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History of surgical stabilization for posterior shoulder instability

Stephen DiMaria, BS *, Steven L. Bokshan, MD, Christopher Nacca, MD, Brett Owens, MD

Department of Orthopaedic Surgery, Warren Alpert School of Medicine, Brown University, Providence, RI, USA

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Background: Posterior shoulder instability is common in young athletes. Although the posterior shoulder instability literature is less robust than its anterior counterpart, many surgical procedures have been developed and refined over the past several centuries to address this condition.

Materials and methods: This article represents a retrospective historical analysis of the most common procedures used to treat posterior shoulder instability after sports injuries. A systematic approach to obtain published information on posterior shoulder instability was performed using the PubMed/MEDLINE database, manual searches of high–impact factor journals, and conference proceedings and books.

Results: A wide array of both soft tissue–based and bone-based procedures have been developed for the treatment of posterior shoulder instability, ranging from procedures addressing the soft tissue alone (capsular shift, labral repair, reverse Putti-Platt) or bone-based procedures (glenoid and/or humeral osteotomy, glenoid bone block) to a combination of both bone and soft-tissue procedures (modified McLaughlin procedure).

Discussion: Over the past several centuries, a number of procedures have been developed to address posterior shoulder instability, particularly as this pathology has become better understood. Future work is required not only to continue to advance these procedures but also to assess their outcomes. An understanding of the historical perspective of posterior shoulder instability procedures is essential as surgeons continue to modify these procedures in an effort to best help their patients.

Posterior shoulder instability represents an array of disorders, ranging from symptomatic subluxation (symptomatic, excessive translation of the humeral head on the glenoid) to multiple frank dislocation events.[66] Classically, posterior glenohumeral instability has been classified into acute or chronic, locked, and voluntary or involuntary.[4] Posterior glenohumeral instability is an increasingly common condition, especially in young athletic male individuals, in whom it represents 10% of all instability events.[58] Isolated posterior shoulder instability has been recognized as a significant problem in contact athletes.[46,93] Posterior instability that develops owing to participation in sports represents another presentation within the spectrum of patients who present with posterior shoulder instability.[2] Although posterior instability has been found to occur commonly in young athletes, it remains underdiagnosed because of a lack of specific diagnostic criteria.[41,86] The relative rarity of posterior shoulder instability makes it difficult to create evidence-based guidelines or to establish the efficacy of newer treatment methods. The goal of this review was to present the history and evolution of the most prominent treatment options for posterior shoulder instability after sports injury with or without glenoid bone loss.

Materials and methods

A systematic review was conducted to identify as much published literature as possible that covers operative techniques to treat posterior shoulder instability. A comprehensive literature search was performed via a computer-based search of the online PubMed/MEDLINE database. The search was not limited by study design or language of publication and used broad terms to help maximize capture of the literature. Referenced articles were selected by examining the title and abstract obtained from the database search. Studies were included if they included outcome data of a procedure used to treat posterior shoulder instability. Other referenced articles and books were included if there was a description of a procedure that was used to treat posterior shoulder instability. Additional studies were identified by reviewing the reference lists and citations of included articles. Articles were not included in the references if they were non–English-language

* Corresponding author: Stephen DiMaria, BS. Department of Orthopaedic Surgery, Warren Alpert School of Medicine, Brown University, 100 Butler Dr. Providence, RI 02906, USA.

E-mail address: stephen_dimaria@brown.edu (S. DiMaria).

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articles that could not be interpreted and if they did not specifically focus on the treatment of posterior shoulder instability (eg, articles that discussed treatment of multidirectional shoulder instability were excluded).

General history of posterior shoulder instability

The earliest documentation of shoulder dislocation is found in the Edwin Smith Papyrus (3000-2500 BCE).[96] In 1741, White[45] reported a treatment for chronic posterior dislocations. Nearly 30 years later, in 1770, White published a general surgical book entitled *Cases in Surgery, With Remarks*.[92] In 1 case, he described admitting a patient to treat a severe dislocation of the head of the humerus passing beyond the coracoid process and lying underneath the pectoral muscle. After multiple attempts at manipulation, White heard a snapping noise and concluded that the arm returned to its proper articulation.[79]

In 1822, Cooper and Cooper[12] documented the first description of posterior shoulder dislocation. Cooper[11] later wrote a report describing the posterior dislocation event in a patient after a seizure. In this report, Cooper characterized in particular detail many of the symptoms associated with posterior dislocation, including impairment in external arm rotation and inability to elevate the arm from the side. This description hints at the first documentation of a reverse Hill-Sachs lesion (McLaughlin lesion), an impaction fracture of the anteromedial aspect of the humeral head following a posterior dislocation of the humerus.

Thirty-three years later, in 1855, Malgaigne[47] documented 37 cases (3 of his own and 34 reviewed from the literature) of posterior dislocation of the shoulder, highlighting the importance of performing a proper physical examination in making the correct diagnosis of posterior glenohumeral instability.

The first published cases of surgical treatment of posterior shoulder dislocation were published in the early 1980s by Tibone et al.[84] They performed a staple capsulorrhaphy in 10 athletes, but unfortunately, none of the patients were able to return to their previous sports status. Regarding sports injuries and posterior shoulder instability, recurrent posterior shoulder dislocation is less common than recurrent posterior subluxation. In athletes, posterior shoulder instability presents more as recurrent posterior subluxation rather than true dislocation.[83]

Extracapsular bone block procedures—acromion and iliac crest: 1947

Use of the bone block procedure was originally described and performed by Rocher[68] in 1931 using a rib graft. In 1943, Ilfeld and Holder[36] proposed the use of a free iliac crest for patients in whom posterior capsule stabilization procedures had previously failed. Thirty-three years later, in 1976, Gosset modified this procedure to provide additional screw fixation of the graft in combination with the posterior capsule procedure proposed by Fronek et al.[10,21,26] This procedure, which involves a larger graft extending beyond the height of the glenoid, is termed the "Gosset bone block procedure."

