Lubiatowski P., Stefaniak J., Kubicka A., Wałecka J., Ślęzak M., Sędłak K., Lubiatowski B. Evaluation of bone defects in shoulder instability. Issue Rehabil. Orthop. Neurophysiol. Sport Promot. 2018; 23: 71–82. DOI: 10.19271/IRONS-00061-2018-23

EVALUATION OF BONE DEFECTS IN SHOULDER INSTABILITY

Przemysław Lubiatowski[1,2]
Jakub Stefaniak[1,2]
Anna Kubicka[3]
Joanna Wałecka[1,2]
Marta Ślęzak[1,2]
Kamil Sędłak[2]
Bartłomiej Lubiatowski[4]
[1]Department of Traumatology, Orthopaedics and Hand Surgery, University of Medical Sciences in Poznan, Poland
[2]Rehasport Clinic, Poznan, Poland
[3]Department of Human Evolutionary Biology, Institute of Anthropology, Adam Mickiewicz University in Poznan, Poland
[4]RSQ Technologies, Poznan, Poland

SUMMARY

Introduction
Both glenoid and humeral defects have been attributed to play significant impact on both the results and the choice of treatment in shoulder instability.

Aim, material and methods
Literature review has been performed as well as the own results and experience have been presented regarding clinical and radiological evaluation of bony defects of glenohumeral joint.

Results
The diagnostic approach in shoulder instability should include: establishing the correct diagnosis, identification of multiple risk factors for recurrence, evaluation of morphology of lesions to finally come the decision of proposed treatment method. Increased suspicion of the bone defects can be raised by taking the history and physical examination (bony apprehension test). The most important part of evaluation is the imaging to identify and measure the bone loss.

OCENA UBYTKÓW KOSTNYCH W NIESTABILNOŚCI STAWU RAMIENNEGO

Przemysław Lubiatowski[1,2]
Jakub Stefaniak[1,2]
Anna Kubicka[3]
Joanna Wałecka[1,2]
Marta Ślęzak[1,2]
Kamil Sędłak[2]
Bartłomiej Lubiatowski4
[1]Katedra i Klinika Traumatologii, Ortopedii i Chirurgii Ręki, Uniwersytet Medyczny w Poznaniu.
[2]Rehasport Clinic, Poznań
[3]Zakład Biologii Ewolucyjnej, Instytut Antropologii, Uniwersytet im Adama Mickiewicza w Poznaniu
[4]RSQ Technologies, Poznań

STRESZCZENIE

Wstęp
Zarówno ubytki panewki jak i głowy kości ramiennej wpływają istotnie na wyniki oraz wybór metod leczenie niestabilności barku.

Cel, materiał i metodyka
Autorzy przedstawiają przegląd literatury oraz własne wyniki i doświadczenie w klinicznej i radiologicznej ocenie ubytków kostnych stawu ramiennego w niestabilności barku

Wyniki
Ocena diagnostyczna w niestabilności barku powinna zawierać ustalenie właściwego rozpoznania, identyfikację czynników ryzyka nawrotu oraz ocenę morfologii uszkodzeń, po to by podjąć właściwą decyzję o metodzie leczenia. Na podstawie wywiadu i badania przedmiotowego można mieć podejrzenie obecności ubytku kostnego („kostny test obawy"). Najważniejszą jednak częścią oceny jest obrazowanie, pozwalające na identyfikację oraz pomiary

Various modalities have been used: radiography, magnetic resonance, computed tomography (CT) and arthroscopy. Three-dimensional CT is the most accurate and reliable in identifying and quantifying the glenohumeral defects. The measurements focus mostly on the size of anterior glenoid defect and Hill-Sachs lesion. However, the evaluation of interplay between the bipolar lesions (engagement/glenoid track) seems to be important for establishing the risk of recurrence and understanding the pathology in shoulder instability.

Conclusions

Clinical data may raise the suspicion of significant glenohumeral osseous deficiency. However, it needs to be confirmed by appropriate imaging. CT scan currently seems to be the gold standard but other techniques can be used as well. The concept of glenoid track allows for evaluation of interplay between bipolar lesions and may help in the surgical decision making.

Keywords: shoulder instability, glenoid defect, Hill-Sachs lesion, shoulder arthroscopy, computed tomography

Date received: 20th January 2018
Date accepted: 10th February 2018

ubytków. Do stosowanych technik obrazowania należą: RTG, rezonans magnetyczny, tomografia komputerowa (KT) i artroskopia. Trójwymiarowa rekonstrukcja KT jest najdokładniejszą metodą identyfikacji i pomiarów ilościowych uszkodzeń. Mierzone są głównie rozmiar ubytku panewki i Hill-Sachsa. Dla ustalenia ryzyka nawrotu niestabilności ważnym elementem jest ocena tzw. uszkodzeń bipolarnych i ich wzajemnych relacji („szlak panewki”).

Wnioski

Dane kliniczne mogą wzbudzić podejrzenie obecności ubytków kostnych w niestabilności stawu ramiennego. Konieczne jest jednak ich potwierdzenie za pomocą właściwego obrazowania barku. KT jest aktualnie złotym standardem diagnostycznym. Koncepcja „szlaku panewki” pozwala na ocenę wzajemnych relacji uszkodzeń bipolarnych i może pomóc w podjęciu decyzji o technice operacyjnej.

