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Anterior Shoulder Instability and Open Procedures: History, Indications, and Clinical Outcomes

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The shoulder, being the most mobile joint in the human body, is often susceptible to dislocations and subluxations more so than other joints. As such, shoulder instability constitutes a common complaint among patients worldwide, especially those who are young, participate in contact sports, and have increased innate flexibility in their joints. Management options in the setting of instability vary between conservative and surgical options that aim to mitigate symptoms and allow return of function. Surgical options can be arthroscopic and open, with a general shift among surgeons towards utilizing arthroscopic surgery in the past several decades. Nevertheless, open procedures still play a role in managing shoulder instability patients, especially those with significant bone loss, recurrent instability, coexisting shoulder pathologies, and high risk of failure with arthroscopic surgery. In these clinical settings, open procedures, like the Latarjet procedure, open Bankart repair, glenoid bone augmentation using iliac crest autograft or distal tibial allograft, and salvage options like glenohumeral arthrodesis and arthroplasty may show good clinical outcomes and low recurrence rates. Each of these open procedures possesses its own set of advantages and disadvantages and entails a specific set of indications based on published literature. It is important to cater treatment options to the individual patient in order to optimize outcomes and reduce the risk of complications. Future research on open shoulder stabilization procedures should focus on the long-term outcomes of recently utilized procedures, investigate different graft options for procedures involving bone augmentation, and conduct additional comparative analyses in order to establish concrete surgical management guidelines.

Keywords: *Latarjet, Bankart lesions, Glenoid bone loss, Contact athlete, Labrum*

The glenohumeral joint is the most mobile joint in the human body, and this mobility predisposes it to a higher risk of dislocations and instability.[1] The natural stability of this joint is maintained through dynamic and static stabilizers that work together to ensure that the ball-and-socket joint remains in place.[2] Dynamic stabilizers are composed of the muscles and tendons that surround the shoulder, and these include the rotator cuff, which allows the active movement of the upper extremity in different directions.[3,4] On the other hand, the static stabilizers include the joint's innate anatomy, the surrounding glenohumeral ligaments, and the glenoid labrum.[2,5] The glenoid labrum is a thick tissue composed of fibrocartilage that surrounds the rim of the glenoid and helps stabilize the humeral head while it translates along the socket, preventing translocation of the humeral head beyond the glenoid.[2,6] When a shoulder dislocation ensues, a tear in the labrum often results (termed a Bankart tear), along with a concomitant potential loss in glenoid bone, humeral head bone (termed a Hill-Sachs lesion), and injury to joint capsule.[7,8] As such, joint instability rises and increases with every subsequent dislocation event.

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Shoulder instability is a very common complaint in the population, and it can present as an anterior (most common), posterior, or multidirectional instability depending on the type and severity of the dislocation event.[9-11] Risk factors often include contact sports, young age, joint hypermobility, and prior dislocation events.[7,12] It is estimated that the incidence of anterior shoulder instability is 0.08 per 1,000 person-years in the general population, with much higher reported rates for young high risk men at 3% per year.[13,14] These high rates of anterior shoulder instability, along with the debilitating presenting symptoms—evident by pain, apprehensive mobility, and decreased function—necessitate careful consideration when deciding appropriate management plans.[15] Treatment options for anterior instability vary between conservative and surgical measures; however, it is often advisable to undergo surgery following the initial dislocation event, especially in high risk young patients to prevent recurrent dislocations and concomitant bone loss.[9] Surgical options include minimally invasive procedures like arthroscopic Bankart repair and more invasive open procedures like open Bankart repair, coracoid transfer procedure or Latarjet, and bone augmentation procedures using different autograft sources.[7,9,16] Each of these procedures possesses its own set of advantages and disadvantages, and management decisions are often based on the severity of instability, evident through clinical and radiographic examination.[9]

Arthroscopic Bankart repair is considered the most commonly used surgical procedure for shoulder instability, constituting 87% of shoulder stabilization techniques in 2006.[17,18] Nevertheless, significantly high failure rates have been reported, mainly in patients with high risk of recurrent instability.[19-22] In these cases, open techniques may be considered, as these can provide better and more sustainable outcomes.[23] That being said, the purpose of this study was to explore the history of open techniques for shoulder stabilization, describe the available open procedures, and highlight the relevant key surgical considerations based on reported clinical outcomes.

