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History of surgical intervention of anterior shoulder instability

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Background: Anterior glenohumeral instability most commonly affects younger patients and has shown high recurrence rates with nonoperative management. The treatment of anterior glenohumeral instability has undergone significant evolution over the 20th and 21 centuries.

Methods: This article presents a retrospective comprehensive review of the history of different operative techniques for shoulder stabilization.

Results: Bankart first described an anatomic suture repair of the inferior glenohumeral ligament and anteroinferior labrum in 1923. Multiple surgeons have since described anatomic and nonanatomic repairs, and many of the early principles of shoulder stabilization have remained even as the techniques have changed. Some methods, such as the Magnusson-Stack procedure, Putti-Platt procedure, arthroscopic stapling, and transosseous suture fixation, have been almost completely abandoned. Other strategies, such as the Bankart repair, capsular shift, and remplissage, have persisted for decades and have been adapted for arthroscopic use.

Discussion: The future of anterior shoulder stabilization will continue to evolve with even newer practices, such as the arthroscopic Latarjet transfer. Further research and clinical experience will dictate which future innovations are ultimately embraced.

Level of evidence: Review Article

Keywords: Anterior glenohumeral instability; dislocation; subluxation; shoulder stabilization; arthroscopic; Bankart

Because of its relative lack of bony limitations and extensive range of motion, the shoulder is the most commonly dislocated major joint in the body.[4,7,120] Anteroinferior instability of the humeral head is the most common pattern, accounting for over 90%.[40] Recurrence after the initial dislocation is common, and young age and activity level are the strongest risk factors.[56,60,132,134] The natural history of shoulder instability was perhaps most effectively illustrated by Hovelius et al[60] in a prospective study of 229 primary dislocations treated nonoperatively. After 25 years of follow-up, 72% of patients originally younger than 22 years had at least 1 recurrent episode of instability, as compared with 27% of patients older than 30 years. Other studies have reported recurrence rates in young athletes as high as 92% to 96%.[122,133,154] Furthermore, young patients who have recurrent dislocations are at greater risk of the development of moderate to severe arthropathies.[15,61] Nearly half of all anterior shoulder dislocations occur in persons aged 15 to 29 years,[160] so operative treatment is increasingly recommended to minimize the risks of recurrence and further complications. Level I evidence suggests that surgical

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Table I History of anterior shoulder stabilization surgery

Open procedures
Open anatomic repair
Sutures (Bankart)
Staples
Soft-tissue reconstruction
Fascia lata autograft (Gallie)
Muscular transposition of subscapularis (Magnusson-Stack)
Shortening of subscapularis and anterior capsule (Putti-Platt)
Osseous glenoid reconstruction
Bristow
Latarjet
Iliac crest autograft (Eden-Hybbinette)
Distal tibia allograft
Corrective osteotomy
Proximal humerus (Weber)
Glenoid (Meyer-Burgdorff)
Open capsular imbrication
Laterally based inferior capsular shift (Neer and Foster)
Medially based inferior capsular shift (Altchek)
Vertical capsulotomy
Horizontal capsulotomy
Arthroscopic procedures
Arthroscopic anatomic repair
Staples
Transosseous sutures
Metallic rivet
Bioabsorbable tack
Suture anchors
Arthroscopic capsular imbrication
Thermal capsulorrhaphy
Split and shift
Multi-pleated capsular plication
Posteroinferior capsular plication
Rotator interval closure
Arthroscopic Latarjet
Targeted management of Hill-Sachs lesions
Humeral head or femoral head allograft
Disimpaction
Partial resurfacing arthroplasty
Hemiarthroplasty
Arthroscopic remplissage

stabilization may be indicated for young first-time dislocators.[13,47,67,75] This article describes the history of shoulder stabilization surgery, from its roots as an open procedure to recent arthroscopic innovations (Table I).

Open shoulder stabilization

Open anatomic repair

Bankart[4] first described the "essential lesion" of recurrent glenohumeral instability in 1923. Before his description, anterior dislocations had been largely attributed to excessive capsular laxity and weakness of the surrounding musculature. In addition to capsular plication techniques, Clairmont and Ehrlich[22] had popularized an operation in which a strip of deltoid was transferred to the inferior joint surface to act as a sling maintaining reduction. Bankart, however, felt that focus on capsular laxity and muscle weakness overlooked rupture of the glenohumeral ligament and labrum off the anterior glenoid. Using a technique previously described by Perthes[109] in 1906, Bankart reapproximated his eponymous lesion with silk suture from a subscapularis-splitting approach.