Słowa kluczowe: niestabilność barku, ubytek panewki, uszkodzenie Hill-Sachsa, artroskopia barku, tomografia komputerowa

Data otrzymania: 20 styczeń 2018
Data zaakceptowania: 10 luty 2018

Introduction

Both glenoid and humeral defects have been attributed to have a significant impact on both the results and the choice of treatment in shoulder instability. Classic work by Burkhart and De Beer (2010) showed that soft tissue repair in the case of instability with significant glenoid defect (of pear-shape appearance) has major risk (67%) for early recurrence, as compared to 4% failure when no such lesion occurs. The authors found 100% failure rate in the patients treated with labral repair in the circumstance of engaging Hill-Sachs (HS). Boileau *et al.* (2006) found that bone defects increased the risk of lost stability after arthroscopic labral repair to 15%: including attritional glenoid defect (>25%) and Hill-Sachs Lesion with stretched anterior capsule. Biomechanical studies show that if significant boney support is lost, the soft tissue repair cannot restore stability. Clinical studies suggest addressing bone loss with appropriate reconstruction (coracoid transfer, bone block).

The reported rates of bone defect occurrence are diverse and range from 5–56% for glenoid and 65–93% for humeral head (Balg and Boileau 2007; Boileau *et al.* 2006; Burkhart *et al.* 2002; Lubiatowski 2016;

Mologne *et al.* 2007; Pagnani 2008; Sugaya *et al.* 2003; Sugaya *et al.* 2005; Zygmunt 2015). Boileau *et al.* presented 13% cases of attritional glenoid defects and 84% HS lesions (Boileau *et al.* 2006). Sugaya *et al.* (2003; 2005) reported 40% of cases with glenoid erosions, mostly medium size (5–20%) and small (<5%).

Therefore, the proper diagnosis both clinical and radiological has utmost importance in the management of shoulder instability with special attention to restoration of osseous anatomy of glenohumeral joint. The diagnostic approach should include: establishing the correct diagnosis, identification of multiple risk factors for recurrence, evaluation of morphology of lesions to finally come the decision of proposed treatment method.

Aim

The aim of the paper was to review the literature and share own-experience with clinical and radiological evaluation of bony defects of glenohumeral joint.

Material and methods

Literature review has been performed as well as the own results and experience have been presented.

Results and discussion

Clinical evaluation to detect bone defects

Increased suspicion of the bone defects can be raised already by taking the history (Ślęzak *et al.* 2016). There is some evidence that younger age at first dislocation and male sex are associated with higher incidence of the defects. Mechanism of the dislocation matters too, with higher risk if results from trauma or falling in abduction and externa rotation (ABER) position. The features of dislocation may be informative. There is 9.5 times higher chance of bone loss with increasing number of dislocations. Similar suspicion comes with increased ease of dislocation, failed previous repair and epileptic seizures. Experiencing dislocation vs. subluxation contributes to the size of HS lesions (3.9 mm vs 2.1 mm, respectively) (Bois *et al.* 2012; Ito *et al.* 2000; Milano *et al.* 2011; Thangarajah *et al.* 2015). Physical examination may suggest the osseous deficiency, with symptoms of clicking, catching and crepitation. Bushnel *et al.* (2008) described and assessed the "bony" apprehension test. According to authors test is positive and suggests the glenoid defect >25% or engaging HS if patient is apprehensive in mid-range of shoulder motion (45˚ abduction and 45˚ external rotation). The test showed 100% sensitivity and 86% specificity.

The most important part of evaluation is the imaging to identify and measure the bone loss. The evaluation focuses on both glenoid (erosions, avulsion fracture-bony Bankart) and humeral head (HS lesion). However, both in the past and even more so recently the evaluation of interplay between the so called bipolar lesions (engagement/glenoid track) has been emphasized.

First line of evaluation is always standard radiographic evaluation. Balg and Boileau (2007) identified the glenoid defect on "true" antero-posterior (AP) view by loos of glenoid contour.

Edwards defined different types of glenoid defects that can be visible on axial radiographs (West-Point, Bernageau)(Edwards *et al.* 2003):

- bony Bankart lesion- avulsed glenoid rim fragment visible,
- cliff-sign- anterior glenoid rim loss, no fragment visible,
- blunted angle (rounding of glenoid rim) (Figure 1).

Humeral head defects can be identified on both AP and Stryker Notch view. The AP view is a part of ISIS score widely used for decision making in shoulder instability (Balg and Boileau 2007). Rouleau *et al.* (2012) showed that the use of ISIS reflected the surgical decision and has high test-retest value (ICC of 0,933) . The diagnostic value of AP radiographs in detection of the