HISTORY OF OPEN STABILIZATION PROCEDURES

It is important to describe the history of open shoulder stabilization procedures in order to reflect on current techniques and procedures available today. Prior to 1980, all shoulder instability cases were treated openly. As a matter of fact, the first anatomic repair of the labrum and the inferior glenohumeral ligament was described by Arthur Sydney Blundell Bankart in 1923, who by doing so, discovered the main lesion involved in anterior shoulder instability (Fig. 1).[24] Since then, numerous open stabilization techniques evolved and developed in an attempt to achieve satisfactory patient outcomes. The Eden-Hybinette procedure, reportedly first described in 1932 as well, involved the utilization of an iliac crest autograft to augment the glenoid in shoulder instability cases (Fig. 1).[25] The subscapularis transfer was described by Magnuson-Stack in 1943, followed by the subscapularis tendon and anterior capsular imbrication (Putti-Platt) described in 1948 (Fig. 1).[26,27]

A major breakthrough occurred in 1954, when Michel Latarjet described an open coracoid transfer onto the anterior glenoid margin in order to help restore shoulder stability (Fig. 1).[28] This was followed by the coracoid tip transfer described by Bristow-Helfet as a modification to Latarjet original procedure (Fig. 1).[29] In 1980, Neer and Foster's open inferior capsular shift was described: an operation that involves tightening the shoulder capsule to achieve better joint stability before arthroscopic repair of the labrum started emerging later that year (Fig. 1).[30]

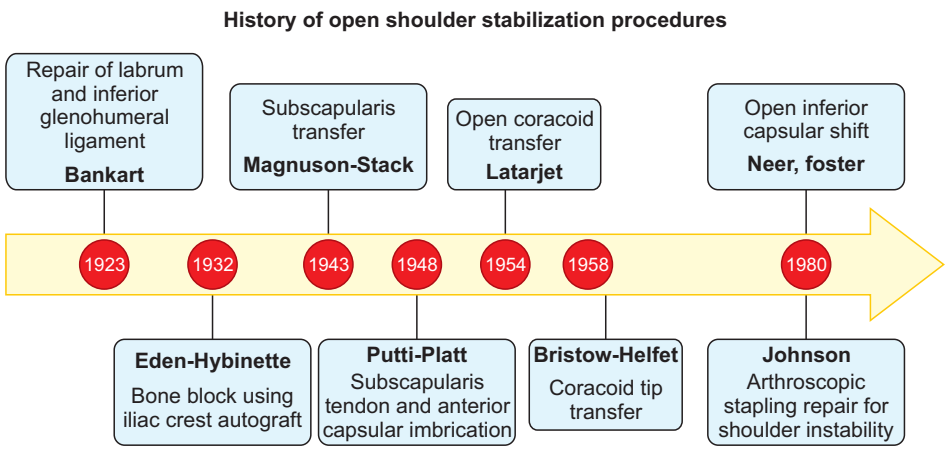

Fig. 1. Timeline of open procedures for shoulder stabilization procedures.

Modifications of these procedures were created and established as credible and beneficial treatment options for recurrent instability, but as times passed, open procedures decreased in frequency, and arthroscopic labral repair procedures gained notable popularity and prominence.[17,18]

Indeed, arthroscopic options for labral repair witnessed prominent rise over the past decades. A study by Riff et al.[17] explored the trends of shoulder stabilization techniques used in the United States and noted a 7.9% increase in the use of arthroscopic stabilization between 1994 and 2006, along with 9.1% decrease in the use of open Bankart procedures, and a 15.4% increase in the use of the Latarjet procedures. As a matter of fact, the breakdown of shoulder stabilization procedures in 2006 showed that 87% of shoulder stabilization procedures were arthroscopic Bankart repairs, 7% were open Bankart repairs, and 3.2% were Latarjet procedures.[17] Considering that arthroscopic labral repairs were first described in 1980, it is impressive to see how popular its use has been in the United States.

It is certain that open procedures still play a role in shoulder stabilization, and their benefits are yet to be replaced by arthroscopic procedures. By adhering to the right indications, open stabilization procedures can provide superior clinical outcomes and achieve better satisfaction for the unstable patient.

