis/tenotomy (applies)
5. LHBT strain

Which of the following is/are associated with long head of biceps tendon (LHBT) injury?

1. Rotator interval injury (applies)

2. Rotator cuff injury (applies)
3. Labral injury (applies)
4. SLAP injury (applies)
5. Humeral fracture (applies)

Which of the following is/are potential complications of long head of biceps tendon (LHBT) tenodesis/tenotomy?
1. Failed fixation (applies)
2. Biceps fatigue (applies)
3. Periprosthetic fracture (applies)
4. Cosmetic deformity from "popeye" lesion (applies)
5. Neurovascular injury (applies)

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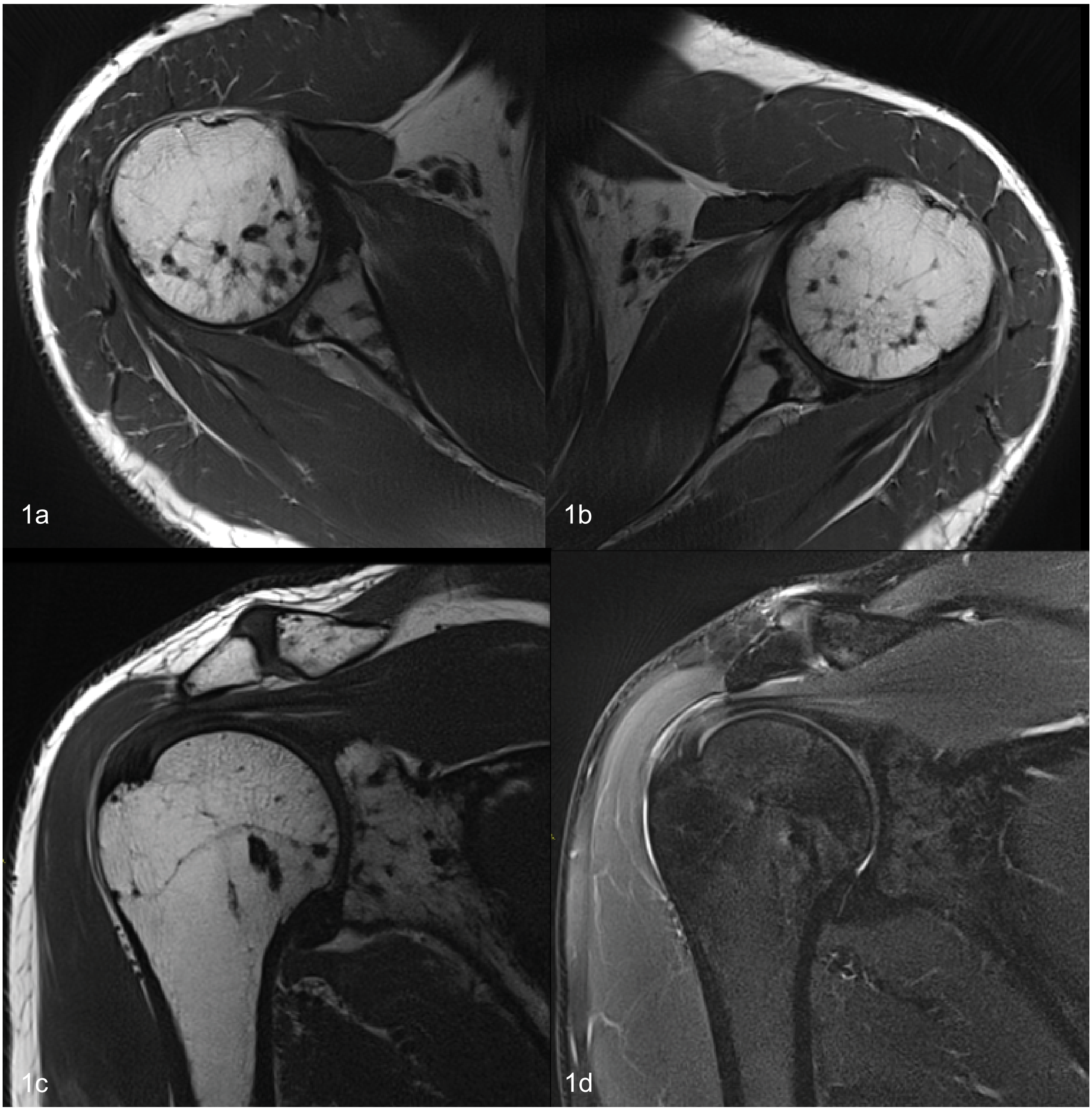
FIGURES



