The Buford Complex—A Variation of Normal Shoulder Anatomy: MR Arthrographic Imaging Features

OBJECTIVE. The purpose of this study was to show the MR arthrographic imaging features of a normal anatomic variation of the shoulder: the absence of the anterior superior labrum and the presence of a “cordlike” middle glenohumeral ligament, which together are known as the Buford complex.

MATERIALS AND METHODS. We retrospectively analyzed the MR arthrographic examinations of 10 patients with arthroscopically proven Buford complexes.

RESULTS. MR arthrographic examinations showed an absent anterior superior labrum and an associated cordlike middle glenohumeral ligament in all patients. No contiguous tear of the superior labrum or anterior inferior labrum was evident. Originally, this variation was mistakenly diagnosed as a labral avulsion in two of the 10 patients. Also, a differential diagnosis of a superior labral tear was mistakenly offered for four patients.

CONCLUSION. An absent anterior superior labrum and an associated cordlike middle glenohumeral ligament represent the normal variation that is known as the Buford complex rather than an avulsed labrum. This normal variation may be mistaken for a detached labrum.

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Isolated detachment of the anterior superior labrum has been reported as a normal variation of shoulder anatomy and has been termed the sublabral hole [1–5]. Recently, the combination of the absence of the anterior superior labrum and the presence of a “cordlike” middle glenohumeral ligament has been reported as a normal anatomic variation and has been termed the Buford complex [5] (Fig. 1). This anatomic arrangement may be mistaken for a pathologic lesion on imaging studies and at arthroscopy [6]. Recognition of this variation by the radiologist is desirable to avoid the false-positive diagnosis of a glenoid labral tear and unnecessary surgery [5, 6].

The purpose of the study was to characterize the MR arthrographic imaging features of the Buford complex and its capsulolabral variant.

Materials and Methods

We identified 10 patients with the Buford complex who underwent both MR arthrography and subsequent arthroscopy between February 1992 and June 1995 at four institutions. Patients were 16–47 years old. Arthroscopy was performed by five surgeons familiar with the Buford complex. The time between MR arthrography and arthroscopy ranged from 1 week to 3 months. Inclusion criteria included suspicion of the Buford complex at MR imaging, which was followed by surgical confirmation, or identification of the Buford complex by arthroscopy after MR arthrography. All patients were described as having normal variations of the anterior superior glenoid quadrant at arthroscopy without evidence of labral tear or degeneration of either the contiguous superior or anterior inferior portions. Patients with adjacent labral or ligamentous lesions (SLAP lesions) did not qualify for “superior labrum anterior posterior,” referring to a superior labral tear involving labral tissue both anterior and posterior to the biceps insertion site as well as the biceps insertion site itself.
anterior inferior labral lesions) at arthroscopy were excluded from the study, regardless of the diagnosis before surgery. For all patients, intraarticular (direct) gadolinium-enhanced arthrograms were obtained. The clinical indications for imaging provided by the referring physicians included possible rotator cuff tear (four patients), possible labral abnormality (two patients), and unexplained generalized shoulder pain (four patients). One patient with generalized shoulder pain also had the diagnosis of spondyloepiphyseal dysplasia.

MR arthrography is typically performed at our institutions for the evaluation of glenohumeral instability and nonspecific shoulder pain. The injection procedure was as follows. With the patient supine, we advanced a 22-gauge needle into the glenohumeral joint under fluoroscopic guidance by an anterior approach. We then injected 1-3 ml of 76% diatrizoate sodium to confirm placement of the needle in the joint. We then injected 12–18 ml of dilute (1:200) gadolinium intraarticularly. Imaging parameters for MR arthrography were as follows: T1-weighted (650/20 [TR/TE] axial, oblique coronal, and oblique sagittal images with frequency-selective fat saturation. (One patient was studied without the use of fat saturation.) Next, we obtained a single fast spin-echo T2-weighted coronal oblique image with frequency-selective fat saturation (2900/84; slice thickness, 4 mm; interslice gap, 1 mm; matrix size, 256 × 192; field of view, 14 cm; two acquisitions).

Arthroscopic examinations were carried out by five orthopedic surgeons from different institutions who used standard techniques and reporting methods. The MR arthrographic imaging criteria used to establish the diagnosis of the Buford complex included (1) nonvisualization of the anterior superior labrum and a normal appearance of the contiguous anterior inferior labrum and superior labrum and (2) visualization of a discrete cordlike ligamentous structure extending from the humerus inferiorly and coursing laterally and obliquely to its site of insertion at the base of the long head of the biceps tendon superiorly at the supraglenoid tubercle.

Arthographic MR images were retrospectively analyzed by three musculoskeletal MR radiologists who knew that the Buford complex was present. The anterior superior quadrant of the shoulder, including the glenohumeral ligaments, glenoid labrum, biceps tendon attachment, and hyaline articular cartilage, was inspected. The three radiologists characterized the anterior labrum and the anterior capsule with respect to signal intensity and morphology and noted the presence or absence of a cordlike middle glenohumeral liga-

ment. A cordlike middle glenohumeral ligament was defined as a linear cylindrical structure (similar in appearance to the long head of the biceps tendon) that extends inferiorly from the humerus to the base of the biceps tendon (biceps anchor). The appearance of the hyaline articular cartilage was noted. Consensus was reached by discussion and agreement on the presence of the MR arthographic findings. The original prospective interpretations of the MR studies were compared with these retrospective findings.