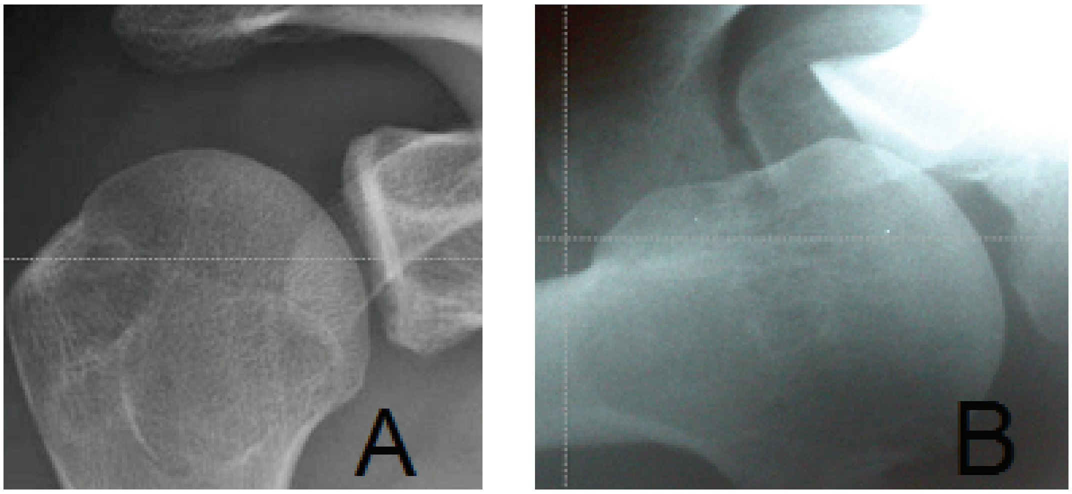

Figure 1. Radiographic evaluation of glenohumeral joint. True AP view showing lost contour of inferior glenoid (A); Axial West-Point view showing anterior glenoid defect (rounded rim) (B).

glenoid defect has been questioned recently. Bouliane *et al.* (2013) analyzed radiographic portion of ISIS. Evaluation showed only moderate intra-rater and inter-rater reliability (0.48–0.74) for glenoid defects and fair-to-almost-perfect intra-rater (0.56–0.74) and fair (0.31) inter-rater reliability. Since the significant part of ISIS score is based on radiographic evaluation, it should be used with caution if evaluation is performed based on plain X-rays.

Magnetic Resonance (*MR*) *and MR arthrography*

MR and MR arthrography is used by many as a standard evaluation protocol. It has several advantages:

- allows for evaluation of both the soft tissue and bone,
- highly accurate in detection of labral tears when used with intraarticular contrast,
- brings no exposure to radiation.

However, it also bears some weaknesses:

- it is less accurate then computed tomography (CT),
- it is more expensive and longer to acquire,
- it is no suitable for some patients (metal implants, pacemakers, size of patients, claustrophobia)
- depends on technical quality (technical error may mislead the judgment of morphology and cannot be corrected after the test),
- presents limited 3D options and reconstruction.

Most recent advances allow for 3D reconstruction base on MR scans. It has been shown by Yanke *et al.* (2017) based on cadaveric model that 3D-CT, 3D-MR (with 1.5T field) and 3D-MR (with 4T field) yielded similar results and strong correlation with actual defect size. We have currently started using the 3D-MR reconstruction experimentally with very promising results (Figure 2).

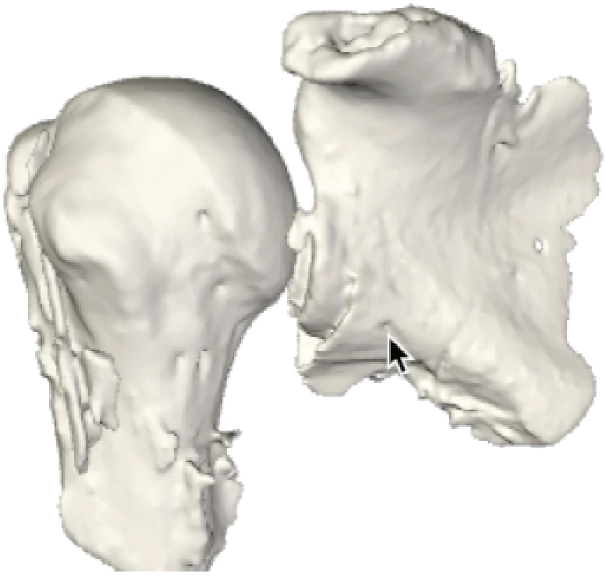

Figure 2. 3D MR reconstruction of the glenohumeral joint.

Computed Tomography
Based on the current knowledge, CT scan proves to be the gold standard of bone loss evaluation in shoulder instability. It provides high resolution allowing relatively easy and quick multiplanar and 3D reconstruction by means of easily available software. With the proper slice thickness, it is also immune to technical errors giving very reliable imaging data. Major drawback however remains the large exposure to radiation, especially if repeated examinations are performed in single patient.

Bishop *et al.* (2013) have shown that 3D-CT is the most reliable diagnostic tool in predicting glenoid bone loss, when compared to standard x-ray, MRI or 2D-CT. We have also proved that 3D-CT is more reliable than 2D-CT and its reliability does not depend on experience of evaluator (Kubicka *et al.* 2016).

Glenoid measurements
Multiple measurements have been described in literature for both glenoid and humeral head (Figure 3). Many of the measurements focus on estimation of glenoid defects, including width, length or surface of the defect.

Commonly used methods rely of surface loss using circle methods. Sugaya *et al.* (2003) described two circles that can be fitted into glenoid surface: small superior circle fills the upper portion, while the larger inferior circle fits into posterior, inferior and anterior glenoid. They have used 3D CT reconstruction for measurements, whereas similar approach has been reported by Baudi *et al.* (2005) based on 2D-CT multi-planar reconstruction (PICO method). Regardless the method, best fitted circle is placed in the lower part of affected glenoid. In the case, when bilateral CT scan has been acquired and the contralateral shoulder is not affected by instability it can be used to obtain the "normal" circle (Figure 4). The circle is then pasted into the affected glenoid. Any area of the circle that is not covered anteriorly by the glenoid represents the missing part/bone loss. It can be presented as percentage of the complete circle surface to show the size of bone defect.

