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Radiological outcomes of iliac crest bone graft augmentation for glenoid bone loss using an open all-suture anchor and washer fixation technique

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A R T I C L E I N F O

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Level of evidence: Level IV

Background: Many of the complications related to bone block augmentation for recurrent shoulder instability are related to metal screw fixation. Alternative fixation techniques using suspensory fixation have been described with good results, although they require an additional posterior incision to manage the button. It was postulated that the use of an all-suture anchor would remove the requirement for a posterior incision, whilst providing equivalent union rates. Thus, the aim of this study was to evaluate the radiological outcome of a technique using all-suture anchor fixation of iliac crest autograft.
Methods: Eleven patients (mean age 28 years, 10 males, 1 female) underwent open anterior shoulder stabilization using an autologous iliac crest bone graft that was fixed with all-suture anchors and supplemented by 2-hole tibial plate. Union of the graft was evaluated 6 months postoperatively using computed tomography.
Results: There were no intraoperative complications and none of the participants needed further surgery. All patients reported a stable shoulder at 6 months follow-up. The grafts united in 10 out of the 11 patients.
Conclusion: An all-suture anchor construct is a viable alternative to metal screw fixation for iliac crest bone grafting in shoulder instability with critical bone loss, and unlike suspensory techniques does not require a second posterior incision.

Glenoid bone loss is an important factor to consider in recurrent shoulder dislocation.[4,17] Once a critical threshold of bone loss has been reached, soft tissue repair alone is not sufficient to impart stability, and augmentation with bone grafting in the form of an anterior bone block is needed to fill the bone loss and stabilize the joint.[4,17] The critical threshold of glenoid bone loss was originally described in the literature as 25%,[5] but this percentage has been reducing, and currently 15% bone loss is considered by some authors as a cutoff for the need for bone graft.[15]

There are a number of grafting options available. The Latarjet procedure remains the most widely performed technique with consistent long-term outcomes.[1,3,18] In the technique, the coracoid is truncated and transferred across to the anterior glenoid defect through the subscapularis. The procedure is associated with a number of complications related to its non-anatomic nature, the non-chondral nature of the graft, the disruption of the subscapularis, and scapular dyskinesia.[7,15]

Because of these drawbacks, autologous iliac crest bone graft (ICBG) has gained increased popularity. A recent randomized controlled trial comparing ICBG to the Latarjet procedure showed similar successful long-term outcomes.[15] Like the Latarjet, ICBG has no chondral surface and harvest site morbidity remains an issue.

Allografts like fresh frozen distal tibia avoid donor site morbidity, but they are costly and bone incorporation rates are lower compared to autograft.[11]

Graft fixation is achieved most commonly with metal screws. Recognized complications related to the use of metal screws include screw head prominence, impingement on the humeral

Institutional review board approval was not required for this study.

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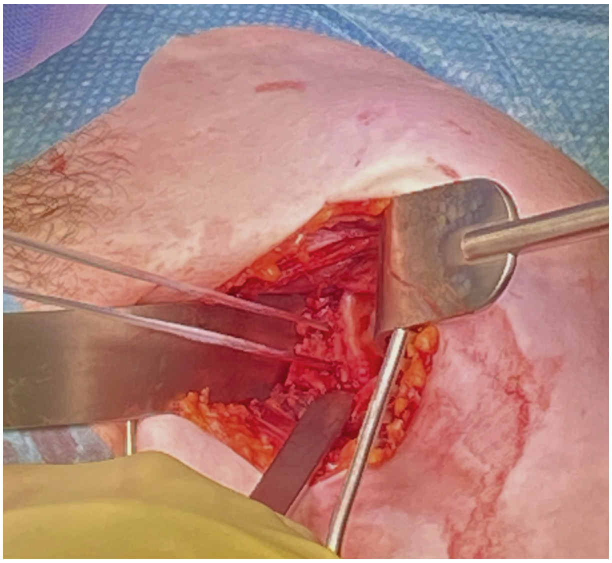

Figure 1 Photograph of a left shoulder showing the position of the anchors in the anterior glenoid.

head, screw migration or breakage, and intraoperative fracture of the graft.[6,9,10,18] Alternative fixation techniques have been described including bioabsorbable screws, suture anchors, and suspensory suture-button fixation.[2,3,8,11,14,25] Whilst they may aim to avoid the complications associated with metal screws, they all have unique problems of their own. Bioabsorbable screws have a high failure rate due to osteolysis.[2] Although suture-button fixation has shown equivalent outcomes to metal screws, they require a posterior shoulder incision to manage the button.[3]