After Bankart's description, anatomic repair of the anterior labrum and inferior glenohumeral ligament (IGHL) remained the mainstay of stabilization surgery for decades. In 1956, similar to Bankart, Du Toit and Roux[29] split the subscapularis parallel with its fibers, but they used barbed staples for their fixation instead of suture. This was perceived as a simpler operation, but 10-year follow-up showed a 12% incidence of staple complications, including articular penetration and loosening with staple migration.[106] Over the 20th century, the surgical exposure evolved from one of subscapularis splitting to a tenotomy and peel-back method for improved visualization. Rowe et al[121] used this approach to drill holes through the anterior glenoid and tie down the avulsed labrum. They reported just a 3.5% recurrence rate in 145 patients.

In a later report, however, Rowe et al[123] found residual Bankart lesions in 84% of instability repairs that required revision. Appropriate anatomic landmarks and fixation methods were not yet fully understood, and an imperfectly anatomic repair failed to restore appropriate IGHL tension. In this context, surgeons began to explore nonanatomic alternatives.

Open soft-tissue reconstruction

By 1948, Gallie and Le Mesurier[36] had concluded that they could not securely fasten the anterior capsulolabral structures in perfect anatomic positioning. They instead devised a soft-tissue reconstruction using tensor fascia lata autograft and a series of drill holes through the scapula, coracoid process, and humerus. The fascia lata graft was passed from posterior to anterior through the scapula and then split to create soft-tissue struts extending to the coracoid and humerus. The authors reported only 7 recurrences in 175 patients, but this technique never achieved enough widespread use because of potential complications from drilling bone tunnels in such precarious locations. Numerous case reports and small series in the past 20 years have presented similar soft-tissue reconstructions using Achilles, hamstring, and tibialis anterior grafts,[2,96,150] but these are now restricted to salvage procedures.

Local soft-tissue transfers proved more popular than the remote autograft of Gallie and Le Mesurier.[36] Magnuson and Stack[89] harkened back to the muscle transfers of the early 20th century when they described their subscapularis muscle transposition in 1943. The Magnuson-Stack procedure transferred the subscapularis attachment from the lesser tuberosity to the greater tuberosity to increase tension across the anteroinferior

joint and act as a sling on the humeral head. This reconstruction was further designed to reduce external rotation, for many investigators believed that increased rotation predisposed to provocative positioning and recurrent instability. Recurrent dislocation rates of the procedure ranged from 2% to 17%.[70,93]

The Putti-Platt procedure[107] was similar and became an attractive alternative in 1948 because it was technically easier than a Bankart repair. The subscapularis tendon and capsule were divided longitudinally and shortened by securing the medial limb to the anterior glenoid and the lateral limb over it. By shortening the subscapularis and tightening the anterior capsule, the Putti-Platt procedure also decreased external rotation.[64,101]

Procedures that limit external rotation, however, have since fallen out of favor. Rowe et al[121] contested the theory that reduced external rotation decreases re-dislocations and showed no change in instability rates when full external rotation was restored. Furthermore, while some authors have reported zero functional deficits athletically,[25,82] most believe that loss of external rotation restricts patients in activities of daily living.[110] More importantly, procedures that excessively tighten the anterior capsule and reduce external rotation have been associated with the rapid onset and progression of glenohumeral arthritis.[49,88]

Open osseous glenoid reconstruction

Open coracoid process transfers to augment the anterior glenoid were introduced by Latarjet[81] in 1954. Some degree of glenoid bone loss has been reported in up to 22% of patients after an initial dislocation[143] and 76% after a recurrent episode.[9,58,59,138] Bankart repair in patients with glenoid bone loss is troubled by recurrence rates as high as 67% to 89% in contact athletes.[15] Bone loss most commonly occurs from the 12- to 6-o'clock straight anterior position on the glenoid clock face,[126] and biomechanical and clinical studies have suggested that persistent instability occurs with bone loss greater than 20% to 30% of the glenoid width.[66,85,97] For these reasons, open bony transfers have remained an increasingly popular treatment alternative to this day.