Figures 1a-1d: Siemens Avanto Fit, 1.5 Tesla, Slice Width 3mm. MRI PD axial sequence TR 3000, T2 39 (Figures 1a,1b), PD coronal sequence TR 3720, TE 44 (Figure 1c), T2 FS coronal sequence TR 4030, TE 73 (Figure 1d). Congenital absence of the bilateral biceps long head tendons and extremely shallow bicipital grooves. Incidental multiple hypointense intramedullary foci with no edema, cortical erosion or aggressive periosteal reaction, in keeping with osteopoikilosis

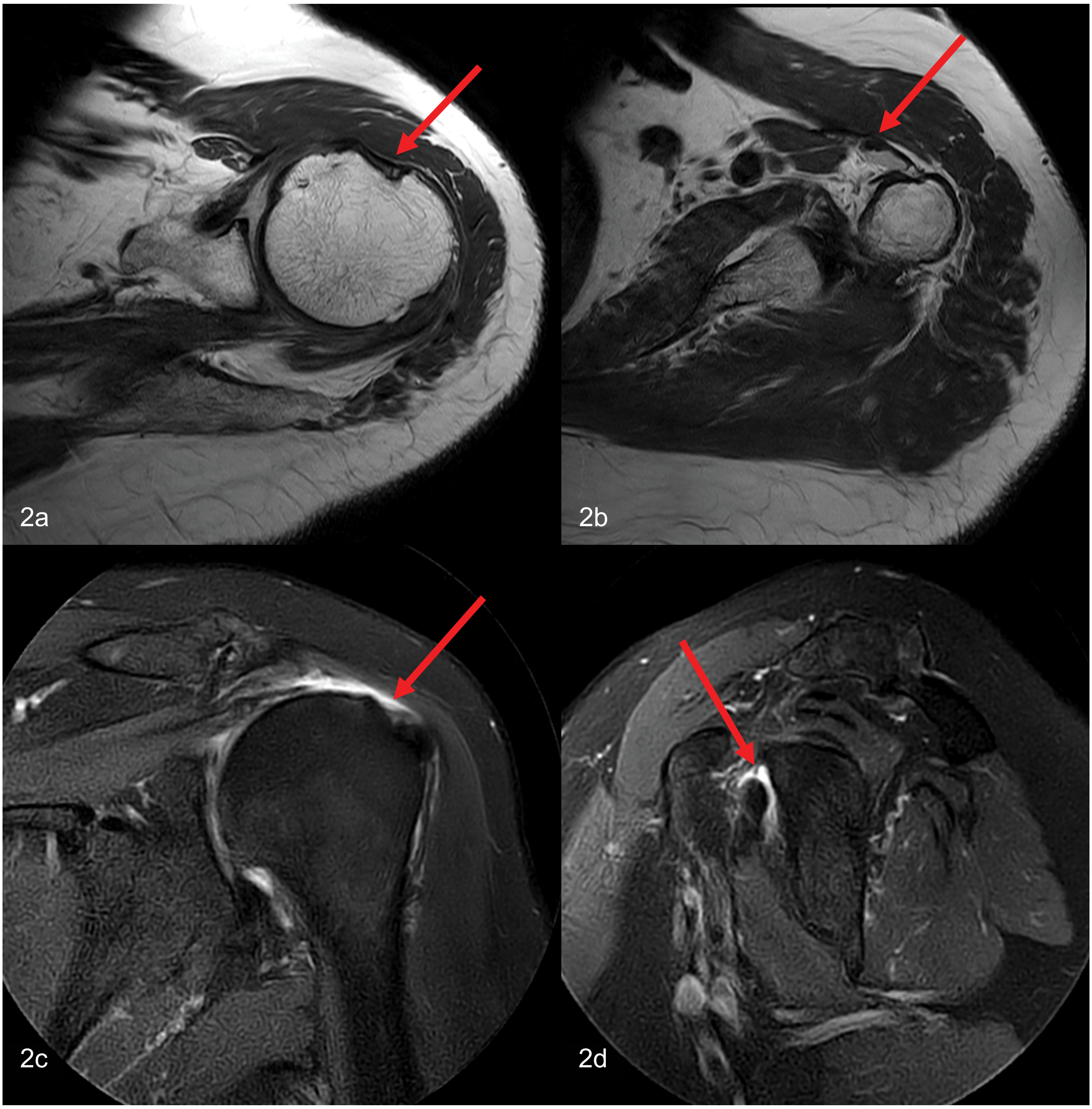
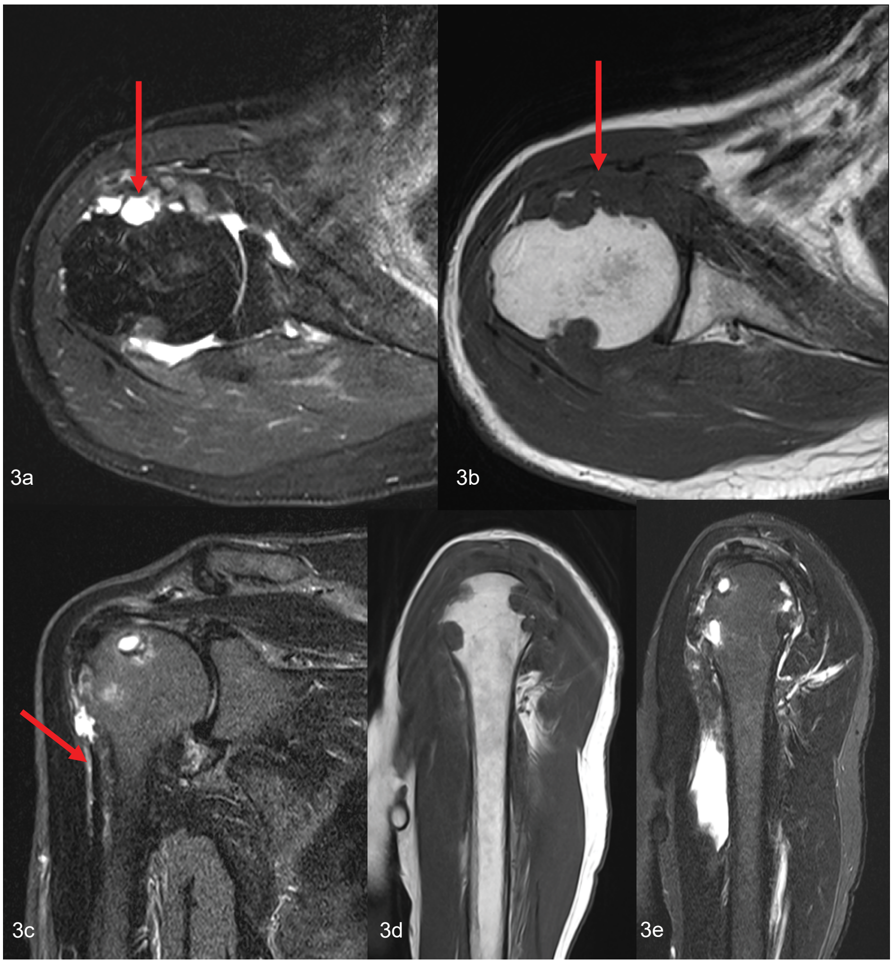


Figure 2a: Philips Ingenia, 1.5 Tesla, Slice Width 3 mm. MRI PD axial sequence TR 2000, TE 37. The left bicipital groove (red arrow) demonstrates adequate depth in keeping with normal development. However, the absence of LHBT within the bicipital groove suggests LHBT pathology

