Navigation-Guided Trans-glenoid Flexible Fixation Technique for Arthroscopic Autologous Iliac Crest Grafting Treatment of Recurrent Shoulder Dislocation

Jiaxing Huang, M.D., Li Wei, M.D., Bo Zhu, M.D., Jiawei Wang, M.D., Wei Huang, M.D., Ning Hu, M.D., and Hong Chen, M.D.

Abstract: Recurrent anterior shoulder dislocations accompanied by severe glenoid bone defects are typically treated with arthroscopy. Until now, autologous iliac grafting has been reported with excellent results, and different techniques of bone fixation have been introduced by numerous scholars. In this article, we introduce a specially designed guide that can achieve accurate positioning of the bone graft and a nonrigid graft fixation technique with a single EndoButton (Smith & Nephew). Using this technique, we greatly simplify the arthroscopic procedure and avoid the use of screws.

Recurrent shoulder dislocation after initial traumatic dislocation is fairly common owing to the relative lack of bony limitations. Moreover, extensive range of motion, young age, and high activity level serve as very strong risk factors for recurrent shoulder dislocations. Numerous surgical techniques have been described over the past 10 decades to correct this situation. For patients with extensive glenoid bone defects, bone augmentation greatly reduces the shoulder dislocation recurrence rate as compared with Bankart repair alone.

At present, the Latarjet procedure and iliac crest grafting are the most commonly used procedures for restoration of the glenoid’s pear shape. The Latarjet procedure works via a mechanical barrier of a coracoid bone block and the sling effect of the conjoint tendon. However, nonanatomic reconstruction destroys the normal kinematics of the subscapularis tendon. Recently, free bone block (FBB) procedures have been proposed as an alternative to or bailout for the Latarjet procedure for the treatment of anterior shoulder instability. Moreover, it was confirmed that the safety and efficacy of the FBB procedure are fairly equal to those of the Latarjet procedure. Furthermore, a recent large-sample meta-analysis has shown that the rates of recurrent instability, osteoarthritis progression, and return to sports were similar between the 2 procedures. In addition, the aforementioned study revealed that screw fixation was related to some complications in both the Latarjet and FBB procedures (including screw loosening, screw impingement, bone nonunion, infection, poor bony position, bony resorption, and osteoarthritis) and was required highly for screw placement.

Therefore, we designed a specific guide to create an accurate trans-glenoid tunnel and presents a nonrigid autologous iliac crest grafting technique, using
EndoButton (Smith & Nephew) fixation, to manage recurrent shoulder dislocation.

Preoperative Assessment
The patients with recurrent shoulder dislocation. Testing the instability, apprehension, relocation, and load-and-shift tests. Bilateral 3-dimensional reconstruction computed tomography (CT) scans of the scapular glenoid and magnetic resonance imaging scans are routinely performed prior to the operation. We remodel the inferior aspect of the intact glenoid as a true circle, and the percentage of glenoid bone loss is calculated perioperatively. The graft size is customized, based on the individual patient, as shown in Figure 1.

Posterior Drill Guide
The guide used in our technique is not yet commercially available and is custom manufactured by Rejoin (Hangzhou, China). This guide has 3 components (Fig 2): The hook component provides a 7-mm offset, and the remaining 2 components guide the 2.0-mm-diameter K-wire. The angle between the bone tunnel and the glenoid articular surface is adjusted between 10° and 30° to avoid injury to the suprascapular nerve.

Surgical Technique
Patient Positioning
With the patient under general anesthesia and an interscalene block, the bony markers of the shoulder and iliac crest are drawn as shown in Figure 3 A and B. The procedure is performed with the patient in the “lazy” lateral decubitus position (Fig 3C). The patient’s body is rotated at approximately 30° to allow the surface of the glenoid to be parallel to the floor. Five kilograms of traction is maintained to keep the shoulder in 60° of flexion (to relax the anterior deltoid) and 30° of internal rotation (to enhance the space under the coracoid process while the axillary nerve is relaxed).

