The Classic

Review of Burkhart and DeBeer's (2000) article on traumatic glenohumeral bone defects and their relationship to failure of arthroscopic Bankart repair: Where have we taken the concept of glenoid bone loss in 2023?

Elizabeth C. Bond, MB ChB, FRACS, Jonathon Florance, MD, Jonathan F. Dickens, MD, Dean C. Taylor, MD *

Duke Sports Sciences Institute, Duke Centre for Living Campus, 3475 Erwin Road, Durham, NC 27705, USA

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ABSTRACT

This classic discusses the original publication by Burkhart and DeBeer “Traumatic Glenohumeral Bone Defects and Their Relationship to Failure of Arthroscopic Bankart Repair” published in 2000 in Arthroscopy. At that time, the authors sought to understand the reasons behind the failure of arthroscopic soft tissue repair. Based on their findings, the authors introduced the concept of the inverted pear glenoid and engaging Hill-Sachs lesion which is now part of the orthopedic lexicon. The importance of bony pathologic changes in anterior glenohumeral instability has become so apparent, that it now forms the basis of clinical understanding and underpins treatment algorithms. Since this publication over 20 years ago, the idea of glenohumeral bone loss has been extensively explored and refined. There is no doubt of the importance of structural bone loss yet there is still uncertainty as to the best management of those with subcritical bone loss. The purpose of revisiting this classic article is to look at where we are in understanding recurrent instability and bony deficiency while appreciating how far we have come.

This review begins with a detailed summary of the classic article along with a historic perspective. Next, we look at the current evidence as it pertains to the classic article and how modern technology and innovation has advanced our ability to assess and quantify glenohumeral bone loss. We finish with expert commentary on the topic from two current surgeons with a research interest in shoulder instability to offer an insight into how modern surgeons view and address this issue. One of the original authors also reflects on the topic. The findings of this classic study changed the way we think about shoulder instability and opened the doors to an exciting body of research that is still growing today. Future research offers an opportunity for high quality evidence to guide management in the group of patients with subcritical bone loss and we eagerly await the results.

Introduction

Rationale for selecting this article

The classic work by Burkhart and DeBeer, published in 2000, introduced the concept of bony deficiency as a contributor to the failure of arthroscopic Bankart repair for anterior glenohumeral instability [1]. Beyond the identification of a risk factor for recurrent instability, this article provoked the orthopaedic community to think in depth about the reasons for failure of what was thought to be an anatomic soft tissue repair. In 2000, recurrence rates after arthroscopic Bankart repair ranged widely from 7% using modern suture anchor techniques that lateralized the capsulolabral complex, up to 44% for trans glenoid repairs which inherently medialized the labrum effectively creating an ALPSA lesion [2–4]. Once these technical issues had been delineated, Burkhart and DeBeer sought to understand the reasons for failure in technically excellent arthroscopic soft tissue repairs. They proposed that the primary driver of failure was not based in soft tissue, but the altered geometry of a joint with significant bone loss. They believed mechanically significant bone defects were not being recognised and addressed adequately, and sought to investigate and characterize traumatic bony deficiency as a risk factor for recurrent instability after Bankart repair (see Figs. 1 and 2).

* Corresponding author. Tel.: + (919) 668-1400.
E-mail addresses: Elizabeth.c.bond@duke.edu (E.C. Bond), Jonathon.florance@duke.edu (J. Florance), Jonathon.dickens@duke.edu (J.F. Dickens), Dean.taylor@duke.edu (D.C. Taylor).

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Based on their findings, the authors introduced the concept of the inverted pear glenoid and engaging Hill-Sachs lesion to characterize the bony cause of failure after treatment. We now know that up to 90% of patients with recurrent instability have either a glenoid or humeral bone defect [5] and that even first-time dislocations have a significant rate of bony Bankart injury or Hill-Sachs lesions with one prospective study demonstrating an average 6.8% glenoid bone loss after a first-time anterior instability event [6,7]. The importance of bony pathology in anterior glenohumeral instability has become so apparent, that it now forms the basis of clinical understanding and underpins treatment algorithms [8].

