JSES International 8 (2024) 686–691

Contents lists available at ScienceDirect

JSES International

journal homepage: www.jsesinternational.org

Arthroscopic humeral head defect filling with osteochondral autografts transplantation for near-track Hill-Sachs lesions

Giuseppe Milano, MD[a,b], Alessandro Colosio, MD[a], Monica Agosti, MD[c], Andrea Bergomi, MD[a,*], Maristella F. Saccomanno, MD, PhD[a,b]

[a]Department of Medical and Surgical Specialties, Radiological Sciences, and Public Health, University of Brescia, Brescia, Italy
[b]Department of Bone and Joint Surgery, Spedali Civili, Brescia, Italy
[c]Department of Clinical Science and Translational Medicine, University of Rome Tor Vergata, Rome, Italy

ARTICLE INFO

Keywords:
Gleno-humeral instability
Bipolar bone loss
On-track
Near-track
Hill sachs
Autologous ostechondral transplantation

Level of evidence: Level V; Surgical Technique

Bipolar bone loss has been recognized as one of the major predisposing factors determining recurrence after arthroscopic Bankart repair.[43,53] Several bi-dimensional (2D) and three-dimensional (3D) measurements have been described to quantify glenoid and humeral head (HH) bone loss (3D).[12,41,47]

The definition of on-track/off-track lesion[7] represented a game changer. It overcome percentages of bone loss and dichotomized the injury pattern, thus simplifying the treatment algorithm of bone loss. However, several studies questioned its reliability with mixed results.[4,6,10,29,36] Apparently, the weakest link remains measurement of the Hill-Sachs lesion (HSL).[10,36,38]

While the true occurrence rate of HSLs remains unclear, reported instances range from 67% to 93% of anterior shoulder dislocations, with a potential escalation up to 100% in patients affected by recurrent anterior instability.[9,35]

Although the arthroscopic Bankart repair represents the standard approach for on-track lesions, recurrence rate after this type of surgery still ranges between 3% and 51%,[30,34,37] which is surely unacceptable in a young population.

The gray zone of the on-track/off-track paradigm has been recently identified. Different labels have been used: peripheral-track,[51] near-track,[17] nearly off-track.[45] The rationale doesn't change: HSLs that are close to being off-track have an increased risk of recurrence and poor functional outcomes[51] after a conventional arthroscopic Bankart repair.[17,52]

Several techniques[2,20,28,31,50] have been described to address subcritical glenoid bone loss aiming to drop down the recurrence rate. On the other side, the management of the HSL remains a challenge. Remplissage is nowadays the most recommended technique to address small to medium HSLs.[22] Lin et al[19] recently showed that remplissage is particularly effective in patients with near-track lesions. However, remplissage is a nonanatomic procedure that is still quick and easy to perform.

Fresh osteochondral allograft (OCA) transplantations represent the available anatomic alternative to remplissage, and they have been proposed in the past with promising outcomes,[5,26,40,48] but poorly popularized afterward. The unpopularity of the procedure is not only probably due to the high costs of fresh allografts but also to the difficult surgical technique.

The purpose of the present article is to present an arthroscopic technique to fill the articular part of the HSL with osteochondral (OC) autografts harvested from the lateral aspect of the trochlea of the knee.

Materials and methods

Indications

Patients affected by primary or recurrent gleno-humeral instability usually undergo a computed tomography (CT) or a magnetic

Institutional review board approval was not required for this technique article.

*Corresponding author: Andrea Bergomi, MD, ASST Spedali Civili, UOC Clinica Ortopedica, Piazzale Spedali Civili 1, Brescia 25123, Italy.
E-mail address: a.bergomi002@unibs.it (A. Bergomi).

https://doi.org/10.1016/j.jseint.2024.02.004

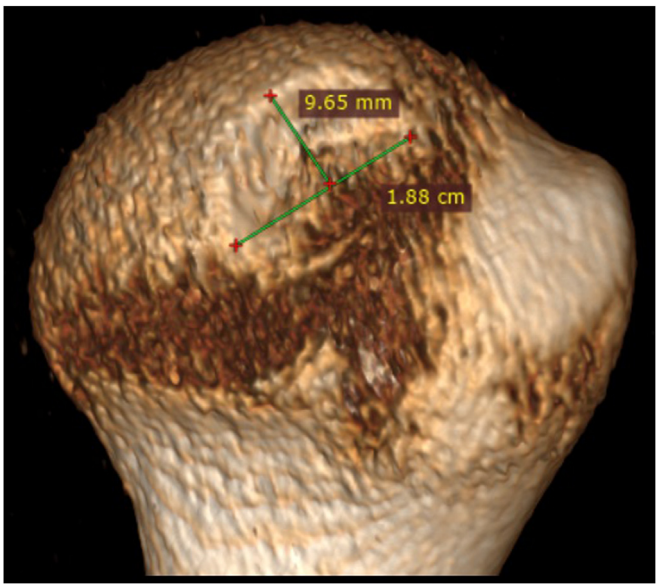

Figure 1 Preoperative assessment of HSL size. Through 3D-CT reconstruction of the HH, the number and size of grafts needed to fill the defect can be planned. Only the articular part of the HS is considered. *HSL*, Hill-Sachs lesion; *HH*, humeral head; *HS*, Hill-Sachs; *CT*, computed tomography; *3D*, three-dimensional.

resonance imaging to assess bipolar bone loss.[41] It is the authors' preference to perform bone loss measurements on CT scans. The following measurements are routinely recorded:

- On-track/off-track
- "Hill-Sachs interval to glenoid track width ratio" (H/G ratio)[52]
- Distance to dislocation[17]

H/G ratio $\geq$0.7[52] and distance to dislocation <8 mm[17] define near-track lesions.

