Orthoplastics Tips and Tricks: Medial Femoral Condyle Vascularized Bone Graft for Scaphoid Nonunion: A Case Report

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Introduction

Scaphoid nonunions occur in 10-15% of scaphoid fractures with increased likelihood in cases with delay in treatment, proximal pole fracture, or carpal instability.[1-3] Fracture of the proximal third of the scaphoid are at an increased risk of osteonecrosis after scaphoid nonunion due the unique blood supply to this region and therefore present a unique challenge for repair.[4,5] When treating scaphoid nonunions, vascularized bone grafts have been demonstrated to improve rates of union when compared to non-vascularized bone graft. Vascularized bone grafts have been reported to achieve a 90% union rate in scaphoid nonunions with proximal pole avascular necrosis.[1]

Historically a number of graft sites have been utilized for treatment of scaphoid nonunions including the distal radius, ulna, and metacarpals.[2,6,7] Recurrent nonunion rates following scaphoid nonunion surgery have been reported as high as 25% due in part to bone graft resorption.[8] Attempts at mitigating this issue with vascularized pedicle bone grafts from the distal radius have added challenges including their short vascular pedicle, unreliable vascular supply, and difficulty shaping the graft to fit the defect without compromising the graft's integrity. In 2000, Doi et al initially described the use of a vascularized medial femoral condyle periosteocortial bone graft as an alternative option for treatment of a scaphoid nonunion with the potential to avoid the pitfalls of other grafts.[8]

The medial femoral condyle vascularized periosteal bone graft is unique in that it includes the periosteum, a full layer of cortical bone, as well as the underlying cancellous bone which is optimal for repair of small bone defects.[9] The blood supply to the periosteum of the medial femoral condyle comes from the femoral artery via the articular branch of the descending genicular artery and from the popliteal artery via the superomedial genicular artery.[8,9] The success of this graft lies in maintaining the cambium layer of the periosteum which is critical to the osteogenic capacity of the MFC graft.[10] The vascularity of the cortical and cancellous bone of this graft allows for significant shaping of the graft to fit into the scaphoid defect without loss of sufficient blood supply to the graft as seen in other grafts from the fibula or iliac crest.[8,9]

Case Report

A 21-year-old right-hand dominant male college student presented to our clinic with a chief complaint of eight months of right wrist pain without known trauma. At the time the patient reported he had increased his sporting activities including basketball and snowboarding over the past year but could not recall a specific trauma to the right wrist. On exam, he had swelling and tenderness to palpation over the anatomic snuff box. Right wrist range of motion was limited by approximately 10 degrees in flexion and extension due to pain. He had full range of motion in supination, pronation, ulnar deviation, and radial deviation. He was neurovascularly intact. X-rays showed a displaced scaphoid waist fracture with no sign of bridging callus (Figure 1). The patient

Figure 1. Radiographs at initial presentation demonstrating right scaphoid waist nonunion.

Figure 2. CT at initial presentation demonstrating scaphoid nonunion without callus formation.

was diagnosed with scaphoid nonunion and a CT wrist was ordered which confirmed the diagnosis (Figure 2). The patient was then referred to our orthoplastics service.

The patient was evaluated by the orthoplastics service one month after initial presentation. His exam was unchanged from prior. Non-operative and operative treatment were discussed with the patient. After discussing surgical options the patient agreed with the recommendation to pursue right wrist scaphoid nonunion open reduction internal fixation with non-vascularized corticocancellous bone graft from the distal radius. At this time the patient was informed that if the distal radius bone graft did not go on to persistent union within three months, the next indicated operative intervention would be a vascularized medial geniculate graft.

The patient underwent right scaphoid nonunion repair with distal radius bone graft and plate and screw fixation two months after index presentation (Figure 3). CT imaging was utilized throughout routine follow-up to assess bony healing. Five months after the distal radius bone graft, CT right wrist demonstrated collapse of the severely comminuted fracture of the proximal pole of the scaphoid with no evidence of bony bridging of the fracture fragments or incorporation of bone graft material despite intact hardware (Figure 4). The decision was made to pursue medial femoral condyle vascularized bone flap for treatment of the patient's right scaphoid nonunion.