The first bone block procedure for the treatment of posterior shoulder instability was described by Hindenach[34] in 1947. Hindenach placed a bone block on the posterior glenoid to increase the posterior glenoid surface and improve stability (Fig. 1). Two years later, Fried[20] performed a posterior bone block procedure to successfully treat recurrent posterior dislocation by creating an extracapsular bone block along the posterior aspect of the glenoid. Fried noted recurrence due to resorption of the graft in 1 of 5 patients. Historically, extracapsular bone block procedures involved either an iliac bone block from the ipsilateral iliac crest or an acromial block with a pediculated deltoid flap.[3] The original use of

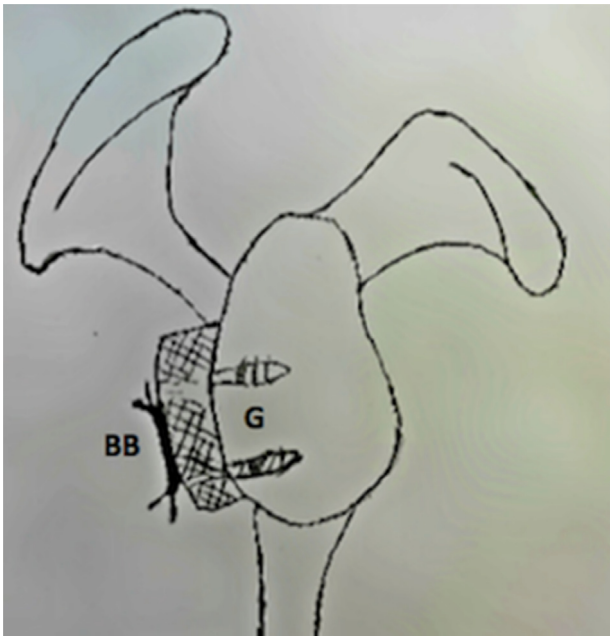

Figure 1 Drawing of glenoid (*G*) bone block *(BB)* (taken from acromion or iliac crest).

the acromial bone block was described by Kouvalchouk et al[40] with an attached deltoid to treat 5 patients with recurrent posterior glenohumeral instability.

The literature reports several extracapsular iliac bone block techniques for treating posterior glenohumeral instability. Mowery et al[55] performed iliac bone block procedures using a horizontal approach through the scapular spine, retracting the deltoid caudally and passing between the infraspinatus and teres minor. Essadki et al[17] conducted a retrospective review of 6 athletes who received a Gosset posterior iliac bone block. They noted that stability and pain relief were achieved in all 6 cases and that 3 patients achieved complete mobility. Barbier et al[3] reported complications with the iliac bone block procedure: In 3 of 8 patients who underwent the procedure, reoperation was performed for persistent pain to remove osteosynthesis material. Furthermore, Sirveaux et al[76] reported placement of an intra-articular screw associated with osteoarthritis in a patient.

The predominant procedure for an acromial bone block is the acromial pediculated block as described by Kouvalchouk et al.[40] Scapinelli[70] proposed an adjustment to the acromial bone block by inverting the posterior border of the acromion, claiming that the posterior border of the acromion exerted a slight pressure over the supraspinatus muscle during posterior instability.

Sirveaux et al[76] divided 18 patients into 2 equal groups and used an iliac crest bone graft combined with either a soft-tissue procedure or an acromial pediculated bone block as originally described by Kouvalchouk et al.[25,40] Sirveaux et al conducted a retrospective review of these 18 patients and found no recurrent dislocation or subluxation events, although 6 patients described apprehension. In addition, 9 patients returned to sports, 7 patients were pain free, and 10 patients had moderate discomfort with effort. Sirveaux et al concluded that the results of the acromial bone procedure looked promising. Unfortunately, long-term clinical results after the use of iliac crest bone grafts as posterior bone blocks have historically been disappointing, with studies reporting high rates of patient dissatisfaction, inability to return to desired levels of activity, and glenohumeral arthritis.[25,43,52,73,78]

McLaughlin procedure: 1952

In 1952, McLaughlin[50] performed a surgical technique, called the McLaughlin technique, to treat what is now known as a reverse Hill-Sachs lesion. McLaughlin was the first author to recognize the importance of an anterior humeral head bone defect (reverse Hill-Sachs, or McLaughlin, lesion) and its resulting effect on posterior shoulder instability. In the McLaughlin technique, the subscapularis tendon is transferred from the lesser tuberosity of the humerus to the bony defect. This procedure was subsequently modified by Hawkins et al[30] in 1987. This modification, which has grown in popularity, involves transfer of the subscapularis and lesser tuberosity into the defect (Fig. 2).[30] This procedure has shown effectiveness for chronic posterior shoulder dislocation.[9] Hawkins et al noted that their modification of the McLaughlin procedure does not involve posterior soft-tissue repair, which simplifies the procedure and may involve less bleeding.[75]

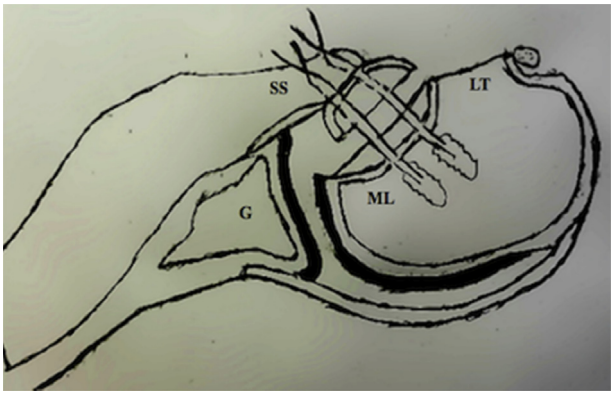

Figure 2 Drawing of modified McLaughlin procedure: transfer of subscapularis *(SS)* and/or lesser tuberosity *(LT)* to McLaughlin lesion *(ML)*. *G*, glenoid.

Reverse Putti-Platt procedure: 1953

The reverse Putti-Platt procedure was first described by Severin[74] in 1953. This procedure is a modification of the Putti-Platt procedure used to manage anterior shoulder instability.[74] The reverse Putti-Platt procedure involves sectioning of the infraspinatus tendon to imbricate the posterior rotator cuff–capsule complex in an effort to create a posterior block to dislocation. In 1984, Hawkins et al[27] reported that 6 of 9 patients who were treated with the reverse Putti-Platt procedure and biceps tendon transfer experienced recurrent posterior dislocation with a loss of internal rotation permanently to about 45°, limiting this procedure to historical relevance only.[80]

Staple capsulorrhaphy: 1956

Du Toit and Roux,[15] in 1956, introduced staple capsulorrhaphy, in which the detached capsule is secured to the glenoid using staples. Unfortunately, the first published case of surgical treatment of posterior shoulder dislocation was not promising. In 1981, Tibone et al[84] published the results of staple capsulorrhaphy in 10 athletes with posterior shoulder dislocation. They concluded that staple capsulorrhaphy is an ineffective procedure for posterior shoulder instability because of the high failure rate (no patients returned to their former throwing ability and 30% of patients experienced recurrent dislocation). Four years later, in 1985, Rao et al[64] performed Du Toit staple capsulorrhaphy in 65 patients followed up for an average period of 9 years. There was 1 dislocation, with 98% of surgical procedures rated excellent or good (94% excellent) with a 58% return-to-sport rate. In 1990, Tibone and Ting[82] revisited staple capsulorrhaphy, now for recurrent posterior subluxation of the shoulder. Unfortunately, the results were again disappointing. They ultimately recommended against staple capsulorrhaphy for posterior subluxation owing to the high failure rate.