Figure 2b: Philips Ingenia, 1.5 Tesla, Slice Width 3 mm. MRI PD axial sequence TR 2000, TE 37. Anteromedial subluxation of the left LHBT (red arrow) with hyperintense signal within the tendon sheath suggestive of mild tendon sheath effusion

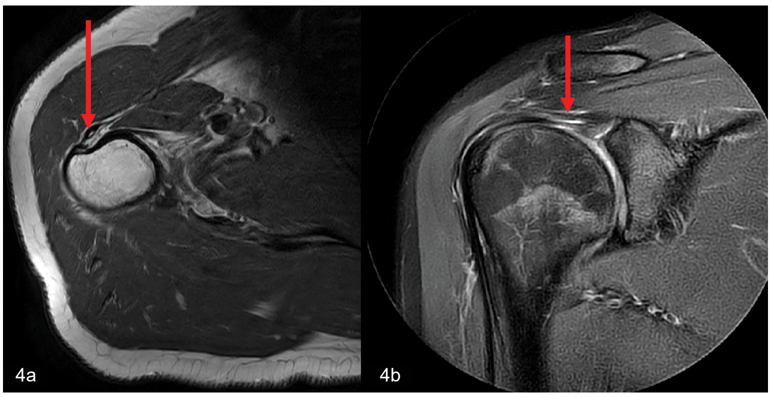
Figure 2c: Philips Ingenia, 1.5 Tesla, Slice Width 3 mm. MRI T2 FS coronal sequence, TR 2254, TE 60. Full thickness left supraspinatus tear (red arrow) with retraction of the tendon stump, an injury that is associated with LHBT pathologies

Figure 2d: Philips Ingenia, 1.5 Tesla, Slice Width 3 mm. MRI T2 FS sagittal sequence, TR 2478, TE 60. Partial thickness left subscapularis superior fibres tear (red arrow) with intact inferior fibres, an injury that is also associated with LHBT pathologies