Near-track lesions represent the main indication for osteochondral autograft transplantation (OAT). Age, activity level, contact sports, number of dislocations, patient expectations, and joint laxity must be taken into account. Focusing on the humeral side, patients affected by HSLs involving the articular part of the HH with the Hill-Sachs occupancy $\geq$75% (peripheral track lesions) are good candidates for this procedure.

The graft size can be estimated from a 3D-CT reconstruction of the HH. Only the articular part of the HSL is considered (Fig. 1).

If the preoperative measurements match the indications, the surgical field preparation will also include the ipsilateral lower limb.

However, indication is confirmed during arthroscopy when the HSL matches one of the two following lesion patterns[16]:

- wide and large.
- narrow but medially located.

Patient positioning and diagnostic arthroscopy

The surgery is performed under general anesthesia. It is the authors' preference to place the patient in lateral decubitus.

Three standard portals are used:

- Posterior: viewing portal during anterior capsulolabral repair/reconstruction; working portal during OAT. A cannula is used only if the indication to OC autografts is confirmed.

Figure 2 Lateral decubitus, left knee (ipsilateral to the affected shoulder): Through a lateral mini-arthrotomy, the proximal lateral aspect of the femoral trochlea (donor site) is exposed. The donor harvester is positioned perpendicular to the donor surface and impacted to a depth of approximately 15 mm.

- Anterior-superior: a 7-mm cannula is placed to facilitate suture management. This portal becomes the viewing portal during the HS filling.
- Anterior mid-glenoid: working portal during anterior capsulolabral repair/reconstruction, an 8-mm cannula is placed.

Diagnostic arthroscopy is first performed. After the evaluation of glenoid labrum and capsular damage, the HSL is assessed. It can be evaluated by keeping the scope in the posterior portal or by switching it to the anterior-superior portal. If the lesion matches the above-mentioned criteria, the scope must be switched in the anterior-superior portal, and the articular part of the HSL will be filled with OC autografts before repairing or reconstructing the capsule-labral complex anteriorly. A soft tissue cannula (Passport Cannula; Arthrex, Naples, FL, USA) is placed in the posterior portal before starting the procedure. A disposable instrument set for OAT (OATS System; Arthrex,

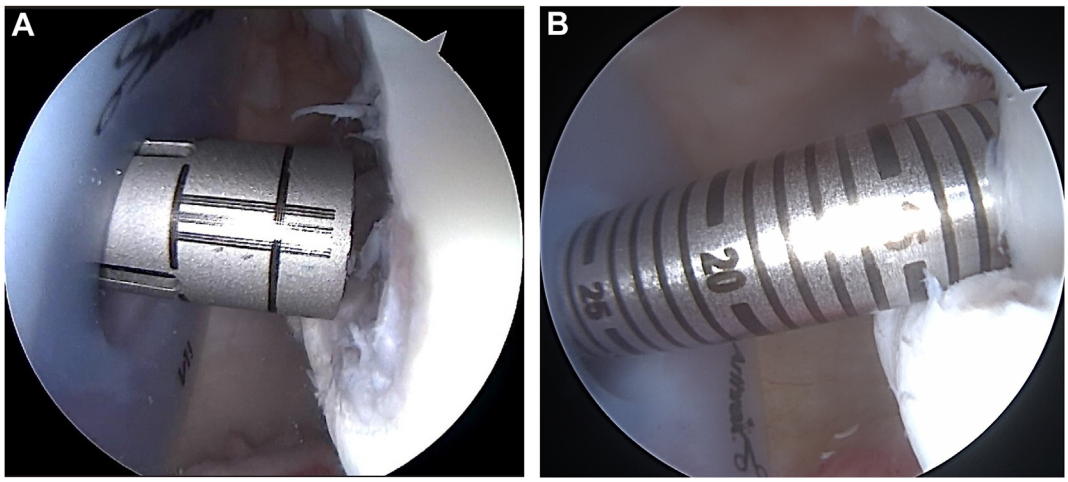

Figure 3 Arthroscopic view through anterior-superior portal of left shoulder with patient in lateral decubitus. (**A**) Through the cannula placed in the posterior portal, the recipient harvester is positioned perpendicular to the osteochondral defect and impacted to a depth of 10-13 mm, then the harvester is removed, creating the bone socket; (**B**) A graduated alignment rod is used to measure the final recipient socket depth and check the correct insertion angle.

Naples, FL, USA), developed for knee articular cartilage lesions, is used and adapted for the HSL. The OATS system offers 6-, 8-, or 10-mm-diameter graft plug sizes. A sizer can be used to confirm the plug size, as already planned on the 3D-CT. According to the authors' experience, two or three 6- or 8-mm grafts are sufficient for the procedure.