Eleven months after initial presentation the patient underwent removal of hardware and nonunion repair with medial femoral condyle vascularized bone flap under general anesthesia. The decision was made to harvest the bone graft from the right lower extremity. Two attending surgeons worked simultaneously on the right wrist and right thigh. The right upper extremity procedure was performed under tourniquet at 250 mmHg. A volar incision was made on the right wrist through the previous surgical incision. The superficial branch of the radial artery was identified as it crossed over flexor carpi radialis. This was carefully preserved, clipped, ligated, and dissected out proximally for potential inflow to the bone flap. The FCR tendon sheath was incised and FCR was retracted laterally allowing for identification and inspection of the radial artery. An arthrotomy was performed through the volar aspect of the wrist capsule. The scaphoid plate was identified and a screwdriver was used to remove the screws and free the plate. The plane of the scaphoid fibrous nonunion was then developed with a freer elevator. The proximal pole of the scaphoid was removed with a rongeur, and a small burr was used to debride the nonunion site at the waist until there was punctate bleeding.

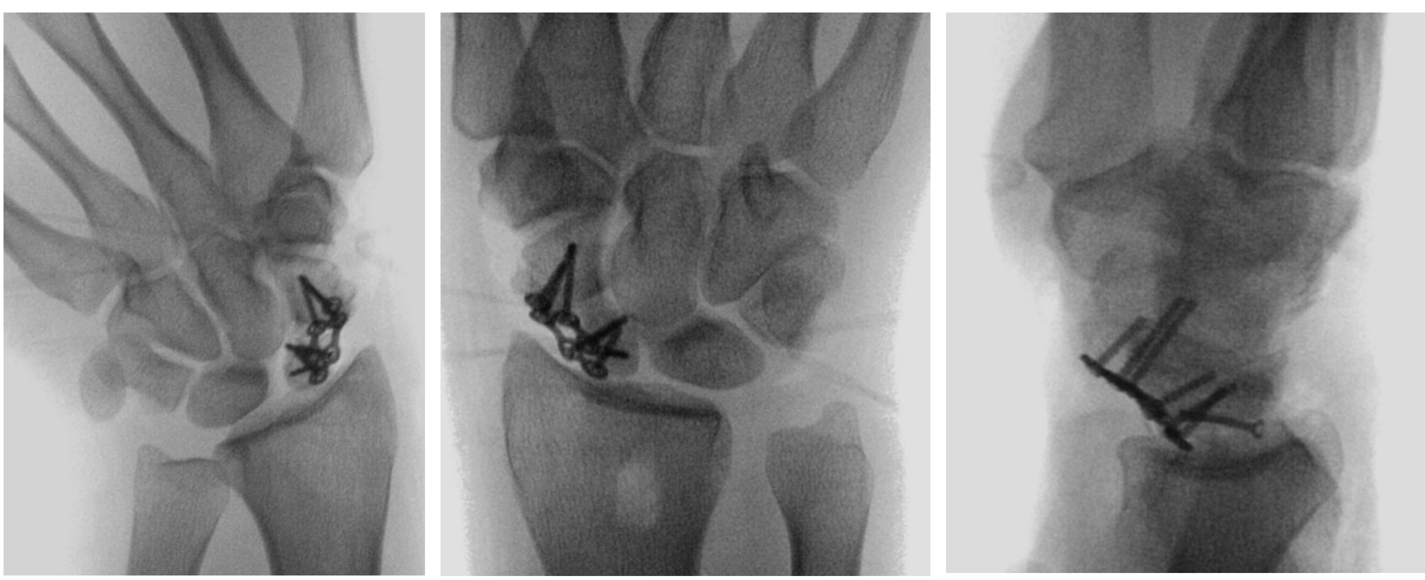

Figure 3. Intra-operative fluoroscopy demonstrating right distal radius nonunion status post right scaphoid nonunion repair with distal radius bone graft and plate and screw fixation.