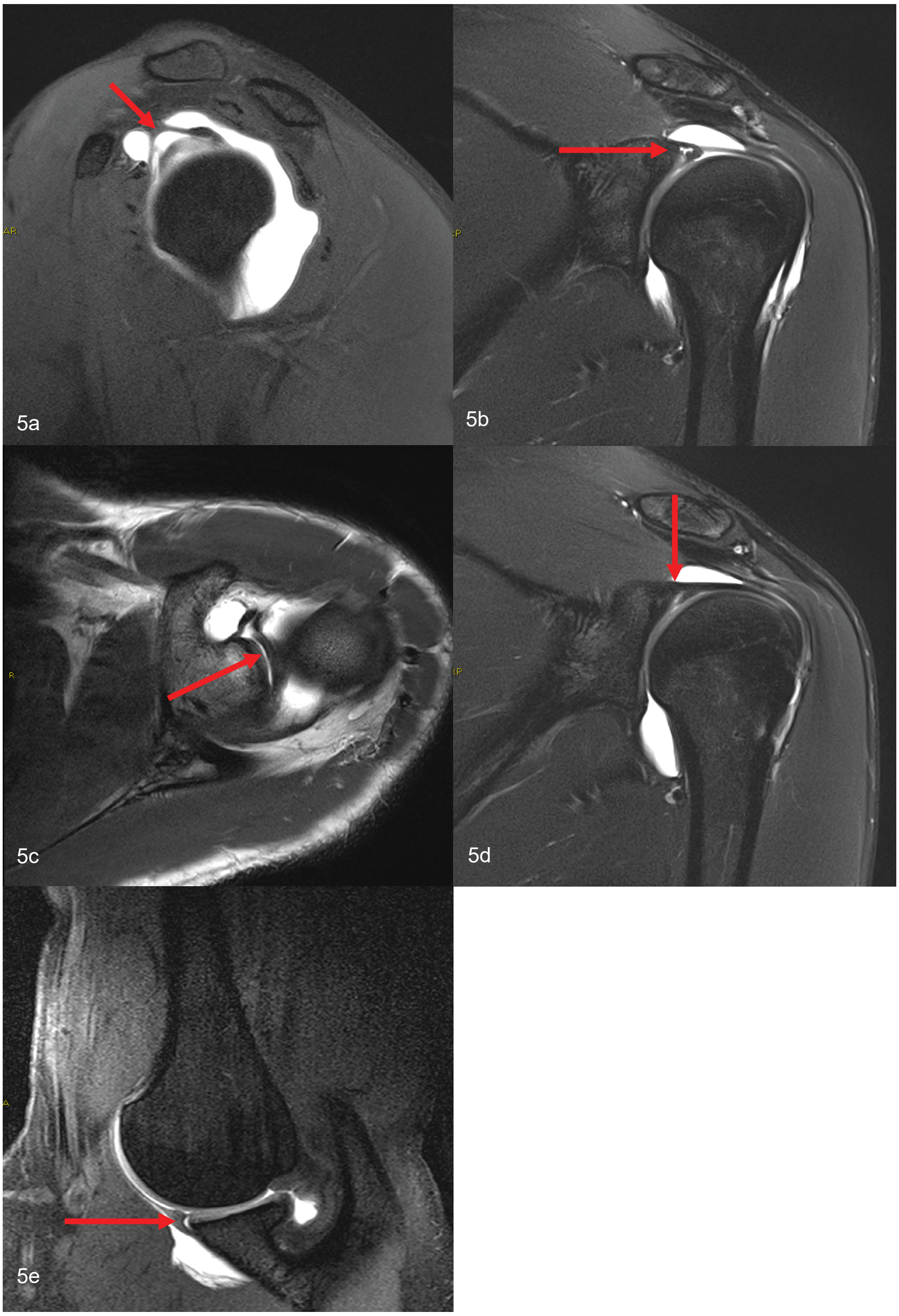


Figures 3a-3c: Siemens Magnetom Sola, 1.5 Tesla, Slice Width 3mm. MRI T2 TIRM axial sequence TR 5730, TE 63 (Figure 3a), T1 axial sequence TR 400, TE 13 (Figure 3b), T2 TIRM coronal sequence TR 4110, TE 79 (Figure 3c). Empty right bicipital groove with fluid (red arrow in Figure 3a) occupying the expected location of the right LHBT and traversing between the retracted tendon (red arrows in Figures 3b and 3c) and humeral head

Figures 3d,3e: Siemens Skyra, 1.5 Tesla, Slice Width 3mm. MRI T1 sagittal sequence TR 428, TE 12 (Figure 3d), T2 TIRM sagittal sequence TR 3100, TE 77 (Figure 3e). Incidental note of PD hypointense, T2 hyperintense foci within the right humeral head juxta-articular surface in keeping with known gouty tophi