Suture anchor fixation does not have the complications associated with metal screws and does not require a posterior incision. The 2.6 FiberTak DR anchor (Arthrex, Naples, FL, USA) is an all-suture anchor which was originally designed to be deployed in the greater tuberosity. It has a number of theoretical advantages. The anchor is inserted via a 2.6 mm tunnel which is significantly smaller than that required for metal screws. The anchor does not deploy until it meets resistance and therefore will not engage the soft tissues but does against the posterior cortex of the glenoid. This means that a posterior incision and dissection are not needed. A further advantage of 2.6 mm bone tunnels containing suture material only is ease and preservation of bone in the revision surgery setting as they do not have to be removed. Furthermore, technically demanding parallel tunnel placement is not needed to achieve compression.

The senior author had successfully used 2.6 FiberTak DR anchors to revise failed Latarjet procedures in which metal screws had been used. The residual glenoid bone tunnels prevented the use of further screws and it was decided to use posterior cortex suspensory fixation. As a consequence of successful outcomes, these anchors are used as the means of primary fixation.

We report the radiological outcome of 11 consecutive patients who had fixation of an ICBG using all-suture anchors.

Materials and methods

The radiological outcomes of a consecutive series of patients who had undergone iliac crest grafting for recurrent anterior shoulder dislocation with greater than 15% bone loss were reviewed. There were no revision procedures included in this cohort. Preoperative bone loss was measured using 3-dimensional computed tomography (CT) with 2 mm fine cut slices. Three-dimensional renders were made from the data and digital subtraction of the humeral head was undertaken to provide an en face view of the glenoid. The same process was repeated for the uninjured glenoid. A circle of best fit was made on the uninjured side and applied to the injured side to determine the degree of glenoid bone loss using the technique described by Sugaya et al.[20]

All patients were clinically assessed preoperatively, at the day of surgery and during postoperative follow-up at 2 weeks, 6 weeks, 3 months, and 6 months. Graft position was assessed with standard radiographs at 2 weeks.[3,12,15] A postoperative CT scan was performed at 6 months to confirm graft bony union as this has previously been shown to be the time at which the majority of grafts have united.[3] All scans were reviewed by 2 musculoskeletal radiologists. No patients were lost to follow-up.

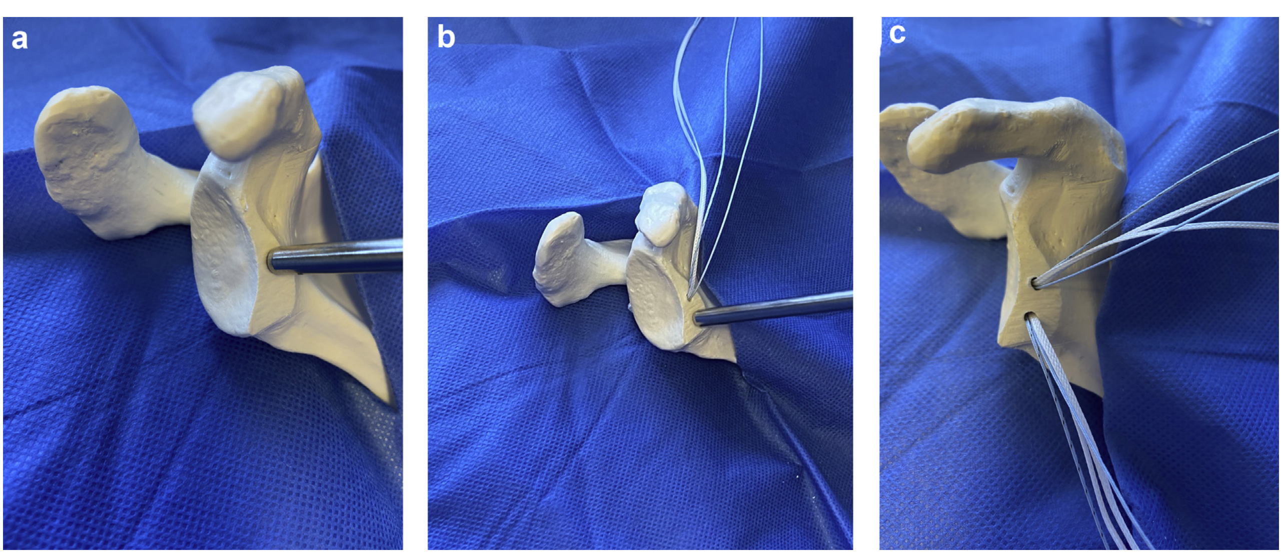

Figure 2 The anchors arrangement process on a sawbone model. (**a**) The green twist drill guide is placed on to the anterior glenoid neck and the first anchor passage is drilled. (**b**) The first anchor is deployed, and the procedure is repeated with a second anchor placed inferiorly. (**c**) The 2 anchors are checked and ready for the passage of the graft.