Arthroscopic measurements
Burkhart *et al.* (2002) have suggested that glenoid bare spot can be used as a constant landmark from which bone loss can be measured. According the technique, distance between the center of the bare spot and both anterior and posterior margin of glenoid are equal. Thus, the segments can be measured with probe and linear size of the defect measured when anterior segment is shorter than the posterior (Figure 5).

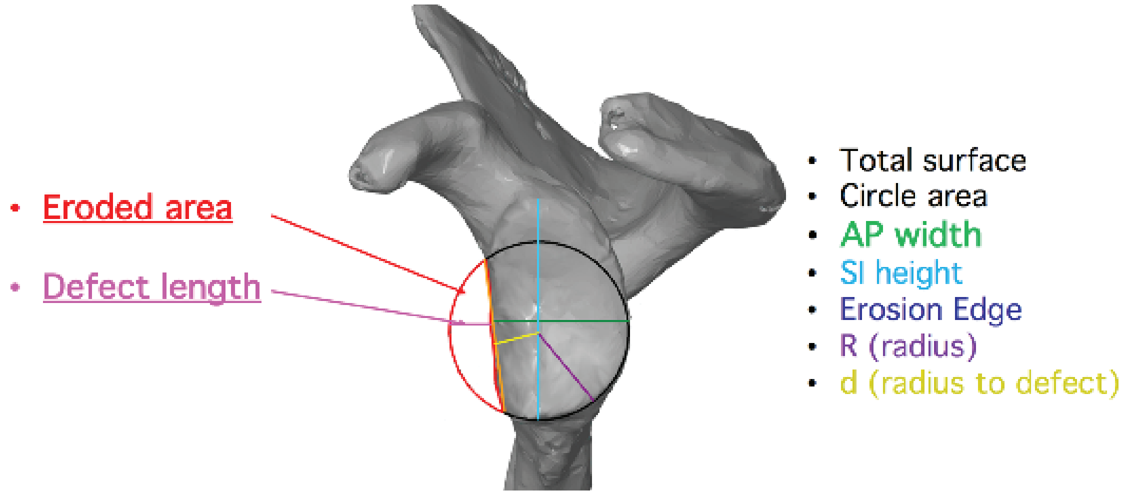

Figure 3. Glenoid measurement based on 3D reconstruction of CT scan.

However, some studies showed that this technique has low reliability. Aigner *et al.*

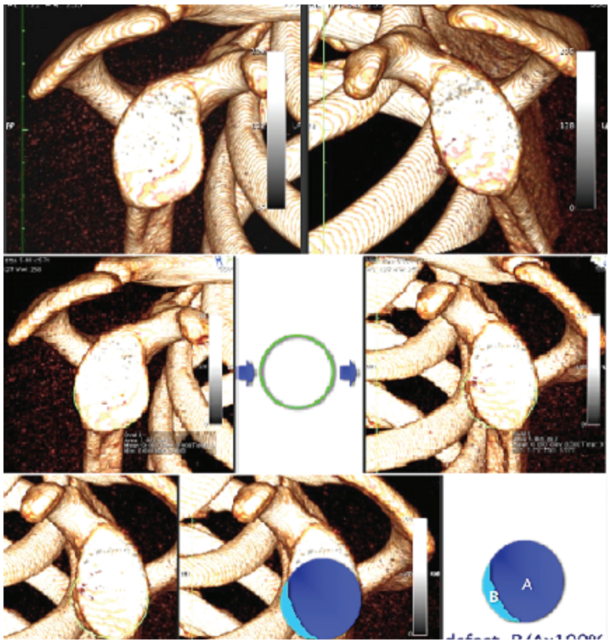

Figure 4. Circle surface evaluation of glenoid defect according to Sugaya's method.

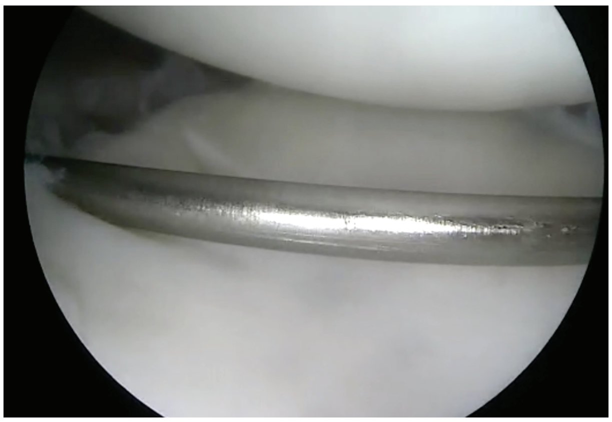

Figure. 5. Arthroscopic measurements of glenoid width and defect based on the bare spot.

(2004) showed in the cadaveric study that the bare sport was eccentric in the most of the examined glenoids. Saintmard *et al.* (2009) reported that bare spot could be visible in only 48% of cases in arthroscopy and in 26% in CT scan.

Humeral Head measurements

Humeral head measurements focus generally on HS defects, including its length, width, depth, angle, volume, surface and position. Saito *et al.* (2009) have found that average depth of HS lesion is 5 mm ± 4.0 mm and its position on horizontal CT scan at 6:46–8:56 o'clock with orientation of 7:58. Rowe *et al.* (1984) have introduced grading based on the depth and length:

- mild: HS lesion less than 0.5 cm deep and less then 2 cm long,
- moderate: HS lesion 0.5–1 cm deep and 2–4 cm long,
- severe: HS lesion more than 1 cm deep and more then 4 cm long.