Summary of the classic

The purpose of the study described in The Classic was to evaluate the results of Bankart repair and to identify factors related to the recurrence of the instability. One hundred and ninety-four consecutive patients met inclusion criteria. The average follow-up was 27 months and all had a minimum follow-up of 14 months. The average age at the time of surgery was 27.9 years and 87.6% of the study population was male with the dominant arm involved in 72.7% of cases. There were 101 contact athletes and all patients underwent an anatomic arthroscopic Bankart repair using a standard surgical approach with an average of three suture anchors.

They defined significant humeral bone defects to be “engaging” Hill-Sachs lesions—where the lesion was oriented in such a way that it engaged with the anterior glenoid in a position of athletic function. Significant glenoid bone defects were defined as one in which the arthroscopic appearance of the glenoid was that of an “inverted pear”—where the inferior glenoid had a smaller diameter than the superior glenoid.

They reported a 10.8% overall recurrence rate. When looking at the population in two groups—those without significant bone defects (n = 173) and those with significant bone defects (n = 21) there was a 4% recurrence rate in the first group and 67% recurrence in the second group (p < 0.0001). In addition, they found that the recurrence rate for contact athletes without significant bone defects was 6.5%. Based on these findings, they concluded that the arthroscopic Bankart repair produces results equal to an open Bankart repair if there is no significant structural defect.

The article went on to describe in detail the concept of an engaging Hill-Sachs lesion and the inverted pear glenoid, providing rationale for recurrent instability based on the altered geometry of the joint secondary to the pathologic anatomy. They clearly articulated the mechanism, and in doing so, introduced a new concept to the orthopaedic community.
Consideration

Historic perspective

Anterior shoulder instability is a common pathology with the incidence of initial traumatic shoulder dislocation ranging from 8.2 per 100,000 person-years to an incidence 20 times higher in the military where the population is younger and more active [9,10]. Surgical intervention for shoulder instability began in the early 20th century, with soft-tissue techniques best popularized by Bankart after World War I [11]. Correction of bone deficits occurred decades later with Michael Latarjet describing an osteotomized coracoid bone block in 1954 [12]. Arthroscopic techniques for shoulder instability began in 1980 with recurrent instability rates nearly as high as 50% [12,13]. These rates improved significantly with the introduction of arthroscopic suture anchors in 1993 which replaced previous techniques of transglenoid sutures and bioabsorbable tacks [14–16]. The new anchors enabled surgeons to lateralise the capsulolabral complex to restore soft tissue tension, thus creating a more anatomic repair [12]. But without a full understanding of the risk factors that explained discrepancies in recurrence rates, critics of arthroscopic management were wary to move away from the standard of open surgical management. This article by Burkhart and DeBeer was the first to demonstrate bone loss as a critical risk factor for the failure of arthroscopic repair.

Current evidence as related to the original article

The Burkhart and DeBeer article firmly established bone loss as a consideration in repair of anterior shoulder instability, and their work has been repeatedly corroborated in the subsequent 20 years. Half a decade later, Balg and Boileau developed the instability severity score (ISS) based on 131 consecutive patients who underwent arthroscopic management for shoulder instability, demonstrating a 14.5% recurrence rate [17]. They analyzed risk factors and ultimately recommended a 10-point score that includes the presence of a Hill-Sachs lesion or loss of glenoid contour on radiographs. While well validated in many populations [18], more recently, the ISS was not found to be predictive of failure in preselected military populations [19,20]. In a response to that finding, Balg explained the difference derived from excluding patients with significant bone loss. He stated that predicting recurrent instability is more difficult after excluding patients with significant bone loss because it is such an important factor in stability [21].