Diagnostic Arthroscopy
Arthroscopy is performed via a standard posterior portal for direct visualization of the anterior glenoid bony defect (Fig 3D). The anterosuperior and anteroinferior portals are established via an outside-in technique (Fig 3E); the arthroscope is then transferred to the anterior portal for evaluation of the glenoid bone defect (Fig 3F).

Glenoid Preparation
A shaver is used to remove any adhesions and simultaneously release the labrum-capsule from the 3-to 7-o’clock position of the glenoid to visualize the bone defect. Then, an arthroscopic burr is used to debride and decorticate the glenoid to create a flat, bleeding bony surface to accommodate the graft.

Graft Harvest and Preparation
An approximately 5-cm skin incision is made along the anterior iliac crest. A sterile ruler is used to mark the required size of the bone block, according to the preoperative plan. Any muscle and periosteum are removed from the graft, and the bone block is reshaped into a rectangular form (Fig 4 A and B). Four holes, 2 mm apart, are drilled (Fig 4C), and a high-strength suture is passed through the 2 middle holes of an EndoButton and the bone block from anterior to posterior; this is performed in the reverse direction for

Fig 1. (A, B) Three-dimensional reconstruction images of the bilateral glenoid are reconstructed by Mimics software (Materialise). A virtual circle (red circle) is drawn on the normal glenoid as a reference. The same-sized circle (diameter ab) on the contralateral glenoid shows the extent of the bone defect (longest diameter [i.e., diameter bc]), and the percentage of the bone defect is roughly estimated as bc/ab.
another suture. The latter acts as a traction wire to facilitate the introduction of the bone graft onto the glenoid neck. The 2 anchor sutures through the upper and lower holes of the bone block serve as anti-rotation wires (Fig 4D and E).

Glenoid Bony Channel Preparation
Next, the arthroscope is moved to the anteroinferior portal, and the aforementioned glenoid guide is inserted from the posterior portal. Then, we introduce the guide into the glenohumeral joint and keep it parallel to
the glenoid face to avoid damaging the articular surface (Fig 5A). With its tip held anchored at the 4-o’clock position (Fig 5B), a 2.0-mm K-wire is drilled from 5 mm below the cartilage (Fig 5C); then, a 4.5-mm drill (Smith & Nephew) is used to enlarge the tunnel (Fig 5D). Subsequently, two 2.3-mm suture anchors (Smith & Nephew) are introduced at the 3- and 5-o’clock positions as landmarks for graft positioning; the anchor sutures prevent graft rotation and are used for future suturing of the anteroinferior capsule (Fig 5E and F).

**Graft Fixation and Bankart Repair**

The rotator cuff interval is fully cleared (Fig 6A), and the bone graft is then introduced into the joint space with the help of traction wires (Fig 6B and C). We next posteriorly pull the traction and flip sutures while keeping the anterior sutures under tension until a “seesaw” sensation is achieved. A grasper from the anterior portal is used to assist in adjusting the graft to achieve proper placement. After the final adjustments (Fig 6D), the anterior anti-rotation anchor sutures are knotted (Fig 6E and F), and the posterior traction suture is tightened and knotted; finally, the anterior suture is knotted. The 2 anchor sutures tails are not cut and are used for labrum-capsule repair, and the additional anchor will be introduced if needed to keep the graft outside the joint (Fig 6G and H). Finally, all arthroscopic instruments are removed, and the skin incisions are closed and steriley dressed. Video 1,
including narration, may provide a better understanding of our entire surgical technique.

**Postoperative Rehabilitation**

The patient is discharged 1 day after the operation. A CT scan is used to evaluate the positioning of the graft and plate. The affected shoulder is immobilized with a neutral-rotation sling for 6 weeks. Elbow and wrist exercises are allowed immediately after the operation. Passive shoulder activity training is started at 3 weeks postoperatively, and full range of motion is allowed at 6 weeks postoperatively. However, heavy lifting is prohibited for at least 12 weeks postoperatively, until the graft has achieved full bony healing.