Osteochondral graft harvesting and preparation

Approach to the lateral aspect of the ipsilateral knee (donor site) is achieved through a mini-arthrotomy (Fig. 2). The donor harvester is positioned perpendicular to the donor surface on the proximal lateral aspect of the trochlea and is impacted to the depth of approximately 15 mm. The graft is disengaged with the harvester and withdrawn from the bone. The procedure can be repeated if additional grafts are needed. At the end of the procedure, an intra-articular drain is recommended. Joint capsule, subcutaneous tissue, and skin are closed in a routine manner.

Humeral head preparation and graft fixation

The recipient harvester is then positioned perpendicular to the OC defect in the posterior aspect of the HH and is impacted to a depth of 10-13 mm. The harvester is then removed creating the bone socket. A graduated alignment rod is used to measure the final recipient socket depth and insertion angle; the plugs should be inserted in the area of the lesion closest to the residual native cartilage with the aim of recreating the lost articular surface (Fig. 3). The graft is inserted and press-fitted with a delivery tube placed perpendicularly into the recipient socket (Fig. 4). Final seating of the graft is performed using a tamp (Fig. 5). Multiple plugs (2-3) may be needed to fill the defect (Fig. 6).

A standard capsulolabral repair/reconstruction is performed subsequently based on the injury pattern of soft tissues (Video 1).

Tip and tricks

- Posterior portal: ideally, it should be perpendicular to the defect. If it is not:
  - an accessory portal can be performed under direct visualization.
  - otherwise, the portal can be kept as it is, but the humerus can be gently rotated to obtain a perfect match.
- Cannulas: a posterior soft cannula (PassPort Cannula; Arthrex, Naples, FL, USA) two millimeters (mm) larger than the selected diameter for graft plug is recommended to facilitate the passage of the graft.
- Recipient socket: when the recipient harvester is used, attention must be paid to reach a depth 2 mm less than the length of the donor graft.
- If more than one graft is needed:
  - gentle humeral rotation helps visualization and graft placement
  - place the grafts from inferior to superior to keep a better view
- Most common grafts size:
  - one or two grafts of 8 mm

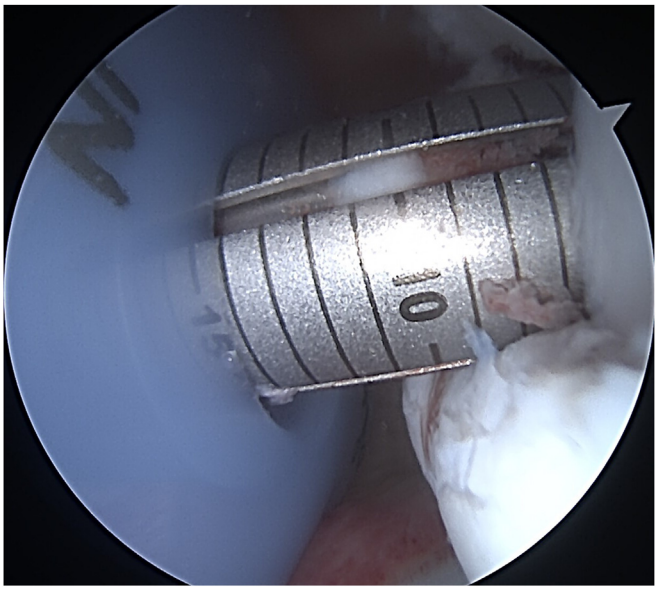

Figure 4 Arthroscopic view through anterior-superior portal of left shoulder with patient in lateral decubitus. The graft, taken from the knee still inside the donor harvester through the posterior portal is inserted and press-fitted perpendicularly into the recipient socket.

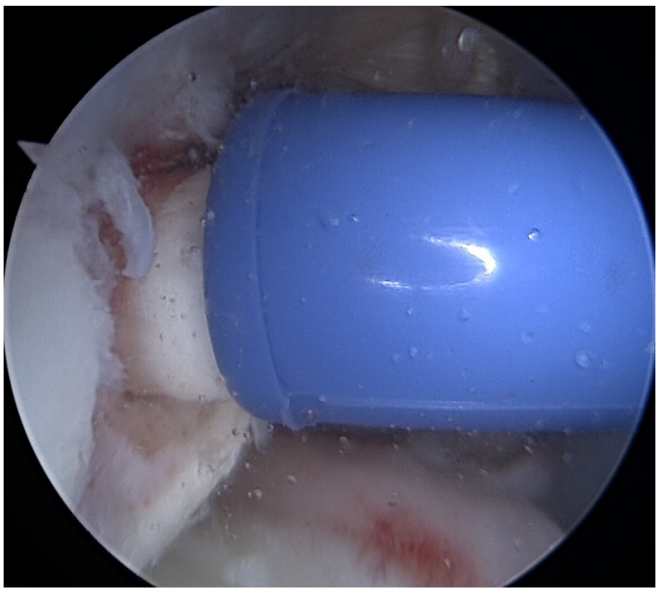

Figure 5 Arthroscopic view through anterior-superior portal of left shoulder with patient in lateral decubitus. Thanks to a specific plastic tamp in the posterior portal, final graft placement is performed at the level of the cartilage edge.

