ANATOMICAL VARIABILITY OF THE SHOULDER REGION: MORPHOLOGICAL INSIGHTS AND CLINICAL RELEVANCE

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ABSTRACT

The shoulder represents one of the most anatomically complex and mobile joints in the human body, requiring a deep understanding of its normal structure and numerous anatomical variants for safe and effective surgical intervention.

While frequently considered as normal, these entities yield a significant clinical and imaging relevance. This paper aims to synthesize current knowledge on common and rare anatomical variants of the shoulder joint, with a focus on the glenoid labrum (such as sublabral recess, sublabral foramen, and Buford complex), posttraumatic labral lesions (Superior Labrum from Anterior to Posterior tear, Bankart lesion), acromial morphology, and acromial ossification anomalies.

The analysis relied on systematic cadaveric dissections, imaging studies, and clinical correlations and aims to provide a comprehensive overview of structural deviations that may influence diagnosis, surgical planning, and treatment outcomes. In this paper, we will highlight key anatomical variants, their imaging features and clinical relevance.

Differential diagnosis is addressed, alongside the relevance of these variants in the context of magnetic resonance imaging and arthroscopy. The results emphasize the necessity of a strong knowledge of these entities in avoiding wrong imaging interpretation and optimizing surgical planning.

This study underlines the importance of recognizing and understanding anatomical variants not as anomalies, but as clinically significant features that should be anticipated and addressed, particularly in orthopedic surgery, sports medicine, and anatomical education.

Key words: anatomical variants, shoulder region, magnetic resonance imaging, labrum, acromion, orthopedics.

INTRODUCTION

Due to its high complexity, the shoulder joint is often the location of traumatic or degenerative conditions [1].

The dynamic stability is ensured by a host of bony structures, ligaments, muscles and capsular elements [2]. Therefore, an adequate understanding of normal anatomy and common or rare variants is instrumental in modern practice.

The structures of the shoulder region, such as the glenoid labrum, acromion or muscle insertions can vary significantly between individuals and can significantly influence imaging interpretations or create significant issues during surgical procedures [3].

The clinical relevance of these variations is evident in the context of pathologies such as SLAP (Superior Labrum from Anterior to Posterior tear), acromial impingement, or glenohumeral instability [4].

In these cases, the adequate therapeutic decision relies heavily on the correct identification of the anatomical configuration [5].

Therefore, the understanding and proper integration of these anatomical variants in clinical decision-making will undoubtedly improve the quality of medical care while also allowing for improvement of medical education leading to a more realistic perspective on the variety of shoulder region configurations.

Anatomical variants of the glenoid labrum

The anatomical dissection of the shoulder region will reveal the glenohumeral joint, allowing for a detailed appreciation of the spatial relationships of the involved elements. This approach can provide a clear and spatially accurate view of the musculoskeletal and neurovascular anatomy which can further support the understanding of the functional and clinical relevance of these structures (Figure 1).