INDICATIONS FOR OPEN STABILIZATION PROCEDURES

Several indications support the use of open procedures for anterior shoulder stabilization, and these include critical glenoid bone loss, failed arthroscopic surgery, massive engaging Hill-Sachs lesions and concomitant shoulder pathologies, and high instability severity scores (ISSs). Open stabilization procedures for the shoulder are indicated in patients who have critical glenoid bone loss, and this can occur as a result of an osseous Bankart lesion, recurrent dislocations, or innate joint hypermobility and laxity.[31] Glenoid bone loss is a risk factor that can lead to recurrent instability, and in these cases, using open stabilization techniques instead of an arthroscopic repair can result in better long-term outcomes and lower rates of recurrence.[32,33] The definition of critical bone loss, which is considered highly unstable, has varied in the literature. Previous reports suggested that defects greater than 20%–25% are considered critical, but more recent ones consider defects as low as 13.5% to be critical and highly unstable.[34-36] It has also been shown that with each dislocation event, 6.8% glenoid bone loss can occur.[37] Accordingly, an open Latarjet procedure can be indicated following three dislocation events necessitating formal reduction.[7,38] Hence, with recurrent instability events, surgical options tend to lean more towards open procedures rather than arthroscopic.

Previously failed surgery for anterior glenohumeral instability is also an indication for an open revision stabilization procedure. Open procedures, such as the Latarjet, traditionally result in a lower recurrence rate for future anterior instability compared to other approaches, such as an arthroscopic revision.[39,40] Although open stabilization procedures have low recurrence rates for future anterior instability, revision surgeries are inferior to primary stabilization surgeries and can lead to higher recurrence and lower outcome predictability.[41]

Concomitant shoulder pathologies, like humeral head fractures, glenoid fractures, or humeral avulsion of anterior glenohumeral ligament, constitute an indication for open stabilization surgery. Similarly, large engaging Hill-Sachs lesions may constitute an indication for open procedures, mainly those that involve bone graft reconstruction or arthroplasty. It is important to determine the severity of Hill-Sachs lesions, as those that affect less than 20% of the humeral head may be treated non-surgically with physical therapy and careful observation. Larger lesions, however, especially those that constitute a defect greater than 40% of the humeral head, usually require open surgical management.[7,8]

Finally, the ISS is a tool that predicts the patient's risk of experiencing recurrent shoulder instability after an arthroscopic Bankart repair. Multiple factors are included when calculating the ISS, such as age, the risks associated with the sport played by the patient, the presence of glenoid loss or a Hill-Sachs lesion, and hyperlaxity.[42,43] Athletes involved in risky contact sports, especially younger athletes, have an increased chance of reinjury or redislocation.[44] The ISS uses a point scoring guideline where differing amounts of points are assigned to the patient for the varying factors that are evaluated before the operation. Higher scores contraindicate an arthroscopic repair because an open procedure would provide more shoulder stability and better patient outcomes.[42-44]

OPEN STABILIZATION PROCEDURES

Latarjet Procedure (Open Coracoid Transfer)

A Latarjet procedure, which involves augmentation of a defected and unstable glenoid using an open coracoid transfer, is indicated in the setting of patients who are at high risk for recurrent shoulder instability (primarily

anterior) (Fig. 2).[45] The procedure is considered the gold standard of open stabilization procedures, and is especially popular among contact athletes under the age of 25, and patients with critical glenoid bone loss.[7,45,46]

Patient outcomes following Latarjet procedures have been extensively explored in the literature. The Latarjet has shown low rates of recurrent shoulder instability and high rates of patient satisfaction in diverse patient populations.[7,47] The procedure is especially popular in the sport setting due to its high return to sport rates. Yapp et al.[48] and Elamo et al.[49] explored the prognosis of athletes who had undergone a Latarjet procedure and found a 100% return to sport rate at 5- and 10-year postoperation. In another study, at 25-year postoperation, out of the 40 patients who underwent a Latarjet procedure, none reported redislocation.[2,13] Another systematic review by Hurley et al.[50] explored outcomes of Latarjet procedures in 2,134 athletes and reported an overall return to play rate of 88.8% at a mean time of 5.8 months, with 72.6% of athletes returning to their previous level of competition. The authors further stratified return to play and return to previous level of play by type of sport: rates of return to play were 88.2% and 90.3%, while rates of return to previous level of play were 69.5% and 80.6% among collision athletes and overhead athletes, respectively.[50]

