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Surgical technique

Arthroscopic treatment of scaphoid nonunion with humpback deformity and DISI with corticocancellous bone grafting: Technical note

Traitement arthroscopique des pseudarthroses du scaphoïde avec plicature et DISI par greffon corticospongieux : note technique

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ABSTRACT

For two decades, scaphoid nonunion has been treated arthroscopically. However, compressed cancellous bone graft does not have the same mechanical properties as corticocancellous bone graft for reducing the scaphoid humpback deformity and DISI tilt. Here, we describe an arthroscopic technique to treat Alnot stage IIB scaphoid nonunion. We treated a 27-year-old male patient for scaphoid waist nonunion with humpback deformity and DISI. A 8 × 8 × 10 mm cylindrical corticocancellous bone graft was harvested from the dorsal aspect of the radius using a single-use osteochondral autograft transfer system (OATS®, Arthrex Inc., Naples, USA). It was inserted in the nonunion site through an arthroscopic volar approach. Bone union was obtained at 3 months with lasting correction of the scaphoid humpback deformity and DISI. The functional result at 6 months was excellent. There were no complications. Scaphoid nonunion with humpback deformity and DISI may be treated arthroscopically with a corticocancellous bone graft.

RÉSUMÉ

Depuis deux décennies, les pseudarthroses du scaphoïde peuvent être traitées sous arthroscopie. Cependant, les greffons spongieux en copeaux ne présentent pas les qualités mécaniques d'un greffon corticospongieux pour réduire la plicature du scaphoïde et la bascule dorsale du lunatum (DISI). Nous présentons ici une technique arthroscopique permettant de traiter les pseudarthroses du scaphoïde de stade IIB d'Alnot. Nous avons traité sous arthroscopie un patient de 27 ans présentant une pseudarthrose évoluée du corps du scaphoïde avec bascule en DISI. Un greffon corticospongieux cylindrique de 8 × 8 × 10 mm prélevé à la face dorsale du radius à l'aide d'un système de transfert d'autogreffe ostéochondrale à usage unique (OATS®, Arthrex Inc, Naples, USA) a été introduit au niveau du foyer de pseudarthrose par un abord arthroscopique antérieur. La consolidation a été obtenue à 3 mois avec correction de la plicature du scaphoïde et de la bascule en DISI. Le résultat fonctionnel à 6 mois était excellent. Nous ne rapportons aucune complication. Il semble possible de traiter les pseudarthroses du scaphoïde avec plicature et bascule en DISI sous arthroscopie par greffon corticospongieux.

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1. Introduction

Arthroscopic treatment of scaphoid nonunion has progressed to the point where the outcomes are comparable to that of treatment with vascularized grafts [1]. The advantages of arthroscopy are well-known: smaller skin incision, preservation of capsule and vascularization, along with reduction of iatrogenic ligament damage and adhesions [2]. When using the midcarpal portal and a volar percutaneous incision, it is possible to decorticate the nonunion site, fill the defect with cancellous bone chips and stabilize the scaphoid with a screw or pins [3]. However, arthroscopic treatment does not allow full correction of the scaphoid humpback deformity or tilt due to dorsal intercalated segment instability (DISI) [4]. Certain authors believe the persistent scaphoid deformity and DISI tilt are a potential cause of osteoarthritis [5].

We will describe an arthroscopic technique for treating Alnot stage IIB scaphoid nonunion [6] (with DISI tilt but no osteoarthritis) by using a 500 mm^3 cylindrical cortiocancellous graft to fill the defect and restore the carpal height.

2. Case report

The case involves a male, 27-year-old, non-smoking patient who worked as a sports teacher and semiprofessional soccer player. He presented with right scaphoid nonunion that had plagued him for 2 years (Fig. 1). Pain on the visual analog scale (VAS) was 0 at rest and 7/10 during activity. His Quick DASH score was 36.4/100. Wrist mobility was 20°/60° in flexion/extension and 90°/90° in pronation/supination. Grip strength measured with a Jamar® dynamometer was 36 kg in the nonunion hand and 45 kg in the opposite hand. X-rays showed slightly reduced carpal height with a Youm index of 0.50 and dorsal lunate tilt with a 75° scapholunate angle.

