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FULL PAPER

Sonoarthrographic examination of posterior labrocapsular structures of the shoulder joint

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Objective: To describe the posterior labral lesions and labrocapsular abnormalities of the shoulder on sonoarthrography and to compare these findings with MR arthrography results.

Methods: 82 shoulders were initially evaluated with ultrasonography and MRI and then were examined with sonoarthrography and MR arthrography following intraarticular injection of diluted gadolinium solution. The ultrasonography images were prospectively evaluated for the presence of posterior labral tear, sublabral cleft, and posterior capsular abnormalities by two radiologists. The diagnostic accuracy of sonoarthrography in the detection of posterior labral tears and posterior labrocapsular variants was compared with that of MR arthrography.

Results: In sonoarthrographic examinations of 82 shoulders, 5 and 6 posterior labral tears were identified by Observer 1 and 2, respectively. Moreover, 6 and 7 posterior sublabral clefts, and 2 and 3 posterior synovial folds were identified by Observer 1 and 2, respectively. All the 82 patients were examined with MR arthrography;

however, only 14 patients underwent arthroscopic examination. No significant difference was found among the 82 patients with regard to age, gender, and the prevalence of posterior labral tear, posterior labral cleft, and posterior synovial fold ($p > 0.05$). Interobserver variability showed substantial agreement between the sonoarthrographic and MR arthrographic results of the posterior labrocapsular structures ($\kappa = 0.71$, $p < 0.05$).

Conclusion: Posterior labral tears and posterior synovial folds of the shoulder joint can be evaluated non-invasively by sonoarthrography.

Advances in knowledge: Variations and pathologies of posterior labrocapsular structures of the glenohumeral joint are relatively uncommon.

Direct (MR) arthrography is the gold-standard imaging modality to evaluate of posterior labrocapsular abnormalities of the glenohumeral joint.

Sonoarthrography of the glenohumeral joint may be utilized in clinical practice in patients with contraindications to (MRI).

INTRODUCTION

Pathologies and anatomical abnormalities of posterior labrocapsular structures of the glenohumeral joint are relatively uncommon.^{1–5} Reverse Bankart lesion, which is a separation of the posteroinferior labrum from the glenoid caused by posterior shoulder instability, is the most common among these pathologies. Posterior instability represents only 2–4% of all shoulder instabilities.^{1,2} Conventional radiography and CT may not be sufficient for diagnosing the injuries in posterior labrocapsular structures of the glenohumeral joint. Although MRI is commonly used in the detection of glenoid labrum tears, direct MR arthrography is a more sensitive imaging technique used for the evaluation of posterior labrocapsular abnormalities of the shoulder joint.^{6–10} Moreover, although

these anatomic variants are relatively rare, they can mimic a labral tear on routine MRI examination.⁵ Therefore, shoulder MR arthrography remains the method of choice for accurate diagnosis of posterior labrocapsular tears and anatomical variants.

The posterior glenoid labrum is not located superficially and is surrounded by the deltoid muscle and rotator cuff structures. Therefore, ultrasonography may not be always suitable for the evaluation of posterior glenoid labrum, although it presents several advantages such as low cost and short procedure time. With the advances in ultrasonography technology, it is now possible to obtain high-resolution images of the musculoskeletal system with ultrasonography. Moreover, the diagnostic performance of

ultrasonography in the examination of posterior labrocapsular structures of the shoulder joint can be improved by the injection of saline or diluted contrast material into the joint capsule before ultrasonography evaluation.

Sonoarthrography of the glenohumeral joint may be utilized in clinical practice in patients with absolute or relative contraindications to MRI such as claustrophobia, pacemakers, and metal hardware near the shoulder. To the best of our knowledge, there has been no study specifically investigating posterior labrocapsular lesions and variants of the shoulder joint by using sonoarthrography with MR arthrographic and arthroscopic correlation. Accordingly, the present study was designed to identify posterior labral lesions and labrocapsular abnormalities on ultrasonography images of the shoulder by using sonoarthrography.