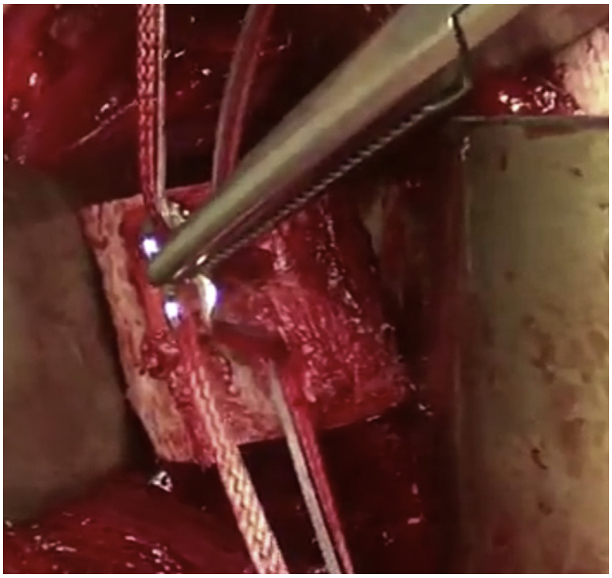

Figure 3 Photograph of the iliac crest bone graft showing the arrangement of the sutures and the tibial plate.

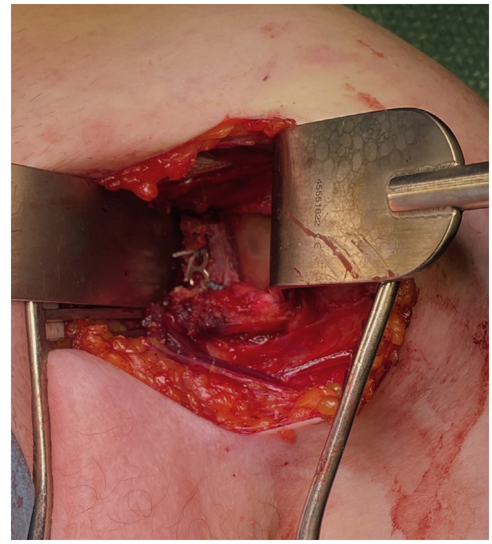

Figure 4 Final position of the iliac crest bone graft on the anterior glenoid.

Surgical technique

All procedures were carried out under general anesthesia supplemented with an interscalene block in the beach chair position.

A deltopectoral approach was utilized. A horizontal split was made in the subscapularis and a medially based T-capsulotomy was performed. The anterior labrum was elevated to expose the glenoid neck which was then prepared to a flat surface with a rasp and a burr. Video 1 illustrates the process in a stepwise manner.

Graft harvesting

An incision was made 5 cm posterior to the anterior superior iliac spine and in line with the iliac crest. The fascia was divided, and the iliac crest was exposed. The superior 2 cm of the attachment of the tensor fascia lata was released from the tuberosity for a length of 2 cm. The soft tissue attachments on the pelvic side were also released over the same length and a malleable retractor was placed behind the iliac crest. A 1.5 cm oscillating saw was used to cut a tricortical bone graft 2 cm wide and 1 cm from superior to inferior. The graft was then contoured to the shape of the anterior glenoid using the saw. Typically, 5-8 mm width of the graft was obtained. Using the 2.6 mm FiberTak drill, 2 drill holes directed toward the cut cancellous surface were made in the graft with a minimum of a 5 mm bridge between them.

Anterior glenoid anchor positioning

The 2.6 mm FiberTak anchor has a specific drill guide though the length of the guide makes the drill too short to reach the posterior cortex of the glenoid. The 6 mm green Twist-In cannula obturator (Arthrex) has almost the same internal diameter but 2 cm shorter enabling the drill to reach the far cortex. This was therefore used as a drill guide. The guide was placed on the anterior glenoid neck and the drill passed bicortically parallel to and approximately 5 mm below the articular surface. The drill was removed, and the anchor passed down the drill guide. Once it was felt to pass the posterior cortex of the glenoid neck the anchor was deployed, and the drill guide was removed. The procedure was repeated with a second anchor placed inferiorly. Figure 1 illustrates the 2 anchor tunnels positioned in the anterior glenoid. Figure 2, a-d illustrates the process on a sawbone model.