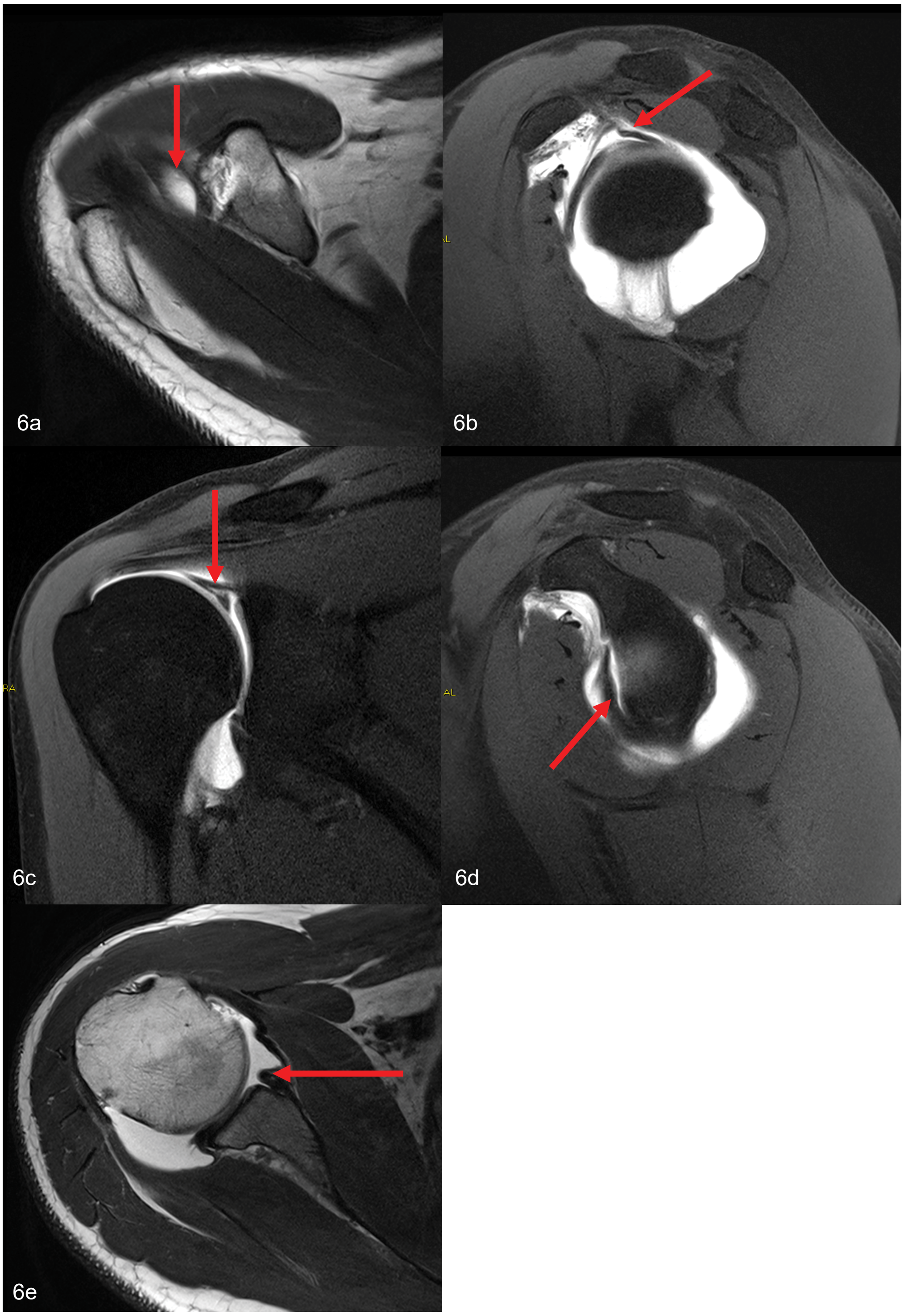
Figures 4a,4b: Philips Ingenia, 1.5 Tesla, Slice Width 3 mm. MRI PD axial sequence TR 2490, TE 37 (Figure 4a), T2 FS coronal sequence TR 2661, TE 60 (Figure 4b). Hyperintense signal fluid cleft (red arrows) within right LHBT suggestive of a split tear (incomplete tear). The LHBT is still enlocated within the bicipital groove



Figures 5a-5c: Siemens Skyra, 1.5 Tesla, Slice Width 3mm. MRI T1 FS sagittal sequence TR 617, TE 10 (Figures 5a and 5b), T1 FS axial sequence TR 724, TE 10 (Figure 5c). Intrasubstance high signal within the torn superior labrum (red arrows in Figures 5a-5c) extending posteriorly (red arrow in Figure 5c) with a “bucket handle” appearance (red arrow in Figure 5a) is suggestive of a Type 3 SLAP tear

Figure 5d: Siemens Skyra, 1.5 Tesla, Slice Width 3mm. MRI T1 FS coronal sequence, TR 707, TE 10. No extension of the SLAP tear into the intact biceps anchor (red arrow). Therefore, this remains as a Type 3 SLAP tear