METHODS AND MATERIALS

Patients

The prospective study included 86 consecutive patients that were referred to our Radiology Department for shoulder MR arthrography between December 2018 and June 2019. Main indications for shoulder MR arthrography included glenohumeral instability and labrocapsular ligamentous injuries. Though infrequent, the remaining indications included rotator cuff tear (especially for differentiation of the partial- and full-thickness tears), adhesive capsulitis and biceps tendon pathology (such as subtle partial tear and instability). All the patients that underwent shoulder MRI and MR arthrography were also examined by shoulder ultrasonography following intraarticular contrast solution injection for the pathologies and variants of posterior capsulolabral structures. Four patients were excluded from the study due to inadequate capsular distension ($n = 2$) and contrast material extravasation around the posterior joint capsule ($n = 2$). The study was approved by the institutional review board and all the patients gave a consent for the procedure.

Injection technique

All the injection procedures were performed by a radiologist with 12 years of experience in arthrographic joint injection. An ultrasonography system (Applio 500 Ultrasound System; Toshiba Medical Systems, Tokyo, Japan) with a 7.5 or 12 MHz linear array transducer was used for all injections. The procedure did not require any sedation or premedication and was performed on an outpatient basis. The glenohumeral joint injections were performed using a 20-gauge needle through a posterior approach. The needle tip was inserted into the joint space using real-time ultrasonography guidance. A volume of 10–18 ml contrast solution (0.5 mmol l^{-1} gadopentetate dimeglumine, Magnevist; Bayer Schering Pharma, Germany) diluted at 1:200 was injected until the shoulder joint capsule was sufficiently distended.

MRI and MR arthrography

Standard MRI and MR arthrography procedures were performed with a 3 T MRI scanner (Magnetom Skyra; Siemens Healthcare, Erlangen, Germany) with an 8-channel shoulder-dedicated coil. Both MRI and MR arthrography examinations were performed with the patient lying in the supine position on the MRI scanner table with the arms slightly externally rotated.

A standard MRI was performed using the following sequence parameters: fast spin echo (SE) T_2 weighted images in axial and coronal oblique planes with frequency-selective fat saturation [repetition time/echo time (TR/TE) ms, 3600/65; echo train length (ETL), 15; section thickness, 4 mm; spacing, 0.4 mm; field of view (FOV), 16 cm; matrix 320×192 ; number of signals acquired, 3) and fast SE T_1 weighted images in sagittal oblique plane (TR/TE, 640/25; ETL, 8; section thickness, 3 mm; spacing, 0.4 mm; FOV, 16 cm; matrix 256×224 ; number of signals acquired, 3).

All MR arthrograms were obtained within 30 min after intra articular injection. The MR arthrography protocol included SE T_1 weighted images in sagittal oblique plane (TR/TE, 650/15 ms; ETL, 8; section thickness, 3 mm; spacing, 0.3 mm; field of view, 130–200 mm; matrix, 256×256 ; number of signals acquired, 3) and fat-suppressed SE T_1 weighted images in the axial, oblique coronal, and oblique sagittal planes. Fat-suppressed 3D T_1 weighted gradient-echo imaging with volumetric interpolated breath-hold examination (VIBE) (TR/TE, 13.2/4.7 ms; flip angle, 11° ; $130 \times 150 \text{ mm}$ FOV; matrix, 512×512 ; one slab of 112 slices with a slice thickness of 0.6 mm; one acquisition) was added to the MR arthrography protocol as it allows multiplanar reconstruction.

Sonographic examination

Indications for shoulder sonography and sonoarthrography included posterior labral defect, labral or sublabral variation, and posterior capsular anomaly. Conventional sonography and sonoarthrography examinations were performed by two radiologists with 4 and 12 years of experience in shoulder joint sonography, respectively, using an Applio 500 scanner with a 7.5 MHz linear array transducer. For shoulder joint examination, the patient was seated on a chair, upright with the back to the radiologist and the ipsilateral hand positioned on the patient's contralateral shoulder. Each shoulder was separately evaluated with ultrasonography by the two radiologists. A transducer was positioned transversely over the long axis of the myotendinous junction of the infraspinatus and teres minor muscles and angled to show the posterior contour of the glenoid rim, posterior labrum, posterior joint capsule, and posterior joint recess. Following articular injection, sonoarthrography was performed in the same manner as in conventional sonography. The examiners were blinded to the results of MRI and MR arthrography.

