Technical Note

Arthroscopic Anterior Glenoid Bone Grafting for Shoulder Instability Using an Interconnected Suture Anchor Technique

Yacine Ameziane, M.D., and Markus Scheibel, M.D., Prof.

Abstract: Anterior bone grafting is an established and frequently used treatment option for recurrent anterior shoulder instability in combination with significant glenoid bone loss. Several open and arthroscopic fixation techniques have been presented to this field in recent years. Some of these techniques are associated with different peri- and postoperative problems or complications. Therefore, the technical gold standard for anterior bone grafting has not been determined, resulting in an ongoing evolvement of bone-grafting techniques. Arthroscopic, metal-free fixation procedures were introduced to the field bone grafting to overcome previous problems of screw fixation. These metal-free techniques frequently include surgically challenging transglenoidal drilling and are placing anterior soft tissues and neurovascular structures at risk. We therefore present an arthroscopic anterior, PEEK (polyether ether ketone)—anchor based, interconnecting bone-grafting technique bypassing previous challenges to restore the anterior glenoid bone stock with adequate positioning and fixation of the bone graft.

Recurrent traumatic anterior shoulder instability frequently is associated with bony defects appearing at the glenoid rim in up to 86% of patients and at the humeral head in more than 90%.[1,2] While small bony defects seem to be sufficiently treated by an isolated capsulolabral reconstruction, larger sizes of glenoidal bone loss require bony augmentation.[3]

Therefore, several open and, later on, arthroscopic bone-grafting procedures have been described within the last century that use either autologous (iliac crest, coracoidal process, distal clavicle) or allogenous bone to restore an adequate joint surface.[4-9] Most initial bone-grafting procedures were based on metal screw fixation of the bone graft, which was associated with several complications, such as screw migration, loosening, breakage, or joint or soft-tissue irritation.[10,11] To overcome metal-associated complications, Kraus et al. presented an arthroscopic autologous bone-grafting technique using biocompression screws. To avoid potential screw-associated osteolysis, Hachem et al.[13] were the first to publish a metal-free arthroscopic bone cerclage technique requiring bicortical, transglenoidal drilling with a posterior fixation by a tape cerclage system.

Recently, Antonios et al.[14] described an all-anterior bone-graft technique using bicortical, transglenoidal knotless all-suture anchors that are positioned through a trans-subscapularis portal. While blind transglenoidal drilling potentially compromises posterior neurologic structures, additional portals through the subscapularis may enlarge the risk of peri- and postoperative problems as well as the duration of rehabilitation.

We therefore present a knotless, interconnecting PEEK (polyether ether ketone) anchor-based technique that avoids transglenoidal drilling and thereby minimizes the risk of potential damage of the suprascapular nerve without the need of an additional portal through the anterior rotator cuff.

Surgical Technique (With Video Illustration)

Indications and Preoperative Planning

Patients with recurrent anterior shoulder instability and glenoid bone loss are diagnosed according to a

From the Schulthess Clinic Zurich, Zurich, Switzerland (Y.A., M.S.); and Center for Musculoskeletal Surgery, Charité - Universitaetsmedizin Berlin, Berlin, Germany (M.S.).

The authors report the following potential conflicts of interest or sources of funding: M.S. reports consultant for Arthex. Full ICMJE author disclosure forms are available for this article online, as supplementary material.

Received April 2, 2022; accepted June 19, 2022.

Address correspondence to Professor Dr. Markus Scheibel, M.D., Center for Musculoskeletal Surgery, Charité - Universitaetsmedizin Berlin, Berlin, Germany; Schulthess Clinic, Lenghalde 2, 8008 Zurich, Switzerland. E-mail: Markus.scheibel@charite.de

2212-6287/22453

https://doi.org/10.1016/j.eats.2022.06.019

Table 1. Classification of Bone Loss in Recurrent Anterior Shoulder Instability

Type	Description
I	Acute fragment lesion
a	Osteochondral avulsion lesion
b	Solitary glenoid rim fracture
c	Multifragmented glenoid rim fracture
II	Chronic fragment-type lesion
	Malunited (extra-anatomically consolidated) or non-united bone fragment lesion
III	Chronic glenoid bone loss without fragment