Graft passage and stabilization

The FiberTak DR anchor has 2 sliding sutures (4 limbs), a Fiberwire, and a Suturetape. All 4 limbs from the superior anchor were passed through the superior drill hole in the graft and the 4 limbs from the inferior anchor were passed through the inferior drill hole in the graft.

When this technique was conceived, concern was raised about the possibility of the sutures cutting into the graft with subsequent loss of tension in the construct. It was therefore decided to tie the suture limbs over a "washer." A 2-hole Tibial Plate (Arthrex) was the correct size and provided a "double washer" for the sutures to be tied over.

The limbs from each anchor were then split into 2 pairs made up of 1 Fiberwire limb and 1 Suturetape limb. One Fiberwire/Suturetape pair from the superior anchor was then passed through 1 of the holes of the 2-hole Tibial Plate whilst the other pair remained outside the plate. One Fiberwire/Suturetape pair from the inferior anchor was then passed through the other hole in the plate. The graft was then parachuted down the limbs and reduced to the anterior glenoid neck, being pushed down by the plate. Figure 3 illustrates this arrangement.

The Fiberwire suture from the superior anchor was tied over the tibial plate followed by the Fiberwire suture from the inferior anchor. The process was then repeated with the Suturetapes from each anchor. Once all of the sutures were tied down the graft position was inspected, and any overhang of the articular surface was sculpted using a burr or a saw until it was no longer proud of the articular surface. Figure 4 shows the graft stabilization after knot tying. Figure 5, a-e illustrates the graft passage and stabilization process on a sawbone model.

Labral repair

The labrum and capsule were repaired to the glenoid face using one or two 1.8 mm FiberTak sutures (Arthrex).

