Assessment of the upper part of the glenoid labrum in the Virtual Convex imaging US examination using ALPINION E-CUBE 15

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ABSTRACT
Tears of the glenoid labrum occur most often during injuries in young people, who do sports that require movements of the upper limb above the head. A standard procedure utilised to examine SLAP lesions is magnetic resonance arthrography. Ultrasonography (US) as a technique that aids the diagnosis may be used to assess the condition of the labrum in its different parts. The upper part of the glenoid labrum is only partially available for ultrasonographic assessment. Until now, dynamic examination was used in US imaging to assess the condition of the upper and anterior part of the glenoid labrum. The work presents the technique of ultrasonographic examination and assessment of the upper part of the glenoid labrum based on static examination with use of Virtual Convex imaging on a premium ALPINION E-CUBE 15; the method can be recommended as a standard procedure in diagnostics of glenohumeral joint injuries. The aim of the work was to determine the possibility to obtain a satisfactory ultrasonographic image of the upper part of the glenoid labrum. However, possible labral tears present in the examined patients were not analysed. In most patients, good and very good diagnostic quality of the images of the upper part of the glenoid labrum were obtained using ALPINION E-CUBE 15.

Key words: glenoid labrum, glenohumeral joint, labral tears, ultrasonography, Virtual Convex imaging US examination

INTRODUCTION
A glenohumeral joint is potentially one of the most unstable joints in our body due to the fact that it is a "hanging" joint, and also due to its localisation (connection of the upper limb with the body). The joint is often at risk of overloads and injuries [1, 2]. Glenoid labrum tears are usually of traumatic origin. The most common mechanism of injuring the glenoid labrum is a fall with a stretched arm, when the limb is also slightly flexed towards the front at the moment of hitting. Most pathologies occur in the anterior part of the glenoid labrum, and secondly in its upper part; however, these are not directly related to the instability of the joint, although they can lead to secondary instability, and occur mainly in young people, who practice sports that require movement of the arm above the head (basketball, swimming, javelin throw, tennis, and also strength-related disciplines [1, 3-4]). The main symptoms of a glenoid labrum tear include: a history of joint dislocation, instability in a dynamic assessment, lack of labral echo in its anatomical position and presence of a cyst around the labrum [2-3, 5-7]. To diagnose injuries of glenohumeral joint, one should begin with X-ray examination that can confirm or exclude possible changes in the bony structures. A standard examination allowing verification of a suspected tear of the upper part of the glenoid labrum is a magnetic resonance arthrography (MRI) [3, 8-9]. For over forty years, also US examination takes an important place in the diagnostics of the muscle and
skeletal system, including lesions located in the glenohumeral joint. In diagnostics of most shoulder conditions, ultrasonography plays an important role, as it confirms or excludes the doctor’s diagnosis determined after talking to the patient, obtaining the medical history, performing the examination and finding specific symptoms. Figure 1 shows a correct anatomy of the area of the upper part of the glenoid labrum in the US image. The US examination is often an additional test that can diagnose both, chronic diseases and post-traumatic conditions, efficiently and accurately.

Important benefits of ultrasonography include: availability, possibility to assess the examined structures dynamically, and non-invasiveness. A many-year observation by the author suggests that when this imaging method is used, the following factors play a significant role: experience of the person who performs the examination and the quality of equipment used during the examination; this is confirmed also by other authors [3, 10-13].

BACKGROUND

A glenoid labrum plays an important role in the glenohumeral joint as it forms a protective "flange" that increases the contact surface between the glenoid and the humeral head, and hence it makes the bony glenoid deeper thus enhancing the stability of the joint as a whole. From the histological point of view, the glenoid labrum is a fibrous and cartilaginous structure built of collagen, similarly as the menisci in the knees. On the cross section, the glenoid labrum is shaped similarly to the knee meniscus and it has similar non-vascularised area and a vascularised one; the latter gets smaller as the age increases, hence the glenoid labrum becomes more echogenic [8, 14-17]. The glenoid labrum is tightly connected in its upper part with tendon of the long head of biceps (attached also to the supraglenoidal tubercle of the scapula), creating a common labrum-tendon complex [14].