Glenoid osteotomy: 1967

Glenoid osteotomy was first performed by Scott[71] in 1967 in a report of 3 patients with recurrent posterior dislocation. In 1984, Hawkins et al[29] advised against surgical reconstruction procedures, especially glenoid osteotomy, because of the high complication rates. In particular, they found a complication rate of 19% (5 of 26 shoulders) and a recurrence rate of 50% (13 of 26 shoulders) and noted that degenerative osteoarthritis was associated with posterior glenoid osteotomy. Since then, several reports have demonstrated the efficacy of glenoid osteotomy, although it is a technically demanding procedure.[7,23,63] Graichen et al[27] performed glenoid osteotomy in 32 patients with atraumatic posterior instability and found that 81% of the outcomes were rated good or excellent by the Constant-Murley and Rowe scores, with a 12.5% recurrence rate. Unfortunately, most published historical techniques using osteotomy procedures were performed prior to the routine use of computed tomography and magnetic resonance imaging and thus did not provide an assessment of glenoid morphology.

Capsular shift: 1980

In 1980, Neer and Foster[57] first described the inferior capsular shift procedure. This procedure aims to reduce capsular and ligamentous redundancy when Bankart repair has previously failed. In the original article, Neer and Foster treated 36 patients (40 shoulders) with only 1 instance of recurrence. This procedure has been performed and modified in numerous studies. Bigliani et al,[4] in 1995, performed a superior shift of the posterior-inferior aspect of

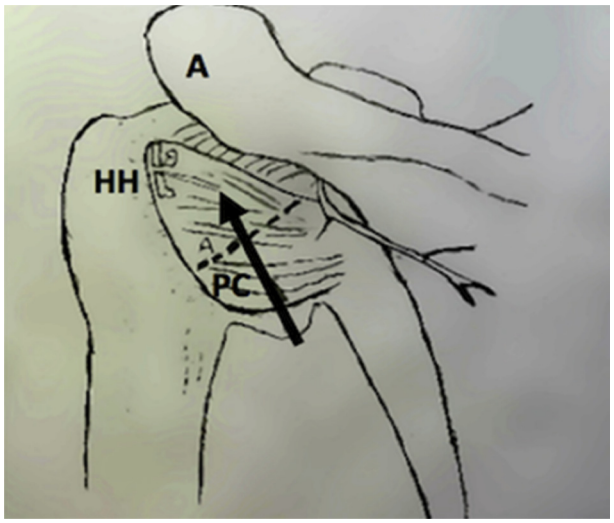

Figure 3 Drawing of posterior-inferior capsular shift. The dashed line represents the initial incision into the deltoid (removed here for illustrative purposes) along a posterolateral raphe. The incision is limited to less than 5.0 centimeters to prevent damage to the underlying axillary nerve. The arrow is demonstrating the superior shift of the posteroinferior flap of the capsule in order to remove the inferior pouch and reinforce the repair. The capsule was initially split in a T-shaped fashion in the mid-glenoid region, which created two capsular flaps. The superior flap was shifted inferiorly and reattached to the lateral aspect of the humeral neck. *A*, acromion; *HH*, humeral head; *PC*, posterior-inferior capsule.

the capsule specifically for posterior glenohumeral subluxation and dislocation (Fig. 3). They found that 28 of 34 patients experienced good or excellent outcomes of the surgical procedure. Fuchs et al[22] conducted a posterior-inferior capsular shift for recurrent posterior instability associated with voluntary subluxation in 26 shoulders. They found that the average relative score for shoulder function was 91% according to the system of Constant and Murley. Furthermore, more than half of all patients were able to perform all activities of the Simple Shoulder Test, although 8 patients still reported discomfort at night.

Humeral rotational osteotomy: 1985

In 1985, Vukov[87] was the first author to report a rotational osteotomy of the humerus in the English-language literature, which was used to treat chronic posterior dislocation. In 1994, Keppler et al[38] reported on 10 patients with locked posterior dislocation of the shoulder. They concluded that rotational osteotomy was an effective procedure at restoring glenohumeral congruity and restoring function in patients with locked posterior dislocation given 3 criteria: (1) healthy articular cartilage, (2) a humeral head defect involving less than 40% of the articular surface, and (3) a patient who is able to participate in an active rehabilitation program. Recently, Ziran and Nourbakhsh[97] performed proximal humeral de-rotational osteotomy for posterior shoulder dislocation in 4 children, following the procedure outlined by Keppler et al. They found that proximal de-rotational osteotomy for acute locked posterior dislocation of the shoulder can be viable for a younger age group since these patients did not have wound or neurologic complications or dislocations.

Other authors have reported complications with humeral rotational osteotomy procedures and 1 patient presented with avascular necrosis of the humeral head. Finally, Brooks-Hill et al[8] reported a high complication rate after humeral rotational osteotomy, finding 25 complications in 19 shoulders, necessitating 9 reoperations in 7 shoulders. Some authors do not recommend this technique because of the degree of technical difficulty and high percentage of osteoarthritis progression.[66,88] Humeral rotational osteotomy remains an uncommon but powerful approach.[8]

Thermal capsulorrhaphy: 1995

In the early 1990s, thermal energy was pioneered to “shrink” rather than suture together elongated glenohumeral ligaments.[18] This thermal energy comes in the form of laser or radiofrequency energy to heat the tissue to a specific temperature. During this procedure, tissue is heated to 65°C or higher to disrupt collagen cross-links and interfere with the triple-helix arrangement of collagen polypeptide chains, causing them to unwind and shorten.[33] Inflammation of the tissue results in synovial hyperplasia and fibroblast proliferation.[1]

Thermal capsulorrhaphy (TCS) has been used for the treatment of shoulder instability since 1994 as an alternative to traditional open capsular shift procedures pioneered by Neer and Foster.[57] The first authors to report on the clinical results using thermal energy to treat shoulder instability were Thabit et al,[81] in 1994. Prior to their report, little clinical information was known regarding the indications and outcomes of TCS.[56,72] Thabit et al used a holmium:YAG (yttrium-aluminum-garnet) laser-assisted capsular shift technique and achieved good or excellent results in the majority of patients (90% of 41 patients) at 6-month follow-up.

