Review Article

Obere Extremität 2021 · 16:22–26
https://doi.org/10.1007/s11678-020-00618-5
Received: 12 October 2020
Accepted: 27 November 2020
Published online: 22 December 2020

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State-of-the art treatment of bony defects in anterior shoulder instability—the European perspective

Shoulder instability is a common pathology that mostly affects young patients [40]. The causes can be either of structural nature (structural shoulder instability) or functional nature (functional shoulder instability; [26]). A key step for successfully treating shoulder instability is the identification of the cause of instability and its subsequent elimination with a specific surgical procedure (structural instability) or physiotherapeutic intervention (functional instability). The purpose of this review is to provide an overview of the European perspective of how to treat structural bony defects in patients with anterior shoulder instability.

Glenoid bone loss

Glenoid bone loss in patients with anterior shoulder instability is a major risk factor for recurrence of instability after soft tissue stabilization surgery [9, 36]. It has been widely accepted that in the case of significant glenoid bone loss, a bony glenoid reconstruction surgery should be performed instead of simply soft tissue stabilization [10]. Since Burkhart and De Beer first highlighted the importance of general glenoid bone loss in the year 2000 [9], several clinical and biomechanical studies have tried to establish the critical threshold that makes a glenoid defect significant.

The earliest biomechanical studies found that the critical glenoid bone loss starts at approximately 20–30% [21, 37, 38]. The main problem was the lack of agreement in terms of measurement technique for bone loss. Among others, the two most common measurements, defect diameter and defect area, were viewed as one and the same in clinical as well as scientific practice. However, these two measurement techniques render widely differing results and have a nonlinear relationship ([6, 31]; ◘ **Fig. 1**). Therefore, several study results reporting on glenoid bone loss have to be reinterpreted. If, for example, the results of the aforementioned earliest biomechanical studies are translated to the Pico method (3D en-face defect area measurement in relation to a best-fit circle; [5]), the critical glenoid bone loss would start at 14–25%.

Furthermore, on closer inspection, the biomechanical data show a progressive but not abrupt decrease of stability with increasing glenoid bone loss, meaning that in reality the critical threshold value will also be variable depending on patient-specific factors such as age and activity level. Accordingly, Bankart surgeries in a cohort of non-athletic patients with large glenoid defects (20–29% diameter or 14–24% area) showed excellent clinical results with a low recurrence rate [22], while Bankart surgeries in a highly active cohort of patients rendered unsatisfactory results already starting with small glenoid defects of 13.5% diameter, which translates to 8% area [35].

Furthermore, in a recent rigid-body computer simulation, it was shown that current (mono- or two-dimensional) measurement techniques oversimplify the issue as they do not account for the concave shape of the glenoid that is responsible for bone-mediated stability by means of the so-called concavity compression effect. In fact, when considering the concave shape of the glenoid, it shows that the relationship between the glenoid defect size and the resulting biomechanical effect is non-linear and that smaller defects have a far greater impact than previously acknowledged [25]. Additionally, a case–control study found large interindividual glenoid shape differences in terms of concavity depth. Patients with unilateral shoulder instability showed significantly flatter glenoids on the unaffected side than did healthy controls. This means that several patients with instability have constitutional biomechanically relevant glenoid shape deficiencies that are not accounted for with current measurement techniques (◘ **Fig. 2**; [27]).

> Increasing glenoid bone loss leads to a gradual decrease of stability

In summary, it can be stated that all glenoid defects lead to a loss of glenohumeral stability. The degree of loss of stability depends on individual constitutional shape differences and the defect extent that needs to be analyzed in a three-dimensional context. The fact that software allowing for these kinds of complex analyses in daily clinical practice are currently not available along with the fact