Visualisation of the upper part of the glenoid labrum is a significant problem in diagnostics of the glenohumeral joint [3, 8, 10]. Glenoid labrum tears – superior labral anterior to posterior (SLAP) tears – are a common clinical problem and were first described by Andrews et al. in 1985 [6, 18], and conditions of the glenohumeral joint occurring and localised in this area were classified by Snyder et al. in 1990 [5-6, 19].

Until now, the approach using ultrasonographic diagnostics was just to determine that the glenoid labrum or the whole labrum-tendon complex in unstable in the superior part.

A standard diagnostic test utilised when glenoid labrum tear is suspected, is the arthrographic MRI [8-9]. However, arthrography is technically difficult, and moreover it is cost- and time-consuming; it is also hard to call it a non-invasive test [9, 20]. Hence, it seems reasonable to look for other possibilities to directly assess the upper part of the glenoid labrum.

![Figure 1. A correct anatomy of the upper area of the glenoid labrum in the Virtual Convex imaging and the probe positioning](image)
Data from the literature and over ten years of the author's personal experience indicate that US examination is useful for assessing the glenoid labrum and other structures in the other joints [2, 7, 10, 21–25]. Such an assessment, based on US examination with use of standard linear transducers, is rarely possible due to the fact that in most patients, the upper part of the glenoid labrum is located in the acoustic shadow of the acromion. Hence, attempts were made to assess the glenoid labrum using convex or vector probes [26]. However it is not always possible to obtain diagnostic images with use of such probes, because even if the glenoid labrum is visualised, low frequency of convex probes does not allow assessment of the image details. Combination of properties of the linear transducers – high quality and especially resolution of the image at 6–12 MHz, with the properties of convex transducers – divergence of the beam – makes it possible to obtain high quality tissue image, practically not available for linear transducers until recently [25]. The width of the field of view in the US examination depends greatly on the construction of the probe used. Along with occurrence of real-time high-resolution imaging in 1980s, the possibility to create a broadened field of view in the US examination was lost; along with it an important diagnostic element disappeared for some time. Owing to development of computer technology, a wide field of view occurred again in the US imaging. A wide field of view of the images can be currently created very easily and conveniently, and what is more, real-time [27–28].

METHODS

The study assessed the usefulness of trapezoid examination and examination with wide beam deviation, with use of L3-12X transducer working with ALPINION E-CUBE 15, for evaluation of the upper part of glenoid labrum.

The essential feature of the trapezoidal imaging (Virtual Convex Imaging) is an appropriate use of the length, frequency and amplitude of the ultrasound wave that is created by vibrations of 256 crystals. Sequential impulse excitation of individual crystals with a small phase shift beginning from the centre of the transducer and moving towards the external ends results in creation of a divergent beam (Figure 2) – and conversely – excitation of the external crystals and then the ones in the centre results in a convergent beam. Hence, electronic lenses are formed; they converge or diverge the image of internal structures [27]. Beginning the excitation on the central crystals diverges the beam by 10 degrees, whereby the image lines allow imaging of the examined tissues in a wider range.

Virtual Convex imaging in ALPINION E-CUBE 15 allows visualisation of tissues with lateral deviation of the beam by 10 degrees. Also, imaging with deviation of the beam in one of the directions by 10, 15 or even 20 degrees can be used; this makes it possible to "look under" the
acromion and to assess the upper part of the glenoid labrum (Figure 3). The best imaging results with use of the Virtual Convex imaging can be obtained by applying an appropriate Virtual setting (selection from a panel), that is based on moving the image on the monitor screen in such a way that the glenoid labrum is located not in the centre, but maximally close to the edge of the examined field (on the right or the left side of the field). This way, in many cases the measurable parameter of the upper part of the glenoid labrum visualisation can be increased significantly above 10 mm, which means practically visualisation of not only the whole width of the glenoid labrum, but also of a part of the long head of the biceps tendon – LHBT.

Although the options of trapezoid imaging are available in ultrasonography for a long time [27–28], in most systems they significantly impair the quality of the obtained image. The loss of image quality in the case of the ALPINION product is also visible and it increases along with the increase in the beam deviation angle; nevertheless, the obtained image is fully diagnostic.