Although introduced by Latarjet,[81] Helfet[53] popularized what is now called the Bristow procedure. First, the coracoid tip undergoes osteotomy with its muscular attachments to the short head of the biceps and coracobrachialis intact. This bone block is then brought through a subscapularis split and fixed to the glenoid base with a screw and its long axis perpendicular to the glenoid. Latarjet modified this technique to use a longer segment of bone and fix its axis parallel to the glenoid (Fig. 1). This procedure has 2 primary effects: (1) the bone block acts as to increase the anterior diameter of the glenoid and (2) the conjoined tendon creates a dynamic sling to reinforce the anteroinferior capsule by lowering the inferior subscapularis when the arm is abducted and externally rotated. The conjoined tendon also may provide blood supply to the bone block. Many surgeons also perform a capsulolabral reconstruction by suturing the coracoacromial ligament to the anteroinferior joint capsule. Any labral repair is performed posterior to the coracoid transfer, which generally remains extracapsular.

Indications for open coracoid transfer are controversial. Most surgeons reserve these operations for primary or revision cases with greater than 20% to 30% loss of the anterior glenoid, although they are commonly performed in Europe is cases with less than 10% bone loss. Long-term studies have shown excellent outcomes. Hovelius et al[63] prospectively reported a 98% satisfaction rate and 3.4% recurrent dislocation rate in 118 patients after 15 years. These same authors showed similar revision, arthritis, and satisfaction rates when compared with Bankart repairs after 15 years.[65]

Concerns do still exist, however. We do not yet know if coracoid transfers' positive outcomes wane with even longer follow-up. Schroder et al[128] reported 70% good to excellent

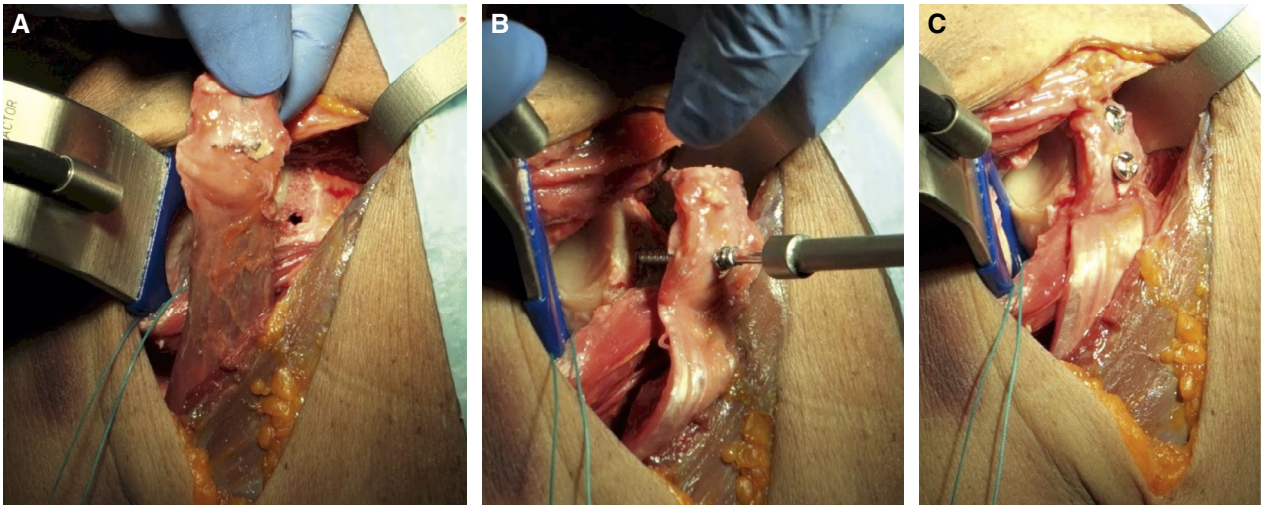

Figure 1 Coracoid process transfer as described by Latarjet.[81] The tip of the coracoid process (**A**) undergoes osteotomy with the conjoined tendon left attached, (**B**) is transferred to the anterior glenoid, and (**C**) is fixed with 2 cortical screws.

outcomes and a 15% recurrent instability rate in 49 patients after 26.4 years. Screw complications such as loosening or migration have been documented in 4% to 5% of patients.[57,146] Some authors have also raised concerns about graft resorption and postoperative dislocation arthropathy. In a repeat analysis of their previous cohort 2 years later, Hovelius et al[62] showed moderate to severe arthropathy in 14% of patients. Ghodadra et al[39] showed, in a cadaveric model, that failure to place grafts flush with the glenoid results in abnormal peak pressures and shifts in contact pressure.