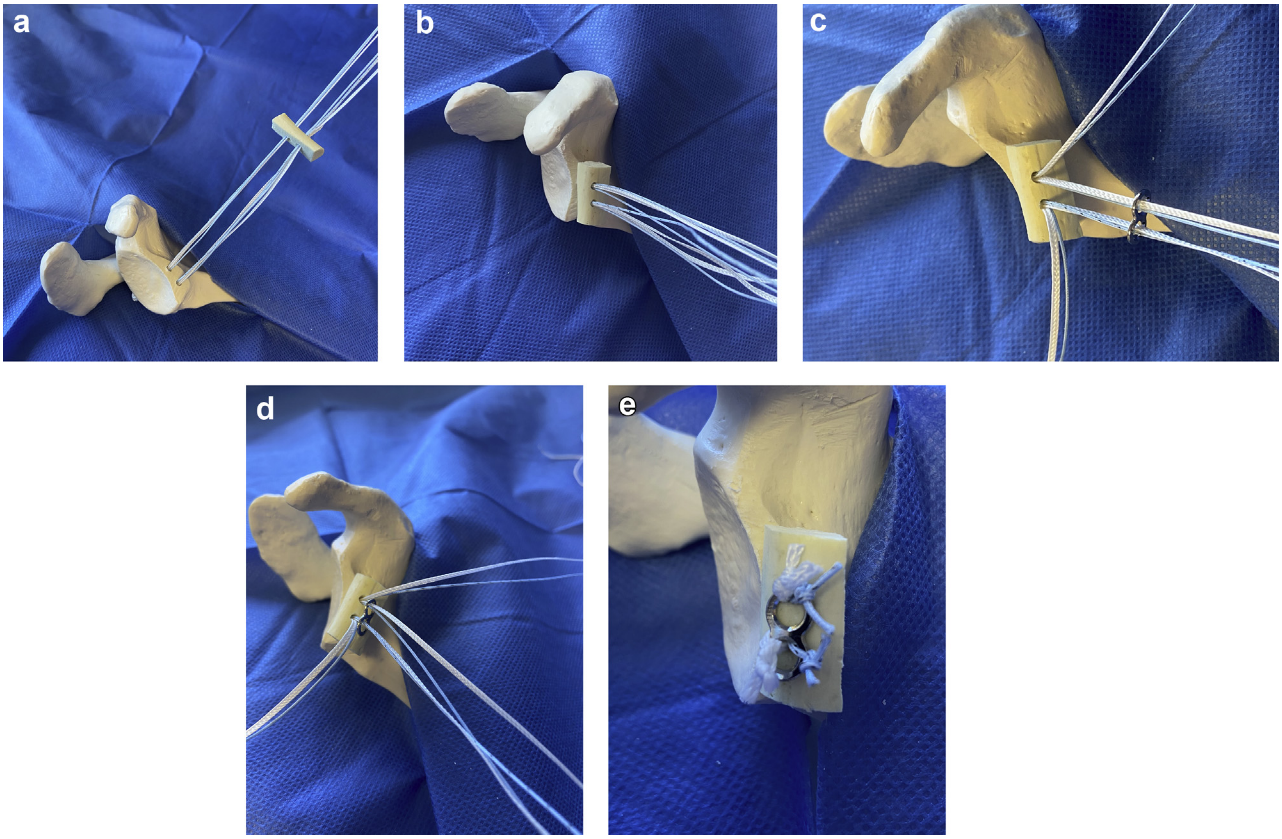

Figure 5 The graft passage and stabilization process on a sawbone model. (**a**) The 4 limbs of each anchor are passed through the corresponding drill hole in the graft. (**b**) The graft is parachuted down to the anterior glenoid neck. (**c**) The limbs of each anchor are split into 2 pairs (1 Fiberwire and 1 Suturetape in each pair). The tibial plate (washer) is passed through 1 pair from each anchor. (**d**) The tibial plate (washer) is parachuted down to sit on the graft. (**e**) The Fiberwire suture from the superior anchor is tied over the tibial plate followed by the Fiberwire suture from the inferior anchor. The process is then repeated with the Suturetapes from each anchor.

Rehabilitation protocol

Postoperatively the shoulder was immobilized in a sling with a body strap for 3 weeks. For the subsequent 3 weeks, a range of movement to neutral external rotation and 90° forward flexion were permitted. Following this, at the 6-week postoperative stage, full active shoulder movement was started with progressive stretching and range of movement exercises. Contact sports were permitted at 6 months following surgery.

Results

Eleven patients underwent the procedure between December 2018 and January 2020 (10 males, 1 female). All patients had a minimum of 15% anterior glenoid bone loss measured on the CT. The average age was 28 (range 18-45) years. All patients completed the rehabilitation and had a postoperative 6-month CT scan.

Postoperatively, no complications were recorded and at the last follow-up, no patient had subluxations/dislocations and no patient required further surgery. Formal outcome measurement was not performed as 6 months is too soon to be clinically meaningful and the primary aim of this study was a radiological assessment. CT scan assessment of the grafts by 2 musculoskeletal radiologists at 6 months confirmed bony union in 10 of the 11 patients. Glenoid diameter had increased to greater than 100% in all cases except the one case in which the graft failed to unite. In 1 patient the graft failed to unite, although he remains asymptomatic and has resumed noncontact sports. Figures 6 and 7 show graft union on the CT images.

As the graft had been shaped with a burr or saw after insertion, all grafts were in a suitable position at final CT.

Discussion

Further evidence continues to emerge to support bone augmentation for recurrent shoulder instability associated with significant anterior glenoid bone loss,[4,17] with defects exceeding 15% being associated with high risk of recurrent dislocation following soft tissue procedures.[17,23]

Two metal screws are traditionally used for graft fixation but a 6.5% incidence of hardware complications has been reported with a proportion requiring subsequent surgery.[6] The senior authors personal experience had been that, although union rates were over 90%, there had been screw breakage and prominent metalwork when union failed, resulting in damage to the humeral head. To combat this issue, other fixation options have been reported in the literature. Bioabsorbable screws have been used but had unacceptably high rates of graft osteolysis.[2] More recently, Boileau et al[3] successfully employed suture-button fixation for the Latarjet procedure. Although the procedure was performed arthroscopically, a drawback is that the technique required a posterior incision to manage the button.

Suspensory techniques have also been described for free grafts (both ICBG and allograft). Taverna et al[21] and Xu et al[25] described techniques using an Endobutton device while Kalogrianitis and Tsouparopoulos[14] published a technique using the Arthrex Tightrope system. More recently, Hassebrock et al[11] used the same device for the fixation of a distal tibia allograft. All of these rely on