Image interpretation

Conventional ultrasonography and sonoarthrography analysis

To compare the diagnostic performance of sonoarthrography, the ultrasonography images were prospectively evaluated for the presence of posterior labral tear, sublabral cleft, and posterior capsular abnormalities by two radiologists (MA and HO) who were blinded to patients' histories and the results of previous examinations.

A normal posterior labrum was defined as a triangular, homogeneously echoic structure detected on sonoarthrography

Figure 1. An 18-year-old female with chronic anterior shoulder pain. Fat-saturated spin-echo T_1 weighted MR arthrography (A) and axial arthrosonography image (B) showing normal posterior labrocapsular structures of the right shoulder (long arrow indicates posterior labrum, short arrow indicates sublabral glenoid cartilage, and arrow head indicates posterior joint capsule).

(Figure 1A–B). The glenoid cartilage under the posterior labrum showed a linear low-echo. A labral tear was accepted in the presence of labral deformation, displacement of labrum, and loss of labrum integrity. A sublabral cleft was accepted in the presence of sublabral fluid echo with a normal posterior labrum. A posterior synovial fold was accepted in the presence of focal capsular thickening of at least 2 mm.

Evaluation of MR arthrography images

The MR arthrographic images were reviewed by two radiologists (MA and HO), with 4 and 12 years of experience, respectively. Presence of posterior labral tears, posterior labral clefts, and posterior synovial folds was analyzed by both observers. Diagnostic criteria for labral tear included an intralabral or sublabral contrast media-filled gap and focal discontinuity of the labrum as detected on axial fat-saturated T_1 weighted MR arthrogram. The diagnostic criterion for posterior labral cleft was a depth or width of ≤ 2 mm in the sublabral contrast material extravasation as detected on axial T_1 weighted MR arthrogram. The diagnostic criteria for posterior capsular fold included a focal thickness of at least 2 mm in the posterior capsule as detected on axial MR arthrogram. There was agreement between the two observers for each case.

Arthroscopy

All arthroscopic examinations were performed by an experienced arthroscopic surgeon. All the posterior labral tears and labrocapsular abnormalities detected on MR arthrography were carefully examined by using arthroscopy. The average time interval between MR/ultrasonography arthrography and arthroscopic procedure was 1–4 weeks.

Statistical analysis

Data were analyzed using SPSS 20 (IBM SPSS Statistics for Windows, Armonk, NY: IBM Corp.). Descriptive statistics were expressed as median (minimum–maximum) and mean $\pm$ standard deviation (SD). Categorical variables were expressed as frequencies (n) and percentages (%) and were compared using χ^2 test. Normality of distribution was assessed using Kolmogorov–Smirnov test and Shapiro–Wilk test. Continuous variables with normal distribution were compared using Independent samples *t*-test and continuous variables with nonnormal distribution were compared using Mann–Whitney *U* test and Kruskal–Wallis test. Interobserver agreement for sonoarthrographic findings was calculated according to the statistical method proposed by Landis and Koch (0.21–0.40: fair agreement; 0.41–0.60: moderate agreement; 0.61–0.80: substantial agreement; 0.81–1.00: almost perfect agreement). A *p*-value of < 0.05 was considered significant.

RESULTS

The study included 82 consecutive patients comprising 33 (40.2%) females and 49 (59.8%) males with a mean age of 37.4 ± 12.9 (range, 14–64) years. The right shoulder was evaluated in 49 (59.8%) patients and the left shoulder was evaluated in 33 (40.2%) patients. Arthroscopy was performed in 14 (17.1%) patients, most of whom had labral defect and were treated arthroscopically. Conventional MRI and MR arthrography were performed all of 82 shoulders. All the patients who underwent conventional MRI and MR arthrography were also examined by shoulder joint sonoarthrography.

Figure 2. A 33-year-old male with posterior shoulder instability. Fat-saturated spin-echo T_1 weighted MR arthrography (A) and axial arthrosonography image (B) showing a tear in the posterior labrum of the left shoulder (long arrow indicates posterior labrum, short arrow indicates sublabral fluid leak, and arrow head indicates posterior joint capsule).