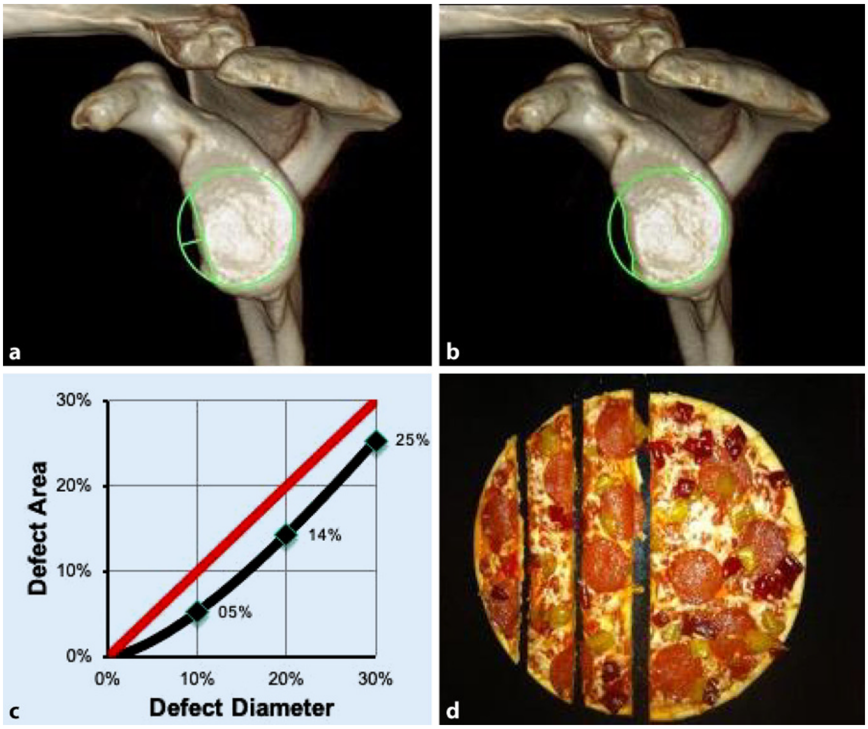

Fig. 1 ▲ Two-dimensional en-face measurement technique for **a** defect diameter and **b** defect area in relation to a best-fit circle of the glenoid. **c** The relationship between both measurements is nonlinear as outlined in the graph. **d** The pizza slice analogy helps to understand this nonlinear relationship. If a pizza is cut into stripes of equal diameter, the outer stripes will have less area than the central stripes

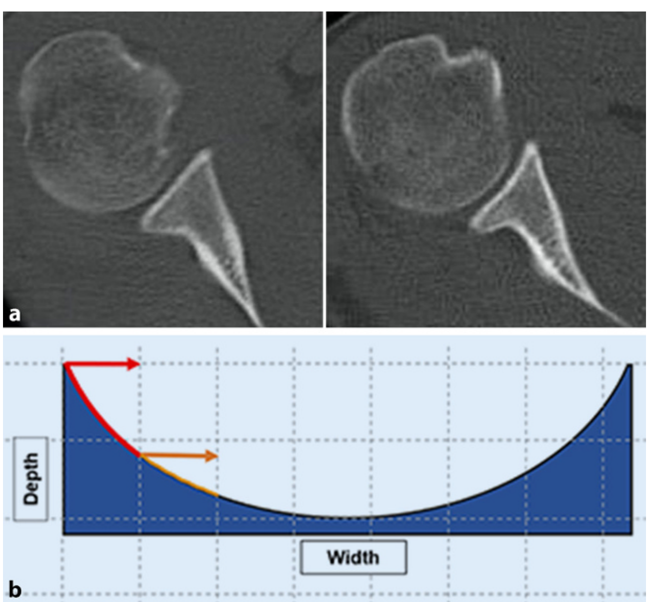

Fig. 2 ▲ **a** Axial computed tomography scans of two right shoulders showing individual constitutional glenoid concavity shape differences. **b** The theoretical half-pipe example shows that the first meter of defect (*red line*) leads to more loss of concavity than the second meter (*orange line*). By analogy, the first millimeter of glenoid defect counts the most in terms of stability. (With kind permission of SAGE Journals [25])

that patient-specific factors such as age and activity level have a significant influence on the clinical effect of glenoid bone loss called into question our natural tendency of trying to set a general threshold value for critical glenoid bone loss in anterior shoulder instability.

Hill–Sachs defect

Similar to glenoid defects, Hill–Sachs defects of the humeral head are also a risk factor for instability. However, the mechanism of instability is different. While glenoid defects diminish the stability ratio of the joint by reducing the concavity ("the ball jumps out of the socket more easily"), Hill–Sachs defects can engage with the glenoid rim during end-range of motion. As explained in the glenoid track concept [15], glenoid defects can increase the risk of engagement, as the glenoid track becomes narrower ("the narrow glenoid falls into the Hill–Sachs defect more easily") thus creating a synergistic negative effect. Biomechanical studies showed that in the presence of a combined Hill–Sachs and glenoid defect (bipolar bone loss; ◘ **Fig. 3**) smaller defects that individually would be considered noncritical become critical defects [2, 18]. Accordingly, the appreciation of bipolar bone loss is a stronger predictor for recurrence of instability after Bankart repair than glenoid bone loss alone [34]. However, the identification of a threshold for critical Hill–Sachs lesions seems to be even more difficult than it is for glenoid defects when considering that the engagement largely depends on rotational capacity, which varies considerably between individuals depending on laxity.

Treatment approaches

Based on the aforementioned considerations, bony stabilization surgeries (e.g., Latarjet or free bone graft transfers) have gained ground against soft tissue stabilization techniques (e.g., Bankart Repair). While a large majority of instability cases are still treated with Bankart surgeries, some authors advocate for the general replacement of Bankart surgeries with the Latarjet due to an admittedly higher stabilization success rate, especially in the long-term follow-up [41]. However, there is also concern regarding this approach, as it leads to overtreatment of patients with a non-anatomical procedure that carries a rather high risk for complications. Obviously, this rate of complications varies from surgeon to surgeon. While we reported low rates of complications in a prospective randomized trial [29], up to 30% of complication rate have been reported in systematic reviews [11]. Hardware problems are among the most frequently mentioned complications. This might be explained by the fact that if bony stabilization techniques are used in the case of no or little bone loss, the graft undergoes extensive resorption processes according to Wolff's law [17] which might lead to secondary hardware protrusion into the subscapularis or even into the joint. This graft resorption has been reported for the Latarjet procedure [14] as well as for the free bone graft transfers [24, 28]. Due to these considerations, an undifferentiated switch from soft tissue to bony stabilization procedures seems to be overtreatment that comes at a price. On the other hand, it cannot be ignored that the soft tissue stabilization procedures show quite high redislocation rates at long-term follow-up [30]. A patient-specific approach factoring in not only bony defects but also other risk factors such as, for example, age and activity level seems feasible [3, 16]. When deciding which bony glenoid reconstruction surgery to choose between Latarjet and free bone graft transfers (e.g., iliac crest bone grafts), there is evidence that both lead to similar outcomes and mostly differ regarding their types of complications [29].