Under regional anesthesia and with a tourniquet, the procedure started by reducing the dorsal lunate tilt as described by Linscheid [7] using a temporary radiolunate pin inserted with the wrist flexed. After applying 10 N distraction with a Whipple tower, two posterior arthroscopic portals were made: MCR for instruments and MCU for scope. We evaluated the opening of the nonunion site and the correction of the scaphoid humpback deformity. The nonunion site was decorticated using a shaver, burr and curette.

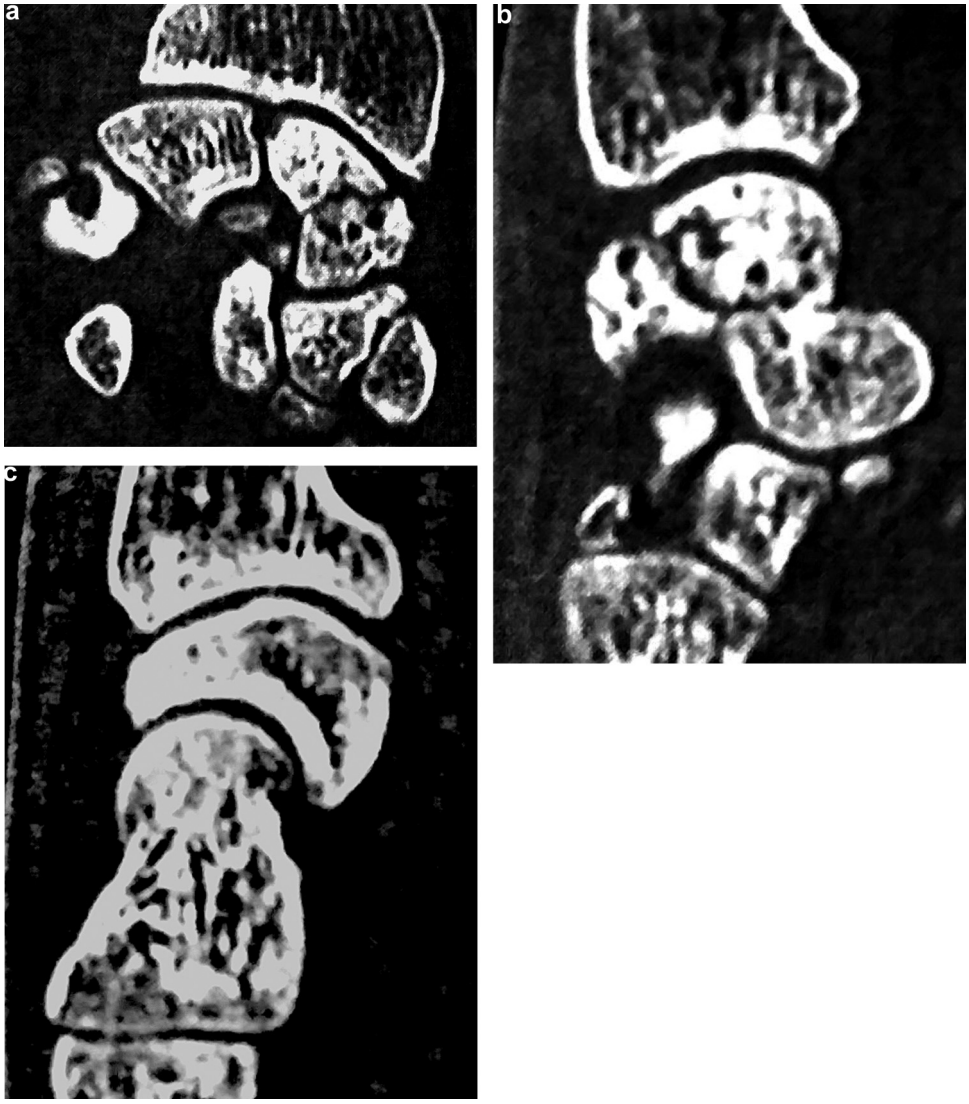

Fig. 1. CT scan of scaphoid nonunion with reconstructions. Coronal (a) and sagittal (b) slices centered over the nonunion site show osteolysis and scaphoid humpback deformity. Sagittal slice centered over the lunate (c) showing the DISI tilt.