A posterior labral tear was detected in 5 (6.1%) and 6 (7.3%) patients on sonoarthrography by Observer 1 and 2, respectively. In MR arthrography and arthroscopy, however, a posterior labral tear was detected in 8 (9.8%) patients (Figure 2A–B). All the posterior labral tears detected by sonoarthrography were confirmed by MR arthrography and arthroscopy. A posterior labral cleft was detected in 6 (7.3%) and 7 (8.5%) patients on sonoarthrography by Observer 1 and 2, respectively. Although all the posterior labral clefts detected by sonoarthrography were confirmed by MR arthrography (Figure 3A–B), only four of these abnormalities were confirmed by arthroscopy. On the other hand, a posterior synovial fold was detected in two (2.4%) and three (3.7%) patients on sonoarthrography by Observer 1 and 2, respectively. Although these synovial folds were confirmed by MR arthrography (Figure 4A–B), they were not confirmed by arthroscopy. There was no significant difference among the 82 patients with regard to age, gender, and the prevalence of posterior labral tear, posterior labral cleft, and posterior synovial fold ($p > 0.05$).

Since arthroscopy was not performed in many of our patients, the results of sonoarthrography were compared with those of MR arthrography. Interobserver variability showed substantial agreement between the sonoarthrographic and MR arthrographic results of the posterior labrocapsular structures ($\kappa = 0.71$, $p < 0.05$). Table 1 compares the findings of sonoarthrography with those of MR arthrography in the evaluation of posterior labrocapsular structures.

DISCUSSION

The present study compared the results of shoulder sonoarthrography with those of MR arthrography and indicated that the prevalence of posterior labral tears in the glenohumeral joint detected by MR arthrography was 9.8%. Moreover, interobserver variability showed substantial agreement between the sonoarthrographic and MR arthrographic results of posterior labrocapsular structures.

Pathologies of the posterior labrocapsular and ligamentous complex include reverse Bankart, reverse humeral avulsion of the glenohumeral ligament, extended superior labral anteroposterior tear, posterior labrocapsular periosteal sleeve avulsion, reverse glenolabral articular disruption, and Kim lesions.^{7,10–12} Literature indicates that only 2% of patients with shoulder instability present with posterior subluxation.¹¹ A reverse Bankart lesion is known as separation of the posteroinferior labrum secondary to macro-trauma; however, numerous variants of posterior glenoid labral lesions have also been described in the literature.^{7,11,12} As it was beyond the purpose of this study, the subtyping of labral lesions was not performed in the study. In eight of our patients, a posterior labral tear was detected on MR arthrography. All of these tears were confirmed by arthroscopy and then repaired arthroscopically. Of these tears, five (63%) and six (75%) tears were detected on sonoarthrography by Observer 1 and 2, respectively. MR arthrography of the glenohumeral joint is accepted as the most sensitive imaging modality for the evaluation of labrocapsular structures.⁹ Therefore, in our study, MR arthrograms were used as the reference standard for comparing the results of sonoarthrography.

Figure 3. A 20-year-old female with chronic anterior shoulder pain. Fat-saturated spin-echo T_1 weighted MR arthrography (A) and axial arthrosonography image (B) showing a sublabral cleft in the right shoulder (long arrow indicates posterior labrum and short arrow indicates sublabral cleft).

On shoulder ultrasonography examination, a normal glenoid labrum is viewed as a hyperechoic triangular anatomical structure located adjacent to the glenoid notch. In a cadaveric study with arthroscopic correlation, Taljanovic et al assessed the

usefulness of ultrasonography in the evaluation of the glenoid labrum and found a concordance of 86% between ultrasonography examination and arthroscopy in the diagnosis of normal labrum and labral lesions including degeneration and tear. The

Figure 4. Posterior synovial fold in a 42-year-old male presenting with clinical left shoulder pain. Fat-saturated spin-echo T_1 weighted MR arthrography (A) and axial arthrosonography image (B) showing a posterior capsular fold (long arrow indicates posterior labrum, short arrow indicates posterior capsular fold, arrow head indicates posterior joint capsule).