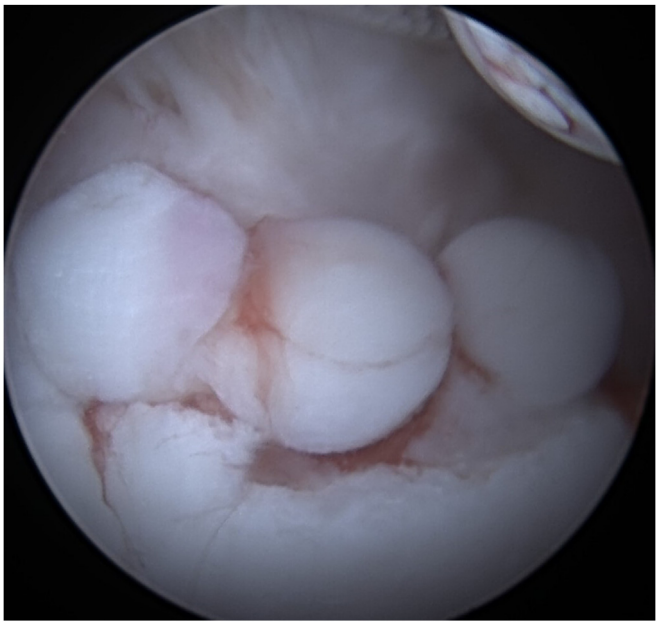

Figure 6 Arthroscopic view through posterior portal of left shoulder with patient in lateral decubitus. Final result at the end of the procedures, with the HSL filled by multiple grafts. *HSL*, Hill-Sachs lesion.

  - two or three grafts of 6 mm
- Drill and fill the recipient socket one at a time to keep the bridge between grafts.
- Ideally, the grafts should be flush with the cartilage of the HH. However, even slightly proud grafts are acceptable.

Postoperative care

Postoperatively, the operated arm is immobilized in an abduction sling with neutral rotation for 4 weeks. The rehabilitation protocol starts 4 weeks after surgery with massotherapy and exercises aimed at recovering passive and active range of motion. Then strengthening exercises are allowed not earlier than 8 weeks after surgery. The lower limb does not require any postoperative rehabilitation. Free range of motion and full weight-bearing are allowed immediately after the surgery.

Full return to manual work and sports activities is achieved in four to six months.

Discussion

Arthroscopic grafting of HSLs using OAT is a surgical technique that can be beneficial for patients with shoulder instability falling into the gray zone where arthroscopic Bankart repair is not sufficient to reduce the risk of recurrence, but a bony procedure such as a Latarjet would be excessive.

Recent literature strongly questions the effectiveness of a standard Bankart repair in recurrent anterior glenohumeral instability.[14,46] According to Verweij et al,[46] it is not a safe choice if the patient has already experienced more than one dislocation and underwent surgery six months after the event. This assumption led to two different trends: first, an increasing indication to arthroscopic or open Latarjet procedures regardless of the amount of glenoid or humeral bone loss; and second, the routine combination of remplissage and Bankart repair.

A systematic review of complications after anterior shoulder stabilization surgery,[49] which included 56 studies, highlighted that arthroscopic or open bone block procedures are extremely effective in lowering the risk of redislocation after surgery, but the complication rate is ten-fold higher than that of soft tissue procedures. As a matter of fact, the remplissage procedure seemed to be the best compromise.[22] A meta-analysis comparing Latarjet procedure and arthroscopic Bankart repair associated with remplissage showed that the addition of remplissage is a safer option.[13] According to this review, which included four studies with levels of evidence II and III, both strategies are equally effective to keep a low risk of redislocation, but the addition of remplissage showed fewer complications compared to Latarjet procedure. More recently, Horinek et al[15] conducted a retrospective comparative study in patients with >15% of glenoid bone loss. They concluded that remplissage and Latarjet provide similar outcomes, although remplissage slightly decreases external rotation.

Although effective, neither Latarjet nor remplissage represent anatomic surgical options. The ideal goal of shoulder instability surgery should be to restore anatomy as much as possible in order to restore joint stability while controlling the risk of late degenerative joint changes. The present surgical technique attempts to restore the spherical contour of the HH to allow smooth articulation with the glenoid and the restoration of the native glenoid track.

In 2004, Miniaci et al[26] first proposed a “deep-dish slice of pie”-shaped fresh-frozen side and size-matched osteoarticular HH allograft in 18 patients with ongoing symptomatic anterior glenohumeral instability or painful clicking, catching, or popping with a large, engaging HSL exceeding 25%. The idea was to restore the “articular arc length mismatch,” previously described by Burkhart et al,[3] as a cause of Bankart failure. Miniaci et al[26] reported no further dislocations and good functional results, with some hardware related complications. In 2019, Zhuo et al[54] reported a similar technique in 19 patients affected by recurrent anterior glenohumeral instability who had never undergone a previous surgery but presented with a large HSL >30% and a glenoid bone loss <20%. The authors reported good functional outcomes with an overall satisfaction rate of 94.7%, even if a graft resorption was observed in 43.1% of patients. Currently, this kind of approach to an allograft reconstruction has spread as a treatment option for reverse HSL in posterior instability.[1,8,18,21,23,27,42]

