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PICTORIAL ESSAY

Ultrasound of glenoid labrum with MR arthrographic correlation

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Abstract

Ultrasound (US) is a reliable non-invasive method to image the rotator cuff tendons. Even though glenoid labral pathology is common, it is not routinely looked at as part of the shoulder ultrasound protocol. Currently, the gold standard for labral imaging remains MR arthrography. However, given the rather long waiting list and cost implications, US may be used as a modality to quickly screen the shoulder for gross labral pathology. Whilst there is relative paucity of the literature outlining labral pathology on US, there is none correlating sonographic and corresponding MRI appearances. We present a pictorial review highlighting scanning positioning, US and corresponding MRI appearances of a normal labrum and various labral pathologies. We discuss useful scanning tips and characteristic US signs which can help the radiologist.

Keywords Ultrasound · Labrum · MRA

Introduction

MRI and especially MRI arthrogram (MRA) is a well-established imaging modality to characterise pathologies of the glenoid labrum. The contrast given during the arthrogram can delineate the labrum well enough to identify SLAP tears and other labral pathologies. The different MRI sequences available can readily characterise bony abnormalities such as Bankart or Hill Sach's lesion. Ultrasound (US) is usually performed prior to MRI to evaluate the rotator cuff, and identify any cuff tears, which could impact on surgery. The use of US in detecting labral lesions is known but not well documented in the literature. A handful of papers and case reports suggest it is only useful in diagnosing pathology of the anterior labrum, and less useful in lesions of the posterior labrum [1, 2]. Given that most labral pathology affects the anterior labrum, US could provide useful information as the first-line imaging modality, while the patient is awaiting MRA. However, US is user dependent with experience and technical expertise of the radiologist playing a crucial role in diagnosing subtle labral lesions.

Given the relative low cost and availability of USS compared to MRI, it may prove a useful tool in the preliminary workup of patients with clinical signs of labral pathology. In a study by Taljanovic and authors, US had a modest sensitivity of 67% in differentiating labral tears from a normal or degenerative labrum [3]. Given the high specificity and negative predictive value of 99%, they concluded that a normal labral appearance on USS was sufficient to exclude a frank tear, although degeneration may exist [3] .

While subtle pathology maybe missed, definitive signs of a labral tear such as avulsion, displacement or absence of a labrum in its normal anatomical position can alert the clinician quickly of potential pathology. Access to US is easier compared to MRI, increasing the likelihood of detecting an abnormality. Most published papers only highlight US appearances of major tears of the labrum, only one paper in particular discusses specific pathology such as soft-tissue Bankart, perthes lesion and paralabral cysts [4]. To the best of our knowledge, correlation with MRI findings has not been available in the literature so far.

We present a pictorial review of different labral pathologies on US with corresponding MRA. We will discuss imaging appearances on the two modalities and features the radiologist may use in diagnosing labral injury confidently on US. Whilst MRA and arthroscopy will always remain the gold standard, US is a quick, non-invasive, widely available

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and a cheap way of examining soft tissues. It is painless, associated with no side effects and permits dynamic examination. These qualities make it useful in detecting glenoid labral injuries.

Normal glenoid labrum and positioning on US

All USS examinations were performed by one musculoskeletal radiologist with 12 years of consultant experience. A Philips IU22 US scanner system was used. For the anterior labrum, a linear or curvilinear transducer was used, varying between 5 and 12 MHz depending on shoulder morphology at the time of scanning. The patient lies down supine on the couch, in accordance with the scanning positions as described by Hinzmann and authors [4, 5]. The radiologist is beside the patient to ensure the transducer can be followed whilst scanning simultaneously. The transducer is applied transversely over the proximal glenohumeral joint (GHJ) line and moved inferiorly to image both the superior and inferior labrum. A slight medial or lateral angulation of the transducer was occasionally used to optimise the image quality.

A passive dynamic evaluation of the labrum is performed by holding the wrist of the patient, and gently moving it through internal and external rotation. The anterior labrum is imaged perpendicular or slightly oblique to the long axis of the arm (Fig. 1). The normal anterior labrum appears thickened due to the close proximity with the anterior band of inferior glenohumeral ligament (IGHL) (Fig. 1). As the anterior joint capsule has a similar echogenicity to the labrum, dynamic assessment in the supine position is usually carried out to clearly differentiate the two [6].

The posterior glenoid labrum is examined with the patient seated, and a linear 12 MHz array transducer applied towards the superior part of the posterior GHJ line (Fig. 2). An axial image of the posterior labrum is obtained through the infraspinatus muscle. It appears as a triangular echogenic structure alongside the bony glenoid (Fig. 2). The joint capsule, which lies deep to the posterior rotator cuff tendons, attaches directly to the labrum.

