Thin-layer plastination of the shoulder

Thomas M[1], Steinke H[2]

Department of Orthopedic Surgery, University of Leipzig, Germany[1]
Department of Anatomy, University of Leipzig, Germany[2]

Summary

Thomas M, Steinke H. Thin layer plastination of the shoulder. *Clinical Sports Medicine International (CSMI) 2004, 1: 9-15.*

Background: The interpretation of split images produced by CT, MRI or sonography requires precise knowledge about topographical anatomy of the shoulder. This is valid special for examinations in new joint positions as the apprehension-test position that is representative for an anterior shoulder instability. Up to now comparative studies were mostly performed with frozen sections. A new anatomical procedure of split images is the thin-layer plastination procedure described by Steinke.

Objective: The purpose of this study was the detailed description of the topographical anatomy of the shoulder in the apprehension-test position using by the thin-layer plastination procedure.

Materials and methods: Two shoulder-arm samples were stored in 90 degree of abduction and maximally external rotation according to the apprehension-test position and then the shoulder-arm samples were plastinated with the procedure of Steinke. The cutting planes were coronal for the right shoulder and axial for the left shoulder-arm sample. The thin-layer plastinates were digitalized in a high-resolution manner and then analyzed at a workstation.

Results: The thin-layer plastinates with a thickness of 800 µm and a resolution of 1200 dpi demonstrated the topographical anatomical relation of all structures in the coronal and axial plane. All anatomical structures of the shoulder could be identified due to detailed reproduction quality.

Conclusion: The thin-layer plastination as a new anatomical sectional procedure allows a detailed description of the topographical anatomy of the shoulder especially for the examination in new joint positions as the apprehension-test position.

Keywords: plastination, normal sectional anatomy, shoulder joint, apprehension-test position

Introduction

The diagnostic of shoulder injuries and diseases contains the history, the clinical investigation and different imaging procedures (sonography, CT, MRI). The most frequently used clinical test for the diagnostic of anterior shoulder instability is the apprehension test [17]. In the apprehension-test position the stabilizing structures of the shoulder are put under stress.

Most frequently a traumatic anterior shoulder instability is due to a lesion of the labral ligamentous complex. In about 80 percent this injury is a Bankart lesion [15]. In neutral position of the arm no subluxation or luxation of the shoulder occurs. In the apprehension-test position the arm is abducted and in external rotation. The injured stabilizing structures are then under stress and do not completely center the humeral head in the glenoid cavity. The clinical signs with a positive apprehension-test are myotony, instability feeling and subluxation. The routine diagnostic includes radiography with special projections. CT and MRI may be used in addition. The MRI is the "gold standard" in the diagnostic of labral lesions. In circumferential high-field, whole body MRI magnets the shoulder is in neutral position and the arm cannot be abducted. In open, whole body MRI magnets the shoulder can be examined in various positions, e.g. the apprehension-test position. This may improve the diagnostic of the anterior shoulder instability [19]. Thereby the detailed knowledge of the topographical anatomy of the applied shoulder positions is essential for the judgement of the MR images.

In the past numerous comparative studies of MR images and corresponding anatomical sections have been published [1,2,3,4,5,9,10,11,12,13,14]. In these studies frozen sections were most frequently used. The use of slice-plastination then improved the histotomy [6,7,8]. The thickness of the segment is determinant for the optical resolution. A new technique to reduce the segment thickness from 3-5 mm to 0,8 mm was described by Steinke in 2001 [18]. The thin-layer plastination allows thin-segment plastinates to be directly scanned with a resolution of 1200 dpi. Such investigations of the shoulder using thin-layer plastinates have not been published yet.

The purpose of this study was to introduce the thin-layer plastination of the human shoulder in the apprehension-test position in the coronal and the axial plane.

Materials and methods

Both shoulders of a body donor were embedded in the apprehension-test position. Then a thin-layer plastination described by Steinke [18] was performed. The steps of thin-layer plastination are summarized in Table 1. The cutting planes of the plastination corresponded to the planes of the MR imaging.

The right shoulder-arm sample was used for the coronal section levels and the left shoulder-arm sample for the axial section segment. The coronal and axial thin-layer plastinates were digitalized (scanning) in high-resolution and analyzed at a workstation.