Transplantation of OC cylindrical plugs was initially developed as a treatment option for chondral and OC defects of the knee. The procedure showed good functional outcomes and good rate of grafts survival and integration.[24,44] The same technique was first introduced in the shoulder in 2005.[5] Chapovsky et al[5] reported a case in which a 16-year-old male athlete with a recurrent anterior shoulder instability after a failed Bankart repair underwent an OCA transplantation to fill an engaging HSL. Three fresh-frozen OCA plugs (two size 5 and one size 6) were placed press-fit into the portion of the defect adjoining the articular surface via a lower inferior portal. A technical note using OCAs was later reported by Snir et al.[40] At the same time, Garcia et al[11] compared remplissage and OCA combined with Bankart repair in patients affected by recurrent anterior instability. No significant differences in redislocation rates were found, albeit patients who underwent remplissage reported better Western Ontario Shoulder Instability Index scores.

Several relevant features make the present technique different from the previous literature reports. First, the indication. While previous studies proposed the grafting solution in medium to large HSLs in both primary and revision arthroscopic Bankart repair, the main indication for the present technique is the near-track bipolar bone defect. It must be highlighted that this can be used to treat not only recurrent instability but also acute dislocations. Nakagawa et al[32,33] clarified the natural history of bipolar bone lesions. HSL comes first, and its prevalence is almost double that of glenoid defects after primary dislocation. After recurrence, glenoid defects become more frequent, while HSLs show a smaller increase. Therefore, the filling of HSL by OAT is a suitable option both for primary and recurrent dislocations. Furthermore, the present technique has at least three main advantages compared to the previous literature. First, the technique is arthroscopic. Arthroscopy guarantees a minimally invasive approach, which is somehow related to a smaller risk of infection. Moreover, no additional portals are needed compared to a standard Bankart repair. Second, no hardware is required to fix the graft because the plugs are press-fit into the recipient socket. This surely reduces the risk of hardware-related complications. Third, the use of autografts makes the procedure cheaper, ensures chondral viability, and probably increases the chances for graft integration.[25]

Donor-site morbidity could be the counterpart of the technique. A recent meta-analysis[39] focused on knee donor-site morbidity after OAT for OC lesions of the talus. The authors showed that donor-site morbidity was only 6.7% (95% confidence interval [CI], 2.8-11.8). Moreover, a subgroup analysis also demonstrated that larger studies ($n \geq 30$) estimated a lower donor-site morbidity risk (<5.0%) than smaller studies ($n < 30$).

Conclusion

The arthroscopic filling of HSL with OAT seems to be a viable anatomic option for the treatment of near-track HSLs in acute and recurrent glenohumeral instability.

Disclaimers:

Funding: The authors declare that no funds were received during the preparation of this manuscript.
Conflicts of interest: Giuseppe Milano reports a relationship with Arthrex Inc. that includes consulting or advisory. The other authors, their immediate families, and any research foundation with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

Supplementary Data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jseint.2024.02.004.