After their landmark article, Burkhart and DeBeer subsequently published on their method of quantifying glenoid bone loss arthroscopically using the bare spot of the glenoid as a consistent reference point [22] and later further characterized the measurements of the “inverted pear” glenoid [23]. In considering standard AP and axillary radiographs, looking for loss of the sclerotic line of the anterior glenoid rim has been deemed sensitive but not specific [24]. Technique influences these values, with the West Point Axillary and Didiee views proving superior for identification of glenoid osseous lesions [25]. The first reported use of Computed Tomography (CT) to characterize glenoid morphology in recurrent shoulder instability was in 2003 [26]. Shortly thereafter, Burkhart published on a series of 25 patients who underwent arthroscopic management of anterior glenohumeral instability who received preoperative bilateral CT where the authors validated a CT measured index for treatment decisions made by arthroscopic evaluation [27]. CT evaluation has undergone several modifications with an attempt to improve measurements, most of which use a variation of a best-fit circle of the glenoid en face based on a cadaveric study by Huysmans et al. [28]. Researchers have demonstrated the ability to use 3D magnetic resonance imaging (MRI) for evaluation of glenoid bone loss with high inter- and intrareader correlation [29], and more recently demonstrated its accuracy in comparison to 3D CT [30].

The first attempt to classify glenoid lesions was by Bigliani in 1998 where the authors categorized 22 patients with recurrent anterior glenohumeral instability into three types, with the third category split into IIIA for less than 25% glenoid erosion and IIIB for greater than 25% erosion measured by radiograph or CT arthrography when radiographs were inconclusive [31]. While only one patient met the IIIB criteria necessitating a Latarjet procedure, this work established a clinical threshold for glenoid bone loss. Soon after, a cadaveric study using sequential osteotomies of the anteroinferior glenoid demonstrated stark decreases to stability upon an osseous defect of 21% of the glenoid width [32]. And while today it is widely accepted that greater than 20% glenoid bone loss is significant, it has been suggested that as little as 13.5% loss needs to be with reconstruction techniques that include bony augmentation of the glenoid [33]. In a different study, retrospective review of 133 consecutive patients who underwent arthroscopic Bankart repair and Hill-Sachs remplissage demonstrated an increased risk for failure and reoperation when glenoid bone loss was >10% [34]. At this time, there is an incomplete understanding of the implications of subcritical range (10%–20%) of glenoid bone loss.

In respect to humeral bone loss following anterior glenohumeral instability events, appreciation of the Hill-Sachs lesion with radiographs has been long described [35]. Given the poor sensitivity of AP and axillary views in identifying humeral bone loss [36], a low threshold for CT is recommended for patients with recurrent instability (Fig. 4). When a CT is unavailable, a notch view can be obtained [37]. When evaluating with CT, axial images often provide the best means to measure humeral defects and have been found to be reliable and accurate [38,39].

In considering humeral bone defects, the lesion size and its engagement with the glenoid remain clinically important but the thresholds of these parameters remain controversial and not precisely determined [40]. Calandra et al. provided an early arthroscopic classification system based on involvement of subchondral bone and size but without clear clinical correlation of these groups [41]. Others have shown that the size of the humeral defect is compounded by a concomitant glenoid defect, a phenomenon known as bipolar bone loss. Arciero et al. demonstrated that an otherwise small and clinically insignificant Hill-Sachs lesions can lead to 25% reduction of stability when paired with a 2-mm glenoid defect [42]. The amplifying effects of bipolar bone loss demonstrate the importance of the glenoid and humeral relationship as described by Burkhart’s and DeBeer’s concept of engaging humeral lesions. Engagement was expanded by Yamamoto et al. as they described the movement of the humeral head along the glenoid track [43]. This concept of on and off glenoid tracking was studied biomechanically by Gyftopoulos et al. utilizing MRI to accurately predict engagement in 84.2% of cases with a negative predictive value of 91.1% [44]. Later, Shaha et al. validated the concept clinically through retrospective review of 57 shoulders treated arthroscopically with Bankart reconstruction, which demonstrated 8%...
treatment failure for on-track lesions and 75% failure for off-track lesions (p < 0.01) [45]. Current understanding suggests recurrent instability is a complex interaction of glenoid and humeral bone loss which fits with Burkhart and DeBeer’s original thoughts on the altered geometry of the joint.