Labral pathology normally manifests as variations in echotexture on US. Most acute pathologies will appear hypoechoic or heterogeneously hypoechoic [3]. Chronic injury may appear hyperechoic due to the presence of calcification [3]. Bony avulsions appear as hyperechoic foci [3]. We now discuss the major tell tale signs of labral pathology on US, and then highlight imaging appearances of specific bony and soft-tissue labral pathology with MRA correlation.

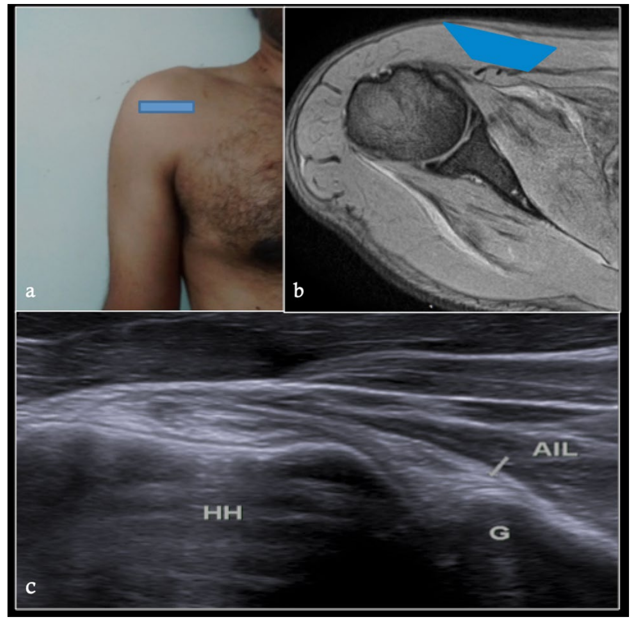

Fig. 1 **a** The blue box highlights the imaging plane of the anterior glenoid labrum on US. Note that the transducer is applied perpendicular or just slightly oblique to the long axis of the arm. **b** The anterior inferior labrum at this level on US. **c** The anterior inferior labrum (AIL) appears as a triangular echogenic structure between the humeral head (HH) and glenoid (G)

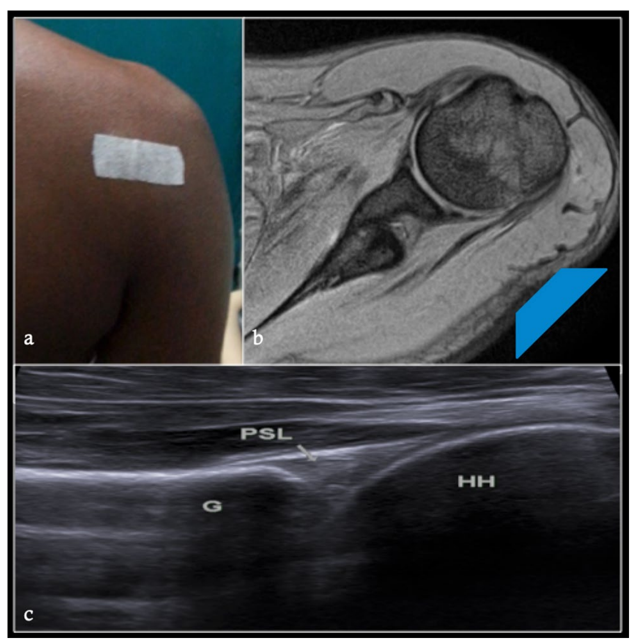

Fig. 2 **a** To image the posterior labrum, the transducer is applied along the posterior GHJ line at the site of the white marker. **b** Axial sections are obtained through infraspinatus. **c** The posterior superior labrum (PSL) appears as a triangular echogenic structure alongside the bony glenoid

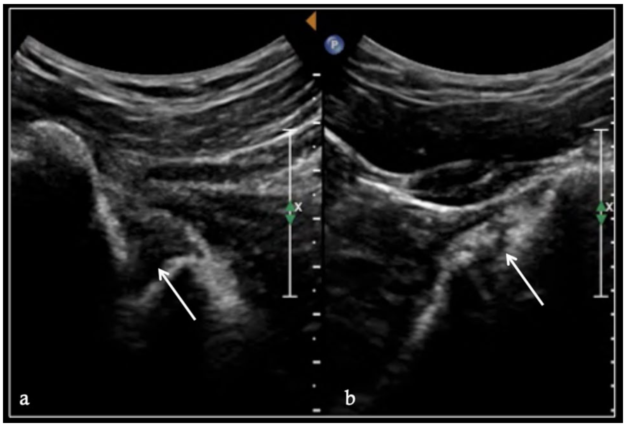

Fig. 3 Axial section of the glenohumeral joints at the level of the anteroinferior glenoid. **a** A bare glenoid sign with absence (white arrow) of echogenic labrum over the anterior bony glenoid compared to **b**–**a** normal triangular echogenic labrum (white arrow)

Discussion

Bare glenoid sign

This refers to complete absence of the echogenic labrum on US (Fig. 3). This will appear as a hypoechoic area between the humeral head and glenoid, giving the appearance of a bare glenoid. The bony cortex of the affected glenoid appears brighter due to the absence of labral attenuation and presence of fluid.