Flatow *et al.* (1998) described 3 categories of HS defects based on percentage of involvement of the humeral head: clinically insignificant (<20%), variable (20–40%) and significant (>40%).

Calandra et al. (1989) concentrated on the depth and proposed:

- grade I – affecting just articular cartilage,
- grade II – extending into subchondral bone,
- grade III – large subchondral defect.

What is significant bone loss?

This issue had been debated with no clear and unequivocal data. Various studies have a slightly different approach. Burkhart *et al.* (2010) suggested primarily that significant bone loss when glenoid gets a shape of inverted pear and HS lesions engages in ABER position. Yamamoto *et al.* (2007; 2010) found in their biomechanical analysis that if osseous defect if larger than 25% of glenoid surface shoulder remains unstable even after Bankart repair. More recently Arciero *et al.* (2015) found that anterior glenoid deficiency of 2 mm (8%) accompanied by medium sized HS lesion (1.5 cm³) may compromise Bankart repair. Similarly, slightly larger glenoid defect (≥ 4-mm–15%) could lead to repair failure with only small-sized HS lesions of 0.8 cm³ volume.

Another issue is that methods of evaluation may not necessarily being comparable to one another. Piasecki *et al.* (2009) performed the literature review and compared 3 different techniques with suggestion of clinical significance of particular deficits: AP defect in mm, AP defect in percentage, surface defect (table). The borderline deficits of glenoid loss (20%) may become clinically significant when accompanied by co-exiting risk factors (laxity, contact sports) (Boileau *et al.* 2006; Parke *et al.* 2012; Piasecki *et al.* 2009; Yamamoto *at al.* 2007; 2009).

Bipolar lesions

Recently the importance of so called bipolar lesions and their interplay gained more attention. Classic concepts of engaging versus non-engaging lesions have been questioned since all lesions really engage during dislocation or subluxation. Kurokawa *et al.* (2013) proposed to define the engagement for the situation when HS lesions still engages after labral repair. The occurrence of such engagement has been reported to affect 7.1% cases (Parke *et al.* 2012). New concept has been proposed by Yamamoto *et al.* looking at not only size but also position of HS defect (Yamamoto *et al.* 2007; 2010). The authors found that track of glenoid shifts from anteromedial to posterolateral direction during elevation, external rotation and horizontal extension of the arm. Glenoid track is the contact area between glenoid and humeral head calculated from medial margin of the rotator cuff footprint to the medial margin of the track (anterior glenoid rim). If the HS defect stays within the track in ABER position then risk of engagement is low (on-track lesion)(Figure 6).

However, if HS extends medial over the glenoid track the risk of engagement increases (of-track lesion). Occurrences of off-track lesions have been reported as 7% (Kurokawa *et al.* 2013) (Figure 7).

The risk of the lesion falling “off-track” increases with: wider HS lesion, HS lesion located more medially and anterior glenoid

Figure 6. Photographs presenting “on-track” lesions based on cadaver, CT based 3D printed model and arthroscopic view.

Figure 7. Photographs presenting "off-track"lesions based on cadaver, CT based 3D printed model.

