Technical Note

Arthroscopic Compaction Bone Grafting for Uncontained Bone Defects of the Greater Tuberosity Associated With a Rotator Cuff Retear

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Abstract: Revision rotator cuff repair is a technically demanding procedure that can be complicated by the presence of large peri-implant cysts. When multiple suture anchors are encountered, massive bone defects may need to be addressed to ensure that tendon–bone fixation and healing can be optimized. This Technical Note discusses arthroscopic compaction bone grafting for massive uncontained bone defects of the greater tuberosity associated with revision rotator cuff repair.

Introduction (With Video Illustration)

Rotator cuff tendon–bone healing requires both robust fixation and tendon-to-bone contact at the enthesis.[1] Bone cysts of the proximal humerus pose a considerable challenge to conventional rotator cuff repair techniques.[2] The cause of degenerative bone cysts is yet to be determined but they are associated with aging and the presence of existing suture anchors during revision surgery.[3] Suture anchors composed of bioabsorbable materials can induce cystic formation and weaken the surrounding bone.[3] This is reported in 10% of cases and significantly increases the risk of a retear following surgery.[4]

In revision cases, solitary bone cysts or small bone cysts can be avoided by altering the position of anchors. The complexity of the situation increases when multiple implants or cysts are present such as during double-row rotator cuff repair. In addition, residual implants/bone cysts may warrant removal if the anchor is prominent or the multiple bone cysts leave little bone stock for tendon-to-bone healing. In these circumstances, a large and sometimes uncontained bony defect remains. This can preclude further suture anchor fixation and mitigate against stable tendon reattachment. Few strategies exist to deal with this difficult problem.

The purpose of this Technical Note is to describe a 2-stage approach to the arthroscopic treatment of rotator cuff retears, associated with large uncontained defects of the greater tuberosity, using compaction cancellous bone grafting (Video 1).

Surgical Technique

Preoperatively, a comprehensive clinical and radiologic assessment is undertaken to plan further surgery, identify degenerative changes, exclude infection, and to evaluate suture anchors for peri-implant cystic formation, prominence, and loosening (Fig 1). The following technique can be performed in either the beach chair or lateral decubitus positions although our preference is for the latter. Under general anesthesia, the patient is positioned in the lateral decubitus position. The arm is held in place with the SPIDER Arm positioner (TENET Medical Products, a wholly owned subsidiary of Smith & Nephew, Andover, MA) that allows simultaneous traction with rotation. After the operative shoulder is prepped and draped, a standard posterior viewing portal is made, and an intra-articular diagnostic arthroscopy is performed. Particular attention is given to the articular side of the rotator cuff and the footprint.

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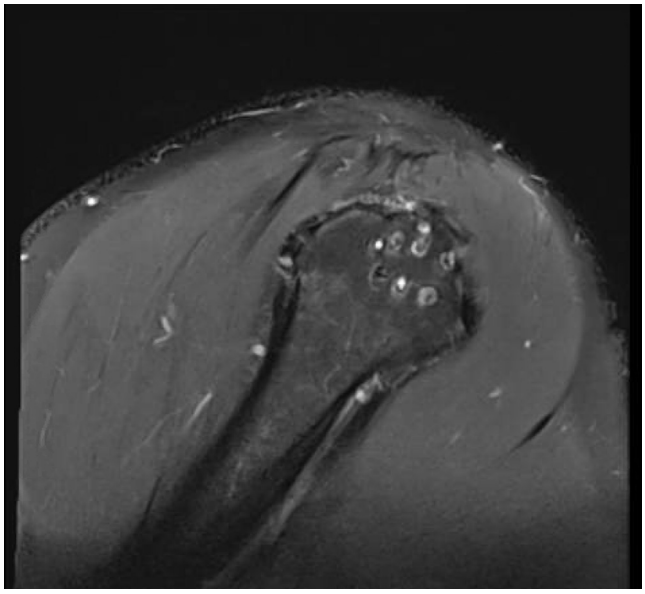

Fig 1. Sagittal, T2-weighted magnetic resonance imaging scan of the right shoulder illustrating multiple cysts in the proximal humerus following a previous rotator cuff repair. Note the close proximity of the cysts to one another, a feature that raises the possibility of a thin-walled cavity that may be uncontained.