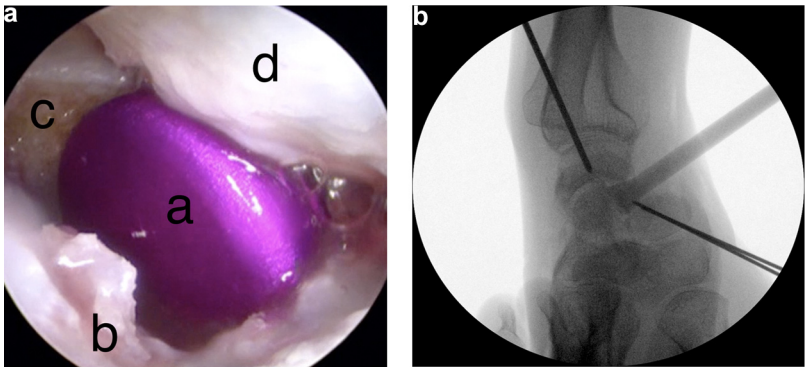

Fig. 2. Evaluation of the bone defect after correcting the DISI tilt and decortication of the nonunion site using 6-, 8- and 10-mm diameter graft sizers by arthroscopy (a) and fluoroscopy (b). a: 8-mm diameter sizer fills the defect sufficiently; b: proximal pole of scaphoid; c: distal pole of scaphoid; d: capitate.

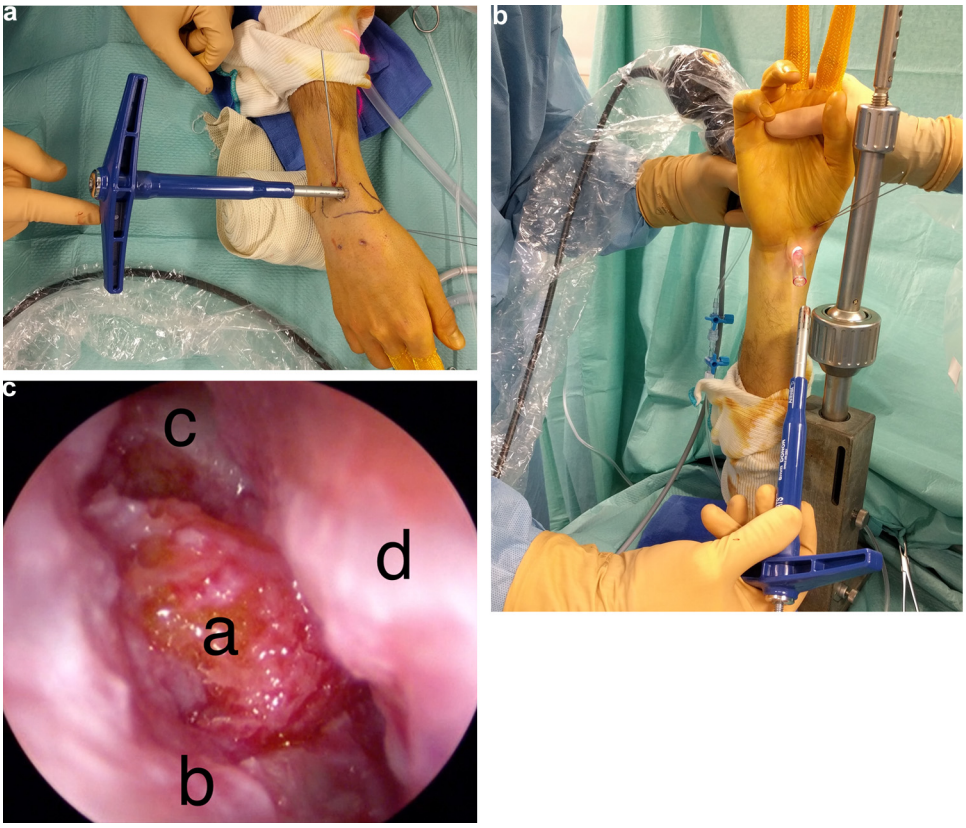

Fig. 3. Preparing the corticocancellous autograft using the Arthrex OATS® (Osteochondral Autograft Transfer System). Harvesting the graft from the dorsal side of the radial epiphysis (a), then introducing the graft by a volar arthroscopic portal using a dedicated cannula (b) and arthroscopic view of the graft in place (c). a: corticocancellous graft; b: proximal pole of scaphoid; c: distal pole of scaphoid; d: capitate.