**Radiographic Assessments**

As part of our routine imaging evaluation, a 3-dimensional CT scan is performed at 6 weeks and 6 months postoperatively to assess graft positioning and bone healing. The ideal graft positioning is defined as
below the glenoid equator (in the vertical plane) and flush against the glenoid rim (in the horizontal plane), as shown in Figure 7.

**Discussion**

A prior study revealed that 90% of patients with post-traumatic recurrent shoulder dislocation exhibit significant glenoid bone loss. Generally, 19% to 30% of glenoid defects necessitate bone surgery. A recent finite element analysis revealed that bone grafting, not soft-tissue repair alone, must be considered if the bone defect exceeds 16%. Otherwise, stability may not be achieved. Xiang et al. reported that autologous scapular spine bone grafts provide satisfactory results in patients with subcritical (10%-15%) glenoid bone loss.

There are 2 major approaches to address glenoid bone defects. One involves the classic Bristow-Latarjet (coracoid transposition) procedure, which uses the sling effect of the coracoid and conjoined tendon and gains better anterior-inferior stability as compared with...
other free bone graft procedures. However, splitting the subscapularis tendon produces long-term internal rotation forces and endurance deficits relative to the healthy shoulder. Moreover, it requires a special guide system for positioning and fixation of the graft and has a steep learning curve, which generally limits its clinical application.

Glenoid bone grafting procedures are another major category of treatment that corrects glenoid defects. Mochizuki et al. first reported a procedure in which the graft was transplanted from the lateral side of the acromion to the glenoid defect area. However, the graft in this procedure was too small to restore the glenoid defect. In a subsequent study, a glenoid-labrum allograft was used by Skendzel and Sekiya to correct glenoid defects. In their procedure, they repaired the native glenoid and sutured the capsule-labrum structure to the labrum allograft. In our technique, the bone block is sufficient to restore the area of the glenoid bone defect. We also introduce the graft through the rotator cuff interval, without affecting the subscapularis tendon. Finally, we suture the capsule-labrum tissue to the native edge of the articular cartilage, which has allowed us to establish an enhanced healing rate owing to the native-to-native reattachment. In addition, according to the theory of Zhao et al., the buttressing effect of the structures surrounding the graft, rather than the rigid fixation itself, plays a critical function in bone healing. Notably, the bone block may slightly displace inward over time owing to the compression effect of the capsule-glenoid labrum tissue, even if the block has been poorly placed.

Graft fixation is a critical aspect of defective glenoid correction. Fixation via 2 hollow screws is the most common method used during Latarjet surgery, and when applied during some free bone graft techniques, it has been shown to achieve good biomechanical and clinical outcomes. However, screws are linked to several hardware complications and are a common contributor to Latarjet revision surgery. Therefore, flexible fixation is currently one of the most widely used modifications. Multiple studies have reported promising outcomes with nonrigid fixation, and it was confirmed as a safe and reliable alternative method of screw fixation. In our procedure, we adopted a single EndoButton to perform an elastic fixation, which greatly simplified the procedure. Nevertheless, an additional piece of EndoButton in front of the graft (Fig 4D, red arrow) is considered to be useful in those patients with osteoporosis to reduce the shearing force.

---

**Table 1. Advantages and Disadvantages of Technique**

**Advantages**
- The graft is introduced via the rotator cuff interval, which avoids splitting the subscapularis tendon.
- The posterior traction wire helps in achieving easy placement of the graft.
- The posterior EndoButton provides reliable elastic fixation, as compared with the use of anchors alone.
- The technique does not involve any metal components anterior to the glenohumeral joint.

**Disadvantages**
- Donor-site morbidity can occur.
- The technique has a relatively steep learning curve.
of the sutures in the bone holes to avoid graft fractures. Although elastic fixation is not sufficient to provide firm fixation, nonrigid fixation offers the possibility of micromovement of the bone graft, which is helpful to adjust to the optimal position for healing; moreover, absorption and remodeling will be better, which will more closely achieve the original pear shape. In addition, the repair of the anterior capsule-labrum complex facilitates healing and improves anterior stability.28

The specific guide used in this technique must be noted. With the special instruments used in our technique, the precise bone channel positioning can be drilled with notable accuracy and safety. A 5-mm offset in the hook of the guide decreases the possibility of the graft overly protruding through the glenoid articular surface, which in turn reduces the incidence of arthritis. The guide can also be used in other surgical procedures, such as modified coracoid transposition. The advantages and disadvantages of our proposed technique are listed in Table 1.