Other donor sites have been considered for bony augmentation of the anterior glenoid. First described in 1967, the Eden-Hybbinette procedure used iliac crest autograft.[55] Because the curve of the iliac wing's inner table closely matched that of the glenoid, this graft was placed in an intracapsular manner. Although early series showed a high rate of arthrosis and a recurrent instability rate of up to 18%,[108] later reports showed a patient satisfaction rate of up to 90%.[46] Fresh cadaveric allografts from the glenoid,[145] femoral head,[152] and distal tibia[115] have all been used successfully over the past 5 to 6 years.

Open correctional osteotomy

In the 1970s, Saha explored the idea of a corrective osteotomy to produce "zero position" of the glenohumeral joint.[124,125] The modified Meyer-Burgdorff glenoid neck osteotomy increased glenoid retroversion to prevent anterior dislocations.[124]

Soon thereafter, authors contemplated humeral osteotomies. In 1984 Weber et al[151] described an osteotomy to bypass Hill-Sachs lesions of the humeral head. Previous work had indicated that large Hill-Sachs lesions may encourage recurrent instability.[123] For moderate to severe Hill-Sachs lesions, the authors thus performed osteotomy of the humeral shaft and internally rotated the head to position the lesion farther posterior from the glenoid. They fixed their osteotomies with a blade plate initially and a semitubular plate later. Only 5.7% of patients had recurrence, but the authors acknowledged the risk of malrotation and nonunion. In addition, their technique shortened the subscapularis and capsule, so it reduced external rotation.[151] Radiographic studies have shown that bony geometry is typically still normal in glenohumeral instability, so initial enthusiasm for osteotomies has waned.[27,117] Soft-tissue remplissage is now the favored treatment over osteotomies for large Hill-Sachs lesions.[158]

Open capsular imbrication

Biomechanical studies have shown that a single labral lesion is insufficient to cause an anterior shoulder dislocation, which requires some element of capsular injury, either stretching or midsubstance tears.[112,136] Therefore, in the past 35 years, there has been renewed interest in the capsular shrinkage techniques that had predated Bankart.

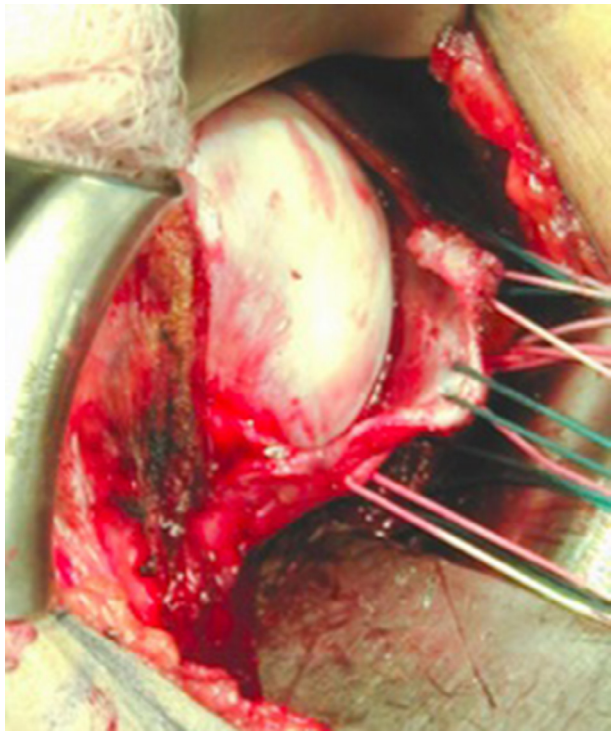

Figure 2 Open inferior capsular shift as described by Neer and Foster.[102] The inferior flap of capsular tissue with sutures attached is advanced superiorly and laterally to create a capsular imbrication.

Neer and Foster[102] were the first authors to describe the open inferior capsular shift, in 1980 (Fig. 2). The procedure consisted of a laterally based T-shaped capsular incision followed by a shift of the inferior flap superiorly and laterally. The superior flap was then reinforced over the inferior flap to reduce capsular redundancy. The authors reported only 1 postoperative subluxation in 40 patients, and Bigliani et al[8] followed with a 2.9% recurrence rate after 4.6 years with only a 7° loss of external rotation.