With regards to open stabilization procedures, the Latarjet remains the gold standard with superior outcomes when compared to other open procedures. Hovelius et al.[51] performed a retrospective analysis of 185 shoulders with a mean follow-up duration of 17 years comparing open techniques: Bristow-Latarjet and open Bankart repair. Patients in the Bristow-Latarjet group had superior shoulder function with significantly better patient-reported outcome scores than patients in the open Bankart group.[51] Patients who underwent a Latarjet procedure also showed significantly lower rates of redislocation, subluxation, apprehension, and revisions than patients who underwent standard open Bankart repair.[51,52] Comparisons have also been drawn between different Latarjet techniques. One study by Dumont et al.[53] compared the computed tomography (CT) findings of patients treated with a traditional Latarjet to those treated with a congruent arc modified Latarjet. In a congruent arc Latarjet, the inferior surface of the coracoid is used to augment the glenoid rather than the lateral edge of the coracoid.[54] In theory, this allows the reconstruction of a greater percentage of glenoid bone deficit, since the inferior portion of the coracoid is wider than its lateral edge.[54] Nevertheless, Dumont et al.[53] found greater bony contact with the glenoid (5.65 cm^2 vs. 3.64 cm^2) and greater bone width on each side of the screws (7.1 mm vs. 4.1 mm) in the traditional technique compared to the modified technique.

The advantages of this procedure, implied by increased joint stability and lower recurrence rates, are challenged by its significant complication profile, which can range from hematomas to graft reunion failure.[7,55,56] Regarding complications, reported rates showed a range of 7% to 30%.[7,55,56] These include screw mispositioning, nerve injury, nonunion, bone overhang, and superior graft resorption.[57] With regards to long-term complications, osteoarthritis appeared to be a concern as studies have shown that it can develop in 23% to 37% of cases.[58,59] Domos et al.[52] reported that postoperative osteoarthritis is usually present in 20% to 25% of open Latarjet procedures. In another long-term study on 822 patients who underwent a Latarjet procedure with an average follow-up of 16.6 years, 38.2% of patients reported degenerative changes, 35.7% reported residual shoulder pain, and 4.8% reported daily pain.[60]

Differences in outcomes and prognostic parameters between arthroscopic stabilization procedures and Latarjet have been explored in the literature. One retrospective analysis of 364 shoulders performed by Zimmermann et al.[61] compared open Latarjet procedure and arthroscopic Bankart repair and reported a significant improvement in Subjective Shoulder Value (SSV) score in both procedures.[61] However, the open Latarjet repair group had a significantly greater increase in overall SSV than the arthroscopic repair group. This may be due to the fact that patients in the open Latarjet repair group scored lower in preoperative SSV and had a greater disability than patients in the arthroscopic repair group, and thus had a significantly greater subjective benefit.[61] Zimmermann et

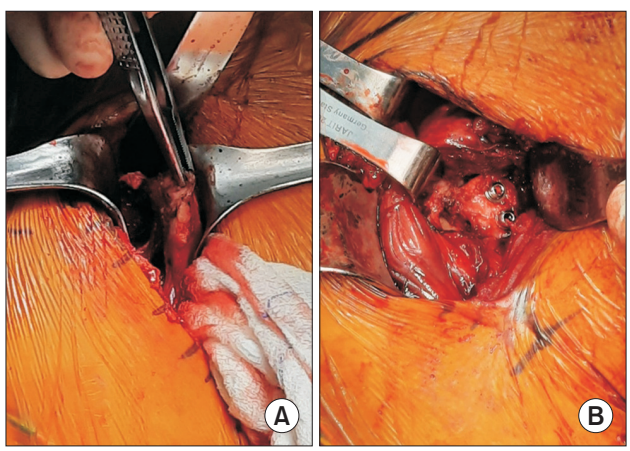

Fig. 2. The Latarjet procedure involves releasing and transferring the coracoid and conjoint tendon (A) and attaching it to the anterior glenoid using one or two screws to augment the anterior glenoid defect (B).

al.[61] similarly recorded a significantly higher recurrence of redislocation, subluxation, apprehension, and revision surgery in the arthroscopic repair group compared to the open Latarjet repair group. In addition, the authors found that while the majority of patients were able to return to their previous sports activity, the Latarjet group had a significantly higher percentage than the arthroscopic Bankart repair group.[61] With regards to arthroscopic Latarjet, outcomes have been similar to those of the open approach.[62] One systematic review by Horner et al.[62] examined all comparative studies exploring the two Latarjet approaches and showed that both produce similarly successful outcomes with no significant differences in complication rates and need for revision surgery. The authors[62] did, however, report less early postoperative pain with arthroscopic Latarjet but increased required operative time.