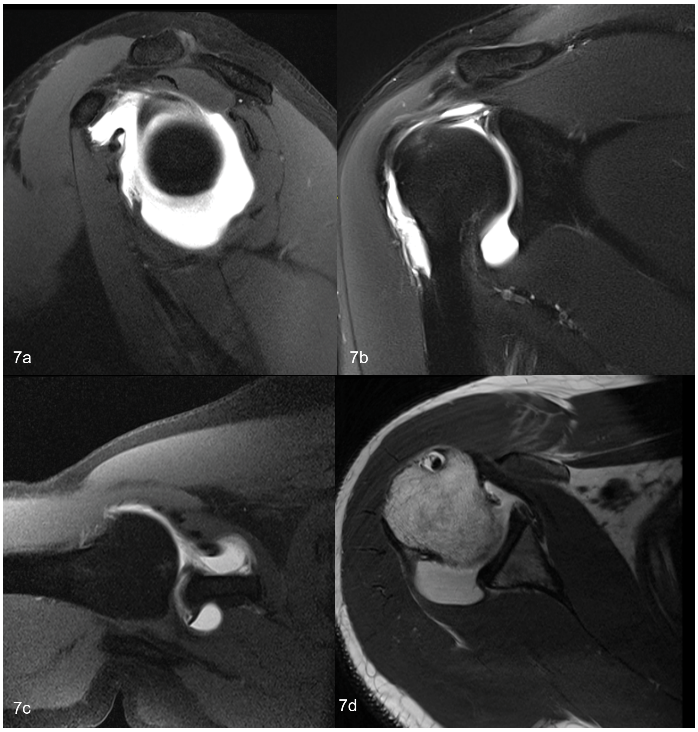
Figure 5e: Siemens Skyra, 1.5 Tesla, Slice Width 3mm. MRI T1 FS ABER (abducted external rotation) sequence, TR 610, TE 9. Intrasubstance high signal of the anteroinferior labrum (red arrow) lifting from the glenoid edge raises the possibility of a Perthes lesion



Figures 6a-6c: Siemens Skyra, 1.5 Tesla, Slice Width 3mm. MR Arthrogram PD axial sequence, TR 3800, TE 41 (Figure 6a), T1 FS sagittal sequence TR 568 (Figure 6b), TE 10, T1 FS coronal sequence, TR 519, TE 11 (Figure 6c). Intrasubstance high signal within the torn superior labrum extending posteriorly with a "bucket handle" apperance (red arrows in 6a and 6b). There is extension into the biceps anchor (Figure 6c). Overall appearance is in keeping with a Type 4 labral tear

Figure 6d: Siemens Skyra, 1.5 Tesla, Slice Width 3mm. MR Arthrogram T1 FS sagittal sequence, TR 568, TE 10. Circumferential labral disruption (red arrow) lifting away from the glenoid suggestive of a Type 6 SLAP tear.

Figure 6e: Siemens Skyra, 1.5 Tesla, Slice Width 3mm. MR Arthrogram PD axial sequence, TR 3800, TE 41. Contrast material enters a cleft between the anteroinferior glenoid and the glenoid labrum. The labrum is stripped off but still adherent to the periosteal attachment (red arrow) suggestive of an Anterior Labroligamentous Periosteal Sleeve Avulsion (ALPSA) lesion



Figures 7a-7d: Siemens Skyra, 1.5 Tesla, Slice Width 3mm. MR Arthrogram T1 FS sagittal sequence, TR 530, TE 10 (Figure 7a), T1 FS coronal sequence, TR 480, TE 10 (Figure 7b), T1 FS ABER sequence, TR 630, TE 9 (Figure 7c), PD axial sequence, TR 3340, TE 41 (Figure 7d). Intrasubstance high signal within the torn superior labrum (Figure 7a) extending posteriorly (Figure 7c) with a "bucket handle" appearance (Figure 7a). There is extension into the biceps labrum (Figure 7b). Overall appearance is in keeping with a Type 4 labral tear