In 1991 Altchek et al[3] modified the T-plasty to be based medially rather than laterally. They reasoned that this would facilitate a concomitant Bankart repair and reported only 1 anterior dislocation in 42 shoulders with multidirectional instability. They did concede, however, that the laterally based procedure of Neer and Foster allowed easier access to the posterior capsule, and they reported 3 posterior dislocations in their cohort. Other variations of the open inferior capsular shift included linear—rather than T-shaped—capsulotomies. Wirth et al[156] performed a vertical cut not in the lateral or medial capsule but in its midportion. The medial flap was then reattached to the anterior glenoid to reinforce any Bankart lesion and subsequently shifted in a superolateral direction. The lateral flap was shifted superomedially to double-breast the anterior capsule. Using this technique, the authors reported just 2 instability events with minimal losses of external rotation in 142 shoulders after 5 years. Conversely, in 1989, Jobe and Glousman[68] used an isolated transverse capsulotomy with overlapping shifts of the inferior and superior flaps. They

also simplified the process of labral repair by using suture anchors instead of drill holes. Montgomery and Jobe[98] reported 1 subluxation, no suture anchor complications, and an 81% return-to-play rate in 31 overhead athletes after 3 years. The average loss of external rotation was just 1°, perhaps because they did not use a medial capsular shift.

Arthroscopic shoulder stabilization

Arthroscopic shoulder stabilization offers numerous advantages over open procedures. It provides circumferential visibility of the unopened shoulder joint and avoids complications related to subscapularis incision. It has been shown to decrease intraoperative blood loss, surgical time, postoperative narcotic use, and the length of the patient's hospital stay.[43] Finally, arthroscopic shoulder surgery is associated with an easier functional recovery, faster return to athletic activities, maximal preservation of joint motion, and improved cosmesis.[43,71] Yet, in its early years, arthroscopic stabilization led to more re-dislocations that its open counterpart. This increased rate—often 15% to 20%[28,51,71,137] and as high as 49%[148]—was historically attributed to some of the earlier methods.

Arthroscopic anatomic repair

Johnson[69] described the earliest technique of arthroscopic Bankart repair and capsulorrhaphy in 1980. Patients were placed in the lateral position, and a staple was used to engage the Bankart lesion and portions of the subscapularis and anterior capsule. Arthroscopic stapling, however, offered only single-point fixation and suffered from a 16% to 33% recurrence rate in addition to a 26% rate of staple loosening.[48,79,161]

In 1987 Morgan and Bodenstab[99] introduced the arthroscopic transosseous suture technique, later popularized by McIntyre and Caspari.[91] After lateral decubitus positioning, a Beath pin was placed from anterior to posterior through the IGHL and transglenoid drill holes. Polydioxanone suture was then pulled through the scapula and tied posteriorly through a separate incision. This technique offered the advantage of placing multiple sutures. The original authors and others reported excellent results with no recurrences through 2 years.[5,99] However, recurrence rates thereafter were inconsistent, as high as 44%.[41,44] Other disadvantages included the risk of scapulothoracic joint penetration[131] and the need to tie sutures over posterior fascia, placing the suprascapular nerve at risk.[42] Many investigators have attempted to modify the Caspari technique; Bigliani et al[6] passed the Beath pin more inferior and lateral to avoid the suprascapular nerve. Nevertheless, this surgical procedure has been largely abandoned in favor of techniques with more consistent success rates.

In 1988 Wiley[155] reported positive outcomes with a metallic rivet placed through the labrum and IGHL. The rivet only penetrated the anterior glenoid and thus did not risk suprascapular nerve injury. In addition, it was removed after soft-tissue healing at 4 to 6 weeks, so there was no concern about migration or loosened hardware. Wiley only reported a 10-patient case series, however, and the method never achieved widespread acceptance.