Slipped cap sign

Here, the avulsed labrum or labroligamentous complex is rolled over the anteromedial aspect of the glenoid, resembling a slipped cap (Fig. 4).

Fragmented labral sign

The glenoid labrum appears as mixed areas of hypoechoic and hyperechoic attenuation in keeping with a labrum torn into multiple fragments (Fig. 5). This appearance can be seen in both acute injuries and chronic degeneration of the labrum.

Fluid cleft sign

A hypoechoic fluid cleft is seen at the base of the labrum, indicating a labral tear (Fig. 6). A fluid cleft of over 2 mm in width is pathological and is usually seen at

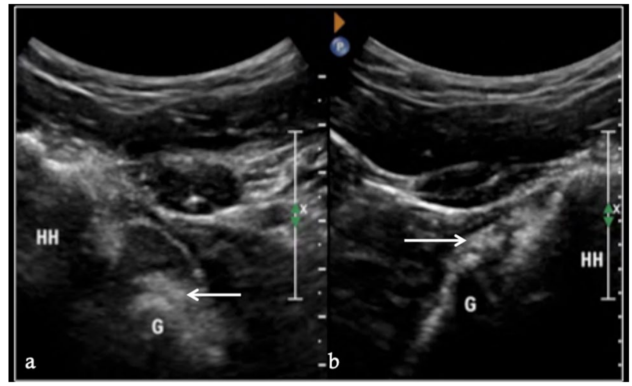

Fig. 4 Axial section of both glenohumeral joints. **a** An antero-medially displaced labroligamentous complex, so called slipped cap sign (white arrow) compared to **b**–**a** normal triangular echogenic labrum (arrow)

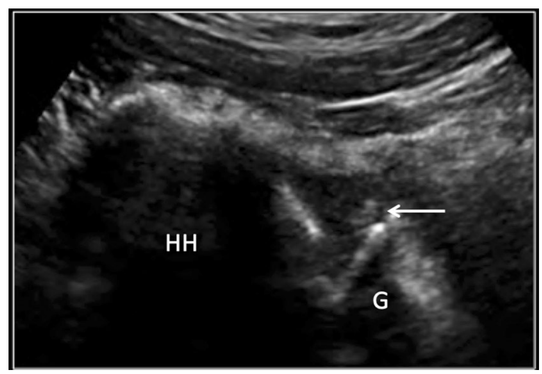

Fig. 5 Axial section of the glenohumeral joint at the level of the anteroinferior glenoid shows a fragmented echogenic labrum (white arrow)

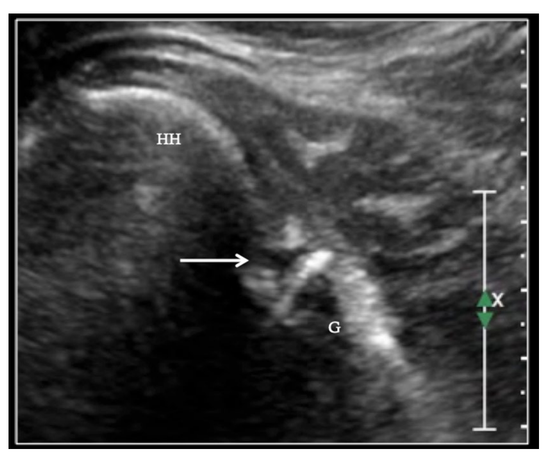

Fig. 6 Axial section of the glenohumeral joint. A hypoechoic fluid cleft (white arrow) is noted at the base of glenoid separating it from the bony cortex, so called 'fluid cleft,' sign

the anteroinferior aspect. If the tear is extensive, it can track up the anterosuperior aspect along the glenoid bony contour.

Specific labral pathology

Acute bony Bankart lesion

A bony Bankart lesion refers specifically to a fracture of the antero-inferior glenoid rim. There maybe frank displacement or actual separation of the anterior glenoid labrum, with or without a glenoid fracture fragment. There may be associated rupture of the scapular periosteum.