Modified from Scheibel et al.[15]

previously published classification by Scheibel et al.[15] (Table 1). Therefore arthroscopic bone grafting is indicated in type Ic (nonreconstructable multifragmentary fracture), type II lesions with insufficient fragment size for reconstruction, and in type III defects presenting significant chronic bone loss of the glenoid surface. Preoperative magnetic resonance imaging and computed tomography of the affected shoulder, including a 3-dimensional reconstruction, are considered to assess the exact glenoidal bone loss as well as to exclude further glenohumeral injuries.

Patient Positioning and Operative Set-Up

After the induction of general anesthesia, the patient is placed into lateral decubitus position with the arm and hand positioned in an atraumatic hand holder (Arthrex, Naples, FL) in 30° abduction and 20° external rotation supported by 5-kg traction weight vertically and 6-kg horizontally (Fig 1). Further, routine preoperative instability-associated examination under anesthesia is performed and standard prepping and draping are carried out.

Portals and Diagnostic Arthroscopy

A standard posterior portal is used to access the glenohumeral joint followed by a diagnostic arthroscopy to display the anterior bone defect and to assess potential concomitant defects (Fig 2A). An anterosuperior viewing portal is placed just behind the biceps tendon. An anteroinferior working portal is placed superior to the subscapularis tendon within the rotator interval and an 8.25-mm × 7-cm twist-in cannula (Arthrex, Naples, FL) is inserted. The scope is switched to the anterosuperior portal and a 6-mm × 7-cm cannula is inserted to the posterior portal (Video 1). In cases of a significant, off-track Hill−Sachs lesion, anchors for an additional remplissage procedure can be placed posteriorly but not tied into the defect before addressing the anterior glenoid rim pathology.

Glenoid and Bone Graft Preparation

After all working portals are established, the anterior glenoid rim is prepared by releasing the capsulolabral complex from the anterior glenoid using a rasp. A #1 Polydioxanone suture is passed percutaneously and through the anterior capsulolabral complex and is used as a temporary outside traction suture for better visualization of the defect area.[16] The anterior glenoid rim is prepared with a 3.5-mm PoweRasp (Arthrex) to ensure a straight and bleeding bone surface (Fig 2B, Video 1).

An arthroscopic 60° measurement instrument is used to determine the position and size of the bone graft as well as the position of the drill holes (Fig 2C, Video 1). According to these measures, 2 glenoidal insertion points of the anchors are prepared using an associated drill and/or a punch (Fig 2D, Video 1). Further, 2 monocortical 4,75-mm PEEK Knotless Corkscrew anchors (Arthrex) are inserted to the prepared insertion points with a recommended minimal distance of 10 mm between both anchors to ensure maximal stabilization of the bone graft (Fig 2 D-F, Video 1). The suture limbs of the anchors are retrieved and separated through the anteroinferior portal and marked as an inferior and a superior pair to prevent suture salad during the interconnection.

A fresh-frozen tricortical iliac crest allograft is prepared according to the obtained measures with an oscillating saw (Video 1). However, this technique also works for any autograft application. In the demonstrated case, the size of the bone graft was measured as 25 mm × 10 mm × 12 mm. Two-millimeter drill holes were placed with a 10-mm distance into the bone graft corresponding to the anchor insertion points at anterior glenoid (Video 1).