Open Bankart Repair

Indications for an open Bankart are usually similar to those of other open stabilization procedures.[7,63,64] The popularity of this procedure has decreased over the recent decades due to its more invasive approach and subsequent higher rate of complications when compared to arthroscopic repair; nevertheless, it still plays a role in shoulder stabilization surgery.[17,18]

Outcomes following an open Bankart repair have been explored extensively in previous literature. A systematic review by AlSomali et al.[65] demonstrated that open Bankart repair is a reliable procedure that allows high-demand populations, such as athletes and people who work in heavy labor, to return to sports and work; in their study, 87% (358/410) of patients who underwent open Bankart repair returned to their previous sports and work. In another study done on 44 athletes who underwent this procedure, 88% of the athletes were able to return to their sport, with 66% reporting similar levels of performance at an average follow-up period of 14.2 months.[66] Neviaser et al.[67] explored 30 patients who underwent open Bankart revision stabilization and found no recurrence at 10 years of follow-up. The authors also noted that 22 out of 23 competitive athletes were able to return to sport.[67] Several negative outcomes, however, have been reported with this procedure, and these often revolve around decreased range of motion in external and internal rotation, but this was typically experienced without concomitant loss of shoulder functionality.[67-69]

When comparing open Bankart repair to arthroscopic repair, findings have been varied. While both procedures have been found to provide similar functional capacities to patients, differences mainly reside in postoperative stability and range of motion.[70] One study by Rhee et al.[19] explored the outcomes of arthroscopic versus open Bankart repair on a group of 46 collision athletes and displayed augmented postoperative instability in those who underwent arthroscopy. A meta-analysis of 16 trials involving 827 shoulders by Chen et al.[71] demonstrated that patients who underwent arthroscopic Bankart repair had better recovery of range of motion, but a significantly higher number of redislocations and revision operations than patients who underwent open Bankart repair. Hohmann et al.[70] performed a meta-analysis of 22 studies separated into two groups by publication date (1995–2004 and 2005–2015) and evaluated recurrence rates between open and arthroscopic repair in the two decades. They found that there was a significant difference favoring open Bankart repair in the 1995–2004 decade, with arthroscopic Bankart repair having twice the risk of recurrence compared with open repair group (odds ratio, 1.96).[70] Although no significant difference was recorded in the more recent 2005–2015 group as well as when all studies were pooled together, the recurrence rate in patients who underwent arthroscopic repair was found to only marginally decrease 2.5% between the two decades.[70] These findings are disputed, however, as a study in patients older than 50 years of age found recurrence rates between the two procedures to be similar.[7,72]

Open Bankart repair is a more invasive procedure than arthroscopic repair and places the patient at higher risk of complications. One of the main differences between the two procedures is that the subscapularis must be detached in open repair, which raises concerns about a potential compromise in function. However, several studies have found no significant differences between the two procedures with regards to subscapularis function. Hiemstra et al.[73] performed a randomized control trial to assess strength deficits between open and arthroscopic repair and demonstrated that while both procedures resulted in deficits in internal and external rotation compared to the contralateral shoulder, there were no significant differences between the two. Degenerative changes to the glenohumeral joint is another concern regarding open repair.[65] AlSomali et al.[65] conducted a systematic review to explore patient outcomes following open Bankart repair and indicated osteoarthritic changes in 33% of patients (89/268), with mild to moderate changes in 81 shoulders and severe changes in 8 using the Samilson-Prieto classification at a mean follow-up of 11.5 years. On the other hand, Chen et al.[71] conducted a systematic review of the clinical trials involving both open and arthroscopic Bankart repairs to assess their safety profile and reported no significant

differences between the two approaches with regards to complications, concluding that both procedures have the same level of safety. No statistical differences were found between the two surgical groups when comparing the number of patients with dysesthesia, persistent pain after surgery, wound infections, and delayed wound healing.[71]

Bone Augmentation Using Iliac Crest Graft

Bone augmentation procedures other than the Latarjet exist can be used in the setting of severe bone loss.[74] Utilizing an iliac crest autograft can augment the glenoid and provide good outcomes in cases of significant anterior or posterior shoulder instability.[74] An example of such cases is an epileptic patient with a history of seizures and numerous dislocations. In these cases, a Latarjet may not be suitable due to high risk of failure and complications.[74] As such, glenoid augmentation using iliac crest autograft can be a suitable stabilization option that can provide more favorable outcomes.[75]