Results

For 10 patients we evaluated four left shoulders and six right shoulders. All patients were described at arthroscopy as having an absent anterior superior labrum in association with a cordlike middle glenohumeral ligament. The contiguous superior labrum and anterior inferior labrum were normal. One patient had a small anterior supraspinatus full-thickness tear of the rotator cuff. Another patient had a posterior labral tear with periosteal stripping. Another patient with spondyloepiphyseal dysplasia had a deformed humeral head and central glenoid chondromalacia consistent with that diagnosis.

MR imaging showed the absence of the usually low-signal-intensity anterior superior labrum (Fig. 2). The portion of the glenoid that was devoid of labral tissue extended from the 1- to the 3-o’clock position (right shoulder) or from the 9- to the 11-o’clock position (left shoulder), when the face of the glenoid is considered like a clock being viewed from a lateral perspective. A cordlike middle glenohumeral ligament (Fig. 2), present in all 10 patients, was the same size as or slightly bigger than a biceps tendon. On axial images, the middle glenohumeral ligament could be followed from the humerus beginning laterally and inferiorly, where it merged with the subscapularis tendon, up to the base of the biceps tendon located superiorly and medially within the joint. The ligament coursed obliquely (from inferolaterally to superomedially with respect to the shoulder joint) and was seen in its entirety in seven patients. Sagittal images showed the ligament as a linear structure separate from the subscapularis tendon in all patients (Fig. 3). In two patients, the portion of the ligament adjacent to the humerus was difficult to see, but the remainder of the ligament was distinct from the anterior inferior labrum. For all patients, the cordlike middle glenohumeral ligament was inserted into the biceps anchor in conjunction with the superior glenohumeral ligament.

On coronal images, the superior labrum appeared normal in all patients. On axial images, the anterior inferior labrum below the region devoid of labral tissue appeared normal in all patients. We identified the inferior glenohumeral ligament in all patients. It appeared normal—as a linear, sheet-like structure that extended from the humerus to the anterior labrum—in all patients. In eight of the 10 patients, the inferior glenohumeral ligament had a thickened area located superiorly (with respect to the ligament) that we identified as the anterior band of that ligament.

On T1-weighted images obtained with fat saturation, the hyaline articular cartilage of the glenoid showed mildly increased signal intensity (compared with that of fluid) and covered the glenoid fossa. On fast spin-echo T2-weighted images obtained with fat saturation, the cartilage showed increased signal intensity (but less than that of fluid). The cartilage extended to the glenoid rim anteriorly in all patients and did not extend medially.

Prospectively, the Buford complex was correctly diagnosed in four patients. In four other patients, this normal variation in...
was also suspected and was suggested as the most likely possibility; however, for all four of these patients, a differential diagnosis of an isolated anterior superior labral tear was also offered. For the remaining two patients, the cordlike middle glenohumeral ligament was misdiagnosed as a torn, detached anterior superior labrum that was believed to represent an unstable (type II) SLAP lesion but that was shown at arthroscopy to represent the ligament without evidence of labral detachment (Fig. 4). In retrospect, MR arthrogram findings for cases that were originally misdiagnosed were similar to those for cases that were correctly diagnosed.

Discussion
The anterior superior labrum is the most common site of normal anatomic labral-ligamentous variations [1, 2, 4–7]. The spectrum of anatomic variations includes an anterior superior labrum that is securely attached to the glenoid rim, sublabral recesses of various sizes, detachment of the labrum, and complete absence of the labrum [1, 2, 4–7]. In addition, the middle glenohumeral ligament is the most variable in appearance anatomically of all the glenohumeral ligaments [6, 8]. Its appearance at arthroscopy can vary from no discernible thickening of the anterior capsule above the

Fig. 2.—MR arthrogram of Buford complex.
A, T1-weighted (640/12 [TR/TE]) axial image obtained with fat saturation through joint shows anterior inferior labrum (arrow) and inferior glenohumeral ligament (arrowhead). Discrete anterior band of inferior glenohumeral ligament was not identified.
B, T1-weighted (640/12) axial image obtained with fat saturation through midjoint shows cordlike middle glenohumeral ligament (arrow) as discrete linear structure that extends from humerus toward scapula. Anterior labrum (arrowhead) is normal.
C, Image obtained 5 mm superior to that in A shows trailing off of middle glenohumeral ligament at humerus (arrow) and slight blunting of anterior glenoid labrum (arrowhead).
D, Image obtained 5 mm superior to that in B shows absence of labral tissue on bony glenoid as middle glenohumeral ligament (arrow) takes more vertical course. Because course of single structure is seen separately from that of labrum in B and C, this structure can be identified as ligament rather than labrum.
E, Image obtained at top of joint shows insertion of middle glenohumeral ligament (arrow) and superior glenohumeral ligament (arrowhead) into biceps tendon insertion site.
inferior glenohumeral ligament to folded thickening of the anterior capsule (66% of cases); the latter is the most common appearance. The ligament may appear as a thickened cordlike structure that resembles the long head of the biceps tendon [6].