They represent a common complication following shoulder dislocation and are often associated with a Hill Sach's lesion. US shows the presence of an avulsed bone fragment or definite fracture near the anteroinferior aspect of the glenoid (Fig. 7). Some may even show small intra-articular bony fragments. The US findings were confirmed with a MRA showing cortical irregularity at the antero-inferior aspect of the glenoid consistent with a bony Bankart lesion. The size of the Bankart lesion maybe difficult to assess fully on USS, and thus an MRA can be expedited depending on the sonographic findings. A 15–20% defect is considered as 'critical bone loss,' and biomechanically unstable requiring both soft-tissue stabilisation and a procedure to restore bone loss [7, 8]. This will be difficult to quantify on US but at least a definite defect should be visualised, expediting subsequent MRA.

Chronic bony Bankart lesion

Chronic bony Bankart lesions are seen in patients who have had recurrent dislocations. Rather than an obvious fracture, there may be a bony defect on US images with an ill-defined labrum and labroligamentous complex. There will usually be labral calcification indicating chronic labral degeneration (Fig. 8).

Reverse Hill Sach's and reverse Bankart lesion

Both these lesions occur during posterior shoulder dislocation. They are typically seen in patients who have had seizures, trauma or an electric shock. A reverse bony Bankart implies a fracture/depression to the postero-inferior glenoid surface. The impact maybe significant enough to cause a reverse Hill Sachs lesion, where there is loss of normal anteromedial humeral head convexity. On US, a reverse Hill Sachs lesion manifests as a clear cortical depression of the anteromedial humeral head surface usually filled in with a hypoechoic fluid cleft at the site of impaction (Fig. 9).

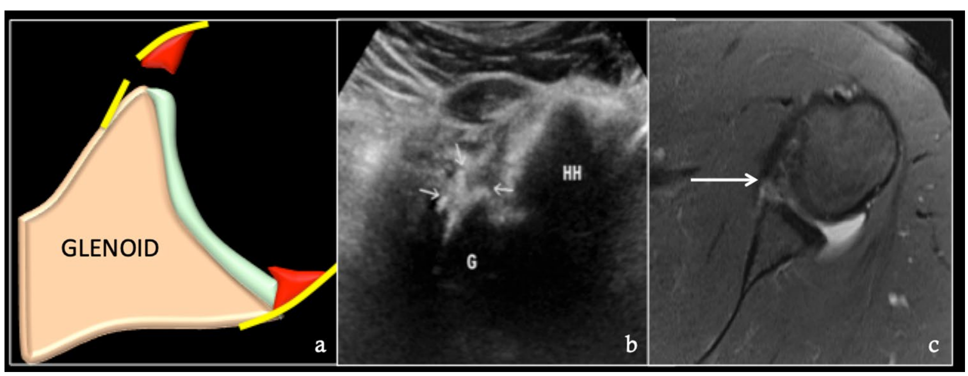

Fig. 7 **a** Illustration of an osseous Bankart lesion. **b** USS and **c** MRI shows sections at the level of anteroinferior glenoid. The arrows point to a bony Bankart lesion with ill-defined labrum and ligamentous complex (white arrows)

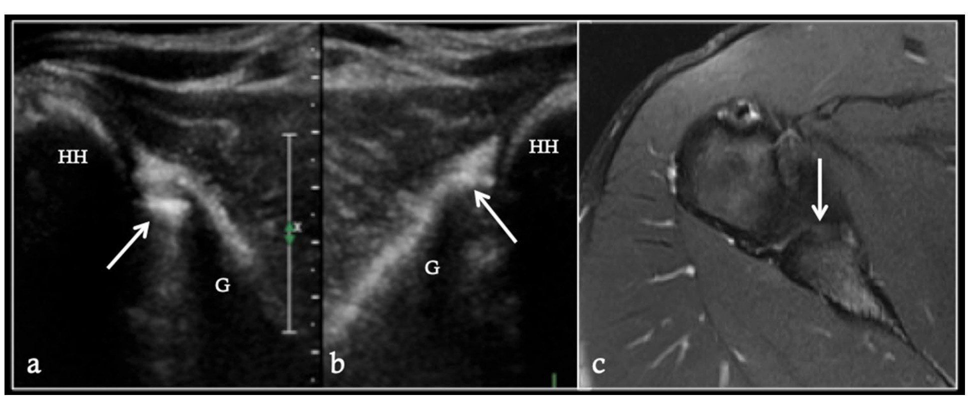

Fig. 8 US axial section of both shoulders at the level of antero-inferior labrum. **a** An ill-defined labrum (white arrow) and bony hyperechoic defect compared to **b**–**a** normal echogenic labrum (white arrow). **b** MRI showing a chronic bony Bankart lesion with an ill-defined labrum and ligamentous complex (white arrow)