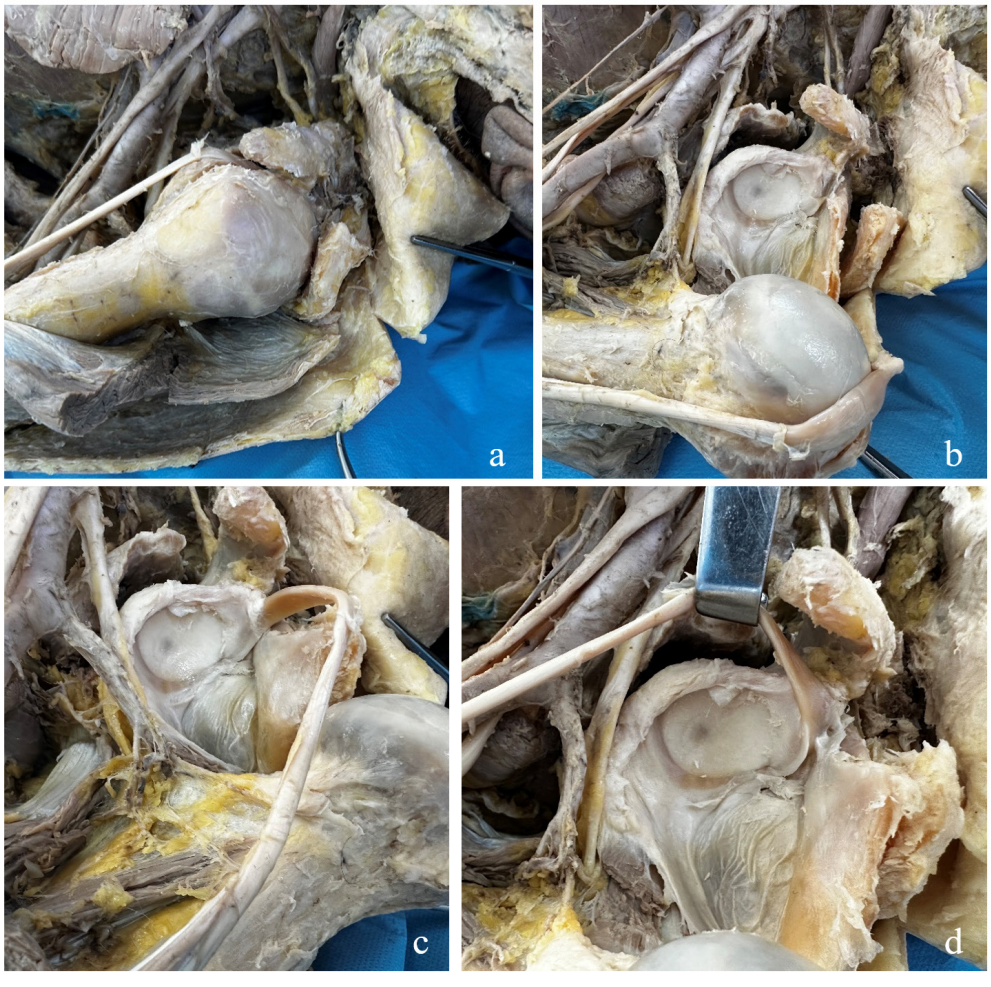

Figure 1. Cadaveric dissection of the shoulder region revealing key musculoskeletal and neurovascular structures. The acromial process and it's proximity to the humeral head (a), the long head of the biceps tendon as it inserts on the superior glenoid tubercle (c, d), the glenoid articular surface and labrum (b-d).

The glenoid labrum is a fibrocartilaginous structure responsible for stabilizing the glenohumeral joint [6]. There are several anatomical variants considered normal but which can be confused for pathological entities on Magnetic Resonance Imaging (MRI). The most frequent normal variants are the sublabral recess, the sublabral foramen, and the Buford complex [7,8] (Figure 2).

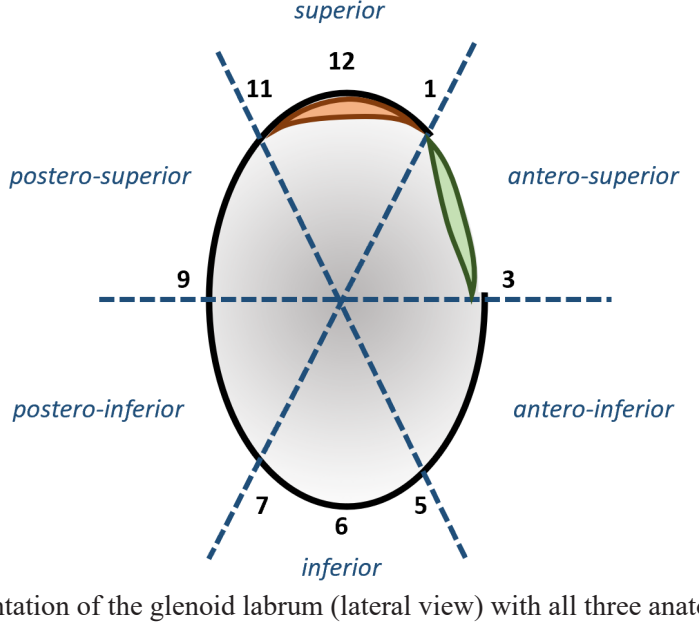

Figure 2. Schematic representation of the glenoid labrum (lateral view) with all three anatomical variants depicted, i.e. sublabral recess (orange), sublabral foramen (green), and Buford complex (antero-superior labrum absence).