Bone Graft Insertion and Fixation

After preparation of the glenoid neck and the bone graft as well as the insertion of the anchors, the scope is changed to the posterior viewing portal. The 8.25-mm × 7-cm cannula is temporarily removed and the anteroinferior working portal is enlarged about 1 cm. Further, the rotator interval is enlarged under direct visualization using expanding scissors, bipolar radiofrequency ablation, and the index finger for blunt

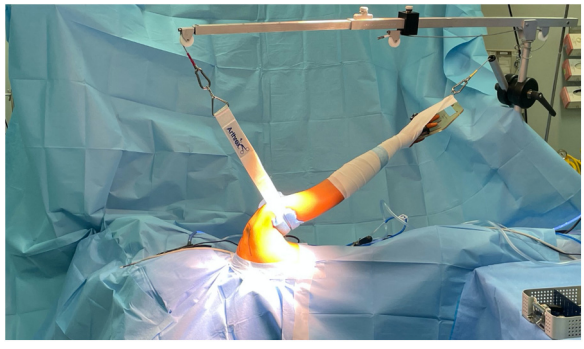

Fig 1. Lateral decubitus position with 5-kg traction weight vertically and 6-kg horizontally.

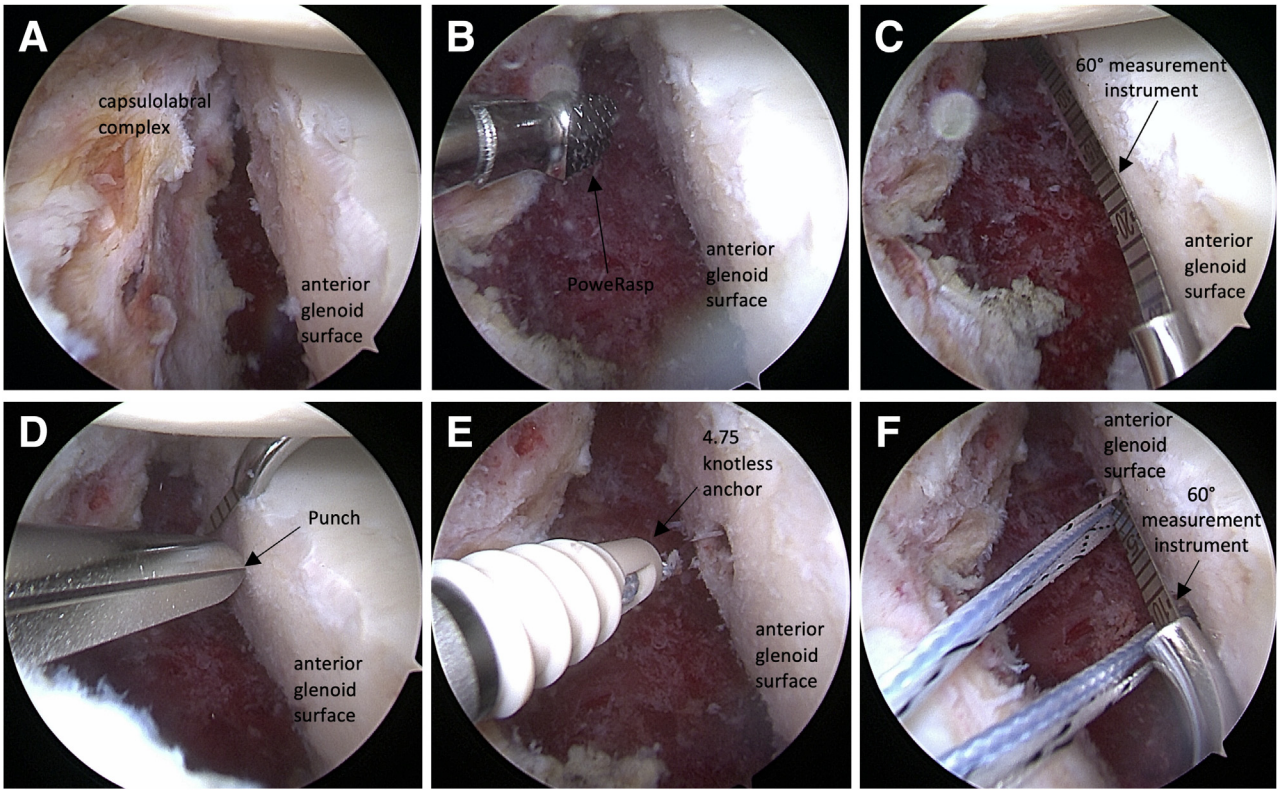

Fig 2. (A) Exposure of the anterior glenoid defect. (B) Preparation of the anterior glenoid defect using a PoweRasp (Arthrex, Naples, FL). (C) Measurement of the straight prepared glenoid surface. (D) Preparation of the anchor insertion using a punch under offset confirmation. (E) Insertion of a 4.75-mm knotless Corkscrew (Arthrex) anchor in to the anterior glenoid defect area. (F) Recommended 10-mm distance between both anchor insertion points.