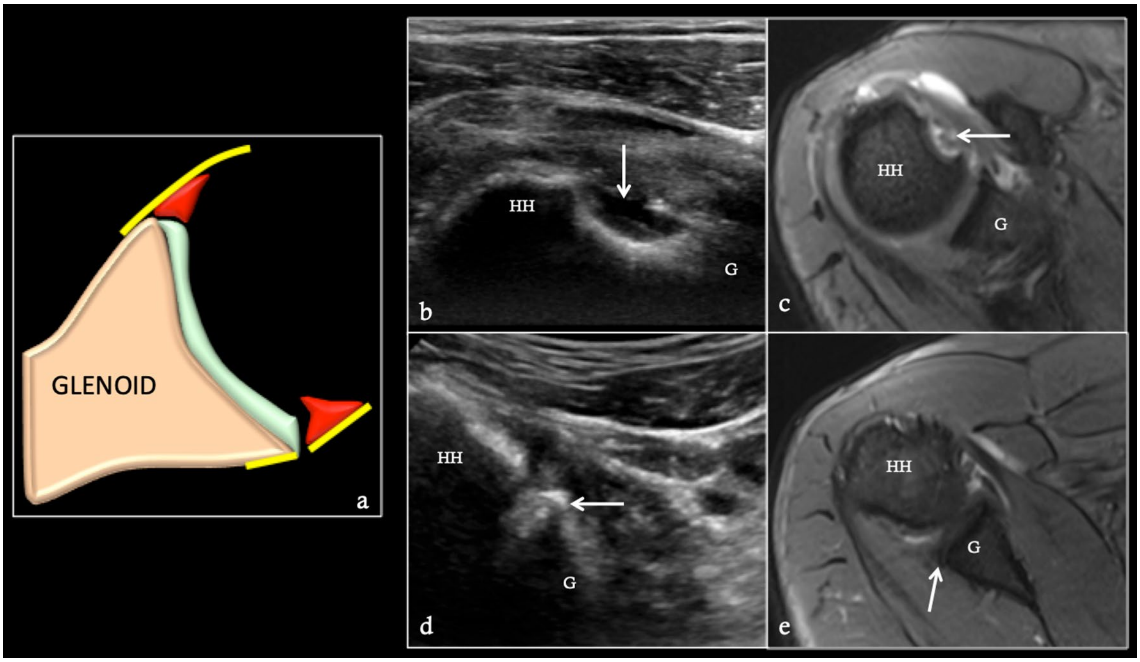

Fig. 9 **a** Illustration of a reverse Hill Sachs lesion. **b** US image shows a clear cortical depression in the humeral head surface, which is filled with a hypoechoic fluid cleft. **c** MRA confirms a reverse Hill Sachs lesion. **d** Illustration of a reverse Bankart lesion. **e** US shows a bony defect with an ill-defined labrum/labroligamentous complex at the postero-inferior glenoid. **f** MRA confirms a reverse Bankart lesion

A reverse Bankart lesion is seen as a bony defect with an ill-defined labrum/labroligamentous complex at the postero-inferior glenoid (Fig. 9). There will usually be labral calcification.

Perthes lesion

Perthes lesion is a variant of a soft-tissue Bankart lesion, presenting as an anterior glenohumeral avulsion injury that occurs when the scapular periosteum remains intact but is stripped medially. The anterior labrum is avulsed from the glenoid but remains partially attached to the scapula by an intact periosteum. US demonstrate antero-inferior displacement of the labrum with buckling of the scapula periosteum (Fig. 10). As the labrum is normally positioned, a perthes lesion maybe difficult to identify on US. The presence of a joint effusion, as in Fig. 11 helps in detection by showing some hypoechoic fluid extending under the labrum occupying the space between the elevated periosteum anteriorly and scapula posteriorly. Imaging the joint in the abducted and externally rotated (ABER) position has been shown to increase detection rates of a perthes lesion on MRA [7].

Anterior sleeve periosteal sleeve avulsion (ALPSA)

The ALPSA lesion is a variation of the Bankart lesion and commonly associated with anterior shoulder dislocation. ALPSA lesions are characterised by avulsion of the antero-inferior labrum, which is pulled medially by an intact anterior scapula periosteum. US shows avulsion and displacement of the labroligamentous complex from the antero-inferior glenoid (Fig. 11). A small bony avulsed fragment is noted.