References

1. Alkaduhimi H, van den Bekerom MPJ, van Deurzen DFP. Step-by-step technique for segmental reconstruction of reverse Hill-Sachs lesions using homologous osteochondral allograft. Tech Hand Up Extrem Surg 2017;21:60-6. https://doi.org/10.1097/BTH.0000000000000151.
2. Brzóska R, Laprus H, Michniowski P, Solecki W, Klon W, Białsiak A. Novel and effective arthroscopic extracapsular stabilization technique for anterior shoulder instability-BLS. Knee Surg Sports Traumatol Arthrosc 2019;27:3897-904. https://doi.org/10.1007/s00167-019-05496-1.
3. Burkhart SS, Danaceau SM. Articular arc length mismatch as a cause of failed bankart repair. Arthroscopy 2000;16:740-4.
4. Chalmers PN, Christensen G, O'Neill D, Tashjian RZ. Does bone loss imaging modality, measurement methodology, and interobserver reliability alter treatment in glenohumeral instability? Arthroscopy 2020;36:12-9. https://doi.org/10.1016/j.arthro.2019.06.025.
5. Chapovsky F, Kelly JD. Osteochondral allograft transplantation for treatment of glenohumeral instability. Arthroscopy 2005;21:1007. https://doi.org/10.1016/j.arthro.2005.04.005.
6. Cognetti DJ, Tenan MS, Dickens JF, Patzkowski JC, Cote MP, Sansone M, et al. The glenoid track paradigm does not reliably affect military surgeons' approach to managing shoulder instability. Arthrosc Sports Med Rehabil 2023;5:e403-9. https://doi.org/10.1016/j.asmr.2023.01.007.
7. Di Giacomo G, Itoi E, Burkhart SS. Evolving concept of bipolar bone loss and the Hill-Sachs lesion: from "engaging/non-engaging" lesion to "on-track/off-track" lesion. Arthroscopy 2014;30:90-8. https://doi.org/10.1016/j.arthro.2013.10.004.
8. Dubey V, Seyed-Safi P, Makki D. Fashioning osteochondral allograft for humeral head defects in reverse Hill-Sachs lesions - a proposed surgical technique. J Orthop Case Rep 2021;11:54-7. https://doi.org/10.13107/jocr.2021.v11.i09.2414.
9. Fox JA, Sanchez A, Zajac TJ, Provencher MT. Understanding the Hill-Sachs lesion in its role in patients with recurrent anterior shoulder instability. Curr Rev Musculoskelet Med 2017;10:469-79. https://doi.org/10.1007/s12178-017-9437-0.
10. Funakoshi T, Hartzler RU, Stewien E, Burkhart SS. Hill-Sachs lesion classification by the glenoid track paradigm in shoulder instability: poor agreement between 3-dimensional computed tomographic and arthroscopic methods. Arthroscopy 2019;35:1743-9. https://doi.org/10.1016/j.arthro.2018.12.005.
11. Garcia GH, Park MJ, Baldwin K, Fowler J, Kelly JD, Tjoumakaris FP. Comparison of arthroscopic osteochondral substitute grafting and remplissage for engaging Hill-Sachs lesions. Orthopedics 2013;36:e38-43. https://doi.org/10.3928/01477447-20121217-16.
12. Green GL, Arnander M, Pearse E, Tennent D. CT estimation of glenoid bone loss in anterior glenohumeral instability: a systematic review of existing techniques. Bone Jt Open 2022;3:114-22. https://doi.org/10.1302/2633-1462.32.BJO-2021-0163.R1.
13. Haroun HK, Sobhy MH, Abdelrahman AA. Arthroscopic Bankart repair with remplissage versus Latarjet procedure for management of engaging Hill-Sachs lesions with subcritical glenoid bone loss in traumatic anterior shoulder instability: a systematic review and meta-analysis. J Shoulder Elbow Surg 2020;29:2163-74. https://doi.org/10.1016/j.jse.2020.04.032.
14. Horinek JL, Menendez ME, Callegari JJ, Narbona P, Lädermann A, Barth J, et al. Consideration may be given to lowering the threshold for the addition of remplissage in patients with subcritical glenoid bone loss undergoing arthroscopic Bankart repair. Arthrosc Sports Med Rehabil 2022;4:e1283-9. https://doi.org/10.1016/j.asmr.2022.04.004.
15. Horinek JL, Menendez ME, Narbona P, Lädermann A, Barth J, Denard PJ. Arthroscopic Bankart repair with remplissage as an alternative to Latarjet for anterior glenohumeral instability with more than 15% glenoid bone loss. Orthop J Sports Med 2022;10:23259671221142257. https://doi.org/10.1177/23259671221142257.
16. Kurokawa D, Yamamoto N, Nagamoto H, Omori Y, Tanaka M, Sano H, et al. The prevalence of a large Hill-Sachs lesion that needs to be treated. J Shoulder Elbow Surg 2013;22:1285-9. https://doi.org/10.1016/j.jse.2012.12.033.
17. Li RT, Kane G, Drummond M, Golan E, Wilson K, Lesniak BP, et al. On-track lesions with a small distance to dislocation are associated with failure after arthroscopic anterior shoulder stabilization. J Bone Joint Surg Am 2021;103:961-7. https://doi.org/10.2106/JBJS.20.00917.
18. Liles JL, Peebles AM, Saker CC, Ganokroj P, Mologne MS, Provencher MT. Talar allograft preparation for treatment of reverse Hill-Sachs defect in recurrent posterior shoulder instability. Arthrosc Tech 2022;11:e1625-31. https://doi.org/10.1016/j.eats.2022.05.009.
19. Lin A, Barrow AE, Charles S, Shannon M, Fox MA, Herman ZJ, et al. Remplissage reduces recurrent instability in high-risk patients with on-track Hill-Sachs lesions. J Shoulder Elbow Surg 2023;32:S99-105. https://doi.org/10.1016/j.jse.2023.02.011.