dilatation until the index finger test is considered positive (sufficient visibility of the index fingertip via the arthroscope) (Fig 3A, Video 1). To insert the graft, the sutures of the inferior anchor are shuttled through the inferior drill hole whereas the sutures of the superior anchor are shuttled through the superior drill hole. A Kocher clamp is used to insert the bone graft while the sutures are kept tensioned by an assistant to guide the graft. After the scope is switched to the anterosuperior viewing portal, the intraarticular adjustment of the graft position is performed with a hooked probe to ensure a flush position of the bone graft to the original glenoid surface (Fig 3B, Video 1). Once the final position of the graft is reached, the interconnection between the inferior and superior knotless PEEK anchors is performed: the inferior blue and white repair suture is passed through the loop of the superior black and white shuttle suture. The free end of the black and white shuttle suture is pulled through the anchor mechanism but is not tightened until this procedure is performed similarly with the blue and white repair suture of the superior anchor and the looped with the black and white shuttle suture of the inferior anchor. Once both repair sutures are shuttled, the knotless mechanisms are equally tightened using suture tensioner with a tensiometer. The remaining ends of the repair sutures are knotted together and cut with an arthroscopic suture cutter.

Capsulolabral Repair/Remplissage

The bone grafting procedure is finalized by an additional capsulolabral repair using FiberWire (Arthrex) sutures that are shuttled through the capsulolabral complex by a 25° suture lasso and fixed with 2 Push-Lock anchors (Arthrex) placed at the 2- and 5-o'clock position to ensure an anatomic reconstruction of the labral fixation (Fig 3E, Video 1). In case of previously placed anchors into the concomitant Hill–Sachs lesion, the additional remplissage procedure is completed after the bone grafting procedure and the capsulolabral repair are finished.

Rehabilitation

The shoulder is immobilized in a sling for 4 weeks. Physical therapy involves passive range-of-motion exercises during that time. Flexion in internal rotation is limited to 90°, and external rotation in adduction is limited to 20°. At week 7, active range-of-motion exercises are initiated. After 12 weeks, an intensive strengthening program including the deltoid, rotator cuff, and scapulothoracic muscles is started.