Superior labral anterior posterior tear (SLAP) with paralabral cyst formation

SLAP tears are associated with people performing sports involving overhead activity and in manual labourers doing frequent excessive abduction and external rotation. They are usually seen on MRA as high fluid signal extending into the labral substance. If full thickness, there may be detachment and separation between the glenoid and labrum on imaging.

There is relative paucity of published reports on the use of USS in the assessment of SLAP lesions. US typically shows a hypoechoic fluid cleft in the substance of the labrum (Fig. 12). MRA confirms the full extent of the SLAP tear. Another patient with a SLAP tear shows a paralabral cyst on USS extending into the spinoglenoid notch causing suprascapular nerve compression (Fig. 13).

SLAP with biceps anchor tear

A type 2 SLAP lesion consists of a SLAP tear, which is also extending into the biceps anchor but with no biceps tendon

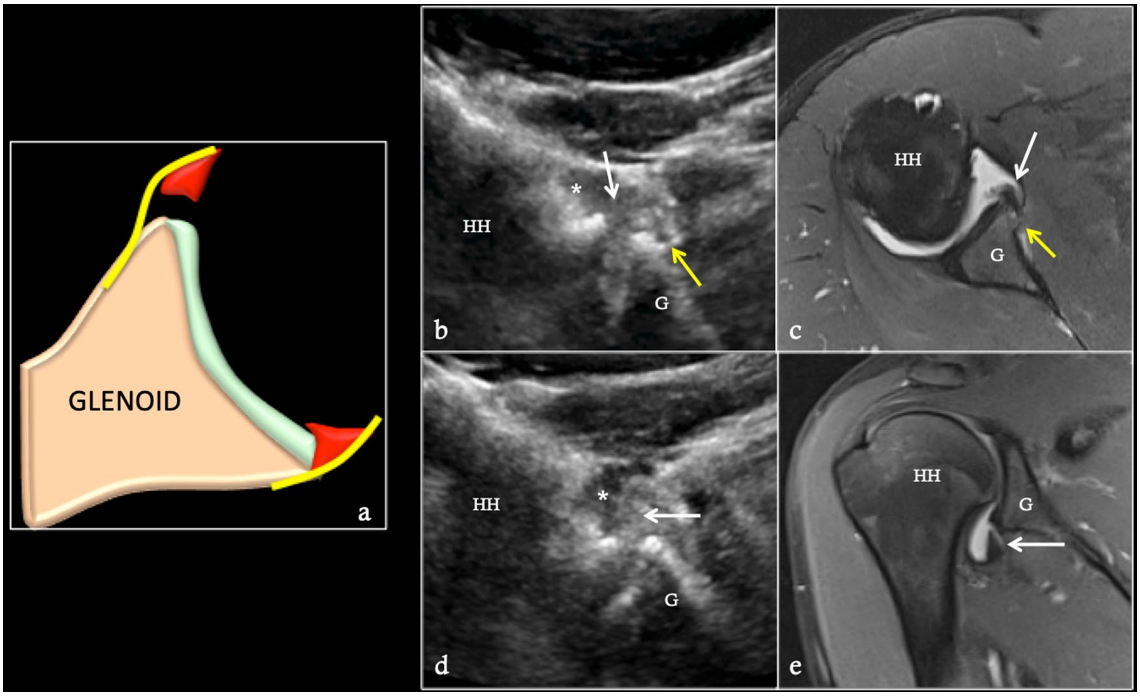

Fig. 10 **a** Illustration of a perthes lesion. **b** Axial US and **c** T2 MRA sections at the level of anteroinferior glenoid showing ventromedial displacement of the labrum(white arrow) with periosteal buckling (yellow arrow) consistent with a perthes lesion. **d** Axial US showing thickened ill-defined labrum (white arrow), **e** PD FS coronal MRA images showing an anteroinferior labral tear (white arrow). In both cases there is a joint effusion (*) accentuating the pathology shown