Table 1. Sonoarthrographic diagnosis of the patients performed by radiologist 1 and 2 with MR arthrographic and arthroscopic correlations

	Sonoarthrographic diagnosis (<i>n</i> = 82)		MR arthrographic diagnosis (<i>n</i> = 82)	Arthroscopic diagnosis (<i>n</i> = 14)
	Radiologist 1	Radiologist 2		
Posterior labral tear	5	6	8	8
Posterior labral cleft	6	7	21	4
Posterior capsular fold	2	3	5	0
Normal posterior labrum and capsule	69	66	48	2

authors also noted that ultrasonography had a sensitivity and specificity of 63 and 98% in differentiating pathologic labrum from normal labrum, respectively.

Sonoarthrographic examination of the shoulder joint has been used in several studies for the evaluation of anterior labral pathologies and rotator cuff tears.^{13–15} In an arthrographic study, Lee *et al*¹⁴ evaluated the diagnostic accuracy of sonoarthrography in the detection of rotator cuff tears. The study used conventional arthrography as the reference standard and found that arthrosography was not superior to conventional ultrasonography in the diagnosis of rotator cuff injuries. In another arthrographic study, Lee *et al*¹³ evaluated the diagnostic accuracy of sonoarthrography after repair of rotator cuff tears. The authors compared the results of conventional ultrasonography with those of sonoarthrography by using MR arthrography as the reference standard and found that sonoarthrography is an effective imaging modality in the assessment of postoperative integrity of rotator cuff tendons. In another arthrography study, Jeong *et al*¹⁵ evaluated a total of 30 patients and compared the diagnostic accuracy of sonoarthrography and conventional ultrasonography in anterior labral tears of the shoulder joint. The authors performed arthroscopy in 18 patients by using MR arthrography as the reference standard and suggested that shoulder sonoarthrography is more accurate than conventional ultrasonography in the diagnosis of anterior labral tears. In a recent arthrography study, Park¹⁶ evaluated the clinical characteristics of patients with posterior superior labral tears using MRI, conventional ultrasonography, and sonoarthrography. However, the authors did not evaluate the diagnostic accuracy of sonoarthrography in posterior labral tears. In this study, we performed sonoarthrography for examination of the glenohumeral joint in 82 patients by using MR arthrography as the reference standard. A posterior labral tear was detected in eight patients on MR arthrography and all of these tears were repaired arthroscopically. The diagnostic accuracy rates in the detection of posterior labral tears by sonoarthrography were 63 and 75% for Observer 1 and 2, respectively. Taken together, these results implicate that sonoarthrography may be a useful method for the diagnosis of posterior labral tears.

To date, numerous anatomical variants of the capsulolabroligamentous complex of the glenohumeral joint have been described in MRI studies.^{17–20} As these normal variants can be confused with some pathologies on conventional MRI,

previous studies suggested CT or MR arthrography as the standard imaging technique for assessing the morphology of the labrocapsular complex.^{21,22} Different variations in the shape of the glenoid labrum have been described in the literature, including triangular, round, cleaved, flat, and notched.²⁰ In routine musculoskeletal imaging, posterior sublabral recesses or clefts are commonly observed on CT or MR arthrography in patients with no clinical findings of posterior instability.^{21,22} To our knowledge, the sonographic and sonoarthrographic features of the anatomical variants of the posterior glenoid labrum have never been studied. In the present study, although the morphological features of the posterior labrum were not evaluated by sonoarthrography, sonoarthrography confirmed the presence of posterior labral cleft abnormalities in 6–7 (according to Observer 1 and 2, respectively) out of 21 patients that were diagnosed with a posterior labral cleft on MR arthrography.

In arthrographic examination of the shoulder joint, capsular distention allows the separation and a better visualization of intra articular anatomical structures such as glenohumeral ligament, glenoid labrum, and posterior capsular fold. Posterior synovial fold of the glenohumeral joint is a capsular thickening similar to that of glenohumeral ligament and is believed to be a normal anatomical variant of the posterior joint capsule. The prevalence of posterior capsular folds detected on MR arthrography has been reported as 5.8%.⁵ The posterior capsular folds of the shoulder joint have been described in detail in several studies.^{5–25} However, to our knowledge, the sonographic or sonoarthrographic features of the posterior capsular folds have not been reported in the English-language literature. In the present study, posterior capsular fold of the shoulder joint was described on sonoarthrography as a triangle- or nodule-shaped capsular thickening behind the posterior glenoid labrum. A posterior capsular fold was detected in 2–3 patients on sonoarthrography and in five patients on MR arthrography. However, no capsular fold could be confirmed arthroscopically.