As described by Naroura et al. [8], a 10-mm volar arthroscopic portal was made from inside to outside, on the radial edge of the flexor carpi radialis tendon, to ensure the radial artery and median nerve were not damaged. The passage between the fibers of the radioscaphocapitate ligament was carefully widened using hemostats. Through this portal, sizers developed to measure the size of cartilage defects during mosaicplasty (6-, 8- and 10-mm diameter) were introduced to estimate the defect's volume. Arthroscopic examination supplemented by fluoroscopy as needed was used to verify whether the sizer filled the defect. In our patient, the 6-mm diameter sizer did not sufficiently fill the gap between the proximal and distal pole, while the 8-mm diameter sizer filled this gap perfectly based on arthroscopy and fluoroscopy (Fig. 2). Consequently, no trials were done with the 10-mm sizer.

With a single-use osteochondral autograft transfer system (OATS®, Arthrex Inc, Naples, USA), an $8 \times 8 \times 10$ mm cylindrical corticocancellous graft was harvested from the dorsal side of the radius at Lister's tubercle, making sure to preserve the anterior cortex (Fig. 3a). A cannula was introduced through the anterior portal through the skin and anterior capsule. Using the cannula as a guide, the graft was placed in the nonunion site under arthroscopic (Fig. 3b) and then fluoroscopic control.

The distraction was released, and the scaphoid stabilized with a compressive 2.5-mm diameter, 24-mm long, continuous thread cannulated screw (Compression FT Screw System, Arthrex Inc, Naples, USA). The temporary radiolunate K-wire was removed. Fluoroscopy and arthroscopy were used to make sure the screw and graft were positioned correctly, the scaphoid height had been

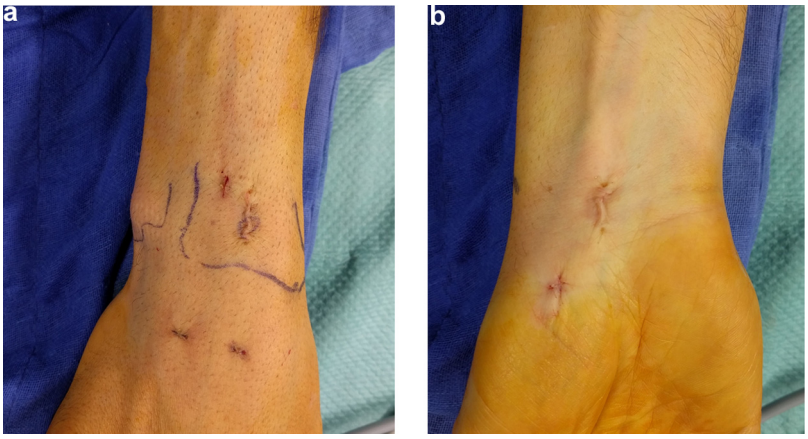

Fig. 4. View of the dorsal (a) and volar (b) incisions after skin closure.

restored and the dorsal lunate tilt had been corrected (Fig. 4). The procedure lasted 1.5 hours. There were no intraoperative or postoperative complications.

The patient's wrist was immobilized with a circular resin short-arm cast for 6 weeks followed by removable splint for an additional 6 weeks. At the 2 and 6 week follow-up visits, X-rays were taken of the wrist, and a CT scan was taken at the 3-month follow-up.

Union was achieved at 3 months, as shown on the CT scan (Fig. 5a). The patient was then allowed to start rehabilitation and resume his work and sports-related activities.

At 6 months postoperative, he was asymptomatic (VAS 0/10 during activity) and his QuickDASH was 0/100. Wrist mobility was 65°/85° in flexion/extension and 90°/90° in pronation/supination. Grip strength was 48 kg on the Jamar® dynamometer versus 46 kg in the opposite hand. The scars were flexible and barely visible. The X-rays showed the carpal height was restored with a Youm index going from 0.50 to 0.56 and the scapholunate angle going from 75° to 35° (Fig. 5b,c).