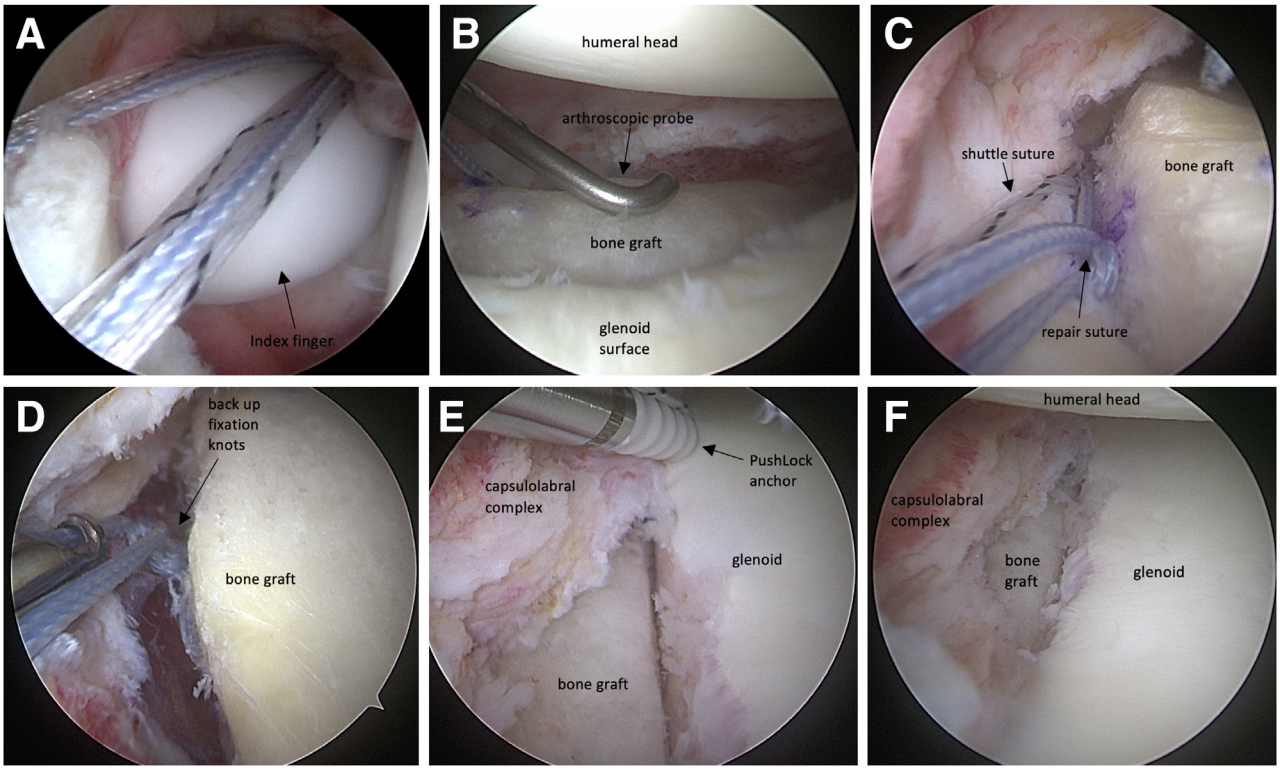

Fig 3. (A) Positive index finger test (index finger tip visible via arthroscopy). (B) Arthroscopic bone graft insertion via the and placement using an arthroscopic probe. (C) Interconnection of the sutures. (D) Backup fixation knots after interconnection. (E) Insertion of a knotless PushLock (Arthrex) anchor in 5-o'clock position for additional capsulolabral repair. (F) Final result after bone block fixation and the capsulolabral repair.

Discussion

Arthroscopic bone grafting methods were introduced and evolved during the last decade.[7-9,12-14,17-21] A recent review of 845 shoulders treated by anterior bone grafting revealed lower overall complication rates and satisfactory short-term outcomes in arthroscopic bone grafting procedures compared with open bone grafting surgery.[22] Despite these favorable outcomes, surgically demanding and in some cases circumstantial surgical steps remain disadvantages of techniques used to date. For instance, recently published arthroscopic techniques, with the advantage of metal-free implants like the bone cerclage or button techniques, have been largely based on a posterior tensioning fixation of the bone graft requiring an additional enlarged posterior incision.[13,17,21,23,24] This posterior fixation of the bone graft has certain disadvantages and carries the risk of multiple potential problems and complications during surgery. First, an additional posterior approach as well as the need of transglenoidal drilling are surgically demanding and uncommon for many surgeons. Second, the risk of remaining tissue bridges is increased, potentially leading to inferior fixation strength and therefore malunion of the graft. Third, blind posterior to anterior drilling is placing anterior neurovascular structures at increased risk potentially resulting in serious consequences to the patients.

These potential complications of posterior fixation of metal-free implants have only been partly overcome by

Table 2. Advantages and Disadvantages

Advantages	Disadvantages, Risks, Limitations
• All-anterior interconnecting fixation technique without the need of an additional posterior approach • Subscapularis-sparing approach, reducing a possible affection of the tendon • Monocortical fixation under direct visualization and reduction of possible neurovascular damage • Metal-free fixation, avoiding implant-associated complications	• Learning curve of arthroscopic surgery • Complications of allogenic bone grafts • Potential risk of premature blocking of the interconnecting fixation mechanism • Unequally and not simultaneously tightened fixation mechanisms may lead to graft malpositioning