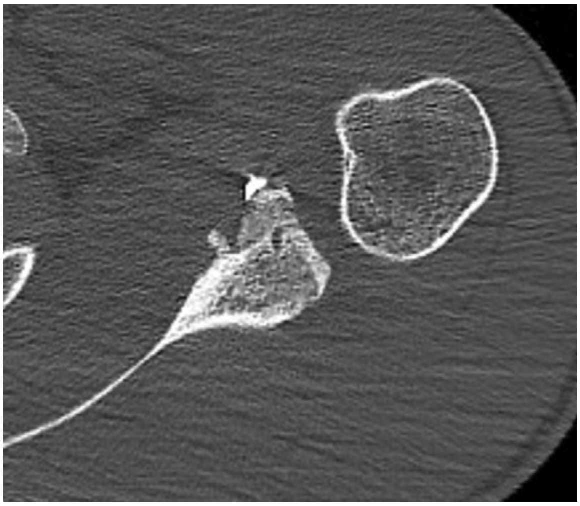

Figure 6 Computed tomography axial images at 6 months showing iliac crest bone graft bony union.

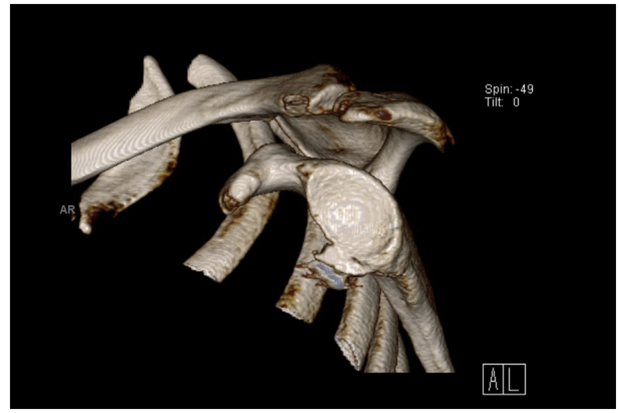

Figure 7 Three-dimensional computed tomography reconstruction at 6 months showing iliac crest bone graft bony union.

adequate tightening at the posterior glenoid neck which is obscured by soft tissue. As with Boileau's technique, this necessitates the use of a posterior incision to ensure that the button lies flush against the cortex with no soft tissue interposition. Recently, Jeong et al published a single all-suture anchor fixation technique using ICBG.[13] It relied on only 1 soft giant knot for fixation with the potentially weaker force applied across the graft and reduced graft rotational stability and the risk of graft toggling.

The 2.6 mm FiberTak DR anchor was originally designed to be used in tuberosity cancellous bone, although a recent cadaveric study demonstrated a higher load to failure value when used in cortical bones.[16]

We describe a novel ICBG fixation technique using 2 all-suture anchors. It is technically relatively simple and has several advantages. The 2-point fixation ensures rotational stability.[6,19,26] In this series the tibial plate was used as a washer to disperse the force over the graft surface and prevent the risk of cheesewire cutting through the bone, and as a consequence allows increased compression. Unlike metal screws, should the graft fail to unite or if the metal plate becomes loose, it is theoretically less likely to impinge on or erode the humeral head because the plate is not rigidly fixed.

The key radiological marker of success is graft union to the anterior glenoid neck. A recent systematic review of the literature identified the rate of graft union when using metal screws to be 90%.[6] A recent case series of 76 patients using a suture-button fixation technique also achieved graft union in 91% of patients. An equivalent result was achieved this study in which 10 of 11 (91%) patients achieved union.

Load to failure of the fixation device is an important factor. A cadaveric study demonstrated a mean load to failure of 202 N (range 95-300 N) in the Latarjet procedure when 2 bicortical metal screws were used.[24] In contrast, 2.6 mm FibreTak anchors demonstrated a mean load to failure of 799.64 N in a recent cadaveric study when fixing proximal hamstring avulsions.[16] This suggests that the anchor fixation is unlikely to be the weak point in the construct.

To our knowledge, this is the first study in the literature where an all-suture anchor technique has been used to anatomically reconstruct an anterior glenoid defect with ICBG, providing an anteriorly fixed construct, and we have demonstrated a rate of bony union equivalent to metal screws.

There are a few limitations in this study. The sample size is small and the follow-up is only 6 months. However, this is a pilot study and the primary aim was to evaluate union which is reliably seen by 6 months.[22] The patients will continue to be followed and clinical results will be reported at 2 years.

Conclusions

Our technique of anatomic reconstruction of anterior glenoid bone loss using a simple technique of suture anchors supplemented by a small plate used as a washer avoids the metal screw complications, does not require a posterior incision, and achieves comparable union rates.

Disclaimers

Funding: No funding was disclosed by the author(s).

Conflicts of interest: Prof Tennent has received royalties for devices and techniques from Arthrex unrelated to this article. All the other authors, their immediate families, and any research foundations 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.xrrt.2021.04.011.

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