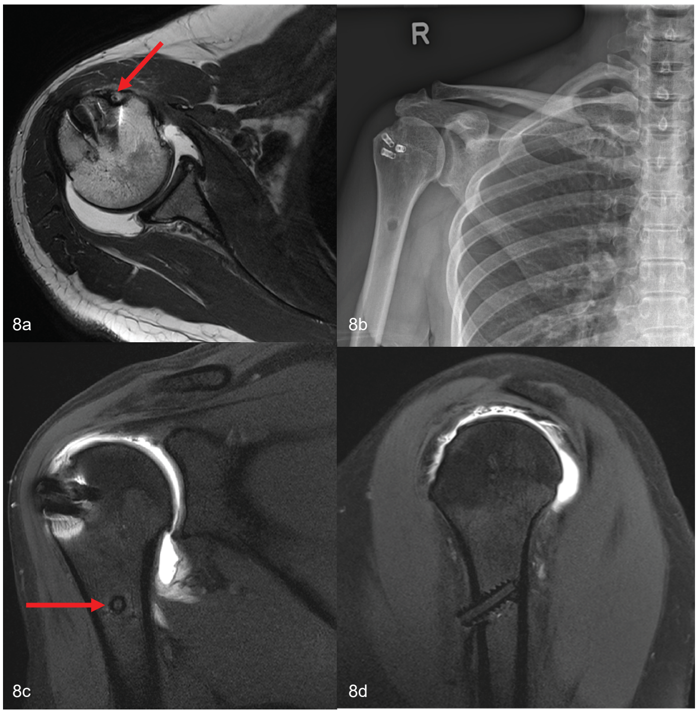


Figure 8a: Siemens Skyra, 1.5 Tesla, Slice Width 3mm. MRI PD axial sequence, TR 3350, TE 41. Empty right bicipital groove (red arrow). Partially visualized suture anchors at the greater tuberosity from prior rotator cuff repair

Figure 8b: Right shoulder Anterior-Posterior radiograph. Well-circumscribed lucency mimics a "lytic lesion" at the right proximal humerus. Suture anchors noted at the greater tuberosity

Figures 8c,8d: Siemens Skyra, 1.5 Tesla, Slice Width 3mm. MRI T1 FS coronal sequence, TR 480, TE 10 (Figure 8c) T2 FS sagittal sequence, TR 568, TE 10 (Figure 8d). Tissue anchor in the right proximal humerus corresponds (red arrow) to the well-circumscribed lucency on right shoulder radiograph in Figure 8b, suggestive of prior tenodesis procedure

SUMMARY TABLE ON CONGENITAL ABSENCE OF LHBT

Etiology	Congenital
Incidence	Rare
Risk factors	Case reports on associations with congenital abnormalities such as vertebral defects, undescended testis and intestinal anomalies
Imaging findings	Shallow/Absent bicipital groove Complete absence of LHBT even in prior imaging
Management	None unless there are other associated injuries
Prognosis	Unknown

DIFFERENTIAL TABLE ON EMPTY BICIPITAL GROOVE

Differential diagnosis	**Clinical features**	**Imaging features on MRI**
LHBT Subluxation/ Dislocation	Pain, instability	Presence of bicipital groove LHBT present but subluxed Associated rotator cuff injury
LHBT Complete tear	Pain, instability, weakness, decrease in range of motion, “popeye” sign	Presence of bicipital groove LHBT present but retracted LHBT tendon sheath effusion Associated rotator cuff injury
Post operative	Prior tenotomy/tenodesis Arthroscopic or Open surgery scar	Presence of bicipital groove LHBT present but anchored in the proximal humerus Presence of suture anchors

KEYWORDS

Bicipital Groove; Biceps; Tendon; Labrum; Musculoskeletal

ABBREVIATIONS

LHBT = Long Head of Biceps Tendon
ADH-CL = Complete Adherence to Labrum
ADH-CO = Complete Adherence to Supraspinatus
SGHL = Superior Glenohumeral Ligament
CHL = Coracohumeral Ligament
ABER = Abducted External Rotation
SLAP tear = Superior Labral from Anterior t o Posterior Tear

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