Despite this early success, TCS had higher long-term failure rates owing to rebound ligamentous stretching.[69] Furthermore, concerns were raised regarding its high initial maintenance costs and technical difficulties. To address the problems of laser-assisted TCS, monopolar-radiofrequency TCS was developed in 1996 and was promoted as having the advantages of the laser TCS technique but with more control.[85]

Controversy remains regarding using TCS to treat the shoulder capsule, particularly with increasing reports of complications including higher-than-expected failure rates, axillary nerve injury, recurrent instability, iatrogenic cartilage injury, and capsular disruption.[16,31,32,44,51,65,89–91,95]

Labral repair: 1996

Labral detachment from the posterior glenoid (reverse Bankart lesion) was first associated with instability by Pappas et al[59] in 1983. In 1996, Hawkins and Janda[28] reported an open labral repair procedure for posterior shoulder subluxation. Of 14 patients, 13 were satisfied with the surgical procedures, and no patient had recurrence of posterior instability. Kim et al,[39] in 2003, described 27 cases of traumatic unidirectional recurrent posterior subluxation of the shoulder and performed arthroscopic labral repair and posterior capsular shift. They further pioneered the use of arthroscopic labral repair to treat posterior shoulder instability, which at the time was primarily treated using open labral repair.[38]

One major advancement in the field of labral repair was the transition from using staples or bioabsorbable tacks to using suture anchors (Fig. 4). Arthroscopic labral repair using staples or bioabsorbable tacks led to complication rates as high as 30%, with hardware breakage and migration occurring frequently.[48,53] The rate of implant-related complications associated with staples and bioabsorbable tacks has declined dramatically since the transition to suture anchors.

Bottoni et al[5] performed arthroscopic stabilization of the posterior shoulder with bioabsorbable suture anchors in 19 patients and open repair in 14 patients with traumatic posterior shoulder instability due to collision and contact sports. They reported that the patients who received arthroscopic stabilization with bioabsorbable suture anchors had significantly better Western Ontario Shoulder Instability Index scores and Rowe scores than the patients in the open-procedure group. Furthermore, Bottoni et al noted that the arthroscopic technique using suture anchor repair with capsular plication led to the most favorable outcomes. Similar results were obtained in a meta-analysis performed by DeLong et al,[13] in which arthroscopic stabilization procedures using suture anchors were found to result in fewer recurrences and revisions than anchorless repairs in young adults engaging in highly demanding physical activity. As a testament to the generalized success with arthroscopic labral repair and capsulorrhaphy, no known randomized controlled trials exist comparing these procedures with other surgical options (eg, open repair).

Intra-articular bone block: 2013

Intracapsular techniques for repairing posterior glenoid bone loss have been increasingly popularized in recent years. Glenoid bone loss is one of the most significant risk factors for recurrent injury after arthroscopic treatment of glenohumeral instability.[37,62] Despite the controversy surrounding the amount of bone loss that necessitates restoration, glenohumeral stability is compromised when bone loss exceeds 20% to 25%.[24,35] Currently, there is no consensus regarding the amount of posterior glenoid loss necessitating bony reconstruction, although it has been recommended that glenoid defects with greater than 25% bone loss of the width of the inferior glenoid (“inverted-pear glenoid”) be reconstructed to re-establish shoulder stability.[54,77]

Unfortunately, bone block reconstruction fails to provide anatomic restoration of the glenoid articular surface; therefore, the

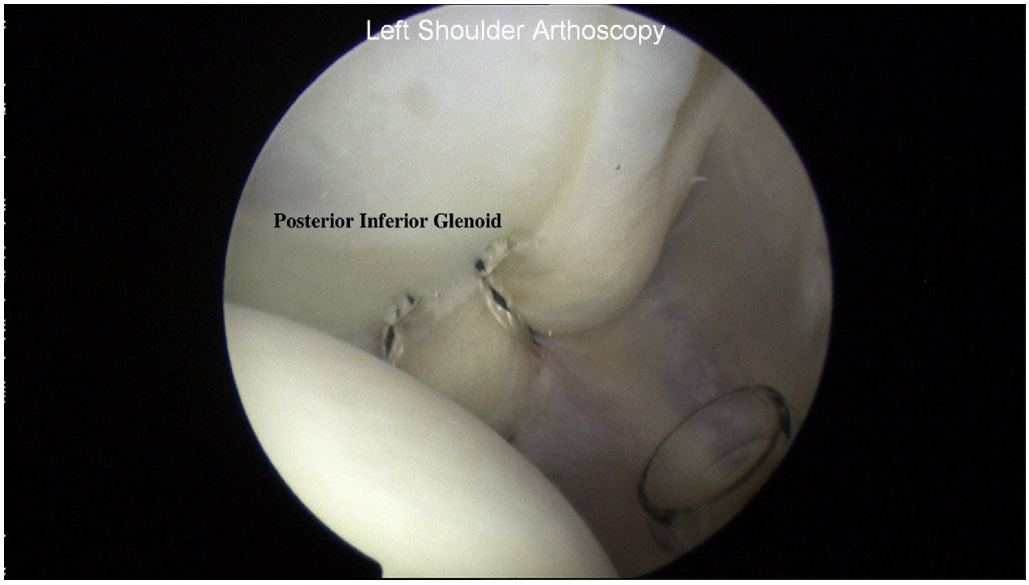

Figure 4 Arthroscopic posterior-inferior labral repair for posterior shoulder instability using 2 bioabsorbable knotless suture anchors and tape.

articular surface of the glenohumeral joint remains incongruent.[19] To address the development of early, symptomatic glenohumeral arthritis associated with extracapsular iliac crest bone graft as a posterior bone block, intracapsular techniques have been developed, such as the use of a distal tibial allograft, which provides an anatomic reconstruction of the glenoid cavity.[19]

In 2013, Millett et al[54] were the first authors to use a distal tibial osteoarticular allograft for the treatment of posterior shoulder instability. They performed an anatomic posterior glenoid reconstruction using a distal tibial allograft in 2 patients with a large posterior glenoid bone defect and concluded that this allograft could be used as a new treatment option for patients with recurrent posterior instability accompanied by significant posterior glenoid bone loss. Both patients returned to noncontact recreational sporting activities. In addition, in 2014, Frank et al[19] found that using distal tibial allograft provided similar contact mechanisms to iliac crest bone graft at the time of surgery in cadaveric shoulders and supported posterior glenoid reconstruction with fresh distal tibial allograft as an alternative procedure to iliac crest bone graft.