Additional expert opinion

Dean C. Taylor, MD

When I first read this article twenty-three years ago, it was a revelation . . . a true “A-ha!” moment (picture an image of a light bulb appearing above my head!). At West Point, we had embraced an aggressive approach to early arthroscopic treatment of traumatic anterior shoulder instability to include operatively treating patients with first-time anterior shoulder dislocations. We learned that 97% of first-time shoulder dislocations had anterior labral tears (Bankart lesions) [46]. We had an opportunity to restore the anatomy arthroscopically and we increasingly recommended arthroscopic Bankart repairs to patients with first-time traumatic shoulder dislocations. Our results were impressive. Essentially, we reversed the natural history of 80%–90% of recurrent instability by treating first-time anterior shoulder dislocations with an arthroscopic anatomic repair [47,48]. Restoring the anatomy restored the stability of the shoulder.

The Burkhart and DeBeer article changed our thinking. We realized that we were only focusing on restoring the soft tissue anatomy and forgetting about the bony anatomy, especially in patients with recurrent shoulder instability. We learned that we had to restore both the soft tissue anatomy, and address bone loss while individualizing the treatment for each patient. Whether that treatment was nonoperative, an arthroscopic Bankart repair, an open Bankart repair, or a bone-block procedure (like a Latarjet) depended on the individual’s circumstances, their pathologic anatomy, and their expectations.

Since 2000, our understanding of the importance of glenoid and humeral head bone loss has grown. We have expanded our arthroscopic and open surgical techniques to treat bone loss. We have also learned how to tailor our treatment to align with the expected outcomes and patients’ expectations, especially in deciding between nonoperative and operative treatment [49,50]. In 2023, although we know more about bone loss, we don’t know which operative techniques are best for each individual patient so we can also tailor our operative treatment to treat bone loss appropriately.

As an aside, the Burkhart and DeBeer publication contributed to the unintended consequence of decreasing appreciation for the utility of the open Bankart repair. The open Bankart repair was the standard procedure for anatomic surgical treatment of anterior shoulder instability prior to the introduction and refinement of arthroscopic techniques in the 1990s and early 2000s. Burkhart and DeBeer chose to compare arthroscopic repair to the Latarjet procedure, without including a comparison with open Bankart repairs. Many surgeons followed suit and either refined or expanded their arthroscopic techniques for recurrent instability, or jumped to Latarjet procedures for revisions or cases with bone loss. Over the last 20 years, the popularity of open Bankart repair has ebbed despite randomized trials showing lower recurrent instability rates of open versus arthroscopic Bankart repair [51]. Admittedly, more technically demanding and time consuming, the open Bankart remains an important technique, and one that should be in every surgeon’s arsenal for addressing the pathologic anatomy associated with anterior shoulder instability without extensive bone loss. The open Bankart repair reliably restores the pathologic anatomy by 1) reapproximating the capsulolabral complex to the glenoid rim; 2) addressing, arguably better than arthroscopic techniques, lax or pathologically deformed capsular anatomy; and 3) in cases of minimal or moderate bone loss, reinforcing the bony anatomy by incorporating available glenoid bone fragments in to the capsulolabral repair.

My current approach includes a shared decision-making process on nonoperative or operative treatment. When we decide on operative treatment, the discussion then centers on choosing from a broad range of surgical options to best restore the anatomy. Arthroscopic techniques include labral repair, capsular plication, closure of rotator interval capsular openings, and bony augmentation procedures. Open techniques include open Bankart repair, capsulorrhaphy, the Latarjet procedure, the Bristow procedure, and bony augmentation using both autogenous (e.g., iliac crest grafts) and allograft (e.g., distal tibial osteochondral grafts, humeral head grafts) sources. Our goal is to individualize surgical treatment through shared decision-making to find the best match for these techniques with each patient based on their pathologic anatomy, their risk profile, their activity levels, their preferences, and expected outcomes of the different treatment techniques based on available scientific evidence and my experience.