Outcomes of iliac crest bone grafting for glenoid reconstruction have been generally favorable in the literature. One prospective study by Moroder et al.[76] compared the outcomes between Laterjet procedure or open iliac crest bone graft transfer in 60 randomized anterior instability patients. Patients of both groups showed improvements and there were no clinical differences in patient-reported outcomes at any of the follow-up points (6, 12, and 24 months after procedure).[76] A systematic review by Malahias et al.[77] reported on 261 patients who underwent iliac crest bone block techniques for shoulder stabilization and reported an overall cause of reoperation rate of 6.1%, a rate of recurrent instability of 4.8%, a graft nonunion rate of 2.2%, and rates of graft fracture, infection, and osteolysis of 0.9%, 1.7%, and 0.4%, respectively, at a mean follow-up ranging between 20.6 and 42 months. The authors[77] also reported a hardware-related complication rate of 3.9%. Another study by Ernstbrunner et al.[78] explored 20 cases of iliac crest bone grafting conducted following failed Latarjet procedure. While 7 of the 20 patients reported recurrence of instability following the revision procedure, the remaining 13 reported significant improvements in Constant score (25 points increase), relative Constant score (25% increase), and SSV (54% increase).[78]

Different techniques exist when conducting an iliac crest autograft bone blocking procedure. One interesting technique is the J-bone graft technique, which uses a bicortical iliac crest autologous bone graft that is sculpted into a J-shaped structure and inserted via a press-fit technique in order to reconstruct the glenoid (Fig. 3).[74,79] The J-bone graft technique restores the anatomic integrity of the defected glenoid and provides good strength, mobility, and functional capacity to the surgical patient.[74,80] The procedure has been shown to produce visual analog scale scores that are comparable to the Latarjet procedure, as well as a similarly low rate of recurrent dislocations at around 3%.[74,80,81] The J-bone technique may entail several advantages over the Latarjet procedure. Since it is inserted via a press-fit technique and does not involve insertion of metal hardware, the J-bone technique might prevent implant-related issues such as screw breakage or loosening, which frequently necessitate revision surgery.[81] In addition, the J-bone grafts are often covered with soft-tissue that can potentially differentiate into hyaline and fibrous cartilage, and this may protect against dislocation arthropathy.[82] Moreover, in contrast to the Latarjet procedure, extended immobilization is not necessary because stability is already present before the remodeling process begins.[74,83]

Several complications can arise when attempting glenoid reconstruction using iliac bone graft and these include subluxations, nonunion, postoperative osteolysis, neurovascular injuries, and arthritis.[74,81] One study showed that the rates of moderate to severe arthritis seen with this technique were comparable to the Latarjet at around 12%.[74] Another major disadvantage is the requirement for a second iliac crest incision for the purpose of harvesting the bone block. This could increase the risk of problems like infection, poor wound healing, or hemorrhage at the donor site as well as the chance of injuring the lateral femoral cutaneous nerve, which could result in short-term or perhaps long-term pain.[84,85] The high learning curve of the procedure when compared to the Latarjet technique, constitutes another limitation.[82]

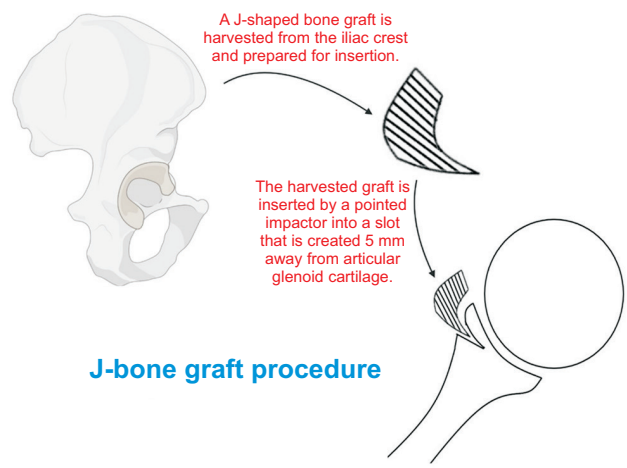

Fig. 3. Schematic representation of the J-bone graft procedure for shoulder stabilization.