Detachment of the anterior superior labrum, which has been described as a normal variation [1–5], is known by different terms: sublabral hole, sublabral foramen, and sublabral recess. The combination of an absent anterior superior labrum and a cordlike middle glenohumeral ligament recently has been described in the orthopedic literature and termed the Buford complex. In a study by Williams et al. [5] in which 200 arthroscopic videotapes were retrospectively reviewed, 13.5% of patients had anterior superior labral variations. Of the 200 patients, 1.5% had the Buford complex [5]. Williams et al. [5] also noted a case in which the cordlike middle glenohumeral ligament was mistaken at arthroscopy for a detached labrum and the ligament was mistakenly attached to the glenoid as treatment. The patient subsequently suffered severely restricted motion that required a second arthroscopy to release the ligament. Recognition of this variation by radiologists and orthopedists is vital to avoid such a surgical error.

At MR arthrography, we found the absence of the anterior superior labrum in association with a cordlike middle glenohumeral ligament in every patient in our study who already had undergone surgery. The contiguous superior labrum and anterior inferior labrum were normal in all 10 patients. We believe that this appearance is characteristic of the Buford complex at MR arthrography and should be considered a normal variation of the shoulder.

Normal variations of labral anatomy probably often result in a decrease in the sensitivity of MR imaging for depicting labral tears. As such, variations may be mistaken for pathologic lesions. Conventional MR imaging has variable sensitivity and specificity for diagnosing labral tears [9–11]. However, MR arthrography has achieved good to excellent results, although false-positives remain a threat to interpretation [3, 12, 13]. Recently, a proliferation of arthroscopy of the shoulder has yielded improved visualization of anatomic variations over that provided by arthrotomy [6]. Two patients in our series were diagnosed with labral tears, and four were diagnosed with the Buford complex. A diagnosis of the Buford complex was suspected for four patients, but a labral abnormality could not be ruled out. We lacked confidence in the diagnosis for these patients and offered a differential diagnosis that resulted in arthroscopy. The patients with a
prospective diagnosis of the Buford complex also underwent diagnostic arthroscopy to evaluate unexplained shoulder pain. The prospective MR imaging interpretations of labral tears for two patients resulted in arthroscopy because the reading radiologist was not aware of the Buford complex as a possible anatomic—but normal—variation.

Tears and detachments of the superior labrum are being recognized with greater frequency because of the advent of arthroscopy [14, 15]. Tears of the entire superior labrum that begin posterior to the biceps anchor and extend anteriorly to involve a variable distance of the anterior superior labrum have been called SLAP lesions. Involvement of the superior labrum at the biceps insertion site by a tear is inconsistent with the Buford complex, as the biceps anchor and sites of insertion of the middle and superior glenohumeral ligaments are normal in the Buford complex. Mistaking the middle glenohumeral ligament as a torn, detached labrum may lead to an erroneous diagnosis of a SLAP lesion, as was the case for two of our patients. Contrast material extending into a tear of the labrum at the site of insertion of the biceps tendon has been described as an MR arthographic finding for SLAP lesions [4, 12, 16–18]. In such cases, the sites of insertion of the middle and superior glenohumeral ligaments are often involved [18]. In our study, the insertion of these ligaments appeared normal in all 10 patients with the Buford complex. A continuation of a sublbral recess may underlie the biceps anchor as a variant of normal [3, 18]. Although this finding may potentially be confusing in distinguishing a sublbral recess or a sublbral hole from a SLAP lesion, with the Buford complex, no labral tissue is present anterosuperiorly. The middle glenohumeral ligament may be confused as a torn labrum in such a case. Recognizing that the apparent labral detachment is in fact the ligament should help avoid this potential mistake.

An isolated tear of the anterior superior labrum that does not involve the biceps anchor may present a diagnostic challenge. Fortunately, this condition is believed to be rare and has been described for professional throwing athletes [14, 18]. We believe that identification of any anterior superior labral tissue still attached to the glenoid or identification of a detached labrum separate from the middle glenohumeral ligament cannot be considered a Buford complex. These characteristics take on greater importance when coupled with the appropriate history.

In our retrospective MR evaluation, we evaluated the appearance of the Buford complex only by arthrography. However, we hypothesize that the Buford complex may be difficult to recognize by conventional MR imaging when no joint fluid leads to a close apposition of the middle glenohumeral ligament to the osseous anterior superior glenoid, which then simulates a labrum or even a sublbral hole.

Our study group was small and highly selective because of the rarity of the Buford complex. Our study method may have introduced selection bias. The true incidence in a patient population cannot be determined with our data.

In conclusion, MR arthrography that shows an absent anterior superior labrum in association with a cordlike middle glenohumeral ligament should be considered to indicate a normal anatomic variation rather than a torn or avulsed glenoid labrum. The Buford complex should be suspected if the contiguous superior labrum and anterior inferior labrum also appear normal.

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REFERENCES