Burkhart and DeBeer helped us learn about the importance of bone loss in shoulder instability. This learning has created many new questions to answer. I look forward to seeing high quality comparative outcomes research answer these questions. These answers will ultimately help our patients by enhancing our ability to treat each patient individually, and optimize their outcomes.

Jonathan F. Dickens, MD

Twenty-three years following Burkhart and DeBeer’s seminal publication, their article remains the most cited article in the field of shoulder instability. Among the many contributions this article has provided to shoulder surgeons—the concept of the “inverted pear glenoid,” a practical description of engaging bipolar bone loss, and the in-depth analysis

Fig. 4. An example of the measurement of a Hills Sachs defect on 2D CT, courtesy of Dr Brian Lau, Duke University.
of anatomic risk factors for failure; perhaps the most impactful and relevant contribution was in defining the limitations of the arthroscopic Bankart repair. Among the several principal conclusions in the article, the authors’ note that contact athletes with bone deficiency require open surgery and those with significant bone loss should be considered for Latarjet. Spurred on by the contributions of Burkhart and DeBeer the understanding of bone loss has improved since 2000; the "critical" amount of bone loss has decreased, and our threshold for recommending open or concomitant procedures has been lowered. Some things, however, remain the same and as the authors note in the opening statement, “the debate over the supremacy of open versus arthroscopic surgical repair for traumatic anterior instability ranges now more energetically than ever.” To this end, future research needs to compare arthroscopic Bankart repair with remplissage, open Bankart repair, and Latarjet for subcritical bone loss. We hope this future research will provide much needed guidance to inform decision-making for the optimal surgical treatment in this at risk population, but regardless of the results of future study, we can be sure that the debate will continue to be energetic.

Stephen S. Burkhart, MD

I first met Joe DeBeer in Cape Town, South Africa, in the 90's, when I was a guest speaker for the South African Sports Medicine Association. Joe had an intense curiosity about the shoulder, and his practice, like mine, was comprised mostly of shoulder cases. Both of us were doing a great deal of shoulder arthroscopy, which was not too common in those days. We became friends, we corresponded and even got together socially at some international meetings. A year or so after our first meeting in South Africa, Joe and I met for dinner at an AAOS meeting in the US. We began to talk about the biggest unsolved problem in each of our practices. We both agreed that the problem for which we did not have a good answer was recurrent anterior instability in an athletic young person after a failed arthroscopic Bankart repair. We both suspected that unrecognized bone loss played a role, either on the glenoid side or on the humeral side or both. We talked about the loss of diameter of the inferior glenoid that we had observed (inverted-pear glenoid), as well as the importance of dynamic arthroscopy to see if the Hill-Sachs lesion engaged the anterior glenoid when the shoulder was taken to a position of combined abduction and external rotation (engaging Hill-Sachs). During that dinner, we decided to combine our cases of arthroscopic instability repair patients to test our hypotheses about bone loss, and that decision resulted in the article that we published in 2000 in Arthroscopy. At that same dinner, we talked about what to do for young patients with failed arthroscopic Bankart repairs. We suspected that unrecognized and unaddressed bone loss was most likely the cause of failure in such cases. We both knew that a repeat arthroscopic Bankart repair was likely to fail. But we also recognized that open surgery that did not address bone loss would also likely fail. Our experience with open soft tissue revisions in such cases was not very good. Even so, the open surgery experts of the day did not consider bone grafting to be a good option, and they were still recommending soft tissue procedures for revision cases.