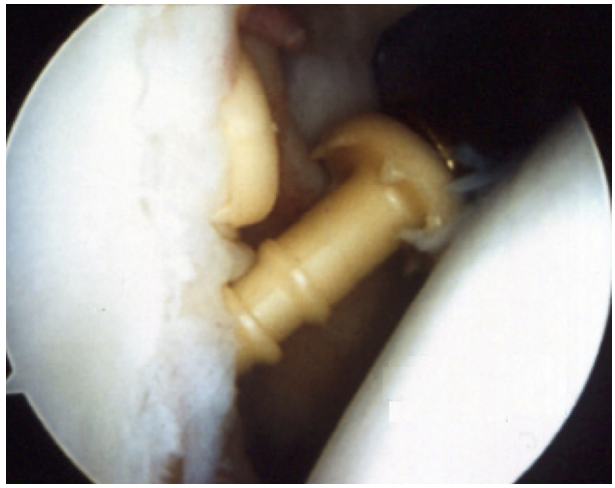

Figure 3 Cannulated bioabsorbable tacks were popularized for arthroscopic Bankart repair in the late 1990s.

Warner et al[149] introduced cannulated bioabsorbable tacks for Bankart repair in 1995 (Fig. 3). These implants had a relatively short learning curve, avoided posterior glenoid penetration, and were resorbed after 4 weeks. Disadvantages included a limited ability to address capsular laxity and a 38% complication rate, including a 6% rate of synovial reaction to the polyglyconate polymer.[31,72] One study even showed a 38% recurrent instability rate and 67% rate of moderate degenerative changes after 7 to 10 years.[72]

Arthroscopic suture anchor placement was first described by Wolf[157] in 1993 and later modified by Snyder and Strafford,[135] who used permanent sutures. Multiple anchors allowed multiple points of fixation, and their pullout strength was similar to that of transosseous sutures.[111] Anchors also facilitated fixation along the glenoid articular edge, as opposed to the medial neck, which had previously re-created anterior labral periosteal sleeve avulsion (ALPSA) lesions.[1] In 2002 Abrams et al[1] reported just a 5% recurrence rate in 662 patients after 2 years, and additional literature has continued to show recurrence rates below 10% for classic Bankart lesions.[24,74,118] For this reason, suture anchors are still the most popular mode of arthroscopic repair today. In 2001 Thal[144] introduced the knotless suture anchor wherein suture is passed through avulsed capsulolabral tissue and then passed without tying through an anchor that is impacted into the glenoid surface. Biomechanical and clinical data have shown equivalent outcomes between knotless and conventional suture anchors.[76,83,103,104]

There are still some controversies over arthroscopic suture anchor techniques. The number of anchors required for a successful outcome has been disputed. Boileau et al[11] reported that patients with 3 anchors or fewer had a significantly increased risk of recurrent instability, so they recommended at

least 4 anchors. Other authors believe that excessive anchors add a needless expense and contribute to postoperative stiffness. Most debates center on the indications for arthroscopic suture anchor repair. Some authors argue that collision sports indicate the need for an open coracoid transfer,[21,119] whereas others, most notably Mazzocca et al,[90] have shown low recurrence rates with arthroscopic treatment of collision athletes.[80,84] Similarly, there is no consensus on arthroscopic indications for glenoid bone defects. There is a consensus that bone loss is important; Burkhart and De Beer[14] reported a 67% recurrence rate after arthroscopic treatment of patients with significant bone loss, as compared with just 4% in those without it. However, there is no consensus on the degree of glenoid bone loss for which arthroscopic suture anchor techniques are insufficient. As alluded to earlier, most authors believe that 20% to 30% glenoid bone loss indicates the need for an open coracoid transfer.

Arthroscopic capsular imbrication

Thermal capsulorrhaphy was introduced by several authors in the late 1990s.[50,52,127] This procedure used a monopolar radiofrequency probe to heat and denature collagen molecules to reduce capsular redundancy. Initial reports showed effectiveness at treating anterior and multidirectional instability,[32,95] and the procedure was rapidly adopted. Luke et al[87] later compared thermal capsulorrhaphy with the open inferior capsular shift and found that the former reduced capsular volume by 20% less than the latter. More recent clinical reports have shown that the procedure offers no significant benefit to arthroscopic stabilization.[20,92] Good et al[40] ultimately showed that thermal capsulorrhaphy had caused rapid chondrolysis necessitating total shoulder arthroplasty in some patients, and this scenario combined with high recurrence rates largely led to the abandonment of thermal capsulorrhaphy.