Steps of thin layer plastination	
1. Perfusion	with an isotonic buffer solution into the axillary artery
2. Shock-freezing	cooling to + 5°C and placing in a solution of 85% acetone and 15% water at – 85°C, then storage at – 25°C
3. Marking and Cutting	Completion the marking of the MR imaging planes, cutting at a room temperature of – 15°C using a modified plastination saw which cut segments at a width of 0.8 mm
4. Dehydration	stepwise freezing-replacement, beginning with a mixture of 85% acetone and 15% water at - 85°C for a day, then at - 25°C for 3 months, finally in pure acetone for one month
5. Embedding	impregnation with BIODUR E 12 modified by Steinke by replacement of acetone for polymerization of epoxy under a negative pressure of 10^{-3} Torr
6. Hardening	fixation of the impregnated segments using the “Sandwich-technique”, final hardening in a thermal chamber

Table 1. Steps of thin-layer plastination decribed by Steinke [18].

Results

Thin-layer plastinates in the coronal plane are displayed in Figure 1.

Figure 1a-h shows thin-layer plastinates of the right shoulder. In Fig. 1a the posterior shoulder segment is displayed. The insertions of the m. supraspinatus and m. teres minor can clearly be identified. The insertion of the m. supraspinatus at the tuberculum majus is shown in Figure 1d-e. The insertions of mm. subscapularis and pectoralis major are shown in Figure 1f-g. The insertion and position of coracobrachialis muscule and short head of biceps brachii can be idenified together with the processus coracoideus in Figure 1h.

Thin-layer plastinates in the axial plane are displayed in Figure 2.

Figure 2a-h shows a series of plastinates of the left shoulder. The plastinates are assorted from superior to inferior. In Figure 2f-h the mm. subscapularis and infraspinatus with the corresponding insertions are displayed.

The high resolution of the thin-layer plastinates is demonstrated in Figure 3-5. Special parts of the plastinates are enlarged.

Figure 3 shows the long head of the biceps tendon.

In Figure 4 the coracoclavicular ligament is displayed.

In Figure 5, nervus axillaris, arteria et vena circumflexa humeri posterior and the joint capsule are shown.

Discussion

In comparison with usual photographs of frozen sections the resolution of scanned thin-layer plastinates is better. The resolution of frozen sections is limited. The frozen tissue fluid lets pass through more light. Structures under the surface shine through. This problem can be solved only with translucent body slices. In 1985 von Hagens [7] described for the first time the body plastination method (procedure E12). Body slices are impregnated with synthetic resin. With the reduction of layer thickness the resolution of the plastinates could be improved. Today the thinnest plastinates can be created with the procedure of thin-layer plastination described by Steinke [18]. This method faciliates a minimum layer thickness is 0.8 mm and a resolution of up to 1200 dpi. Thus even smallest anatomical structures such as axillary nerve, inferior capsule, enthesis and the glenoid labrum may be identified. With this detailed knowledge of the topographical anatomy an exactly interpretation of MR- and CT images is possible. MR imaging with new section planes can be evaluated by this new procedure.