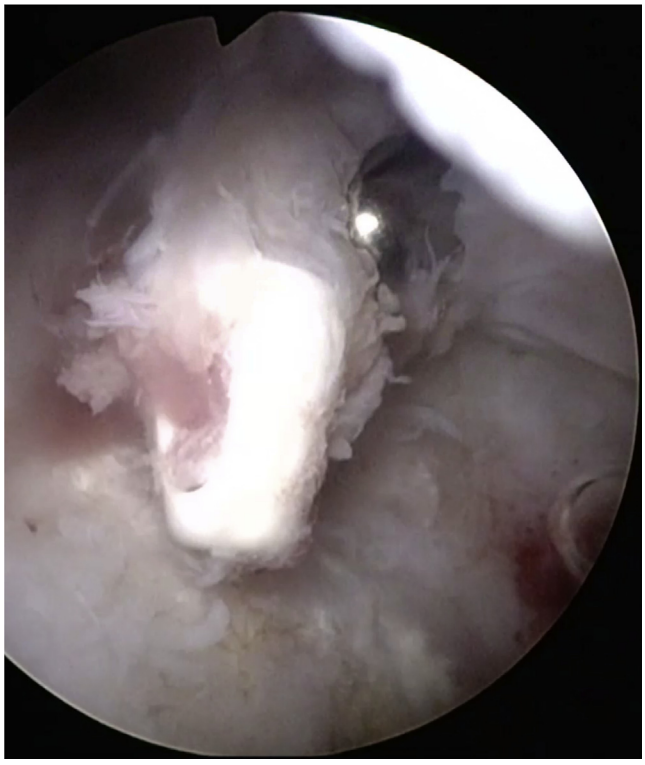

Fig 2. Right shoulder viewed from the posterior portal, in the lateral decubitus position, illustrating the removal of a suture anchor used in a previous rotator cuff repair. Note the soft tissue adherent to the suture anchor indicating that a large defect may be encountered.

The subacromial space is evaluated through the posterior portal. A lateral working portal is established and made in-line with the rotator cuff tear and parallel to the underside of the acromion. All bursa and fibrofatty tissue are removed from the rotator cuff, including the lateral gutter so that the entirety of the greater tuberosity can be visualized. An acromioplasty is not carried out in the presence of a full thickness defect so as to not cause anterosuperior escape resulting from resection of the coracoacromial ligament. The lateral footprint is cleared of soft tissue and all suture material with their accompanying anchors are removed using a grasper (Fig 2). The bone is examined using a switching stick to determine the presence and extent of any cystic regions both at existing anchor sites, and in adjacent regions.

Previous anchors are located and any buried suture, partially resorbed residual anchor material, and accompanying soft tissue is removed from the anchor holes. If an additional area of soft bone is identified, the cortex is gently broken with the switching stick or an elevator to reveal the cavity. The cyst and its contents are carefully excavated using an arthroscopic shaver to create a bleeding bone bed without violation of the cavity wall (Fig 3). When hard anchors are encountered (e.g., metal, PEEK [polyether ether ketone]), a judgment is made whether they can be left in situ or removed. This is based on the prominence or depth of