20. Maiotti M, Massoni C, Russo R, Schroter S, Zanini A, Bianchedi D. Arthroscopic subscapularis augmentation of Bankart repair in chronic anterior shoulder instability with bone loss less than 25% and capsular deficiency: clinical multicenter study. Arthroscopy 2017;33:902-9. https://doi.org/10.1016/j.arthro.2016.09.008.
21. Marcheggiani Muccioli GM, Rinaldi VG, Lullini G, Ritali A, Mosca M, Romagnoli M, et al. Mid-term outcomes following fresh-frozen humeral head osteochondral allograft reconstruction for reverse Hill Sachs lesion: a case series. BMC Musculoskelet Disord 2021;22:768. https://doi.org/10.1186/s12891-021-04657-z.
22. Martinez-Catalan N, Kazum E, Zampeli F, Cartaya M, Cerlier A, Valenti P. Long-term outcomes of arthroscopic Bankart repair and Hill-Sachs remplissage for bipolar bone defects. Eur J Orthop Surg Traumatol Orthop Traumatol 2023;33:947-53. https://doi.org/10.1007/s00590-022-03237-8.
23. Mastrokalos DS, Panagopoulos GN, Galanopoulos IP, Papagelopoulos PJ. Posterior shoulder dislocation with a reverse Hill-Sachs lesion treated with frozen femoral head bone allograft combined with osteochondral autograft transfer. Knee Surg Sports Traumatol Arthrosc 2017;25:3285-8. https://doi.org/10.1007/s00167-016-4220-0.
24. Melugin HP, Bernard CD, Camp CL, Saris DBF, Krych AJ. Bipolar cartilage lesions of the knee: a systematic review of techniques, outcomes, and complications. Cartilage 2021;13:17S-30S. https://doi.org/10.1177/1947603519855761.
25. Migliorini F, Maffulli N, Baroncini A, Eschweiler J, Knobe M, Tingart M, et al. Allograft versus autograft osteochondral transplant for chondral defects of the talus: systematic review and meta-analysis. Am J Sports Med 2022;50:3447-55. https://doi.org/10.1177/03635465211037349.
26. Miniaci A, Gish MW. Management of anterior glenohumeral instability associated with large Hill–Sachs defects. Tech Shoulder Elbow Surg 2004;5:170. https://doi.org/10.1097/01.bte.0000137216.70574.ba.
27. Mitchell JJ, Vap AR, Sanchez G, Liechti DJ, Chahla J, Moatshe G, et al. Concomitant reverse Hill-Sachs lesion and posterior humeral avulsion of the glenohumeral ligament: treatment with fresh talus osteochondral allograft and arthroscopic posterior humeral avulsion of the glenohumeral ligament and labrum repair. Arthrosc Tech 2017;6:e987-95. https://doi.org/10.1016/j.eats.2017.03.012.
28. Moroder P, Böhm E, Scheibel M. The arthroscopic bankart-plus procedure for treatment of anterior shoulder instability with small to intermediate glenoid defects. Arthrosc Tech 2018;7:e379-84. https://doi.org/10.1016/j.eats.2017.10.009.
29. Mulleneers LIC, Van Rompaey H, Haloui B, Pouliart N. Determining on-/off-track lesions in glenohumeral dislocation using multiplanar reconstruction computed tomography is easier and more reproducible than using 3-dimensional computed tomography. Am J Sports Med 2021;49:137-45. https://doi.org/10.1177/0363546520971856.
30. Murphy AI, Hurley ET, Hurley DJ, Pauzenberger L, Mullett H. Long-term outcomes of the arthroscopic Bankart repair: a systematic review of studies at 10-year follow-up. J Shoulder Elbow Surg 2019;28:2084-9. https://doi.org/10.1016/j.jse.2019.04.057.
31. Nair AV, Mohan PK, Jangale A, Kuntwad V, Kumar MP, Goud N, et al. Dynamic anterior stabilization using transosseous bone tunnel technique with the adjustable loop length cortical button incorporating high-strength suture augmentation for recurrent shoulder instability. Arthrosc Tech 2022;11:e1929-35. https://doi.org/10.1016/j.eats.2022.07.007.
32. Nakagawa S, Iuchi R, Hanai H, Hirose T, Mae T. The development process of bipolar bone defects from primary to recurrent instability in shoulders with traumatic anterior instability. Am J Sports Med 2019;47:695-703. https://doi.org/10.1177/0363546518819471.
33. Nakagawa S, Sahara W, Kinugasa K, Uchida R, Mae T. Bipolar bone defects in shoulders with primary instability: dislocation versus subluxation. Orthop J Sports Med 2021;9:23259671211003553. https://doi.org/10.1177/23259671211003553.
34. Pasqualini I, Rossi LA, Ariel Franco JV, Denard PJ, Fieiras C, Liquitay CE, et al. Results after arthroscopic bankart repair in contact athletes should not be reported globally due to the high variability in recurrences among the different contact/collision sports: a systematic review. Arthroscopy 2024;40:523-539.e2. https://doi.org/10.1016/j.arthro.2023.06.037.
35. Rutgers C, Verweij LPE, Priester-Vink S, van Deurzen DFP, Maas M, van den Bekerom MPJ. Recurrence in traumatic anterior shoulder dislocations increases the prevalence of Hill-Sachs and Bankart lesions: a systematic review and meta-analysis. Knee Surg Sports Traumatol Arthrosc 2022;30:2130-40. https://doi.org/10.1007/s00167-021-06847-7.
36. Schneider AK, Hoy GA, Ek ET, Rotstein AH, Tate J, Taylor DM, et al. Interobserver and intraobserver variability of glenoid track measurements. J Shoulder Elbow Surg 2017;26:573-9. https://doi.org/10.1016/j.jse.2016.09.058.