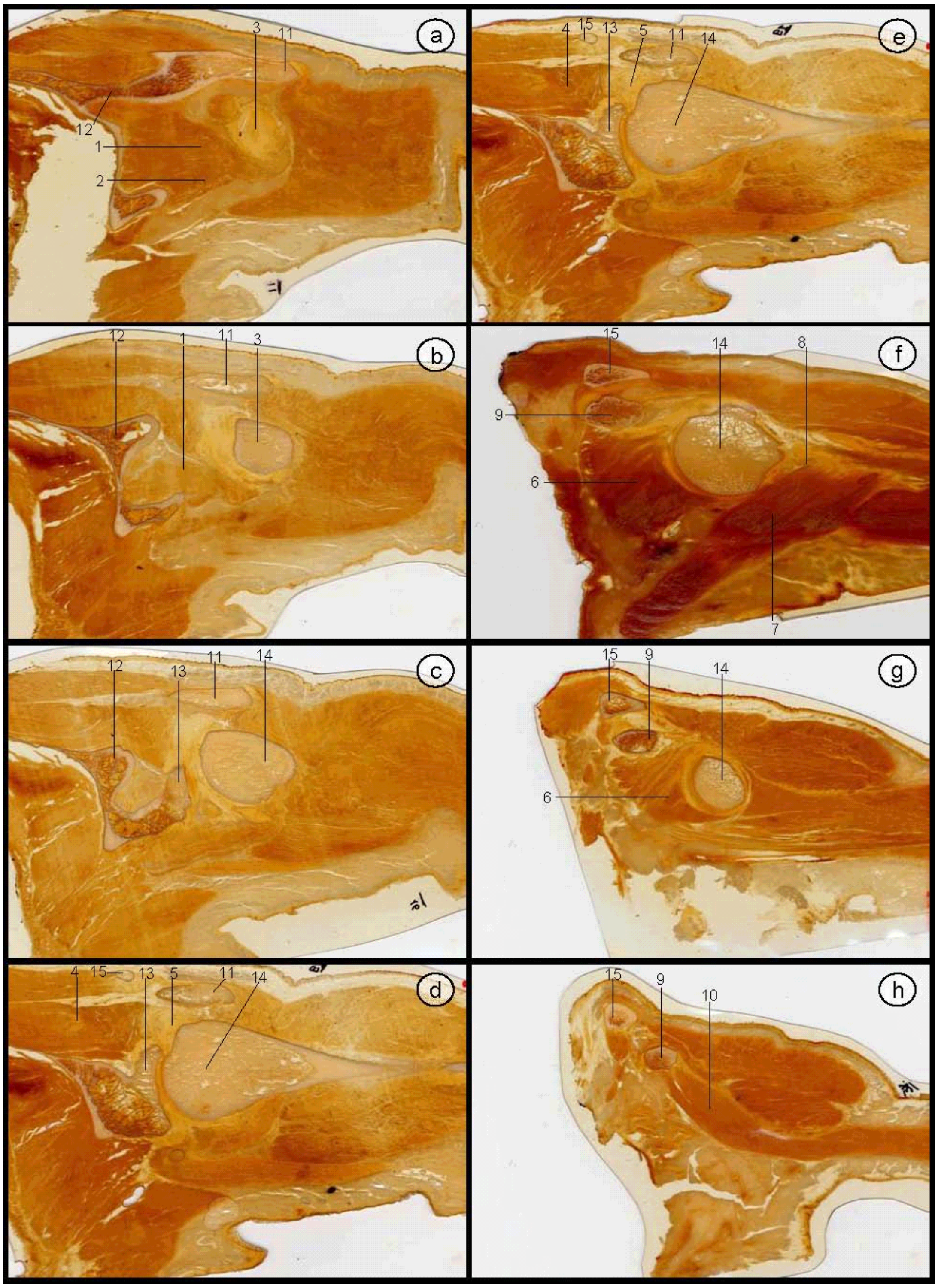

Figure 1. Thin-layer plastinates of the shoulder stored in the apprehension-test position in the coronal plane from posterior (a) to anterior (h). 1a-b: Insertion of tendon of m. infraspinatus (1) and m. teres minor (2) on the tuberculum majus (3). 1d-e: m. supraspinatus (4) and the tendinous insertion (5) on the tuberculum majus. 1f-g: m. subscapularis (6) and the m. teres major (7) with insertion on the crista tuberculi majoris humeri (8). 1h: processus coracoideus (9) with coracobrachial muscles (10). Bones: acromion (11), spina scapulae (12), cavitas glenoidalis (13), caput humeri (14), clavicula (15).