Surgical stabilization of posterior shoulder instability due to sports injury with or without glenoid bone loss

The best outcomes in patients with posterior shoulder instability after sports injuries seem to occur with open or arthroscopic procedures to repair posterior labral pathology and capsulolabral reconstruction.[67] The current trend favors lesion-specific treatment, and this recent development has improved clinical results, especially when performed arthroscopically.[67] Arthroscopic repair of traumatic posterior shoulder instability is an effective way of eliminating symptoms of pain and instability in athletes.[93] The 1980s marked the advent of shoulder arthroscopy and assisted shoulder surgeons in identifying specific lesions that were associated with posterior shoulder instability. Although surgery can be performed through either an open or arthroscopic approach, the arthroscopic approach allows the surgeon to address intra-articular pathology in the same setting.[2] However, the first report of arthroscopic shoulder stabilization was not published until years later, in 1998.[94] Reported clinical outcomes after arthroscopic posterior shoulder stabilization are good to excellent, and to date, this approach has had the highest success rates for treating posterior shoulder instability after sports injury, at around 90%.[13,42,46,49,60,61] In a study conducted by DiFelice et al,[14] the results of arthroscopic capsulolabral reconstruction for the treatment of posterior shoulder instability were reported in 100 athletes and showed an 89% success rate, with 67% of patients being able to return to the same level of play postoperatively. Furthermore, in one of the largest prospective studies to date on posterior shoulder instability due to sports injury, Bradley et al[6] performed arthroscopic capsulolabral reconstruction in 188 athletes and found that 94% of patients were satisfied with the results and 90% returned to contact sports, with 64% returning to the same level of play. Another study found that for traumatic posterior shoulder subluxation, surgical treatment with both open and arthroscopic procedures provided satisfactory results; however, the arthroscopic technique using suture anchor repair with capsular plication provided the most favorable outcomes.[5]

Conclusion

A wide array of both soft tissue–based and bone-based procedures have been developed for the treatment of posterior shoulder instability, ranging from procedures addressing the soft tissue alone (capsular shift, labral repair, reverse Putti-Platt) and bone-based procedures (glenoid and/or humeral osteotomy, glenoid bone block) to a combination of both bone and soft-tissue procedures (modified McLaughlin procedure). Each of the procedures should be considered in the correct historical perspective and chosen based on an individualized approach regarding patient selection. Although arthroscopic labral repair as well as capsulorrhaphy is the currently favored approach to posterior instability, shoulder surgeons should be aware of the individual treatment options for posterior shoulder instability and how those options have evolved over time. Over the past several centuries, a number of procedures have been developed to address posterior shoulder instability, particularly as this pathology has become better understood. More recently, the advent of arthroscopic repair has led to increased interest in treating posterior instability after sports injury with or without glenoid bone loss without the morbidity of open surgery. The current trend for treating posterior shoulder

instability from sports injuries favors lesion-specific treatment, and improved clinical outcomes are seen especially with arthroscopic repair. Ultimately, future work is required not only to continue to advance these procedures but also to assess their outcomes.

Disclaimer

Brett Owens is a consultant for Mitek, ConMed, Musculoskeletal Transplant Foundation, and Vericel and receives royalties from ConMed.