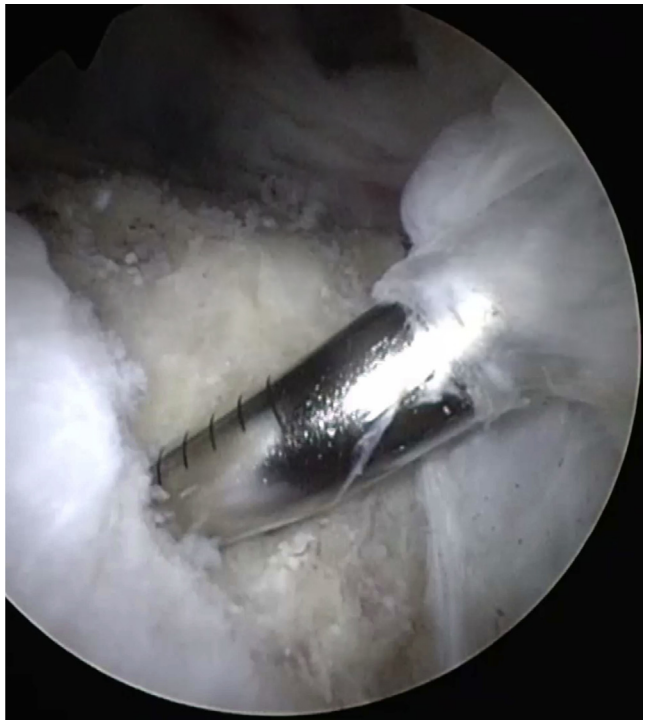

Fig 3. Excavation of a greater tuberosity cyst of the right shoulder, in the lateral decubitus position, using an arthroscopic shaver inserted through a mid-lateral portal. Caution should be taken when doing this in order to not violate the walls of the cyst.

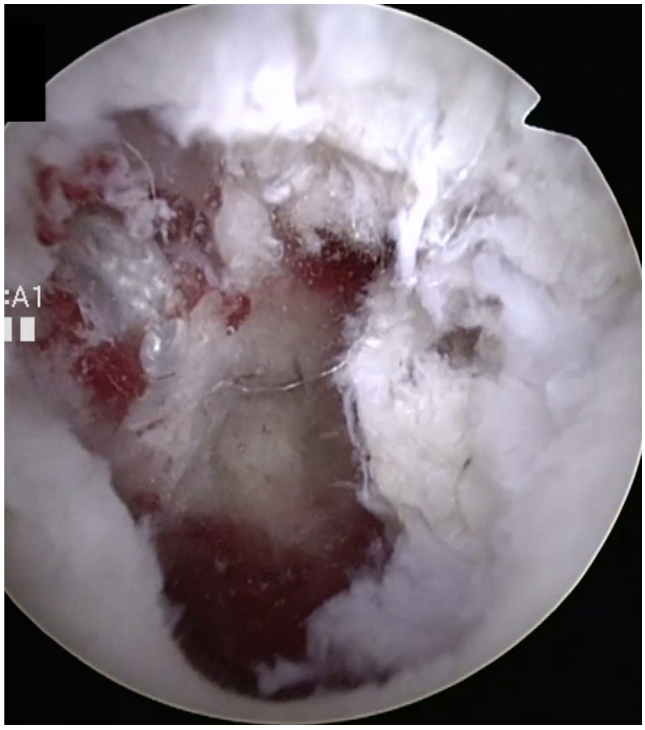

Fig 4. Uncontained bony defect on the greater tuberosity of the right shoulder, in the lateral decubitus position viewing through the posterior portal, following suture anchor removal and debridement. The entirety of the cystic contents should be removed so that it can be completely filled with bone graft, in an attempt to completely restore the normal bony architecture of the greater tuberosity.

the anchor, the potential damage that can be caused during removal, and the remaining bone available for tendon–bone healing.

When a large solitary defect is encountered then a single-stage grafting procedure may be considered.[5] For massive uncontained defects this is not possible due to the considerable bone loss which precludes stable anchor fixation as well as tendon–bone contact for healing (Fig 4). Instead, a 2-stage approach is used to ensure that a good-quality bone bed can be achieved for subsequent rotator cuff repair. If infection is suspected, multiple biopsies including residual anchors and implant materials may be sent for culture including long-term analysis for *Cutibacterium acnes*. A 2-stage procedure allows for treatment of infection in addition to restoring bone stock.

A smooth cannula (5.5-mm Universal Cannula; CONMED-Linvatec, Largo, FL) or a 5-mL syringe is inserted through an accessory superolateral portal localized adjacent to the acromion and in-line with the bone defect. This facilitates passage of the cancellous bone chips directly into the defect. The arthroscopic fluid is then shut-off and the residual fluid drained with suction. A dry scope is performed so that the cancellous bone can be controlled without fluid flow. Cancellous allograft bone chips are inserted through the superolateral portal and are delivered directly into the cavity using an arthroscopic grasper. The graft is compacted using a grasper with the 'jaws' closed, and the process is repeated multiple times until the cyst has completely been filled and impacted (Fig 5). To improve visualization during the dry scope, intermittent suction may be required or retraction of the deltoid using a switching stich (Table 1).