Caspari[17] pioneered the transition from open capsular imbrication to an arthroscopic vertical shift. In 1994 Tauro and Carter described an arthroscopic capsular split/shift procedure to reduce axillary pouch laxity.[139] They split the inferior capsule from the inferior glenoid pole into the axillary pouch through a midanterior arthroscopic portal. Axillary nerve injury was avoided as long as the split did not extend within 1 cm of the capsular insertion onto the humeral head. To complete the superior shift, the anterior corner of the split was then advanced 2 cm along the glenoid rim and secured with suture anchors. Subsequent analyses of this technique have shown few complications, 6% to 7% recurrence rates, and improved functional outcomes.[1,140,141] Duncan and Savoie[30] reported excellent outcomes in 10 consecutive patients with a similar arthroscopic variation of the Altchek T-plasty.

In 2005 Sekiya[129] described a multi-pleated capsular imbrication that did not require an incision into the capsule. Instead, the capsular volume was reduced by using a soft-tissue penetrator to capture and imbricate folds of capsule with limbs from the suture anchors. When tested in a cadaveric model, this capsular plication resulted in a 13% greater reduction in capsular volume than the open capsular shift.[130] This method allows concomitant labral repair and capsulorrhaphy using the same suture anchors and is in widespread use today.

Biomechanical analysis has also shown that increased posteroinferior capsular strain may accompany anterior shoulder dislocations.[105] Westerheide et al[153] thus described a "pinch-tuck" technique to imbricate the posteroinferior capsule. Castagna et al[18] reported excellent outcomes with this technique, but concomitant anterior and posterior procedures may increase iatrogenic morbidity in the surrounding rotator cuff musculature. For this reason, Levy et al[84] reported percutaneous placement of suture anchors rather than through portals to increase maneuverability and decrease soft-tissue damage.

Savoie and colleagues[147] and Gartsman et al[37] championed rotator interval closure in the late 1990s as another method of augmenting glenohumeral stability. Provencher et al[116] presented biomechanical data showing that arthroscopic rotator interval closure does improve anterior stability, but they expressed concern that it may lead to significant losses of external rotation. Today, the decision to move forward with rotator interval closure is based on surgeon preference.

Arthroscopic versus open stabilization

Before 2000, five separate comparative trials had reported greater recurrence rates with arthroscopic stabilization than open surgery.[23,34,38,45,137] The only known benefits of arthroscopy at that time were a 1.8-fold decreased surgical time, 10-fold decrease in blood loss, and 2.5-fold decrease in postoperative narcotic use.[44] Recurrent instability after arthroscopy began to decrease, however, after technical innovations, such as the use of suture anchors and capsular imbrication. In 2004 Freedman et al[35] published a meta-analysis showing that arthroscopic Bankart repair's inferior outcomes could be largely traced to the use of transglenoid sutures and bioabsorbable tacks. Two subsequent randomized controlled trials using suture anchors in the arthroscopic group showed no advantage to the open technique. Fabbriciani et al[33] reported no recurrent dislocations 2 years after open or arthroscopic surgery, and Bottoni et al[12] similarly published zero recurrences as well as a significantly shorter operative time in the arthroscopic group. Today, the decision of open versus arthroscopic surgery is largely based on surgeon preference and experience, although most surgeons agree that an open technique is preferred for substantial glenoid bone loss.

In the past 10 years, French surgeons have designed an arthroscopic coracoid transfer. Lafosse et al[78] were the first group to report this technique in 2007. They exposed the coracoid arthroscopically by opening the rotator interval and brought the osteotomized fragment through a split in the

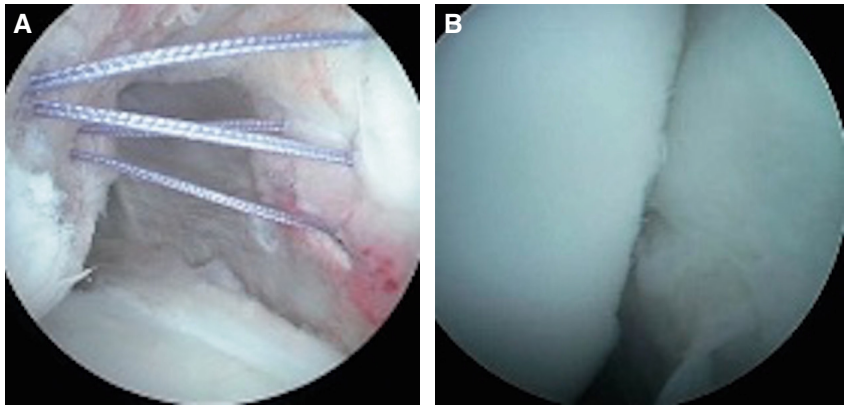

Figure 4 Arthroscopic remplissage for Hill-Sachs lesions. (**A**) Suture anchors are placed inside the bony defect of the humeral head, and sutures are passed through the infraspinatus. (**B**) Suture tying tightens down the infraspinatus so that it fills the bony defect.