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References

1. Abrams JS. Thermal capsulorrhaphy for instability of the shoulder: concerns and applications of the heat probe. Instr Course Lect 2001;50:29–36.
2. Antosh IJ, Tokish JM, Owens BD. Posterior shoulder instability: current surgical management. Sports Health 2016;8:520–6. https://doi.org/10.1177/1941738116672446.
3. Barbier O, Ollat D, Marchaland J, Versier G. Iliac bone-block autograft for posterior shoulder instability. Orthop Traumatol Surg Res 2009;95:100–7. https://doi.org/10.1016/j.otsr.2008.09.008.
4. Bigliani LU, Pollock RG, McIlveen SJ, Endrizzi DP, Flatow EL. Shift of the posteroinferior aspect of the capsule for recurrent posterior glenohumeral instability. J Bone Joint Surg Am 1995;77:1011–20.
5. Bottoni CR, Franks BR, Moore JH, DeBerardino TM, Taylor DC, Arciero RA. Operative stabilization of posterior shoulder instability. Am J Sports Med 2005;33:996–1002. https://doi.org/10.1177/0363546504271509.
6. Bradley JP, McClincy MP, Arner JW, Tejwani SG. Arthroscopic capsulolabral reconstruction for posterior instability of the shoulder: a prospective study of 200 shoulders. Am J Sports Med 2013;41:2005–14. https://doi.org/10.1177/0363546513493599.
7. Brewer BJ, Wubben RC, Carrera GF. Excessive retroversion of the glenoid cavity. A cause of non-traumatic posterior instability of the shoulder. J Bone Joint Surg Am 1986;68:724–31.
8. Brooks-Hill AL, Forster BB, van Wyngaarden C, Hawkins R, Regan WD. Weber osteotomy for large Hill-Sachs defects: clinical and CT assessments. Clin Orthop Relat Res 2013;471:2548–55. https://doi.org/10.1007/s11999-013-3024-5.
9. Charalambous CP, Gullett TK, Ravenscroft MJ. A modification of the McLaughlin procedure for persistent posterior shoulder instability. Arch Orthop Trauma Surg 2009;129:753–5. https://doi.org/10.1007/s00402-008-0721-8.
10. Clavert P, Furioli E, Andieu K, Sirveaux F, Hardy MB, Nourissat G, et al. Clinical outcomes of posterior bone block procedures for posterior shoulder instability: multicenter retrospective study of 66 cases. Orthop Traumatol Surg Res 2017;103:S193–7. https://doi.org/10.1016/j.otsr.2017.08.006.
11. Cooper A. On the dislocations of the os humeri upon the dorsum scapulae, and upon fractures near the shoulder joint. Guys Hosp Rep 1839;4:265–84.
12. Cooper SA, Cooper BB. A treatise on dislocations and fractures of the joints. London: Longman, Hurst, Rees, Orme and Brown; 1822.
13. DeLong JM, Jiang K, Bradley JP. Posterior instability of the shoulder: a systematic review and meta-analysis of clinical outcomes. Am J Sports Med 2015;43:1805–17. https://doi.org/10.1177/0363546515577622.
14. DiFelice GS, Williams RJ III, Cohen MS, Warren RF. The accessory posterior portal for shoulder arthroscopy: description of technique and cadaveric study. Arthroscopy 2001;17:888–91.
15. Du Toit GT, Roux D. Recurrent dislocation of the shoulder; a twenty-four year study of the Johannesburg stapling operation. J Bone Joint Surg Am 1956;38:1–12.
16. Elhassan B, Warner JJ, Ozbaydar MU. Complications of thermal capsulorrhaphy of the shoulder: management of the capsular deficiency. Tech Shoulder Elbow Surg 2007;8:111–1116. https://doi.org/10.2106/00004623-200100022-00013.
17. Essadki B, Dumontier C, Sautet A, Apoil A. Instabilité postérieure de l'épaule chez le sportif traitée par butée iliaque. A propos de 6 observations [Posterior shoulder instability in athletes: surgical treatment with iliac bone block. Apropos of 6 case reports]. Rev Chir Orthop Reparatrice Appar Mot 2000;86:765–72 [in French].
18. Fanton GS, Khan AM. Monopolar radiofrequency energy for arthroscopic treatment of shoulder instability in the athlete. Orthop Clin 2001;32:511–23.
19. Frank RM, Shin J, Saccomanno MF, Bhatia S, Shewman E, Bach BR Jr, et al. Comparison of glenohumeral contact pressures and contact areas after posterior glenoid reconstruction with an iliac crest bone graft or distal tibial osteochondral allograft. Am J Sports Med 2014;42:2574–82. https://doi.org/10.1177/0363546514545860.
20. Fried A. Habitual posterior dislocation of the shoulder-joint; a report on five operated cases. Acta Orthop Scand 1949;18:329–45.
21. Fronek J, Warren RF, Bowen M. Posterior subluxation of the glenohumeral joint. J Bone Joint Surg Am 1989;71:205–16.
22. Fuchs B, Jost B, Gerber C. Posterior-inferior capsular shift for the treatment of recurrent, voluntary posterior subluxation of the shoulder. J Bone Joint Surg Am 2000;82:16–25.
23. Gerber C, Ganz R, Vinh TS. Glenoplasty for recurrent posterior shoulder instability. An anatomic reappraisal. Clin Orthop Relat Res 1987:70–9.
24. Gerber C, Nyffeler RW. Classification of glenohumeral joint instability. Clin Orthop Relat Res 2002;400:65–76. https://doi.org/10.1097/00003086-200207000-00009.
25. Gosens T, Van Biezen FC, Verhaar J. The bone block procedure in recurrent posterior shoulder instability. Acta Orthop Belg 2001;67:116–20.