3. Discussion

In 1873, Professor John Struthers [9], an anatomist at the University of Aberdeen, published the first known description of scaphoid nonunion: "The scaphoid is represented by two bones of nearly equal size. (..) this case is not one of natural variation, but one of fracture of the scaphoid followed by the formation of a false joint". In 1936, Professor Hermann Matti of Bern, who was inspired by work performed on the femur and tibia, described a treatment for scaphoid nonunion using cancellous autograft through a dorsal approach [10]. In 1960, Dr Otto Russe, an Austrian surgeon, made two improvements to this technique: volar approach to preserve the scaphoid's vascularization and use of a corticocancellous graft to reinforce the stability of the reduction [11]. In 1997, Dr. Pak Cheong Ho proposed to decorticate and then fill the nonunion site through arthroscopic portals [12]. The study published by Wong and Ho reported a 91.2% union rate [12].

But when we focus on treating scaphoid nonunion, several questions arise.

3.1. Should the carpal deformity be corrected during treatment of scaphoid nonunion?

The answer is controversial. In a recent study, Mathoulin and Arianni [13] questioned whether the dorsal lunate tilt (DISI) needs to be corrected. They reiterated that DISI tilting alters carpal biomechanics and reduces the probability of scaphoid union [14]. Amadio et al. showed that scaphoid malunion with more than 45° angulation produces poor functional outcomes in nearly 3 out of 4 cases and osteoarthritis in more than 1 out of 2 cases [5]. However, more recently, the same team did a retrospective study comparing the functional outcomes of patients operated for scaphoid malunion to those of non-operated patients and found no long-term benefit to corrective osteotomy [15]. The Nakamura et al. [16] and Fernandez et al. [17] studies contradict these findings as they found good clinical and radiological outcomes.

3.2. Can the carpal deformity be corrected with arthroscopy?

In their study of 69 scaphoid nonunions treated arthroscopically [12], Wong and Ho found DISI tilt in 29% of cases; this was corrected using the radiolunate K-wire trick described by Linscheid [12]. The K-wire was removed after 2 weeks. The authors did not specify whether the correction of the carpal deformity was maintained over time. Delgado and Baca were able to significantly reduce the radiolunate angle (RLA) from 31° to 4° by arthroscopy, by combining radiolunate pinning with compacted bone graft [18]. According to other authors such as Kim et al. [4], arthroscopic techniques are indicated during the early stages of nonunion and stable fibrous nonunion cases, as it is difficult to correct the scaphoid humpback deformity and DISI tilt. In a retrospective study, they showed that arthroscopic techniques restore wrist function but do not allow good correction of the scaphoid humpback deformity and the DISI tilt. The Jegal et al. study also concluded arthroscopic techniques were not well-suited to restoring carpal alignment [1]. Thus Kang et al. consider carpal deformity a contraindication to arthroscopy treatment [19].

3.3. Should a cancellous or corticocancellous graft be used?

From a structural viewpoint, there are three types of bone grafts: corticocancellous, monoblock cancellous and cancellous chips.

Popularized by Russe [11] then Fernandez [20], corticocancellous grafts are the most widespread, as reported in the systematic review by Sayegh and Strauch [21]. The review compiled 23 studies and 604 patients. Despite some limitations, it concluded cancellous grafts lead to faster bone union, while corticocancellous grafts provide better correction of the DISI tilt and lead to better functional outcomes. These results could be biased by the heterogeneity between the two groups in terms of fixation: 61% screw fixation in the corticocancellous group versus 16% in the cancellous group.

Kim et al. recently published a retrospective study of two homogeneous groups of 17 and 18 patients who received a corticocancellous and cancellous graft, respectively [22]. Contrary to the Sayegh and Strauch review, screw fixation was used in both