An arthroscopic approach to this procedure has been described in the literature as well. Anderl et al.[79] explored the outcomes of 14 patients treated with arthroscopic bone block using iliac crest autograft and reported adequate restoration of the glenoid anatomy, excellent clinical outcomes, and no signs of recurrent instability on follow-up. An interesting finding was that in the arthroscopic approach, no postoperative osteoarthritic progression was found, which may be explained by the maintenance of natural biomechanics.[79] Nevertheless, a longer follow-up period is required to confirm this conclusion.[79] When compared to the open technique, advantages of the arthroscopic technique include better cosmetic results, a reduced risk of infection, fewer scars, quicker recovery, the ability to effectively treat concurrent injuries, easier situation in case of revision surgery, and its muscle-sparing properties.[79] Thus, the risk of decreased shoulder function can be reduced by limiting damage to the shoulder joint's musculotendinous unit, preserving its structural and biomechanical integrity, and further bolstering the anatomical approach of the described treatment.[86]

Bone Augmentation Using Distal Tibial Allograft

The use of fresh distal tibia allograft (DTA) for glenoid reconstruction has also been described in the literature.[87-89] In this procedure, a fresh distal tibial allograft is prepared and fashioned to appropriately fit and augment the defect in the patient's glenoid. This specific type of implant was first used due to studies that showed, even among non-laterality-matched cadaveric specimens, a fairly similar radius of curvature between the lateral aspect of the distal tibia and that of the glenoid exists.[88,90] It was shown that throughout the whole range of motion, the lateral third of the distal tibia's articular surface is congruent with the humeral head.[88-91] A biomechanical analysis by Bhatia et al.[92] compared this procedure with the Latarjet and showed a higher contact area and lower peak forces with the DTA graft when the shoulder was tested in 60° of abduction and in abducted external rotation, making this procedure viable for glenoid reconstruction.

Clinically, this technique showed excellent outcomes.[89] A study by Provencher et al.[89] explored 27 male patients who underwent glenoid reconstruction using DTA, with a minimum of 15% anterior glenoid bone loss prior to procedure. The authors noted significant improvements in patient-reported outcome scores and no cases of recurrent instability at an average follow-up of 45 months.[89] The authors also reported an overall graft healing rate of 89% and a mean allograft lysis rate of 3% on CT scans performed at a median time of 1.4.[89] Another study by Robinson et al.[93] retrospectively reviewed 12 patients, with an average glenoid bone loss of 33%, who underwent DTA glenoid reconstruction. The authors reported significant improvement in clinical patient-reported outcomes and range of motion at an average follow-up of 28 months.[93]

Arthroscopic DTA glenoid reconstruction has also been described in the literature and has been gaining popularity worldwide. Wong et al.[94] reported on 73 patients treated with arthroscopic glenoid reconstruction using DTA and reported significantly improved patient-reported outcome scores, no recurrent instability, and union rates around 100% at a mean follow-up of 4.7 years. Amar et al.[95] explored this procedure and reported an excellent safety profile, no intraoperative issues such as neurovascular injury, adverse events, hemorrhage, or infections, and 100% graft healing on CT scan at a mean radiographic follow-up of 6.31 months in 31 out of 42 patients. As such, both open and arthroscopic DTA glenoid reconstructions are utilized in shoulder surgery with appropriate outcomes for both. Comparative studies exploring the two approaches should be conducted in order to assess which procedure has better therapeutic efficacy. In addition, studies with longer follow-up periods should be done to appropriately assess its efficacy and safety profile.

Salvage Procedures

Patients with significant instability frequently pose diagnostic challenges and may continue to be resistant to surgical intervention. A tiny subgroup may experience multiple surgical failures, resulting in severe impairment from ongoing pain and instability. In these situations, salvage options, like glenohumeral arthrodesis or arthroplasty, may be utilized.