26. Gossett J. Luxations récidivantes postérieures de l'épaule. Technique de butée osseuse scapulaire postérieure. À propos de quatre cas personnels [Recurrent posterior shoulder dislocations. A posterior scapular bone block technique. A report of 4 personal cases]. Ann Chir 1976;30:569–72.
27. Graichen H, Koydl P, Zichner L. Effectiveness of glenoid osteotomy in atraumatic posterior instability of the shoulder associated with excessive retroversion and flatness of the glenoid. Int Orthop 1999;23:95–9.
28. Hawkins RJ, Janda DH. Posterior instability of the glenohumeral joint: a technique of repair. Am J Sports Med 1996;24:275–8.
29. Hawkins RJ, Koppert G, Johnston G. Recurrent posterior instability (subluxation) of the shoulder. J Bone Joint Surg Am 1984;66:169–74.
30. Hawkins RJ, Pianta RM, Mendoza FX. Locked posterior dislocation of the shoulder. J Bone Joint Surg Am 1987;69:9–18.
31. Hayashi K, Hecht P, Thabit G III, Peters DM, Vanderby R Jr, Cooley AJ, et al. The biologic response to laser thermal modification in an in vivo sheep model. Clin Orthop Relat Res 2000;373:265–76.
32. Hayashi K, Massa KL, Thabit G III, Fanton GS, Dillingham MF, Gilchrist KW, et al. Histologic evaluation of the glenohumeral joint capsule after the laser-assisted capsular shift procedure for glenohumeral instability. Am J Sports Med 1999;27:162–7.
33. Hayashi K, Thabit G III, Massa KL, Bogdanske JJ, Cooley AJ, Orwin JF, et al. The effect of thermal heating on the length and histologic properties of the glenohumeral joint capsule. Am J Sports Med 1997;25:107–12.
34. Hindenach J. Recurrent posterior dislocation of the shoulder. J Bone Joint Surg 1947;29:582–6.
35. Hovelius LK, Sandström BC, Rösmark DL, Saebö M, Sundgren KH, Malmqvist BG. Long-term results with the Bankart and Bristow-Latarjet procedures: recurrent shoulder instability and arthropathy. J Shoulder Elbow Surg 2001;10:445–52.
36. Ilfeld FW, Holder HG. Recurrent dislocation of the shoulder joint: a combination procedure. A preliminary report. J Bone Joint Surg 1943;25:651–8.
37. Itoi E, Lee S, Berglund LJ, Berge LL, An K. The effect of a glenoid defect on anteroinferior stability of the shoulder after Bankart repair: a cadaveric study. J Bone Joint Surg Am 2000;82:35–46.
38. Keppler P, Holz U, Thielemann FW, Meinig R. Locked posterior dislocation of the shoulder: treatment using rotational osteotomy of the humerus. J Orthop Trauma 1994;8:286–92.
39. Kim SH, Ha KI, Park JH, Kim YM, Lee YS, Lee JY, et al. Arthroscopic posterior labral repair and capsular shift for traumatic unidirectional recurrent posterior subluxation of the shoulder. J Bone Joint Surg Am 2003;85:1479–87. https://doi.org/10.2106/00004623-200308000-00008.
40. Kouvalchouk JF, Coudert X, Watin Augouard L, Da Silva Rosa R, Paszkowski A. Le traitement des instabilités postérieures de l'épaule par butée acromiale pédiculée à un lambeau deltoïdien [Treatment of posterior instability of the shoulder joint using an acromial stop with a pediculated deltoid flap]. Rev Chir Orthop Reparatrice Appar Mot 1993;79:661–5 [in French].
41. Lanzi JT Jr, Chandler PJ, Cameron KL, Bader JM, Owens BD. Epidemiology of posterior glenohumeral instability in a young athletic population. Am J Sports Med 2017;45:3315. https://doi.org/10.1177/0363546517725067.
42. Lenart BA, Sherman SL, Mall NA, Gochanour E, Twigg SL, Nicholson GP. Arthroscopic repair for posterior shoulder instability. Arthroscopy 2012;28:1337–43. https://doi.org/10.1016/j.arthro.2012.03.011.
43. Levigne C, Garret J, Walch G. Posterior bone block for posterior instability. Tech Shoulder Elbow Surg 2005;6:26–35. https://doi.org/10.1097/01.bte.0000156392.00292.96.
44. Levine WN, Clark AM Jr, D'alessandro DF, Yamaguchi K. Chondrolysis following arthroscopic thermal capsulorrhaphy to treat shoulder instability: a report of two cases. J Bone Joint Surg Am 2005;87:616–21. https://doi.org/10.2106/JBJS.D.02158.
45. Loebenberg MI, Cuomo F. The treatment of chronic anterior and posterior dislocations of the glenohumeral joint and associated articular surface defects. Orthop Clin North Am 2000;31:23–4.
46. Mair SD, Zarzour R, Speer KP. Posterior labral injury in contact athletes. Am J Sports Med 1998;26:753–8.
47. Malgaigne JF. Paris. Traité des fractures et luxations [A treatise on fractures], vol II. Paris: J.B. Bailliére; 1855 [in French].
48. McFarland EG, Park HB, Keyurapan E, Gill HS, Selhi HS. Suture anchors and tacks for shoulder surgery, part 1: biology and biomechanics. Am J Sports Med 2005;33:1918–23. https://doi.org/10.1177/0363546505282621.
49. McIntyre LF, Caspari RB, Savoie FH. The arthroscopic treatment of posterior shoulder instability: two-year results of a multiple suture technique. Arthroscopy 1997;13:426–32.
50. McLaughlin HL. Posterior dislocation of the shoulder. J Bone Joint Surg 1952;34:584–90.