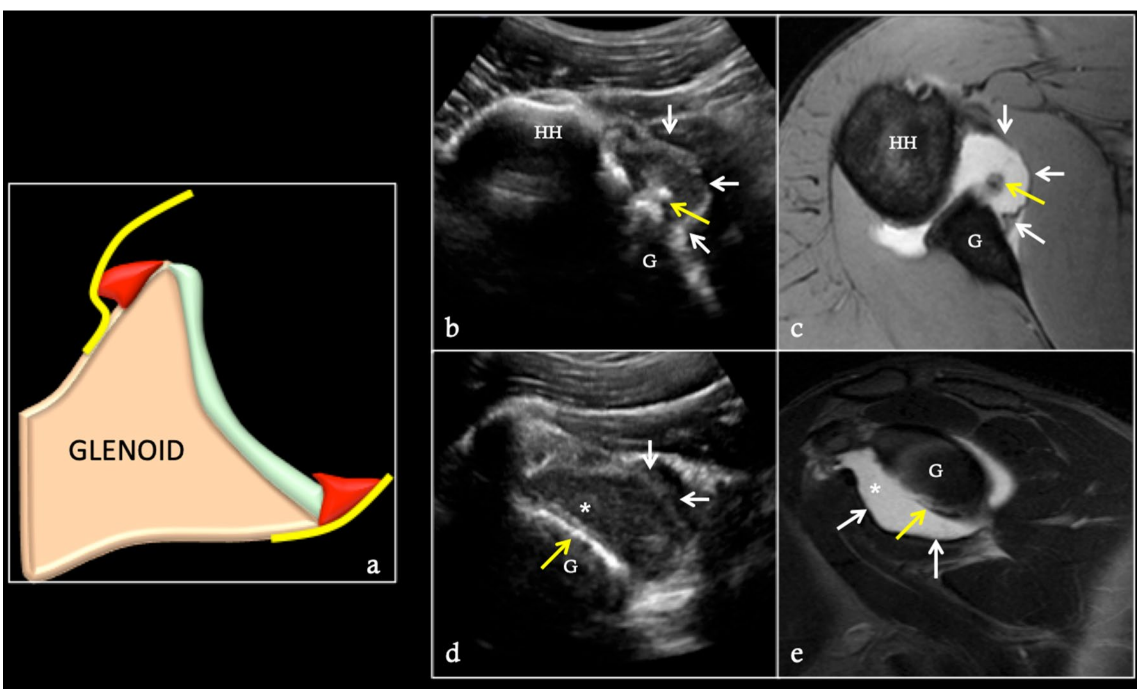

Fig. 11 **a** Illustration of an ALPSA lesion. **b** US axial sections of the shoulder and **c** T2 MRA in the region of the inferior labrum shows avulsion and displacement of the labroligamentous complex (white arrow) from the anteroinferior aspect of the glenoid, with complete stripping of the scapular periosteum consistent with an ALPSA lesion. Small bony fragment (yellow arrow) is noted. **d** Sagittal views on US and **e** PDFS MRA demonstrate the stripped periosteum and labroligamentous complex (white arrows) with flattened and irregular anterior glenoid surface (yellow arrow). Gross joint effusion (*) is seen

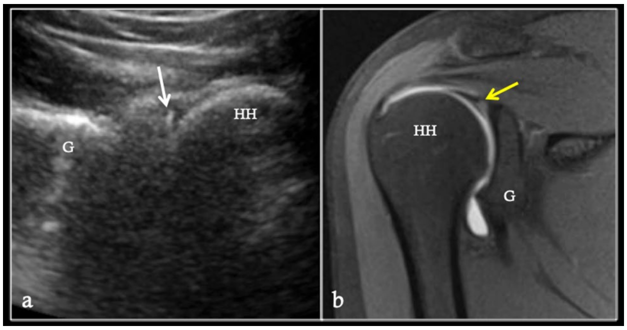

Fig. 12 **a** US at level of superior labrum shows a fluid cleft in the substance of the labrum (white arrow) consistent with a SLAP tear. **b** MRA of the shoulder depicting a SLAP tear (yellow arrow)

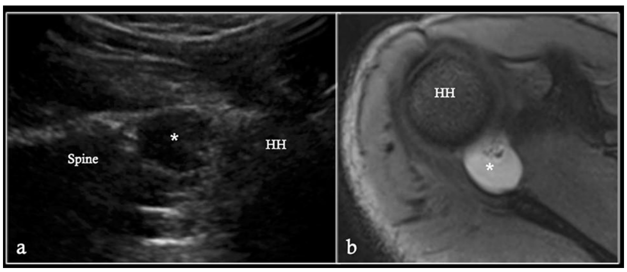

Fig. 13 **a** US and **b** T2 MRI axial showing a paralabral cyst (*) extending into the spinoglenoid notch causing suprascapular nerve compression

tear. In younger patients, these are associated with a Bankart lesion, in older patients, it has been linked with rotator cuff tears. A Type 2 tear is often difficult to differentiate from a sublabral recess but various signs have been discussed in the literature to confidently delineate both. US shows a SLAP tear with a small hypoechoic fluid cleft in the biceps anchor (Fig. 14). MRA confirms the SLAP tear with antero-posterior extension into the anchor on subsequent image slices.