Our study was limited in several ways. First, not all the sonoarthrography results could be confirmed by arthroscopy; therefore, MR arthrography was used as the reference standard. Second, symptomatic patients with variable shoulder pathologies were enrolled in the study; therefore, we could not determine if there was a relationship between the patients'

symptoms and labrocapsular abnormalities. Third, our data had a small sample size; therefore, larger studies are needed to draw full scientific conclusions. Finally, ultrasonography, unlike MR arthrography, is operator-dependent and has a learning curve.

In conclusion, posterior labral tears and posterior capsular folds of the shoulder joint can be evaluated non-invasively by sonoarthrography. However, further sonoarthrographic experience is needed for evaluating posterior labral abnormalities.

REFERENCES

- Boyd HB, Sisk TD. Recurrent posterior dislocation of the shoulder. *J Bone Joint Surg Am* 1972; **54**: 779–86. doi: <https://doi.org/10.2106/00004623-197254040-00008>
- McLaughlin HL. Posterior dislocation of the shoulder. *The Journal of Bone & Joint Surgery* 1952; **34**: 584–90. doi: <https://doi.org/10.2106/00004623-195234030-00011>
- Hottya GA, Tirman PF, Bost FW, Montgomery WH, Wolf EM, Genant HK. Tear of the posterior shoulder stabilizers after posterior dislocation: MR imaging and Mr arthrographic findings with arthroscopic correlation. *AJR Am J Roentgenol* 1998; **171**: 763–8. doi: <https://doi.org/10.2214/ajr.171.3.9725313>
- Provencher MT, LeClere LE, King S, McDonald LS, Frank RM, Mologne TS, et al. Posterior instability of the shoulder: diagnosis and management. *Am J Sports Med* 2011; **39**: 874–86. doi: <https://doi.org/10.1177/0363546510384232>
- Ogul H, Tuncer K, Kose M, Pirimoglu B, Kantarci M. Mr arthrographic characterization of posterior capsular folds in shoulder joints. *Br J Radiol* 2019; **92**: 20180527. doi: <https://doi.org/10.1259/bjr.20180527>
- Shah N, Tung GA. Imaging signs of posterior glenohumeral instability. *AJR Am J Roentgenol* 2009; **192**: 730–5. doi: <https://doi.org/10.2214/AJR.07.3849>
- Harish S, Nagar A, Moro J, Pugh D, Rebello R, O'Neill J. Imaging findings in posterior instability of the shoulder. *Skeletal Radiol* 2008; **37**: 693–707. doi: <https://doi.org/10.1007/s00256-008-0487-7>
- Chiavaras MM, Harish S, Burr J. Mr arthrographic assessment of suspected posteroinferior labral lesions using flexion, adduction, and internal rotation positioning of the arm: preliminary experience. *Skeletal Radiol* 2010; **39**: 481–8. doi: <https://doi.org/10.1007/s00256-010-0907-3>
- Tung GA, Hou DD. Mr arthrography of the posterior labrocapsular complex: relationship with glenohumeral joint alignment and clinical posterior instability. *AJR Am J Roentgenol* 2003; **180**: 369–75. doi: <https://doi.org/10.2214/ajr.180.2.1800369>
- Ogul H, Ayyildiz V, Pirimoglu B, Polat G, Tuncer K, Kose M, et al. Magnetic resonance arthrographic demonstration of association of superior labrum anterior and posterior lesions with extended anterior labral tears. *J Comput Assist Tomogr* 2019; **43**: 51–60. doi: <https://doi.org/10.1097/RCT.0000000000000775>
- Roy EA, Cheyne I, Andrews GT, Forster BB. Beyond the cuff: MR imaging of labroligamentous injuries in the athletic shoulder. *Radiology* 2016; **278**: 316–32. doi: <https://doi.org/10.1148/radiol.2015150364>