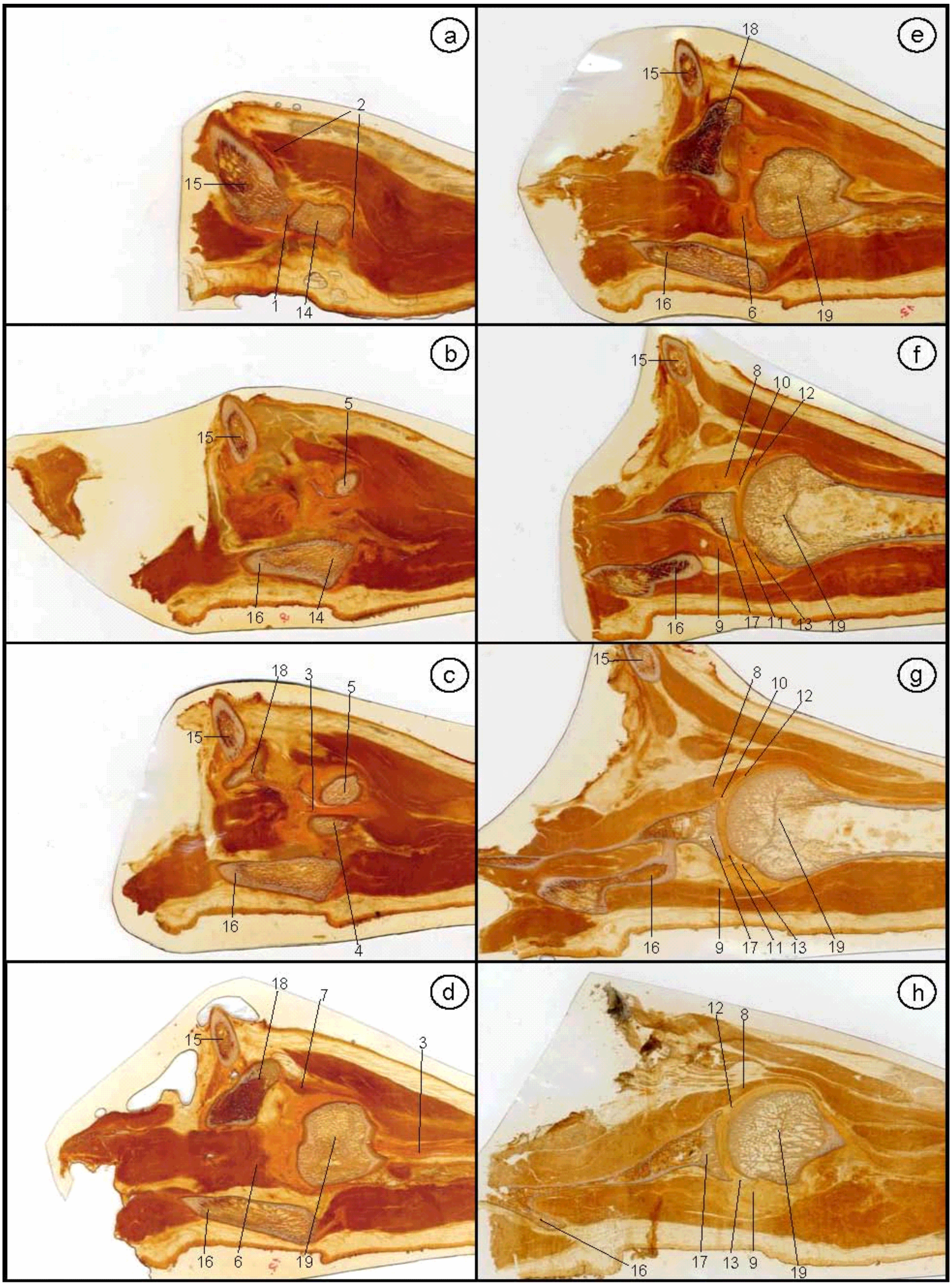

Figure 2. Thin-layer plastinates of the shoulder stored in the apprehension-test position in the axial plane from superior (a) to inferior (h). 1a-b: Insertion of tendon of m. infraspinatus (1) and m. teres minor (2) on the tuberculum majus (3). 1d-e: m. supraspinatus (4) and the tendinous insertion (5) on the tuberculum majus. 1f-g: m. subscapularis (6) and the m. teres major (7) with insertion on the crista tuberculi majoris humeri (8). 1h: processus coracoideus (9) with coracobrachial muscles (10). Bones: acromion (11), spina scapulae (12), cavitas glenoidalis (13), caput humeri (14), clavicula (15).