Internal impingement

Postero-superior or internal impingement is a rare form of shoulder impingement involving the infraspinatus tendon and postero-superior glenoid labrum. An extreme abduction and external rotation (ABER) position results in repeated impingement of infraspinatus and posterior portion of the supraspinatus between the humeral head and postero-superior glenoid rim. This results in tendinosis, reactive humeral head cysts and labral degeneration of the aforementioned tendons.

US can also be used in cases of internal impingement, but needs to be done using dynamic assessment in the ABER

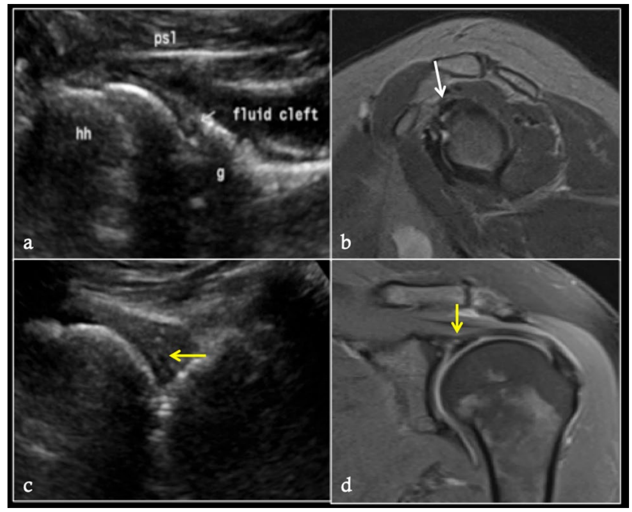

Fig. 14 **a** Sagittal US and **b** PDFS sagittal MRI showing sections at the level of superior glenoid with a fluid cleft (white arrow) in the substance of the labrum. **c** US and **d** PDFS MRI coronal sections at the level of superior labrum showing fluid extending into the substance of the biceps anchor (yellow arrow). Findings are consistent with a SLAP tear extending into the biceps labral anchor

position. US shows infraspinatus and capsular impingement between the humeral head and glenoid (Fig. 15).

Limitations

Perhaps, the main limitation of the review is that only a small patient sample was used in our case series. However, the radiologist performed US prior to MRA in every case, eliminating any bias during the US procedure itself. A large prospective study will be needed to evaluate the true sensitivity, specificity, positive and negative predictive values of the various US signs discussed. In our limited case series, all positive US studies was supported by pathology on subsequent MRA. No similar review or case series has been published in the current literature depicting sonographic signs of labral pathology other than SLAP tears. Alali et al. [9] has shown substantial agreement and accuracy for high-resolution US in depicting SLAP tears when compared to MRA. US was accurate in determining the presence or absence of a tear as well as the grade. To further consolidate the role of US in detecting SLAP pathology, normal anatomical variants such as a sublabral recess should be evaluated as these can often prove challenging to properly characterise even on MRI.

Conclusion

The pathologies that have been illustrated on US with MRA correlation are multiple. We have shown that it is possible to accurately determine the presence of a labral injury

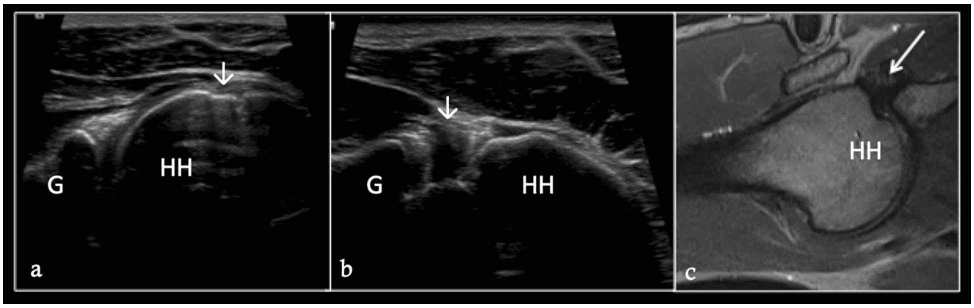

Fig. 15 **a** Static and **b** dynamic ABER US images showing subcortical erosions in posterior humeral head (arrow), mild flattening of the posterosuperior glenoid. Infraspinatus, posterior capsule seen impinged (arrow) between the humeral head and posterosuperior glenoid on ABER. **c** MRI ABER views showing infraspinatus and posterior joint capsule impingement (arrow), so called internal impingement

on ultrasound if performed by an experienced operator. Although MRA remains the gold standard, we suggest that US can be a good screening tool as a first-line investigation in view of its widespread availability. Pathology seen here may then help to expedite the subsequent MRA. While the learning curve for radiologists in US glenoid labral imaging is steep, a good technique, methodical survey and keen visualisation skills should allow common pathologies to be detected.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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