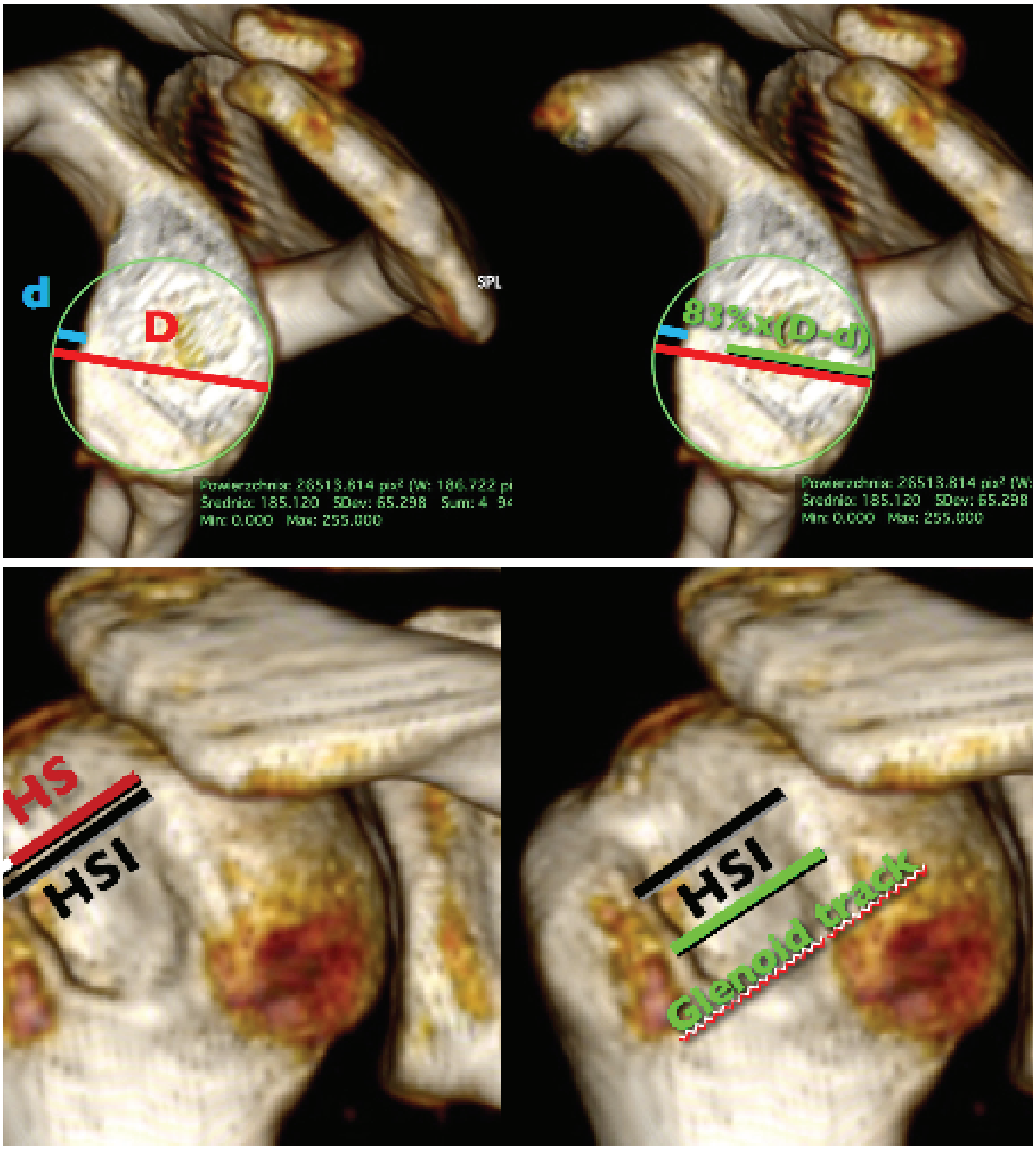

Figure 8. Glenoid track measurements based on 3D-CT scan. Glenoid track is calculated by deducting defect size in mm (d) from predicted normal glenoid width (D). Track size is estimated as 83% of the difference. Then HS index (HSI) is calculated by adding HS width and bone bridge (BB) between HS and tendon attachment. HS is off-track if HSI is larger than glenoid track.

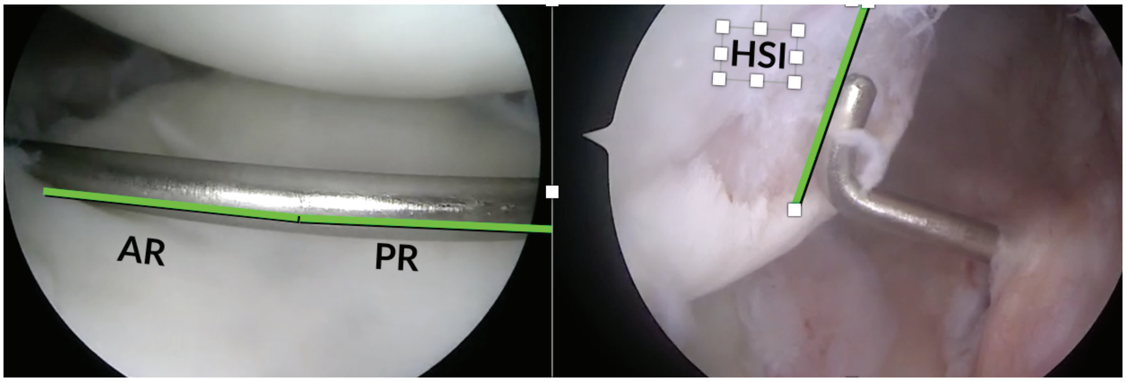

Figure 9. Arthroscopic measurements of glenoid track using probe. "d" is calculated as difference of 2x PR and 1xAR. HSI is then measured. Further calculations are performed as described in previous figure.

deficiency. The interplay of bipolar lesions can be predicted and calculated based on both CT scan (Figure 8) and arthroscopy (Figure 9).

Basing on this concept Di Giacomo *et al.* () have proposed treatment algorithm suggesting Bankart repair in case of glenoid with defects of less than 25% and HS remaining on track (Table 1) (Di Giacomo *et al.* 2014). For larger defects and HS extending beyond track glenoid augmentation should be considered. Its clinical use and relevance needs to be showed by clinical studies. Other risk factors should also be considered in choosing the optimal surgical technique (laxity, tissue quality, age, sport involvement, previous surgeries).

Conclusions

Clinical data may increase suspicion of significant glenohumeral osseous deficiency. This however needs to be confirmed by appropriate imaging. CT scan currently seems to be the gold standard but other techniques can be used as well. Among numerous measurements surface of the glenoid using the circle technique is most commonly utilized as well as size and position of HS lesions. New concept of glenoid track allows for evaluation of interplay of bipolar lesions. The concept may to help in the surgical decision making.

Table 1. Treatment strategy in traumatic shoulder instability based on evaluation of glenohumeral defects and glenoid track concept.

Group	Glenoid defect	Hill-Sachs Lesion	Strategy
1	< 25%	On track	AS Bankart
2	< 25%	Off track	AS Bankart + remplissage
3	≥ 25%	On track	Latarjet/bone graft
4	≥ 25%	Off track	Latarjet + humeral procedure (remplissage, graft, resurfacing)

REFERENCES

Aigner, F., Longato, S., Fritsch, H., Kralinger, K. (2004) *'Anatomical considerations regarding the "bare spot" of the glenoid cavity.'* Surg Radiol Anat., 26, pp. 308–311.