References
1. Bigliani LU, Kelkar R, Flatow EL, et al. Glenohumeral stability. Biomechanical properties of passive and active stabilizers. Clin Orthop Relat Res 1996:330:13-30.
2. Hovelius L, Olofsson A, Sandström B, et al. Nonoperative treatment of primary anterior shoulder dislocation in patients forty years of age and younger: A prospective twenty-five-year follow-up. J Bone Joint Surg Am 2008;90:945-952.
3. Levy DM, Cole BJ, Bach BR. History of surgical intervention of anterior shoulder instability. J Shoulder Elbow Surg 2016;25:e139-e150.
4. Huxel Bliven KC, Parr GP. Outcomes of the Latarjet procedure compared with Bankart repair for recurrent traumatic anterior shoulder instability. J Athl Train 2018;53:181-183.
5. Bessière C, Trojani C, Carles M, et al. The open Latarjet procedure is more reliable in terms of shoulder stability than arthroscopic Bankart repair. Clin Orthop Relat Res 2014;472:2345-2351.
6. Boehm E, Minkus M, Moroder P, et al. Arthroscopic iliac crest bone grafting in recurrent anterior shoulder instability: Minimum 5-year clinical and radiologic follow-up. Knee Surg Sport Traumatol Arthrosc 2021;29:266-274.
7. Moroder P, Plachel F, Becker J, et al. Clinical and radiological long-term results after implant-free, autologous, iliac crest bone graft procedure for the treatment of anterior shoulder instability. Am J Sports Med 2018;46:2975-2980.
8. Carbone S, Moroder P, Runer A, Hertel R, et al. Scapular dyskinesis after Latarjet procedure. J Shoulder Elbow Surg 2016;25:422-427.
9. Anderl W, Pauzenberger L, Laky B, et al. Arthroscopic implant-free bone grafting for shoulder instability with glenoid bone loss. Am J Sports Med 2016;44:1137-1145.
10. Ernstbrunner L, Pastor T, Waltenspül M, et al. Salvage iliac crest bone grafting for a failed Latarjet procedure: Analysis of failed and successful procedures. Am J Sports Med 2021;49:3620-3627.
11. Gilrat R, Haunschild ED, Lavoie-Gagne OZ, et al. Outcomes of the Latarjet procedure versus free bone block procedures for anterior shoulder instability: A systematic review and meta-analysis. Am J Sports Med 2021;49:805-816.
12. Gilrat R, Wong SE, Lavoie-Gagne O, et al. Outcomes are comparable using free bone block autografts versus allografts for the management of anterior shoulder instability with glenoid bone loss: A systematic review and meta-analysis of the non-Latarjet. Knee Surg Sport Traumatol Arthrosc 2021;29:2159-2174.
13. Hovelius L, Albrektsson B, Berg E, et al. Bristow-Latarjet procedure for recurrent anterior dislocation of the shoulder: A 2-5 year follow-up study on the results of 112 cases. Acta Orthop 1983;54:284-290.
14. Hendy BA, Padegimas EM, Kane L, et al. Early postoperative complications after Latarjet procedure: A single-institution experience over 10 years. J Shoulder Elbow Surg 2021;30:e300-e308.
15. Boileau P, Gendre P, Baba M, et al. A guided surgical approach and novel fixation method for arthroscopic Latarjet. J Shoulder Elbow Surg 2016;25:78-89.
16. Kalogrianitis S, Tsoupouropoulos V. Arthroscopic iliac crest bone block for reconstruction of the glenoid: A fixation technique using an adjustable-length loop cortical suspensory fixation device. Arthrosc Tech 2016;5:e1197-e1202.
17. Yamamoto N, Itoi E, Abe H, et al. Effect of an anterior glenoid defect on anterior shoulder stability: A cadaveric study. Am J Sports Med 2009;37:949-954.
18. Yamamoto BN, Muraki T, Sperling JW, et al. Stabilizing mechanism in bone-grafting of a large glenoid defect. J Bone Joint Surg Am 2010;92:2059-2066.
19. Lo IKY, Parten PM, Burkhart SS. The inverted pear glenoid: An indicator of significant glenoid bone loss. Arthroscopy 2004;20:169-174.
20. Deitch J, Mehlman CT, Foad SL, et al. Traumatic anterior shoulder dislocation in adolescents. Am J Sports Med 2003;31:758-763.
21. Xiang M, Yang J, Chen H, et al. Arthroscopic autologous scapular spine bone graft combined with Bankart repair for anterior shoulder instability with subcritical (10%-15%) glenoid bone loss. Arthroscopy 2021;37:2065-2074.
22. Paladini P, Merolla G, De Santis E, et al. Long-term subscapularis strength assessment after Bristow-Latarjet procedure: Isometric study. J Shoulder Elbow Surg 2012;21:42-47.
23. Caubère A, Lamir D, Boileau P, et al. Is the subscapularis normal after the open Latarjet procedure? An isokinetic and magnetic resonance imaging evaluation. J Shoulder Elbow Surg 2017;26:1775-1781.
24. Valencia M, Fernández-Bermejo G, Martín-Ríos MD, et al. Subscapularis structural integrity and function after arthroscopic Latarjet procedure at a minimum 2-year follow-up. J Shoulder Elbow Surg 2020;29:104-112.
25. Lafosse L, Boyle S. Arthroscopic Latarjet procedure. J Shoulder Elbow Surg 2010;19:2-12 (suppl).
26. Mochizuki Y, Hachisuka H, Kashiwagi K, et al. Arthroscopic autologous bone graft with arthroscopic Bankart repair for a large bony defect lesion caused by
recurrent shoulder dislocation. *Arthroscopy* 2007;23:677.e1-677.e4.