» Free bone graft transfers and coracoid transfers lead to similar clinical outcomes

Examples of recent attempts to decrease complication rates for both methods include altered fixation types in the form of endobuttons [8] or the use of allografts for the free bone graft transfers [33]; however, both modifications still need further evaluation [7, 19].

Abstract · Zusammenfassung

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P. Moroder

State-of-the art treatment of bony defects in anterior shoulder instability—the European perspective

Abstract

Depending on their size, all glenoid defects lead to a certain amount of loss of glenohumeral stability and therefore may represent a risk factor for the recurrence of instability after soft tissue stabilization procedures. The degree of loss of stability depends not only on the extent of the defect but also on differences in individual constitutional shape, which need to be analyzed in a three-dimensional context. Additionally, patient-specific factors such as age and activity level have a significant influence on the clinical effect of glenoid bone loss. Therefore, when treating a patient with glenoid bone loss, a bony glenoid reconstruction surgery in the form of a free bone graft transfer or Latarjet should be considered based on the extent of the defect, native glenoid shape, age, and activity level. Furthermore, in the presence of a relevant Hill–Sachs defect, the addition of a remplissage to a Bankart procedure should be considered or the use of a bony glenoid augmentation procedure instead.

Keywords

Shoulder instability · Glenoid defect · Hill-Sachs lesion · Bone loss · Latarjet · Bone graft

Goldstandard in der Behandlung knöcherner Defekte bei vorderer Schulterinstabilität – die europäische Sichtweise

Zusammenfassung

Abhängig von ihrer Größe führen alle Glenoiddefekte zu einem mehr oder weniger relevanten Verlust von glenohumeraler Stabilität und müssen deshalb als ein Risikofaktor für Rezidivinstabilität nach Weichteilstabilisierungsoperationen der Schulter angesehen werden. Das Ausmaß des Stabilitätsverlusts hängt jedoch nicht nur von der Defektgröße ab, sondern auch von der individuellen Glenoidmorphologie, welche in einem dreidimensionalen Kontext betrachtet werden muss. Zusätzlich haben patientenspezifische Faktoren wie Alter und Aktivitätsniveau einen großen Einfluss auf die klinische Auswirkung von Glenoiddefekten. Deshalb sollte bei Patienten mit Glenoiddefekt nicht nur die Defektgröße, sondern auch die individuelle Glenoidmorphologie, das Patientenalter und Aktivitätsniveau in die Entscheidung für oder gegen eine knöcherne Glenoidrekonstruktionstechnik in Form einer Spanplastik oder einer Latarjet-Operation mit einbezogen werden. Zusätzlich sollte im Fall einer relevanten Hill-Sachs-Läsion die Durchführung einer Remplissage als Zusatz zur Bankart-Operation erwogen werden oder stattdessen die Durchführung einer knöchernen Glenoidaugmentationsoperation.

Schlüsselwörter

Schulterinstabilität · Glenoiddefekt · Hill-Sachs Läsion · Knochendefekt · Latarjet · Spanplastik

Regarding the Hill–Sachs defect, there is growing evidence that its treatment in the form of a remplissage can improve outcomes in terms of stability [4, 20, 23]. However, this procedure conveys the risk for affecting rotational range of motion [1, 32]. As an alternative treatment, the Latarjet procedure has been proposed for patients with subcritical glenoid but critical Hill–Sachs defects as it leads to comparable stability levels. However, the restriction in range of motion is similar and the complication risk seems to be higher [12, 13]. Despite this elevated risk for complications, significant advantages have been observed in revision cases and contact athletes [39].

Practical conclusion

- **Even moderate glenoid defects are a relevant risk factor of recurrence of instability after soft tissue stabilization procedures.**
- **Therefore, a bony glenoid reconstruction surgery in the form of a free bone graft transfer or Latarjet should be considered based on the extent of**

Fig. 3 ▲ Three-dimensional computed tomography scan of a right shoulder joint showing bipolar bone loss (=glenoid defect and Hill–Sachs defect)

the defect and the patient's age and activity level.

- **The effect of Hill–Sachs lesions should not be disregarded. If a relevant Hill–Sachs defect is present, the addition of a remplissage to a Bankart procedure should be considered or the use of a bony glenoid augmentation procedure instead.**

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Compliance with ethical guidelines

Conflict of interest. P. Moroder declares that he has no competing interests.

For this article no studies with human participants or animals were performed by the author. All studies performed were in accordance with the ethical standards indicated in each case.

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