RESULTS

Using ALPINION E-CUBE 15, the possibility to visualise the upper part of the glenoid labrum of the glenohumeral joint via the Virtual Convex imaging method was assessed in 60 patients treated and diagnosed by the author in the years 2014–2015 in various medical centres none of the examined patients showed any symptoms of SLAP lesion before the examination.

The aim of this work was to determine the possibility to obtain a satisfactory US image of the upper part of the glenoid labrum, and not to analyse the injuries possibly present in the examined patients. A measurable parameter of the obtained image was defined as the distance \(n(d)\) of the furthest located point on the central part of the glenoid labrum width (or LHBT) still visible in the ultrasound examination from the bony edge of the glenoid (Figure 4).

The obtained images were qualified as unsatisfactory, when \(d<6\) mm, satisfactory, for \(d\) in the range 6-8 mm, good (\(d\) in the range 8-10 mm, then a part of the humeral head and the cartilage covering it are visible), very good (when \(d>10\) mm, the following are visible: a part of the humeral head and the cartilage that covers it and a part of the tendon originating at the glenoid labrum – LHBT).

In most of the examined patients, a standard option Virtual Convex imaging was enough to obtain a correct image, and only sometimes unilateral beam deviation by 15 degrees was necessary. An example of this type of imaging is shown in Figure 5.

After analysis of the US images of all 60 patients, it must be stated that the distance of the furthest located point from the edge of the glenoid was often over 10 mm, which allows visualisation of not only the whole width of the glenoid labrum but also partially the tendon of the long head of the biceps that is attached to the labrum. Moreover, it should be noted that it is more difficult to identify the glenoid labrum rim and the glenoid itself in elderly patients and hence beam deviation by 15 degrees was used.

![Figure 3. Comparison of images of the upper part of the glenoid labrum in the same patient examined using standard imaging (on the left) and Virtual Convex imaging (on the right)](image-url)
In the examined group of 60 patients, including 34 women and 26 men, with mean age of 39.6 years (the youngest patient was 17.1 and the oldest 72.3 years, whereas among women the mean age was 38.9, and among men 42.2 years), no unsatisfactory results were found. In the whole group, however, only one satisfactory result was found (1.7%), moreover 5 good results (8.3%) and as many as 54 very good results which is 90.0% of all results within the scope of imaging the upper part of the glenoid labrum (Graph 1). The greatest number of very good results were obtained in patients aged 31-50 years (34, being 61.7%), and secondly among patients older than 50 years (26.7%). The relevant statistics is shown in Graph 3. Depending on the sex of the examined patients, among women the obtained results were mostly very good (94.1%) and 5.9% good results, among men, very good results were 84.6%, and 11.5% were good results (Graph 2).

CONCLUSION

Apart from clinical assessment, diagnostics of glenoid labrum tears is based mainly on MRI, especially after
intra-articular administration of a shadowing agent (MRI arthrography). Until recently, there was a lot skepticism about the possibility to assess SLAP-type glenoid labrum tears in the US examination. As it was presented in this work, even the upper part of the glenoid labrum is available for assessment in the US examination when trapezoid imaging Virtual Convex is used; such imaging is available on ALPINION E-CUBE 15 as a standard option. Figure 6 shows an example of the image with a very good result obtained in the Virtual Convex imaging.

An imaging approach using the Virtual Convex imaging, presented in this paper, is innovative, as US techniques of imaging the upper and antero-upper part of the glenoid labrum known from the literature have until recently included assessment in a dynamic examination with an external or internal rotation of the limb, using linear or convex heads; such examinations were a big challenge for the examining physician. The author of this paper wants to stress that in a dynamic assessment, a higher weight is set on the analysis of the examined
structures during abduction and adduction of the arm. Based on the obtained results, the author of the paper recommends to expand the diagnostic range by a routine US examination with an assessment of the upper part of the glenoid labrum using a method of trapezoidal imaging (Virtual Convex imaging) using a high-quality ultrasound system with such an option, like ALPINION E-CUBE 15; hence, the whole examination may be more complex and should make further diagnostic and therapeutic procedure easier.

REFERENCES