The sublabral recess is a small physiological tear located between the hours 11 and 1, when looking at the glenoid cavity from the lateral and imaging it as a clock face [9].

This recess is located between the bicipital-labral complex and the superior glenoid cartilage and appears on MRI as a thin hyperintense line on T2 or PD (proton density) weighted sequences, following the cartilage curve, no deeper than 5 mm [10].

What is relevant for the differential diagnosis is that it does not imply discontinuity of the labrum and is not associated with other signs such as edema or instability [11] (Figure 3).

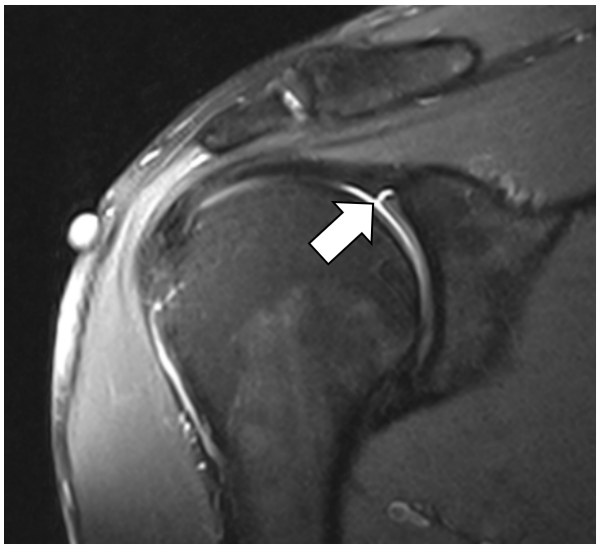

Figure 3. MRI examination of the right shoulder: sublabral recess (arrow) appearing as a fissure between the bicipital-labrum complex and the superior glenoid cartilage.

The sublabral foramen is a normal anatomic detachment of the anterosuperior labrum from the glenoid cartilage, situated between the hours 1 and 3, and can be identified together with the sublabral recess [9].

MRI describes it as normal anatomic space between the labrum and the bony edge in the absence of inflammation.

The Buford complex represents the absence of the anterosuperior labrum combined with an enlarged middle glenohumeral ligament [12,13].

This anatomical variant can be found in up to 3% of normal individuals and is clinically relevant in planning arthroscopy for labral reconstructions and when assessing anterior instability [14] (Figure 4).