Arciero, R.A., Parrino, A., Bernhardson, A.S., Diaz-Doran, V., Obopilwe, E., Cote, M., Golijanin, P., Mazzocca, A.D., Provencher, M.T. (2015) *'The Effect of a Combined Glenoid and Hill-Sachs Defect on Glenohumeral Stability A Biomechanical Cadaveric Study Using 3-Dimensional Modeling of 142 Patients.'* Am J Sports Med., 43 (6), pp. 1–8.

Balg, F., Boileau, P. (2007) *'The instability severity index score: a simple pre-operative score to select patients for arhroscopic or open shoulder stabilization.'* J Bone Joint Surg Br., 89-B, pp. 1470–1477.

Baudi, P., Righi, P., Bolognesi, D. (2005) 'How to identify and calculate glenoid bone deficit.' Chir Organi Mov., 90(2), pp. 145–152.

Bishop, J.Y., Jones, G.L., Rerko, M.A., Donaldson, C. (2013) *'3-D CT is the Most Reliable Imaging Modality When Quantifying Glenoid Bone Loss.'* Clin Orthop Relat Res., 471, pp. 1251–1256.

Boileau, P., Villalba, M., Héry, J.Y., Balg, F., Ahrens, P., Neyton, L. (2006) *'Risk factors for recurrence of shoulder instability after arthroscopic Bankart repair.'* J Bone Joint Surg Am., 88(8), pp. 1755–1763.

Bois, A.J., Fening, S.D., Polster, J., Jones, M.H., Miniaci, A. (2012) *'Quantifying glenoid bone loss in anterior shoulder instability: reliability and accuracy of 2-dimensional and 3-dimensional computed tomography measurement techniques.'* Am J Sports Med., 40(11), pp. 2569–2577.

Bouliane, M.J., Chan, H., Kemp, K., Glasgow, R., Lambert, R., Beaupre, L.A., Sheps, D.M., (2013) *'The intra- and inter-rater reliability of plain radiographs for Hill-Sachs and bony glenoid lesions: evaluation of the radiographic portion of the instability severity index score.'* Shoulder & Elbow, 5, pp. 33–38.

Burkhart, S.S., De Beer, J.F. (2010) *'Traumatic glenohumeral bone defects and their relationship to failure of arthroscopic Bankart repairs: significance of the inverted-pear glenoid and the humeral engaging Hill-Sachs lesion.'* Arthroscopy, 16(7), pp. 677–694.

Burkhart, S.S., DeBeer, J.F, Tehrany, A.M., Parten, P.M. (2002) *'Quantifying Glenoid Bone Loss Arthroscopically in Shoulder Instability.'* Arthroscopy, 18 (5), pp. 488–491.

Bushnell, B.D., Creighton, R.A., Herring, M.M. (2008) *'The bony apprehension test for instability of the shoulder: a prospective pilot analysis.'* Arthroscopy, 24(9), pp. 974–082.

Calandra, J.J., Baker, C.L., Uribe, J. (1989) *'The incidence of Hill-Sachs lesions in initial anterior shoulder dislocations.'* Arthroscopy, 5(4), pp. 254–257.

Di Giacomo, G., Itoi, E., Burkhart, S.S. (2014) *'Evolving Concept of Bipolar Bone Loss and the Hill-Sachs Lesion: From 'Engaging/Non Engaging" Lesion to 'On-Track/Off-Track" Lesion.'* Arthroscopy, 30(1), pp. 90–98.

Edwards, T.B., Boulahia, A., Walch, G. (2003) *'Radiographic analysis of bone defects in chronic anterior shoulder instability.'* Arthroscopy, 19, pp. 732–739.

Flatow, E.L., Warner, J.I. (1998) *'Instability of the shoulder: Complex problems and failed repairs. Part I: Relevant biomechanics, multidirectional instability, and severeglenoid loss.'* Instr Course Lect., 47, pp. 97–112.

Ito, H., Takayama, A., Shirai, Y. (2000) *'Radiographic evaluation of the Hill-Sachs lesion in patients with recurrent anterior shoulder instability.'* J Shoulder Elbow Surg., 9(6), pp. 495–497.

Kubicka., A.M., J. Stefaniak, Lubiatowski, P., Długosz, J., Dzianach, M., Redman, M., Piontek, J., Romanowski, L. (2016) *'Reliability of measurements performed on two dimensional and three dimensional computed tomography in glenoid assessment for instability.'* Int Orthopaedics, 40(12), pp. 2581–2588.

Kurokawa, D., Yamamoto, N., Nagamoto, H., Omori, Y., Tanaka, M., Sano, H., Itoi, E. (2013) *'The prevalence of a large Hill-Sachs lesion that needs to be treated.'* J Shoulder Elbow Surg., 22, pp. 1285–1289.

Lubiatowski, P. (2016) *'Recurrence of instability after the Latarjet procedure'* Issue Rehabil. Orthop. Neurophysiol. Sport Promot., 14, pp. 27–36.

Milano, G., Grasso, A., Russo, A., Magarelli, N., Santagada, D.A., Deriu, L., Baudi, P., Bonomo, L., Fabbriciani, C. (2011) *'Analysis of risk factors for glenoid bone defect in anterior shoulder instability.'* Am J Sports Med., 39(9), pp. 1870–1876.

Mologne, T.S., Provencher, M.T., Menzel, K.A., Vachon, T.A., Dewing, C.B. (2007) *'Arthroscopic stabilization in patients with an inverted pear glenoid: results in patients with bone loss of the anterior glenoid.'* Am J Sports Med., 35(8), pp. 1276–1283.