51. Medvecky MJ, Ong BC, Rokito AS, Sherman OH. Thermal capsular shrinkage: basic science and clinical applications. Arthroscopy 2001;17:624–35.
52. Meuffels DE, Schuit H, Van Biezen FC, Reijman M, Verhaar J. The posterior bone block procedure in posterior shoulder instability: a long-term follow-up study. Bone Joint J 2010;92:651–5. https://doi.org/10.1302/0301-620X.92B5.23529.
53. Meyer DC, Gerber C. Failure of anterior shoulder instability repair caused by eyelet cutout of absorbable suture anchors. Arthroscopy 2004;20:521–3. https://doi.org/10.1016/j.arthro.2004.01.033.
54. Millett PJ, Schoenahl J, Register B, Gaskill TR, van Deurzen DF, Martetschläger F. Reconstruction of posterior glenoid deficiency using distal tibial osteoarticular allograft. Knee Surg Sports Traumatol Arthrosc 2013;21:445–9. https://doi.org/10.1007/s00167-012-2254-5.
55. Mowery CA, Garfin SR, Booth RE, Rothman RH. Recurrent posterior dislocation of the shoulder: treatment using a bone block. J Bone Joint Surg Am 1985;67:777–81.
56. Naseef GS, Foster TE, Trauner K, Solhpour S, Anderson RR, Zarins B. The thermal properties of bovine joint capsule: the basic science of laser-and radio-frequency-induced capsular shrinkage. Am J Sports Med 1997;25:670–4.
57. Neer CS II, Foster CR. Inferior capsular shift for involuntary inferior and multidirectional instability of the shoulder. A preliminary report. J Bone Joint Surg Am 1980;62:897–908.
58. Owens BD, Campbell SE, Cameron KL. Risk factors for posterior shoulder instability in young athletes. Am J Sports Med 2013;41:2645–9. https://doi.org/10.1177/0363546513501508.
59. Pappas AM, Goss TP, Kleinman PK. Symptomatic shoulder instability due to lesions of the glenoid labrum. Am J Sports Med 1983;11:279–88.
60. Pennington WT, Sytsma MA, Gibbons DJ, Bartz BA, Dodd M, Daun J, et al. Arthroscopic posterior labral repair in athletes: outcome analysis at 2-year follow-up. Arthroscopy 2010;26:1162–71. https://doi.org/10.1016/j.arthro.2010.01.006.
61. Provencher MT, Bell SJ, Menzel KA, Mologne TS. Arthroscopic treatment of posterior shoulder instability: results in 33 patients. Am J Sports Med 2005;33:1463–71. https://doi.org/10.1177/0363546505278301.
62. Provencher MT, Bhatia S, Ghodadra NS, Grumet RC, Bach BR Jr, Dewing CB, et al. Recurrent shoulder instability: current concepts for evaluation and management of glenoid bone loss. J Bone Joint Surg Am 2010;92(Suppl 2):133–51. https://doi.org/10.2106/JBJS.J.00906.
63. Provencher MT, LeClere LE, King S, McDonald LS, Frank RM, Mologne TS, et al. Posterior instability of the shoulder: diagnosis and management. Am J Sports Med 2011;39:874–86. https://doi.org/10.1177/0363546510384232.
64. Rao JP, Francis AM, Hurley J, Daczkewycz R. Treatment of recurrent anterior dislocation of the shoulder by duToit staple capsulorrhaphy. Results of long-term follow-up study. Clin Orthop Relat Res 1986:169–76.
65. Rath E, Richmond JC. Capsular disruption as a complication of thermal alteration of the glenohumeral capsule. Arthroscopy 2001;17:1–3.
66. Robinson CM, Aderinto J. Posterior shoulder dislocations and fracture-dislocations. J Bone Joint Surg Am 2005;87:639–50. https://doi.org/10.2106/JBJS.D.02371.
67. Robinson CM, Aderinto J. Recurrent posterior shoulder instability. J Bone Joint Surg Am 2005;87:883–92. https://doi.org/10.2106/JBJS.D.02906.
68. Rocher H. Butée glénoïdienne postérieure par greffon costal dans une subluxation habituelle de l'épaule due à une paralysie obstétricale [Posterior glenoid bone block by costal (rib) graft in a repetitive subluxation of the shoulder due to obstetrical palsy]. Paris Chir 1931;2:33–43 [in French].
69. Rolfes K. Arthroscopic treatment of shoulder instability: a systematic review of capsular plication versus thermal capsulorrhaphy. J Athl Train 2015;50:105–9. https://doi.org/10.4085/1062-6050-49.3.63.
70. Scapinelli R. Posterior addition acromioplasty in the treatment of recurrent posterior instability of the shoulder. J Shoulder Elbow Surg 2006;15:424–31. https://doi.org/10.1016/j.jse.2005.10.012.
71. Scott DJ Jr. Treatment of recurrent posterior dislocations of the shoulder by glenoplasty: report of three cases. J Bone Joint Surg Am 1967;49:471–6.
72. Selecky MT, Vangsness CT, Liao W, Saadat V, Hedman TP. The effects of laser-induced collagen shortening on the biomechanical properties of the inferior glenohumeral ligament complex. Am J Sports Med 1999;27:168–72.
73. Servien E, Walch G, Cortes ZE, Edwards TB, O'Connor DP. Posterior bone block procedure for posterior shoulder instability. Knee Surg Sports Traumatol Arthrosc 2007;15:1130–6. https://doi.org/10.1007/s00167-007-0316-x.
74. Severin E. Anterior and posterior recurrent dislocation of the shoulder: the Putti-Platt operation. Acta Orthop Scand 1953;23:14–22.
75. Shams A, El-Sayed M, Gamal O, ElSawy M, Azzam W. Modified technique for reconstructing reverse Hill-Sachs lesion in locked chronic posterior shoulder dislocation. Eur J Orthop Surg Traumatol 2016;26:843–9. https://doi.org/10.1007/s00590-016-1825-4.
76. Sirveaux F, Leroux J, Roche O, Gosselin O, De Gasperi M, Molé D. Traitement de l'instabilité postérieure de l'épaule par butée iliaque ou acromiale: À propos d'une série de 18 cas [Surgical treatment of posterior instability of the shoulder joint using an iliac bone block or an acromial pediculated bone block: outcome in eighteen patients]. Rev Chir Orthop Reparatrice Appar Mot 2004;90:411–9. https://doi.org/10.1016/S0035-1040(04)70167-1 [in French].
77. Skogland LB, Sundt P. Recurrent anterior dislocation of the shoulder: the Eden-Hybbinette operation. Acta Orthop Scand 1973;44:739–47.
78. Smith T, Goede F, Struck M, Wellmann M. Arthroscopic posterior shoulder stabilization with an iliac bone graft and capsular repair: a novel technique. Arthrosc Tech 2012;1:e181–5. https://doi.org/10.1016/j.eats.2012.07.003.
79. Tan CK, Guisasola I, Machani B, Kemp G, Sinopidis C, Brownson P, et al. Arthroscopic stabilization of the shoulder: a prospective randomized study of absorbable versus nonabsorbable suture anchors. Arthroscopy 2006;22:716–20. https://doi.org/10.1016/j.arthro.2006.03.017.
80. Tannenbaum E, Sekiya JK. Evaluation and management of posterior shoulder instability. Sports Health 2011;3:253–63. https://doi.org/10.1177/1941738111400562.
81. Thabit G, Thorpe W, Horne R. Treatment of unidirectional and multidirectional glenohumeral instability by an arthroscopic holmium: YAG laser-assisted capsular shift procedure. Laser application in arthroscopy. Available at: https://ci.nii.ac.jp/naid/10008120719/; 1994. accessed April 23, 2019.
82. Tibone J, Ting A. Capsulorrhaphy with a staple for recurrent posterior subluxation of the shoulder. J Bone Joint Surg Am 1990;72:999–1002.
83. Tibone JE, Bradley JP. The treatment of posterior subluxation in athletes. Clin Orthop Relat Res 1993:124–37.
84. Tibone JE, Prietto C, Jobe FW, Kerlan RW, Carter VS, Shields CL Jr, et al. Staple capsulorrhaphy for recurrent posterior shoulder dislocation. Am J Sports Med 1981;9:135–9.
85. Toth AP, Warren RF, Petrigliano FA, Doward DA, Cordasco FA, Altchek DW, et al. Thermal shrinkage for shoulder instability. HSS J 2011;7:108–14. https://doi.org/10.1007/s11420-010-9187-7.
86. Van Tongel A, Karelse A, Berghs B, Verdonk R, De Wilde L. Posterior shoulder instability: current concepts review. Knee Surg Sports Traumatol Arthrosc 2011;19:1547–53. https://doi.org/10.1007/s00167-010-1293-z.
87. Vukov V. Posterior dislocation of the shoulder with a large anteromedial defect of the head of the humerus. Int Orthop 1985;9:37–40.
88. Walch G, Boileau P, Martin B, Dejour H. Luxations et fractures-luxations postérieures invétérées de l'épaule. A propos de 30 cas [Unreduced posterior luxations and fractures-luxations of the shoulder. Apropos of 30 cases]. Rev Chir Orthop Reparatrice Appar Mot 1990;76:546–58 [in French].
89. Wallace AL, Hollinshead RM, Frank CB. Creep behavior of a rabbit model of ligament laxity after electrothermal shrinkage in vivo. Am J Sports Med 2002;30:98–102. https://doi.org/10.1177/03635465020300012901.
90. Wallace AL, Hollinshead RM, Frank CB. Electrothermal shrinkage reduces laxity but alters creep behavior in a lapine ligament model. J Shoulder Elbow Surg 2001;10:1–6.
91. Wallace AL, Hollinshead RM, Frank CB. The scientific basis of thermal capsular shrinkage. J Shoulder Elbow Surg 2000;9:354–60.
92. White C, Miller J, van Rymsdyk J. *Cases in surgery, with remarks: Part the first.* W. Johnston, in Ludgate-Street; 1770.
93. Williams RJ, Strickland S, Cohen M, Altchek DW, Warren RF. Arthroscopic repair for traumatic posterior shoulder instability. Am J Sports Med 2003;31:203–9. https://doi.org/10.1177/03635465030310020801.
94. Wolf EM, Eakin CL. Arthroscopic capsular plication for posterior shoulder instability. Arthroscopy 1998;14:153–63.
95. Wong KL, Williams GR. Complications of thermal capsulorrhaphy of the shoulder. J Bone Joint Surg Am 2001;83(Suppl 2):151.
96. Zimmerman LM, Veith I. Great ideas in the history of surgery. Baltimore: Williams & Wilkins; 1961.
97. Ziran B, Nourbakhsh A. Proximal humerus derotational osteotomy for internal rotation instability after locked posterior shoulder dislocation: early experience in four patients. Patient Saf Surg 2015;9:15. https://doi.org/10.1186/s13037-015-0062-9.