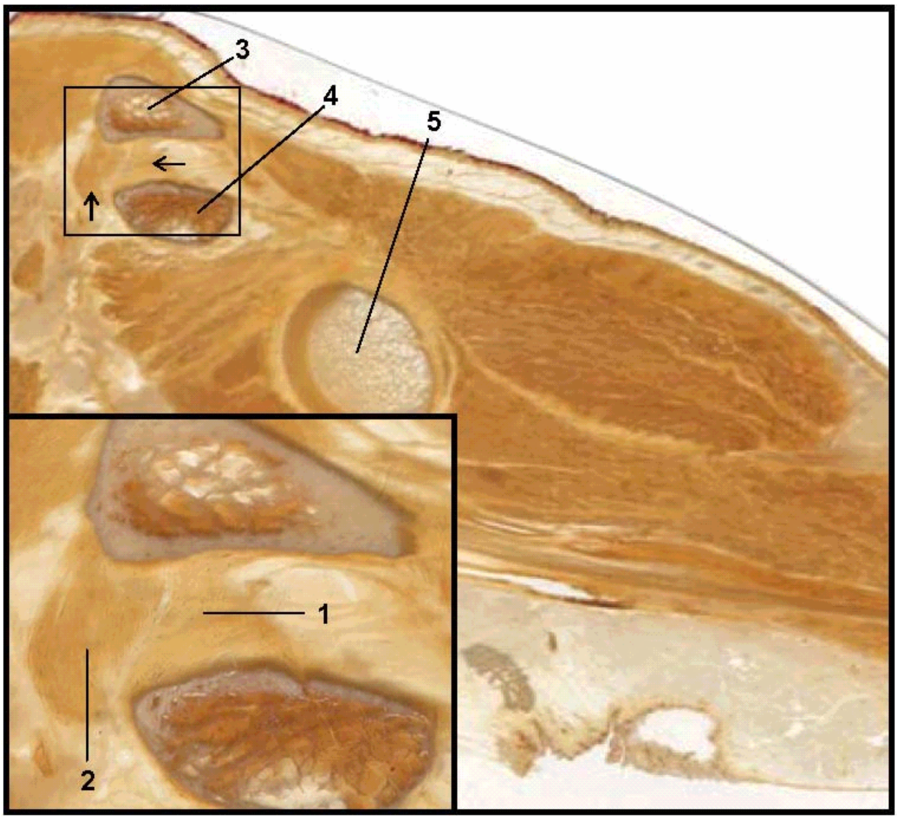

Figure 3. Thin-layer plastinate of a shoulder in the apprehension-test position (coronal plane). The ligamentum coracoclaviculare is indicated by the arrows, the pars trapezoidea anterior and the pars conoidea posterior are indicated by 1 and 2. Bones: clavicle (3), processus coracoideus (4), caput humeri (5).

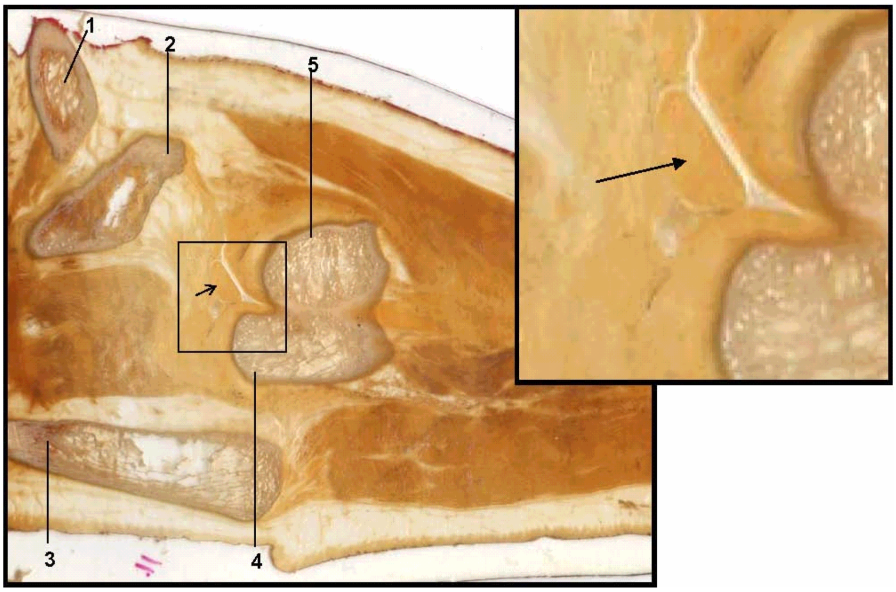

Figure 4. Thin-layer plastinate of a shoulder in the apprehension-test position (axial plane). The long head of the biceps tendon in the rotator interval is indicated (arrow). The high solution is demonstrated in the right smaller figure. Bones: clavicle (1), processus coracoideus (2), spina scapulae (3), greater tubercle of humerus (4), lesser tubercle of humerus (5).