27. Skendzel JG, Sekiya JK. Arthroscopic glenoid osteochondral allograft reconstruction without subscapularis takedown: Technique and literature review. *Arthroscopy* 2011;27:129-135.

28. Zhao L, Lu M, He L, et al. Arthroscopic autologous iliac crest bone grafting for reconstruction of the glenoid: A nonrigid fixation technique. *Arthros Tech* 2021;10:e2597-e2605.

29. Giles JW, Puskas G, Welsh M, et al. Do the traditional and modified Latarjet techniques produce equivalent reconstruction stability and strength? *Am J Sports Med* 2012;40:2801-2807.

30. Shah AA, Butler RB, Romanowski J, et al. Short-term complications of the Latarjet procedure. *J Bone Joint Surg Am* 2012;94:495-501.

31. Yang JS, Mazzocca AD, Cote MP, et al. Recurrent anterior shoulder instability with combined bone loss. *Am J Sports Med* 2016;44:922-932.

32. Butt U, Charalambous CP. Complications associated with open coracoid transfer procedures for shoulder instability. *J Shoulder Elbow Surg* 2012;21:1110-1119.

33. Boileau P, Saliken D, Gendre P, et al. Arthroscopic Latarjet: Suture-button fixation is a safe and reliable alternative to screw fixation. *Arthroscopy* 2019;35:1050-1061.

34. Zhao J, Huangfu X, Yang X, et al. Arthroscopic glenoid bone grafting with nonrigid fixation for anterior shoulder instability: 52 patients with 2- to 5-year follow-up. *Am J Sports Med* 2014;42:831-839.

35. Nebelung W, Reichwein F, Nebelung S. A simplified arthroscopic bone graft transfer technique in chronic glenoid bone deficiency. *Knee Surg Sport Traumatol Arthrosc* 2016;24:1884-1887.