Table 3. Pearls and Pitfalls

Pearls	Pitfalls
• Provide an adequate exposure of the anterior glenoid surface by using temporary outside traction sutures • Ensure a minimal distance of 10 mm between the anchors for optimal fixation strength • Mark the bone graft in inferior and superior position for better in situ orientation • Tension the knotless fixation mechanisms sequentially to achieve an optimal fixation and avoid premature blocking	• Avoid too-early enlargement of the anterior working portal through the rotator interval • Avoid premature blocking of the fixation mechanisms by carefully managing repair and shuttle sutures

Antonios et al.[14] presenting an arthroscopic anteriorly based bone grafting technique using knotless all suture anchors. Beside the all-anterior design, this technique is still based on blind, bicortical, transglenoidal drilling with an attendant risk of soft-tissue bridges and nerval damage. Further, a potential interference between the suture anchors used for bone grafting and additional anchors used for the capsulolabral repair may potentially lead to a greater failure rate of this procedure. This potential interference is based on an enlarged suture distance of the knotless anchors that are blocked at posterior glenoid and do further lead to a decreased fixation strength. Lastly, the anterior anchor placement is performed through a 6-mm subscapularis-splitting portal. These trans-subscapularis portals have been shown to be relatively close to the axillary nerve and artery and the cephalic vein and should therefore be carefully used and avoided whenever possible.[25,26]

The aim of the invention of the present bone-grafting technique was to introduce a reproducible stabilization method containing most positive aspects of previously described procedures and avoiding possible pitfalls leading to postoperative complications. Primarily, this is achieved by an anterior interconnecting fixation method that avoids an additional posterior incision and the associated complications. Second, the monocortical fixation of the bone graft with knotless PEEK anchors allows a safe and easy insertion of the anchors under direct visualization reducing the risk of soft tissue/neurovascular damage. Further, the suture distance between the anchors and the bone graft is minimized providing a greater fixation strength and avoiding complications during additional capsulolabral refixation.

While this arthroscopic bone grafting method offers a reproducible and less challenging treatment option for anterior bone loss management, a learning curve concerning arthroscopic surgery should still be considered (Table 2). Care should further be taken concerning the knotless tensioning mechanisms which should be tightened sequentially ensuring the absence of soft-tissue bridges and avoiding premature blocking to assure adequate graft positioning and fixation (Table 3).

References

1. Griffith JF, Antonio GE, Yung PSH, et al. Prevalence, pattern, and spectrum of glenoid bone loss in anterior shoulder dislocation: CT analysis of 218 patients. *Am J Roentgenol* 2008;190:1247-1254.
2. Yiannakopoulos CK, Mataragas E, Antonogiannakis E. A comparison of the spectrum of intra-articular lesions in acute and chronic anterior shoulder instability. *Arthroscopy* 2007;23:985-990.
3. Itoi E, Lee SB, Berglund LJ, Berge LL, An KN. 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.
4. Latarjet M. Treatment of recurrent dislocation of the shoulder. *Lyon Chir* 1954;49:994-997.
5. Resch H, Golser K, Thöni H. Shoulder dislocation and -subluxation. *Orthopade* 1989;18:247-255; discussion 255-256 [in German].
6. Eden R. Zur Operation der habituellen Schulterluxation unter Mitteilung eines neuen verfahrens bei Abriß am inneren Pfannenrande. *Deutsche Zeitschrift Für Chir* 1918;144:269-280 [in German].
7. Taverna E, Golanò P, Pascale V, Battistella F. An arthroscopic bone graft procedure for treating anterior—inferior glenohumeral instability. *Knee Surg Sports Traumatol Arthrosc* 2008;16:872-875.
8. Scheibel M, Kraus N, Diederichs G, Haas NP. Arthroscopic reconstruction of chronic anteroinferior glenoid defect using an autologous tricortical iliac crest bone grafting technique. *Arch Orthop Trauma Surg* 2008;128:1295-1300.
9. Tokish JM, Fitzpatrick K, Cook JB, Mallon WJ. Arthroscopic distal clavicular autograft for treating shoulder instability with glenoid bone loss. *Arthrosc Tech* 2014;3:e475-e481.
10. Butt U, Charalambous CP. Complications associated with open coracoid transfer procedures for shoulder instability. *J Shoulder Elbow Surg* 2012;21:1110-1119.
11. Ueda Y, Sugaya H, Takahashi N, et al. Arthroscopic iliac bone grafting for traumatic anterior shoulder instability with significant glenoid bone loss yields low recurrence and good outcome at a minimum of five-year follow-up. *Arthroscopy* 2021;37:2399-2408.
12. Kraus N, Amphansap T, Gerhardt C, Scheibel M. Arthroscopic anatomic glenoid reconstruction using an autologous iliac crest bone grafting technique. *J Shoulder Elbow Surg* 2014;23:1700-1708.