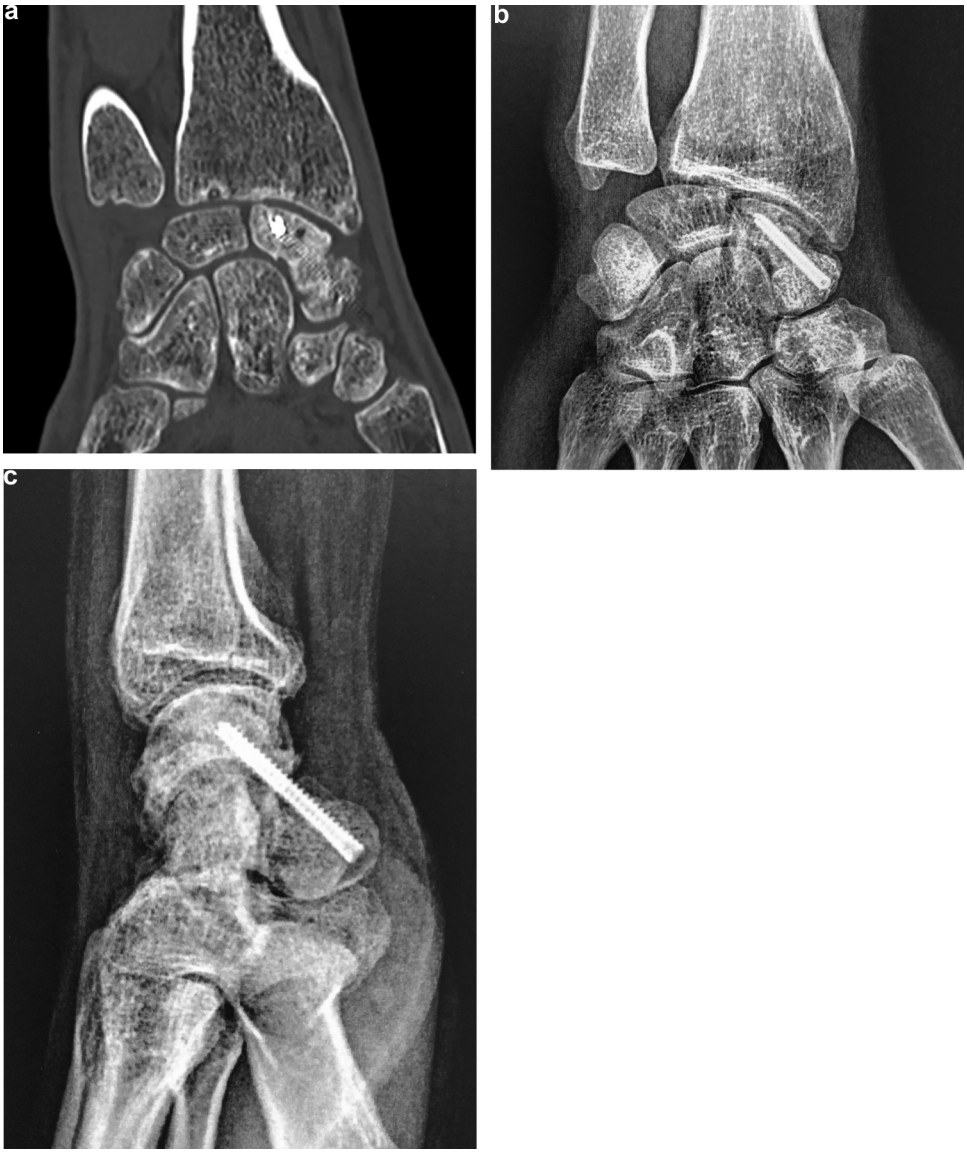

Fig. 5. Union achieved at 3 months, as seen on this sagittal CT slice (a). AP and lateral radiographs at 6 months (b, c) showing that the carpal height is restored and the DISI tilt has been corrected, along with filling of the graft harvest site.

groups. Without this bias, the functional and radiological outcomes were similar between cancellous and corticocancellous grafts. However, the authors reported faster union in the cancellous group.

In a 12-patient case series of scaphoid nonunion operated through a standard volar approach, Cohen et al. showed that good screw fixation meant corticocancellous or monoblock cancellous grafting was not necessary [23]. Cancellous bone chips taken from the radius and compressed in a syringe were used to filled the bone defect after correcting the scaphoid deformity, with a 100% union rate and lasting correction.

Up to now, all the arthroscopic techniques have used cancellous bone chips because of the small skin incision. Wong and Ho recommend compressing the chips at the site using a volume 3–5 times larger than the volume of the bone defect after debridement [12].