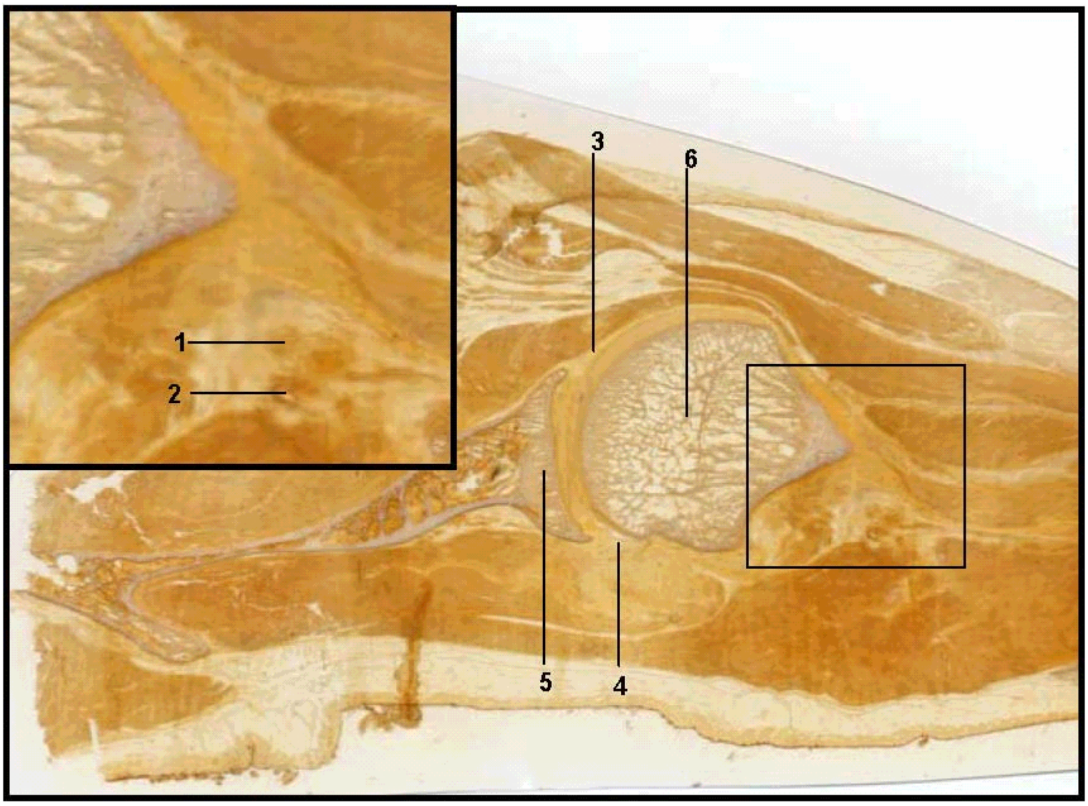

Figure 5. Thin-layer plastinate of a shoulder in the apprehension-test position (axial plane). Topographical-anatomical relationship of the n. axillaris (1) and the a. et v. circumflexa humeri posterior (2) to the humerus. The high solution is demonstrated in the smaller figure to the left. The anterior and posterior capsule are indicated by 3 and 4. Bones: cavitas glenoidalis (5), humerus (6).

Thus the thin-layer plastination represents a new anatomical procedure for direct and indirect comparative studies with clinical imaging. This is particularly valid for new investigation positions as the apprehension-test position.

Abduction and external rotation in the shoulder cause a considerable change of the topographical anatomy comparative to the neutral position. In the apprehension-test position, e.g., the tuberculum majus with the insertion of the mm. teres minor, infraspinatus and supraspinatus are rotated to posterior position. The long head of the biceps muscle with the rotator interval is localized superior and posterior. The axillary nerve and the concomitant vessels approach the humerus. The essential stabilizing structures in the apprehension-test position such as the anterior glenoid labrum and the inferior glenohumeral ligament can be represented with the thin-layer plastination.