- De Coninck T, Ngai SS, Tafur M, Chung CB. Imaging the glenoid labrum and labral tears. *Radiographics* 2016; **36**: 1628–47. doi: <https://doi.org/10.1148/rg.2016160020>
- Lee KW, Yang DS, Chun TJ, Bae KW, Choy WS, Park HJ. A comparison of conventional ultrasonography and arthrosonography in the assessment of cuff integrity after rotator cuff repair. *Clin Orthop Surg* 2014; **6**: 336–42. doi: <https://doi.org/10.4055/cios.2014.6.3.336>
- Lee HS, Joo K-B, Park CK, Kim YS, Jeong WK, Kim YS, et al. Sonography of the shoulder after arthrography (arthrosonography): preliminary results. *J Clin Ultrasound* 2002; **30**: 23–32. doi: <https://doi.org/10.1002/jcu.10021>
- Jeong WK, Ah Ryu J, Choi SH, Choi J-ho, Ho Kim S, Kim J, et al. Shoulder sonography after intraarticular fluid injection for evaluation of anterior labral tears: comparison with conventional sonography. *J Clin Ultrasound* 2013; **41**: 94–100. doi: <https://doi.org/10.1002/jcu.21981>
- Park D. Clinical characteristics of patients with posterolateral labral tear: a comparison with patients with other shoulder disorders. *J Pain Res* 2018; **11**: 1795–802. doi: <https://doi.org/10.2147/JPR.S166934>
- Robinson G, Ho Y, Finlay K, Friedman L, Harish S. Normal anatomy and common labral lesions at Mr arthrography of the shoulder. *Clin Radiol* 2006; **61**: 805–21. doi: <https://doi.org/10.1016/j.crad.2006.06.002>
- Fitzpatrick D, Walz DM. Shoulder MR imaging normal variants and imaging artifacts. *Magn Reson Imaging Clin N Am* 2010; **18**: 615–32. doi: <https://doi.org/10.1016/j.mric.2010.07.006>
- De Maeseneer M, Van Roy F, Lenchik L, Shahabpour M, Jacobson J, Ryu KN, et al. Ct and Mr arthrography of the normal and pathologic anterosuperior labrum and labral-bicipital complex. *Radiographics* 2000; **20 Spec No**: S67–81. doi: https://doi.org/10.1148/radiographics.20.suppl_1.g00oc03s67
- Park YH, Lee JY, Moon SH, Mo JH, Yang BK, Hahn SH, et al. Mr arthrography of the labral capsular ligamentous complex in the shoulder: imaging variations and pitfalls. *AJR Am J Roentgenol* 2000; **175**: 667–72. doi: <https://doi.org/10.2214/ajr.175.3.1750667>
- Tuite MJ, Currie JW, Orwin JF, Baer GS, del Rio AM. Sublabral clefts and recesses in the anterior, inferior, and posterior glenoid labrum at Mr arthrography. *Skeletal Radiol* 2013; **42**: 353–62. doi: <https://doi.org/10.1007/s00256-012-1496-0>
- Lee GY, Choi J-A, Oh JH, Choi J-Y, Hong SH, Kang HS. Posteroinferior labral cleft at direct CT arthrography of the shoulder by using multidetector CT: is this a normal variant? *Radiology* 2009; **253**: 765–70. doi: <https://doi.org/10.1148/radiol.2533081997>
- Landis JR, Koch GG. The measurement of observer agreement for categorical data. *Biometrics* 1977; **33**: 159. doi: <https://doi.org/10.2307/2529310>
- Taljanovic MS, Carlson KL, Kuhn JE, Jacobson JA, Delaney-Sathy LO, Adler RS. Sonography of the glenoid labrum: a cadaveric study with arthroscopic correlation. *AJR Am J Roentgenol* 2000; **174**: 1717–22. doi: <https://doi.org/10.2214/ajr.174.6.1741717>
- Novak LM, Lee JK, Saleem AM. Synovial fold of the posterior shoulder joint capsule. *Skeletal Radiol* 2009; **38**: 493–8. doi: <https://doi.org/10.1007/s00256-008-0635-0>