3.4. Radial or iliac crest graft?

In an older comparative study, Hull et al. showed iliac crest grafts were superior to radial grafts. But this study had an obvious bias: the surgical approach differed between groups [24]. More recently, a randomized controlled trial performed by Goyal et al. found no significant different between the two types of grafts, both for the union rate and functional outcomes [25]. According to these authors, a radial graft has several advantages over an iliac crest graft: regional anesthesia can be used, second surgical field not necessary, easier harvesting, smaller scar, less harvest site pain, lower risk of hematoma and neuropathic pain.

3.5. Is a vascularized graft needed?

A systematic review of the literature compiling 144 studies found an 84% union rate for vascularized grafts and 80% for non-vascularized grafts. This difference is magnified in cases of avascular necrosis with union rates of 74% and 62%, respectively [26]. Thus, several authors recommend using a vascularized graft when signs of avascular necrosis are present. However, as pointed out by Schuind et al., there are no prospective randomized studies to support this recommendation [27].

Preoperatively, the viability of the proximal pole is analyzed on an MRI of the wrist. Intraoperatively, the vascularization of the

proximal pole can be evaluated after debridement and releasing the tourniquet. According to Jegal et al., the absence of bleeding is an indication for a vascularized graft [1].

Recently, Lee et al. published a retrospective study of 27 cases of scaphoid nonunion treated by arthroscopic decortication, cancellous grafting and pinning [28]. In three cases, scaphoid union was achieved despite proximal pole necrosis, which was confirmed by the absence of bleeding at the nonunion site after decortication. In our team's experience, we have also found union in all cases of scaphoid proximal pole nonunion treated by arthroscopy, despite pre- and intraoperative evidence of avascular necrosis. This can be explained by the capsule's vascularization being preserved with arthroscopy but not during open surgery. But here also, no firm conclusions can be made until a randomized study is performed comparing vascularized and cancellous grafts applied by arthroscopy.

Up to now, we reserved arthroscopic treatment to nonunion cases without carpal deformity or with minimal DISI and scaphoid humpback deformity. In fact, like some authors [1,4,5,19] and for biomechanical reasons, we have always felt it is preferable to reduce a large scaphoid humpback deformity and to stabilize it by adding corticocancellous bone graft. In this scenario, our preferred technique is the vascularized bone graft one described by Kuhlmann [29]. However, as more patients were operated, we found these patients had clearly inferior functional outcomes to those treated by arthroscopy. Convinced that the dissection needed to raise and apply the vascularized bone graft was at the source of these poor outcomes due to capsule and skin adhesions, we came up with the idea of borrowing a system initially developed for mosaicplasty to harvest and then apply a corticocancellous bone graft by arthroscopy.

However, this techniques is challenging because a 10-mm volar arthroscopic portal is needed. The radial midcarpal approach (RMCA) described by Naroura et al. [8] must be made in a methodical way while keeping track of the anatomical landmarks. Passing the sizers and then the cannula through the extrinsic ligaments can be challenging. The incision must be widened using hemostats.

The other stumbling block relates to the graft's positioning. The cannula allows the graft to be pushed directly into the nonunion site. However, there is little opportunity to orient it or reposition it if necessary. Surgeons should not hesitate to convert to an open anterior approach.

According to Lenoir et al. [30], over-correction of the scaphoid humpback deformity and the DISI tilt contributes to poor functional outcomes. They attribute this over-correction to systematic and unplanned correction of the nonunion in the early stages where little bone resorption has occurred. The technique we described here is not very likely to result in over-correction. On one hand, we perform it only in cases of advanced nonunion with significant carpal deformity. On the other hand, we adjust the graft's size to the volume of the bone defect, which we estimate using graft sizers after the DISI tilt has been corrected using Linscheid's trick.

This technical note shows how to use arthroscopy to treat Alnot stage IIB scaphoid nonunion with a corticocancellous graft and complete DISI correction. The technique has a reasonable operative time, is easy to carry out, reduces the scar burden and has good clinical and radiological outcomes. The findings have encouraged us to continue using this technique and to evaluate the outcomes in small case series to expand the indications for arthroscopic treatment of Alnot stage IIB scaphoid nonunion.

Disclosure of interest

A. Zemirline: NewClip Technics, Kérimédical.
C. Taleb: NewClip Technics, Arthrex.
F. Lebailly: NewClip Technics.

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