Stark et al.[96] and Cofield et al.[97] both reported improvements in pain, stability, and range of motion after arthrodesis for instability. Richards et al.,[98] however, reported contradicting results, noting persistent postoperative pain and instability at a mean follow-up of 43 months in 4 out of 6 patients who underwent the procedure for multidirectional instability. Diaz et al.[99] explored the outcomes of glenohumeral arthrodesis in 8 patients, with an average of 7 prior stabilization attempts at a mean follow up of 35 months. Despite some functional limitations and residual pain, the authors reported no postoperative instability complaints and good patient satisfaction postoperatively, with all patients stating that they would repeat the surgery under the same preoperative condition.[99]

Shoulder arthroplasty procedures can also be considered salvage procedures for severe shoulder instabil-

ity.[100,101] This procedure can improve range of motion and reduce pain.[101,102] However, complications such as posterior instability and component loosening requiring revision may occur.[101] Having a shorter time between the injury and the arthroplasty can improve the postoperative outcomes.[101] Yet, a history of a previous surgery (which is often the case), the necessity of an anteromedial approach or the concurrent presence of rotator cuff repair can compromise the outcomes.[101]

As stated earlier, a critically large Hill-Sachs lesion may entail prominent instability and require open surgical management. In this setting, allograft bone reconstruction and humeral resurfacing are two of the main open surgical procedures available. Allograft humeral head reconstruction has been widely explored in the literature, with different reported techniques and good resultant outcomes. One study by Miniaci and Gish[103] reported on 18 cases of instability patients treated with humeral head structural osteoarticular allografts. Patients had failed previous stabilization procedures and had humeral head defects of at least 25%.[103] At a mean follow-up of 50 months, 89% of patients returned to work, average Constant score was 78.5, and no incidents of recurrent instability were reported.[103] With larger Hill-Sachs lesions, typically greater than 40%–45%, hemiarthroplasty can be used to treat instability symptoms.[104,105] Nevertheless, the use of this procedure in this setting has several limitations and the published available literature suggests mixed results.[104,105] While some studies report generally favorable outcomes, especially in older patients, others highlight the risk of prosthetic loosening and the need of additional retroversion to achieve proper stability.[104,105]

RECOMMENDATIONS

Open stabilization procedures for the shoulder remain valid options for many presenting patients. It is important, however, to recognize when these procedures are more favorable over arthroscopic procedures. All patients are different, and hence, a holistic assessment of the history, presentation, and expected outcomes of the patients is always necessary before deciding on a management plan. In specific, factors like age, bone loss, type of athletic participation, coracoid size, and degree of laxity should factor in when choosing the appropriate surgical procedure. Generally, arthroscopic procedures are praised for their minimally invasive approach and retention of range of motion at the expense of higher recurrence rates and risk of failures. Open stabilization procedures, on the other hand, offer increased stability and lower recurrence rates at the expense of a possible nonanatomic restoration of glenohumeral stability and a consequently higher complication profile. Hence, patient selection and education is key. While arthroscopic procedures are popular and offer significant benefits for the average patient, patients who are involved in contact sports and those with high risk of recurrence, severe glenoid bone loss, or concomitant glenohumeral pathologies may be more suited for open stabilization procedures.

Research and innovation targeting both open and arthroscopic stabilization procedures have produced several new surgical procedures with much promise. Quite recently, the addition of soft-tissue repair to Bankart procedures, such as the case of remplissage, has been garnering a lot of attention.[106-111] Some studies in the literature show superior results and very low rates of revision or recurrence at long-term follow-up when compared to other procedures, while other studies challenge any superior benefit from this technique.[106-111] With continuous medical and surgical advancements and innovations, it is possible that the addition of soft-tissue repair to arthroscopic stabilization procedures may replace the need for some of the more robust and invasive open procedures. That being said, conducting additional research that compares different stabilization procedures (open and arthroscopic) is necessary for the establishment of proper treatment guidelines and strategies. In addition, exploring new graft options for bone-block procedures can be beneficial in light of the cost and supply restraints of available cadaveric options.

CONCLUSION

Shoulder instability is a very common pathology that affects many patients worldwide. While arthroscopic management of this pathology has been the standard treatment for the average presenting patient, many cases involve much more complex presentations that necessitate the use of an open approach. Open stabilization procedures are usually indicated for patients with recurrent instability, severe glenoid bone loss, concomitant shoulder pathologies, and high risk for failure with arthroscopic management. Some of these procedures include the Latarjet procedure, open Bankart repair, bone-blocking procedures using iliac crest autograft or DTA, and salvage procedures like shoulder replacement or glenohumeral arthrodesis. Each of these procedures entail different advantages and disadvantages, and accordingly, it is of pivotal importance to cater management to the individual patient. Additional research should be conducted to determine the best treat-

ment approach for different patient presentations, report on long-term outcomes of some of the newer procedures, and explore additional graft options for bone-blocking procedures.

CONFLICT OF INTEREST

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