13. Hachem AI, Carmen MD, Verdalet I, Rius J. Arthroscopic bone block cerclage: A fixation method for glenoid bone loss reconstruction without metal implants. *Arthrosc Tech* 2019;8:e1591-e1597.
14. Antonios T, Arnander M, Pearse E, Tennent TD. arthroscopic iliac crest bone graft augmentation using all-suture anchors for shoulder instability caused by glenoid bone loss. *Arthrosc Tech* 2021;10:e2709-e2715.
15. Scheibel M, Hug K, Gerhardt C, Krueger D. Arthroscopic reduction and fixation of large solitary and multifragmented anterior glenoid rim fractures. *J Shoulder Elbow Surg* 2016;25:781-790.
16. Boileau P, Ahrens P. The TOTS (temporary outside traction suture): A new technique to allow easy suture placement and improve capsular shift in arthroscopic Bankart repair. *Arthroscopy* 2003;19:672-677.
17. Taverna E, Garavaglia G, Perfetti C, Ufenast H, Sconfienza LM, Guarrella V. An arthroscopic bone block procedure is effective in restoring stability, allowing return to sports in cases of glenohumeral instability with glenoid bone deficiency. *Knee Surg Sports Traumatol Arthrosc* 2018;26:3780-3787.
18. Zhao J, Huangfu X, Yang X, Xie G, Xu C. Arthroscopic glenoid bone grafting with nonrigid fixation for anterior shoulder instability. *Am J Sports Med* 2014;42:831-839.
19. Boehm E, Gerhardt C, Kraus N, Scheibel M. Arthroscopic glenoid reconstruction for chronic anteroinferior shoulder instability using a tricortical iliac crest bone graft. *JBJS Essent Surg Tech* 2016;6:e39.
20. Boehm E, Minkus M, Moroder P, Scheibel M. Arthroscopic iliac crest bone grafting in recurrent anterior shoulder instability: Minimum 5-year clinical and radiologic follow-up. *Knee Surg Sports Traumatol Arthrosc* 2021;29:266-274.
21. Hassebrock JD, Starkweather JR, Tokish JM. Arthroscopic technique for bone augmentation with suture button fixation for anterior shoulder instability. *Arthrosc Tech* 2019;9:e97-e102.
22. Wei J, Lu M, Zhao L, Zeng X, He L. Free bone grafting improves clinical outcomes in anterior shoulder instability with bone defect: A systematic review and meta-analysis of studies with a minimum of 1-year follow-up. *J Shoulder Elbow Surg* 2022;31:e190-e208.
23. 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.
24. Scheibel M, Lorenz CJ. Metal-free fixation for free bone-block reconstruction of chronic anteroinferior shoulder instability. *Video J Sports Med* 2022;2:263502542110626.
25. Cvetanovich GL, Hamamoto JT, Campbell KJ, McCarthy M, Higgins JD, Verma NN. The use of accessory portals in Bankart repair with posterior extension in the lateral decubitus position. *Arthrosc Tech* 2016;5:e1121-e1128.
26. Meyer M, Graveleau N, Hardy P, Landreau P. Anatomic risks of shoulder arthroscopy portals: Anatomic cadaveric study of 12 portals. *Arthroscopy* 2007;23:529-536.