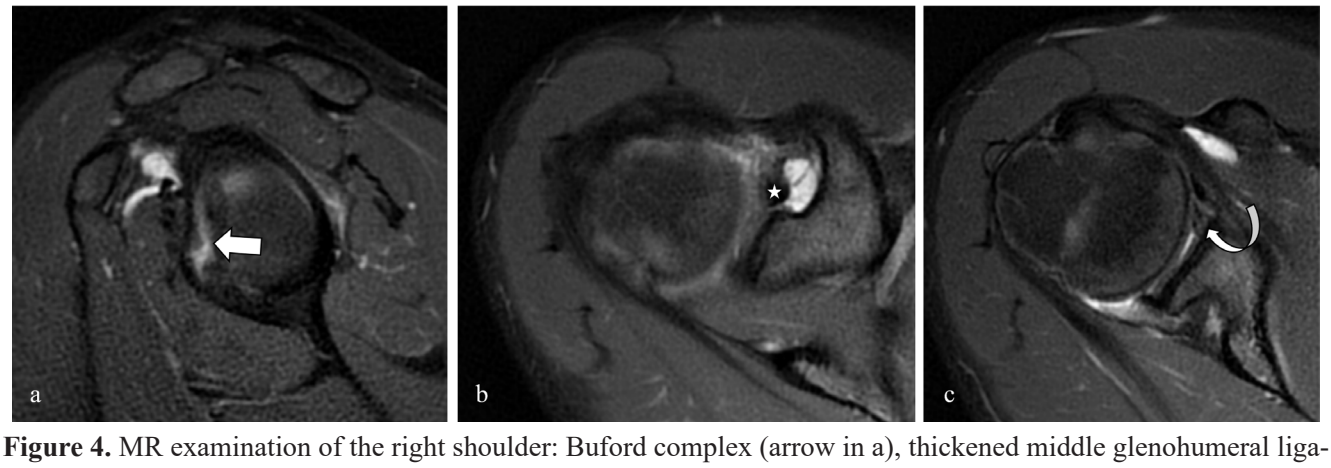

Figure 4. MR examination of the right shoulder: Buford complex (arrow in a), thickened middle glenohumeral ligament (asterisk in b) and SLAP lesion (curved arrow in c).

The relevance of these anatomical variants relies in the necessity of distinguishing them from labral lesions in this area, such as SLAP, Bankart, or post-traumatic labral detachment [15].

Proper clinical, imaging and arthroscopic correlation is required to adequately recognize these anatomical variants and avoid wrong diagnoses and unnecessary surgical treatment.

Clinical impact and differential diagnosis of labrum variants

As mentioned above, anatomical variants of the labrum need to be differentiated from the main glenoid labrum traumatic lesions. SLAP lesions are more frequently identified in athletes with repetitive throwing motion [16].

The lesions manifest as instability with profound shoulder pain and can be visualized on MRI as a hyperintensity of the superior labral insertion with associated tear of the long head of the biceps tendon [17].

Bankart lesions imply the traumatic detachment of the anteroinferior labrum, usually following an anterior dislocation and associates soft tissue edema and glenoid fractures [18,19].

Posterior labral tears are rare and also appear in trauma or forced internal rotation. When not accompanied by capsular irregularities or other ancillary signs, these lesions may be mistaken for anatomical variants albeit their posterior location [20].

The clinical relevance of distinguishing between normal variants and pathological lesions relies in the entirely different therapeutic approach and potential long-term complications of neglecting labral tears such as poor function, arthritis, and chronic instability [21].

Therefore, a quick and correct diagnosis is imperative and only possible through integration of anatomical, imaging, clinical, and arthroscopic data.

Anatomical types of the acromion

The acromion represents a bony extension of the posterolateral aspect of the scapula and contributes to the functional stability of the shoulder [22].

Bigliani has classified the anatomical types of the acromion in 4 categories: type I has a flat inferior margin and is associated with decreased incidence of subacromial pathology; type II is characterized by a curved inferior margin, and is the most common type; type III is hook shaped and is mainly associated with subacromial impingement syndrome and rotator cuff tears; type IV is a rare form of posterior convexity and is often underdiagnosed [23, 24] (Figure 5).