subscapularis. This latter step requires extensive thermal ablation to expose and avoid the axillary nerve at the base of the subscapularis. The authors also cautioned against veering off the coracoid during the bone block osteotomy lest the surgeon injure the brachial plexus posterior to the pectoralis minor. They reported no complications or neurologic injuries in 44 patients after 2 years. Unlike Lafosse et al, Boileau et al[10] used 5 anterior portals and 1 posterior portal and performed a Bankart repair posterior to the bone block. In 2010 this team reported no recurrences, complications, or neurologic injuries in 41 patients. In addition, they used postoperative computed tomography scans to assess the accuracy of their bone block and found optimal positioning in 91% of patients. The primary barrier to widespread use of this procedure is its difficulty and the risk of severe neurologic injury to the brachial plexus, musculocutaneous, and axillary nerves. Castricini et al[19] showed that the arthroscopic Latarjet procedure has a steep learning curve, and an Italian group has already developed a similar arthroscopic operation using iliac crest bone graft.[142]

Hill-Sachs lesion management

In 1940 Hill and Sachs[54] first described a compression fracture of the humeral head resulting from anterior shoulder dislocation. Large Hill-Sachs lesions that engage the anterior glenoid rim may cause persistent instability. Classic surgical options, such as Bankart repair, capsulorrhaphy, coracoid transfer, and even humeral osteotomy, have attempted to bypass the defect by preventing the arm from reaching the point of engagement. Today, treatment of engaging Hill-Sachs lesions still mostly focuses on correcting glenoid and capsular abnormalities. In the past 15 years, however, more treatment strategies have emerged to correct the humeral defect, particularly when it is greater than 25% of the articular surface.[114]

In 2002 Yagishita and Thomas[159] used femoral head allograft in an open procedure to treat an engaging Hill-Sachs lesion. Miniaci and Gish[94] later reported successful outcomes with humeral head allograft in 18 patients with Hill-Sachs lesions larger than 25%. Fresh-frozen humeral head allografts continue to be an area of active research.[77,145] Open or percutaneous disimpaction[73] using a tamp and underlying bone graft is another treatment strategy, whereas partial resurfacing[100] and hemiarthroplasty[113] are salvage options for severe defects.

Arthroscopic remplissage has become the most popular treatment for engaging Hill-Sachs lesions (Fig. 4). *Remplissage* is French for "filling" and is a unique procedure in which a bony defect is replaced with soft-tissue coverage. Connolly[26] first described filling humeral head defects with local infraspinatus tissue in 1972, and this procedure was redefined arthroscopically by Wolf et al[158] in 2007. Wolf et al performed tenodesis of local infraspinatus and posterior capsule into the defect of 22 patients with just a 10% recurrence rate. A recent systematic review showed improved outcomes, minimal losses of external rotation, and few complications with arthroscopic remplissage,[16] and a separate review of 26 studies assessing all treatment options for humeral bone defects showed arthroscopic remplissage to be the safest and most stable option.[86]

Conclusion

Anterior shoulder stabilization is an increasingly common surgical procedure as operative indications have expanded. The duration, frequency, and complexity of anterior glenohumeral instability dictates a wide assortment of treatment options. Myriad techniques have been developed over the past century. Some methods, such as the Magnusson-Stack procedure, Putti-Platt procedure, arthroscopic stapling, and transosseous suture fixation, have been almost completely abandoned. The failure of these methods provides insight into the challenges we face when treating shoulder instability. Other strategies, such as the Bankart repair, capsular shift, and remplissage, have remained in place for decades and have been adapted for arthroscopic use.

The future of anterior shoulder stabilization will continue to evolve with even newer practices, such as the arthroscopic Latarjet transfer. Further research and clinical experience will dictate which future innovations are ultimately embraced.

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