Conclusion

The thin-layer plastination is an innovative procedure for the precise visualization of the topographical anatomy. Clinically relevant shoulder positions such as the apprehension-test position can be shown in any desired section planes. This may faciliate the assessment of MR and CT images especially in new joint positions.

References

1. Basset WL, Ullis K, Seeger LL, Rauschning W (1991) Anatomy of the hip: correlation of coronal and sagittal cadaver cryomicrosections with magnetic resonance images. Surg Radiol Anat 13: 301-306
2. Beyersdorff D, Schiemann T, Taupitz M, Kooijman H, Hamm B, Nicolas (2001) Sectional depiction of the pelvic floor by CT, MR imaging and sheet plastination: computer-aided correlation and 3D model. Eur Radiol 11: 659-664
3. Burgkart R, Merl T, Weinhart H, Eckstein F, Schittich I, Gerhardt P (1996) Schnittanatomie des Schultergelenkes. Sportorthopädie Sporttraumatologie 12: 222-226
4. De Brux JL, Pernes JM, Grenier P (1987) Magnetic resonance imaging of the heart compared with anatomic and ultrasonographic data. Surg Radiol Anat 9: 303-314
5. Entius CAC, van Rijn RR, Holstege JC, Stoeckart R, Zwamborn AW (1997) Correlating sheet plastinated slices, computed tomography images and magnetic resonance images of the pelvic girdle: a teaching tool. Acta Anat 158: 44-47
6. Hagens G v (1977) Patentschrift. DBP. 27 0 147, Erf.: G von Hagens
7. Hagens G v (1985) Heidelberger Plastinationshefter. Anatomisches Institut Heidelberg
8. Hagens G v, Tiedemann K, Kritz W (1987) The current potential of plastination. Anat Embryol 175: 411-421
9. Hodler J, Trudell D, Kang HS, Kjellin I, Resnik D (1992) Inexpensive technique for performing MR-Pathologic correlation in cadavers. Invest Radiol 27: 323-325
10. Hodler J, Trudell D, Pathria MN, Resnick D (1992) Width of the articular cartilage of the hip: quantification by using fatsuppression spin-echo MR imaging in cadavers. AJR 159: 351-355
11. Hodler J, Haghighi P, Trudell D, Resnick D (1992) The cruciate ligaments of the knee: correlation between MR appearance and gross and histologic findings in cadaveric specimens. AJR 159: 357-360
12. Lufkin R, Rauschning W, Seeger L, Bassett L, Hanafee W (1987) Anatomic correlation of cadaver cryomicrotomy with magnetic resonance imaging. Surg Radiol Anat 9: 299-302
13. Mackenzie R, Logan BM, Shah NJ, Keene GS, Dixon AK (1994) Direct anatomical-MRI correlation: the knee. Surg Radiol Anat 16: 183-192
14. Magiros M, Kekic M, Doran GA (1997) Learning relational anatomy by correlation thin plastinated sections and magnetic resonance images: preparation of specimens. Acta Anat 158: 37-43
15. Morgan CD, Rames RD, Snyder SJ (1993) Anatomical variations of the glenohumeral ligaments. In: Snyder SJ (ed) Shoulder arthroscopy. McGraw-Hill, New York-St. Louis-San Francisco
16. Neer CS (1983) Impingement lesions. Clin Orthop 173: 70-77
17. Rowe CR, Zarins B (1981) Recurrent transient subluxation of the shoulder. J Bone Joint Surg 63 A: 863-872
18. Steinke H (2001) Plastinated body slices for verification of magnetic resonance tomography images. Ann Anat 183: 275-281
19. Wintzell G, Haglund-Akerlind Y, Larsson H, Zyto K, Larsson S (1999) Open MR imaging of the unstable shoulder in the apprehension test position: description and evaluation of an alternative MR examination position. Eur Radiol 9: 1789-1795

Correspondence address: M. Thomas, M.D.
Orthopädische Klinik und Poliklinik, Universität Leipzig
Semmelweisstrasse 10
D-04103 Leipzig, Germany
E-mail: thom@medizin.uni-leipzig.de