The arthroscope is withdrawn, the portals closed with sutures, and a standard sling applied. Rehabilitation following this first stage requires the sling to be worn for 6 weeks and passive movements to be allowed during this period. Active range of motion including overhead motion is allowed at 6 weeks with progressive stretching.

The second-stage procedure can be carried out 3 months later. We do not perform computed tomography routinely but will consider doing so if the patient has a biological predisposition to poor graft incorporation, such as a history of diabetes or smoking. In the second stage, careful assessment of the greater tuberosity is made to ensure that the defect has been filled with new bone (Fig 6). A standard rotator cuff repair is then performed with conventional footprint preparation and suture anchor insertion.

Postoperatively, a sling is worn for 6 weeks and during this period. Rehabilitation will be dependent on

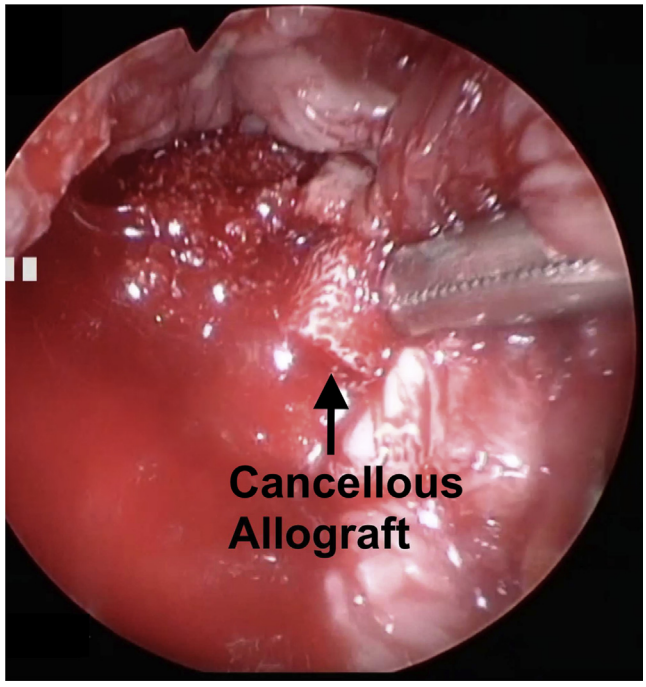

Fig 5. Impaction of cancellous allograft into the uncontained bony defect within the greater tuberosity of the right shoulder, in the lateral decubitus position through the mid-lateral portal. Note how the jaws of the grasper are closed to compress the bone graft in a controlled manner.

Table 1. Pearls and Pitfalls

Pearls	Pitfalls
The cyst should carefully be evacuated without compromising its potentially thin wall.	Carefully impact the cancellous bone to avoid breaking the walls of the cyst and worsening the defect.
Bone graft is inserted after turning the arthroscopic flow off.	Exercise caution when debriding the cyst cavity to not violate its walls.
	The procedure should not be undertaken in the presence of infection.
	Avoid a single-stage procedure in the presence of uncontained bone defects so as to not compromise suture anchor fixation.

the procedure that has been performed (e.g., superior capsular reconstruction, repair, etc.).

Discussion

Cystic changes of the greater tuberosity are associated with the presence of rotator cuff tears.[2] Although cyst formation can occur in isolation, they can additionally be found around existing suture anchors thereby making future revision surgery fraught with problems.[3] Several techniques have been described to address this problem.[5,6] Reda et al.[5] used demineralized bone matrix to fill the cavity and medial row anchors to repair the tendon, but this is both technically demanding and expensive. In a further single-stage approach, Agrawal and Stinson[6] applied a correspondingly sized TruFit BGS cylindrical implant (Smith & Nephew, San Antonio, TX) into the cyst and then repaired the rotator cuff using a tension-band technique with anchors distal and lateral to the footprint. Although the appeal of these procedures lies in their single-stage approach, when massive, uncontained defects are encountered, alternative methods are usually required to ensure stable anchor fixation and sufficient tendon–bone contact to allow healing.