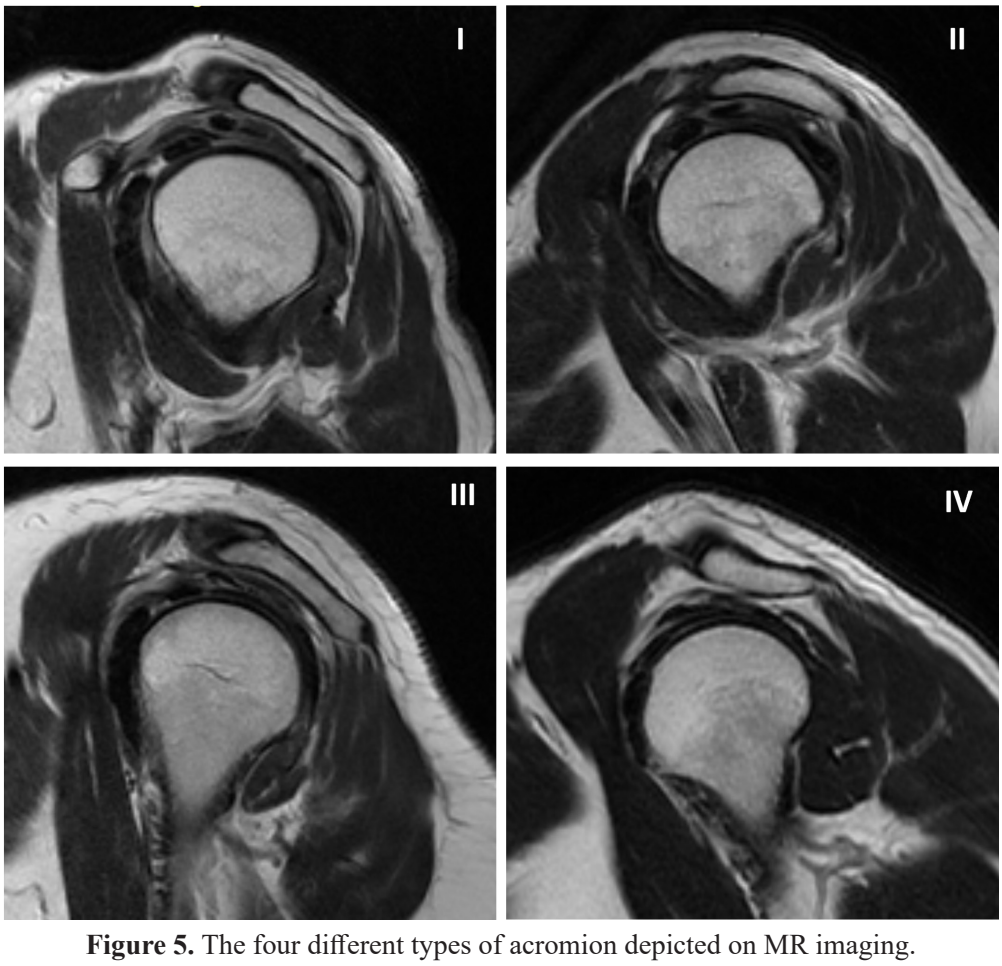

Figure 5. The four different types of acromion depicted on MR imaging.

Imaging studies can reveal the detailed shape of the acromion. X-rays with outlet views can efficiently depict the acromial shape, while computed tomography (CT) can reveal additional morphological details and allow for three dimensional reconstructions [25, 26].

MRI not only depicts the acromial type but also can identify and accurately describe associated soft tissue pathology [25, 27].

The type III acromion shape reduces the subacromial space and hinders the supraspinous tendon, leading to chronic inflammation and possible tears [28].

Clinically, acromial type is relevant in the assessment of chronic shoulder pain, especially when no trauma is reported in patient history [29].

Furthermore, acromial morphology influences therapeutic decisions like acromioplasty and arthroscopic treatment [30].

Os acromiale and clinical relevance

Os acromiale is an ossification variant which results as a fusion failure of one or more acromion ossification centers [31].

This entity is classified based on location into four types: preacromion, mesoacromion (most common), metaacromion (second most common), and basiacromion [32] (Figure 6).

Figure 6. MRI examination of the left shoulder depicting mesoacromion (arrow).

Medical imaging can identify os acromiale as a bony structure with a cortical rim which includes a clear demarcation line from the rest of the acromion [33].

X-rays can reveal the condition on outlet views while CT can evaluate the degree of pseudarthrosis [34]; MRI can additionally highlight bony edema and surrounding soft tissue inflammation [35, 36].

Clinically, os acromiale can associate chronic subacromial pain, limited mobility, and weakness and should be differentiated from impingement or rotator cuff tendinopathy [37].

Correctly identifying this anatomical variant is important for arthroscopic surgery, especially acromioplasty and fixation [38, 39]. Failure to recognize it can lead to postoperative instability and pain [38].

CONCLUSIONS

A strong knowledge of the shoulder region anatomy is essential for the correct diagnosis and adequate management of shoulder pathology.

While considered normal, anatomical variants may significantly influence image interpretation and may be mistaken for pathological lesions.

High resolution and high performance imaging, especially MRI, can play a crucial role in delineating normal variants from traumatic lesions, significantly impacting patient care.

The recognition and adequate description of anatomical variants can prevent erroneous treatment and help in surgical planning especially arthroscopy, where anatomical details dictate surgical precision.

Integration of anatomical and imaging information in a unitary diagnostic and therapeutical approach is essential in the modern management of shoulder pathology.

Continuous education and refresher courses in shoulder anatomy are priorities for all medical professionals involved in patient care.

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