During the dinner, we talked about the absurdity of performing a revision soft tissue repair that was virtually guaranteed to fail, and we resolved to find a better way for our patients. Joe had recently been to Lyon, France, to visit Gilles Walch. He was very impressed with Gilles’ performance of a Latarjet procedure. He sketched out for me on a napkin how Gilles had done his procedure. We both agreed that the Latarjet seemed to be an excellent procedure for treating bone loss, but we also thought the procedure would be improved by rotating the coracoid graft 90° on its long axis before fixing it to the glenoid, in order to create a congruent arc between the glenoid and the graft. Many people have stories about sketching their ideas on the back of a napkin in a restaurant or bar, but that is exactly what happened that evening.

When we each returned home after that AAOS meeting, we began collecting our data, and sharing it through the relatively new technology of e-mail. As far as I know, this was one of the very first orthopaedic studies that was done by surgeons on opposite sides of the world who communicated by email to complete the study. In the end, it was a very gratifying study that proved our hypothesis, and we knew we were onto something.

We also resolved to start using the Latarjet procedure to treat patients with significant bone loss. As for learning to do the Latarjet, I did my first one about 3 weeks after Joe explained to me how Gilles Walch had done the operation. I like to say that Gilles taught me how to do the Latarjet by means of a correspondence course taught by Joe DeBeer. I must admit that, on my first Latarjet, I was very surprised by how stable the shoulder became on the OR table, immediately after fixation of the graft. Even though that patient had significant bipolar bone loss, I could not manually dislocate his shoulder once the coracoid graft had been fixed in place. At that point, I was sold on the value of the Latarjet in treating this very difficult group of patients.

Years later, I was fortunate enough to collaborate with Dr’s DiGiacomo and Itoi to more thoroughly study the role of the Hill-Sachs lesion in recurrent instability, to reconcile the concept of the “engaging Hill-Sachs lesion” with the geometric constraints of the “glenoid track,” and to formulate a treatment paradigm based on our newly articulated “on-track/off-track” concepts. But that is another story for another day...

Conclusion

The findings of this classic study changed the way we think about shoulder instability by characterizing the bone defects associated with recurrence. According to US national data from 2010 to 2019 including over 100,000 procedures, arthroscopic repair remains the predominant treatment modality for shoulder instability, comprising 90% of all stabilization procedures [52]. In this population, the rate of recurrent instability was 10.2% after arthroscopic stabilization and 12.3% after open stabilization. While we have made incredible progress in determining appropriate candidates for arthroscopic management, the endeavor to evaluate and understand the implications of bone loss continues today as we explore bony deficiency in the glenohumeral joint. Future research is seeking to clarify the outcomes of arthroscopic Bankart repair with remplissage, open Bankart repair and open Latarjet in individuals with subcritical (10–20%) glenoid bone loss [54]. The results of this study will further build upon Burkhart and DeBeer's early work to inform management decisions in anterior instability patients with glenohumeral bone loss.

Ethics approval

This study was exempt from ethics approval.

Declaration of competing interest

The authors declare the following financial interests/personal relationships that may be considered as potential competing interests:

Dean Taylor, Jonathon Dickens reports a relationship with DePuy Mitek Inc that includes: consulting or advisory and funding grants. Dean Taylor, Jonathon Dickens reports a relationship with Smith and Nephew Inc that includes: funding grants. Dean Taylor reports a relationship with Breg that includes: funding grants. Dean Taylor reports a relationship with Enovis Corporation that includes: funding grants. Dean Taylor, Jonathon Dickens reports a relationship with Arthrex Inc that includes: funding grants. Dean Taylor, Jonathon Dickens reports a relationship with American Orthopaedic Society for Sports Medicine that includes: board membership. Dean Taylor reports a relationship with Piedmont Orthopaedic Society that includes: board membership. Dean Taylor reports a relationship with OJSM Editorial Board that includes: board membership. Dean Taylor reports a relationship with Magellan Orthopaedic Society that includes: board membership. Dean Taylor reports a relationship with Vericel Corporation that includes: funding grants. Dean Taylor reports a relationship with Medacta USA INC that includes:
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