We present our technique to reliably restore normal bony anatomy of the greater tuberosity using a simple procedure, designed to treat uncontained defects. This facilitates subsequent rotator cuff repair because suture anchors can be placed in the ideal position and the tendon repaired using standard techniques. Delaying the definitive rotator cuff repair ensures that there is a stable bony bed into which suture anchors can be inserted without the risk of immediate pull-out. In addition, restoration of the anatomy of the greater tuberosity improves tendon-bone contact during the definitive revision procedure.

The principal drawback is the mandatory second procedure, which delays definitive surgery until normal bony architecture has been re-established. We believe this is crucial in the case of massive cavitary defects associated with existing implants that do not resorb and result in new bone formation. The main risk of the technique is that debriding the cavity of the cyst or forcefully impacting the bone graft, may further compromise the wall of the defect. With adequate care, this can be avoided and ensure bone grafting can be performed. In addition, if infection is suspected, the delay of second surgery allows diagnosis and treatment as required (Table 2).

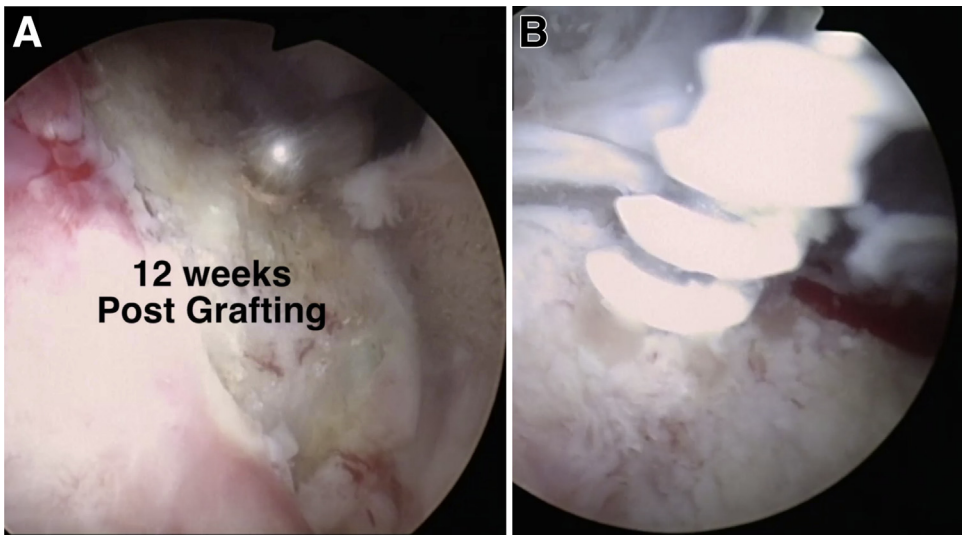

Fig 6. (A) New bone formation 12 weeks following bone grafting of the greater tuberosity of the right shoulder in the lateral decubitus position viewing through the posterior portal. (B) Suture anchor insertion into the previously bone grafted greater tuberosity through a percutaneous incision inferior to the acromion. Note the restoration of the greater tuberosity bone surface (A), which can be prepared to accommodate a suture anchor.

Table 2. Advantages and Disadvantages of the Described Technique to Treat Uncontained Bone Defects of the Greater Tuberosity Associated With a Rotator Cuff Retear

Advantages	Disadvantages
Arthroscopic technique.	Two-stage procedure.
Reliable method to restore the bone stock in the greater tuberosity despite uncontained defects.	Without due caution, there is a risk of damaging the wall of the cyst with debridement and impaction grafting.
Avoids donor-site morbidity	

In conclusion, a 2-stage arthroscopic approach using compaction bone grafting is our preferred method of addressing rotator cuff retears associated with large uncontained defects of the greater tuberosity. It is a reliable way of restoring the bony scaffold of the proximal humerus so that suture anchor fixation is not compromised, and sufficient contact is achieved for tendon repair to bone.

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