37. Schwihla I, Wieser K, Grubhofer F, Zimmermann SM. Long-term recurrence rate in anterior shoulder instability after Bankart repair based on the on- and off-track concept. J Shoulder Elbow Surg 2023;32:269-75. https://doi.org/10.1016/j.jse.2022.07.025.
38. Sgroi M, Huzurudin H, Ludwig M, Dornacher D, Reichel H, Kappe T. With the exception of the Hill-Sachs interval, CT and MRI show no significant differences in the diagnostic value of the HSL measurement regardless of the measurement technique. Knee Surg Sports Traumatol Arthrosc 2021;29:3981-8. https://doi.org/10.1007/s00167-021-06695-5.
39. Shimozono Y, Seow D, Yasui Y, Fields K, Kennedy JG. Knee-to-talus donor-site morbidity following autologous osteochondral transplantation: a meta-analysis with best-case and worst-case analysis. Clin Orthop Relat Res 2019;477:1915-31. https://doi.org/10.1097/CORR.0000000000000719.
40. Snir N, Wolfson TS, Hamula MJ, Gyftopoulos S, Meislin RJ. Arthroscopic anatomic humeral head reconstruction with osteochondral allograft transplantation for large Hill-Sachs lesions. Arthrosc Tech 2013;2:e289-93. https://doi.org/10.1016/j.eats.2013.04.002.
41. Thacher RR, Retzky JS, Dekhne MS, Oquendo YA, Greditzer HG. Current concepts in the measurement of glenohumeral bone loss. Curr Rev Musculoskelet Med 2023;16:419-31. https://doi.org/10.1007/s12178-023-09852-0.
42. Toker G, Ozan F, Bora OA. Treatment of reverse Hill-Sachs lesion by autograft reconstruction. Acta Orthop Traumatol Turc 2012;46:398-402. https://doi.org/10.3944/aott.2012.2506.
43. Trasolini NA, Dandu N, Azua EN, Garrigues GE, Verma NN, Yanke AB. Inconsistencies in controlling for risk factors for recurrent shoulder instability after primary arthroscopic Bankart repair: a systematic review. Am J Sports Med 2022;50:3705-13. https://doi.org/10.1177/03635465211038712.
44. Trofa DP, Hong IS, Lopez CD, Rao AJ, Yu Z, Odum SM, et al. Isolated osteochondral autograft versus allograft transplantation for the treatment of symptomatic cartilage lesions of the knee: a systematic review and meta-analysis. Am J Sports Med 2023;51:812-24. https://doi.org/10.1177/03635465211053594.
45. Verweij LPE, van Iersel TP, van Deurzen DFP, van den Bekerom MPJ, Floor S. “Nearly off-track lesions” or a short distance from the medial edge of the Hill-Sachs lesion to the medial edge of the glenoid track does not seem to be accurate in predicting recurrence after an arthroscopic Bankart repair in a military population: a case-control study. J Shoulder Elbow Surg 2023;32:e145-52. https://doi.org/10.1016/j.jse.2022.10.003.
46. Verweij LPE, van Spanning SH, Grillo A, Kerkhoffs GMMJ, Priester-Vink S, van Deurzen DFP, et al. Age, participation in competitive sports, bony lesions, ALPSA lesions, > 1 preoperative dislocations, surgical delay and ISIS score > 3 are risk factors for recurrence following arthroscopic Bankart repair: a systematic review and meta-analysis of 4584 shoulders. Knee Surg Sports Traumatol Arthrosc 2021;29:4004-14. https://doi.org/10.1007/s00167-021-06704-7.
47. Vopat ML, Peebles LA, McBride T, Cirone I, Rider D, Provencher CMT. Accuracy and reliability of imaging modalities for the diagnosis and quantification of Hill-Sachs lesions: a systematic review. Arthroscopy 2021;37:391-401. https://doi.org/10.1016/j.arthro.2020.08.005.
48. Wang KC, Waterman BR, Cotter EJ, Frank RM, Cole BJ. Fresh osteochondral allograft transplantation for focal chondral defect of the humerus associated with anchor arthropathy and failed SLAP repair. Arthrosc Tech 2017;6:e1443-9. https://doi.org/10.1016/j.eats.2017.06.008.
49. Williams HLM, Evans JP, Furness ND, Smith CD. It's not all about redislocation: a systematic review of complications after anterior shoulder stabilization surgery. Am J Sports Med 2019;47:3277-83. https://doi.org/10.1177/0363546518810711.
50. Wu C, Xu J, Fang Z, Chen J, Ye Z, Wang L, et al. Arthroscopic dynamic anterior stabilization using either long head of the biceps or conjoined tendon transfer for anterior shoulder instability results in a similarly low recurrence rate. Arthroscopy 2023;39:1618-27. https://doi.org/10.1016/j.arthro.2022.12.040.
51. Yamamoto N, Shinagawa K, Hatta T, Itoi E. Peripheral-track and central-track Hill-Sachs lesions: a new concept of assessing an on-track lesion. Am J Sports Med 2020;48:33-8. https://doi.org/10.1177/0363546519886319.
52. Yang T-C, Chen K-H, Chiang E-R, Chang M-C, Ma H-L. Using the “Hill-Sachs interval to glenoid track width ratio” for prediction of recurrent instability after arthroscopic Bankart repair. Orthop Traumatol Surg Res 2018;104:797-801. https://doi.org/10.1016/j.otsr.2018.02.013.
53. Zhang M, Liu J, Jia Y, Zhang G, Zhou J, Wu D, et al. Risk factors for recurrence after Bankart repair: a systematic review and meta-analysis. J Orthop Surg 2022;17:113. https://doi.org/10.1186/s13018-022-03011-w.
54. Zhuo H, Xu Y, Zhu F, Pan L, Li J. Osteochondral allograft transplantation for large Hill-Sachs lesions: a retrospective case series with a minimum 2-year follow-up. J Orthop Surg 2019;14:344. https://doi.org/10.1186/s13018-019-1366-8.