Pagnani, M.J. (2008) *'Open capsular repair without bone block for recurrent anterior shoulder instability in patients with and without bony defects of the glenoid and/or humeral head.'* Am J Sports Med., 36(9), pp. 1805–1812.

Parke, C.S., Yoo, J.H., Cho, N.S., Rhee, Y.G. (2012) *'Arthroscopic remplissage for humeral defect in anterior shoulder instability: Is it needed?'* 39th Annual Meeting of Japan Shoulder Society, Tokyo, October 5–6, 2012.

Piasecki, D.P., Verma, N.N., Romeo, A.A., Levine, W.N., Bach Jr, B.R., Provencher, M.T. (2009) *'Glenoid Bone Deficiency in Recurrent Anterior Shoulder Instability: Diagnosis and Management.'* J Am Acad Orthop Surg., 17, pp. 482–493.

Rouleau AJSM 2012

Rowe, C.R., Zarins, B., Ciullo, J.V. (1984) *'Recurrent anterior dislocation of the shoulder after surgical repair: Apparent causes of failure and treatment.'* J Bone Joint Surg Am., 66(2), pp. 159–168.

Saintmard, B., Lecouvet, F., Rubini, A., Dubuc, J.E. (2009) *'Is the bare spot a valid landmark for glenoid evaluation in arthroscopic Bankart surgery?'* Acta Orthop. Belg., 75, pp. 736–742.

Saito, H., Itoi, E., Minagawa, H., Yamamoto, N., Tuoheti, Y., Seki, N. (2009) *'Location of the Hill-Sachs lesion in shoulders with recurrent anterior dislocation.'* Arch Orthop Trauma Surg., 129, pp. 1327–1334.

Sugaya, H., Moriishi, J., Dohi, M., Kon, Y., Tsuchiya, A. (2003) *'Glenoid rim morphology in recurrent anterior glenohumeral instability.'* J Bone Joint Surg Am., 85-A(5), pp. 878–884.

Sugaya, H., Moriishi, J., Kanisawa, I., Tsuchiya, A. (2005) *'Arthroscopic osseous Bankart repair for chronic recurrent traumatic anterior glenohumeral instability.'* J Bone Joint Surg Am., 87(8), pp. 1752–1760.

Ślęzak, M., Lubiatowski, P., Lubiatowski, B., Łepski, M., Imirowicz, A., Olczak, I., Kowalik, Ł., Romanowski, L. (2016) *'Polish cultural adaptation of shoulder assessment scores for shoulder instability: WOSI, Oxford Shoulder Instability Score, Walch-Duplay* (*Part II*)*. Preliminary study.' Issue Rehabil. Orthop. Neurophysiol. Sport Promot., 17, pp. 28–46.*

Thangarajah, T., Lambert, S. (2015) *'The management of recurrent shoulder instability in patients with epilepsy: a 15-year experience.'* J Shoulder Elbow Surg., 24(11), pp. 1723–1727.

Yamamoto, N., Itoi, E., (2015) *'Osseous Defects Seen in Patients with Anterior Shoulder Instability'* Clinics in Orthopedic Surgery, 7, pp. 425–429.

Yamamoto, N., Itoi, E., Abe, H., Minagawa, H., Seki, N., Shimada, Y., Okada, K. (2007) *'Contact between the glenoid and the humeral head in abduction, external rotation, and horizontal extension: A new concept of glenoid track.'* J Shoulder Elbow Surg.,16, pp. 649–656.

Yamamoto, N., Muraki, T., Sperling, J.W., Steinmann, S.P., Cofield, R.H., Itoi, E., An K.N. (2010) *'Stabilizing Mechanism in Bone-Grafting of a Large Glenoid Defect.'* J Bone Joint Surg Am., 92, pp. 2059–2066

Yanke, A.B., Shin, J.J, Pearson, I., Bach Jr. B.R., Romeo, A.A., Cole, B.J., Verma, N.N. (2017) *'Three-Dimensional Magnetic Resonance Imaging Quantification of Glenoid Bone Loss Is Equivalent to 3-Dimensional Computed Tomography Quantification: Cadaveric Study.'* Arthroscopy, 33 (4), pp. 709–715.

Zygmunt, A., Lubiatowski, P., Lisiewicz, E., Stefania, J., Kaczmarek P., Romanowski, L.(2015) *'Assessment of the shoulder function* *after arthroscopic surgery of shoulder joint instability.'* Issue Rehabil. Orthop. Neurophysiol. Sport Promot., 5, pp. 4–14.

Authors reported no source of funding.
Authors declared no conflict of interest.

Autorzy nie zgłosili źródła finansowania.
Autorzy nie deklarowali konfliktu interesów.

Author responsible for correspondence:
Przemysław Lubiatowski
Department of Traumatology, Orthopaedics and Hand Surgery, University of Medical Sciences in Poznan, Poland
28 Czerwca 1956 Str., No 135/147
61-545 Poznan, Poland
p.lubiatowski@rehasport.pl

Autor odpowiedzialny za korespondencję:
Przemysław Lubiatowski
Katedra i Klinika Traumatologii, Ortopedii i Chirurgii Ręki
Uniwersytet Medyczny w Poznaniu
Ul. 28 Czerwca 1956, 135/147
61-545 Poznań, Polska
p.lubiatowski@rehasport.pl