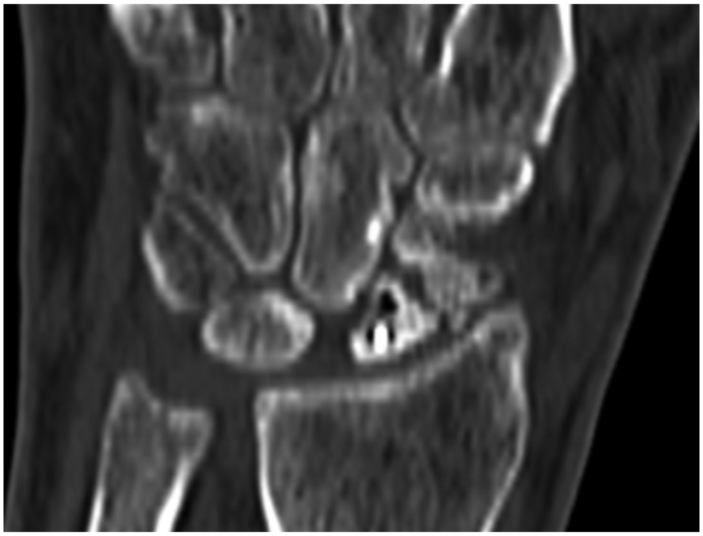

Figure 4. CT R wrist five months status post right scaphoid nonunion repair with distal radius bone graft and plate and screw fixation demonstrating no evidence of bony bridging or incorporation of bone graft.

Simultaneously the right lower extremity tourniquet was inflated to 350 mmHg. A longitudinal incision was made over the medial thigh. Dissection was taken down to the vastus fascia which was incised, allowing the vastus medialis to be reflected anteriorly. The medial geniculate artery was identified and traced retrograde to the takeoff of the superficial femoral artery. A subperiosteal dissection performed at the interface of the geniculate artery and the femoral condyle using the vascular geniculate vessels on a periosteal leash. The vessels were then cross-clamped proximally and the block of corticoperiosteal cancellous bone was transferred to the scaphoid. A drain was placed at the distal thigh prior to closure.

The bone graft was tailored to fit into the defect of the proximal pole of the right scaphoid with a rongeur. A proximal mold was created with bone wax to help define the necessary size and margin of the graft. Additionally, cancellous bone that had been excised from the MFC flap was used also to pack the distal aspect of the scaphoid. A 2.4 24 mm headless cannulated screw was then placed from the distal pole of the scaphoid into the new reconstructed proximal pole of the scaphoid. Placement was confirmed with direct inspection and intra-operative fluoroscopy (Figure 5). Microvascular anastomosis was performed between the dorsal branch of the radial artery and vena comitans using a 2 mm coupler for outflow. An end-to-end anastomosis of 9-0 nylon with spatulated vessels was performed on the arterial side yielding excellent inflow and outflow. The wound was copiously irrigated and closed. Excellent arterial signals were present at the conclusion of the case and a stitch was used to mark the vascular pedicle of the flap for post-operative monitoring. The right wrist was immobilized in a bulky compressive volar splint. The patient was discharged home from the hospital on post-operative day three.

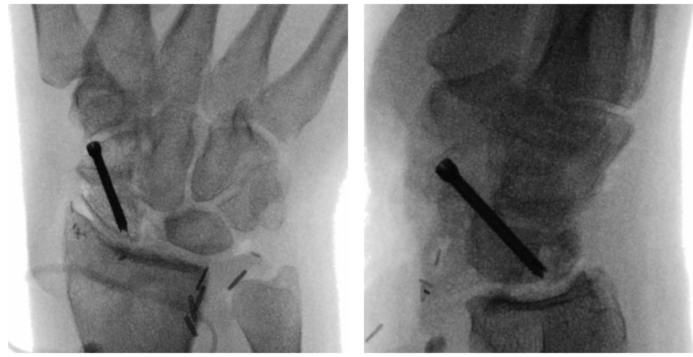

Figure 5. Intra-operative fluoroscopy of the right wrist during medial femoral condyle vascularized bone flap to the right scaphoid.

At the patient's two-week post-op appointment he reported he was doing well and denied new numbness or paresthesias to the hand. The surgical incisions were healing well, and his sutures were removed. The vascularized graft had excellent doppler signals. Radiographic images obtained in clinic demonstrated excellent alignment between the native scaphoid and the geniculate osteocartilaginous graft. The headless screw in place without signs of hardware complication. The patient was placed in a thumb spica cast with a plan to follow-up in two weeks. At four week-follow-up the patient had some painless wrist range of motion and was neurovascularly intact. Radiographs again demonstrated intact fixation of the right scaphoid. The patient was placed in a thumb spica cast and scheduled for a CT right wrist to be obtained eight weeks post-operatively to assess healing. CT right wrist demonstrated progressive healing with sites of early bony bridging adjacent to the surgical screw, though fracture lines were still visible.

At four-month follow-up the patient demonstrated continued increase in painless wrist range of motion. He reported some residual wrist stiffness as well as a painless prominence on the volar aspect of his wrist. He was otherwise neurovascularly intact. CT right wrist performed at that time demonstrated interval bone healing along the scaphoid waist with hardware intact. A hypertrophic spur

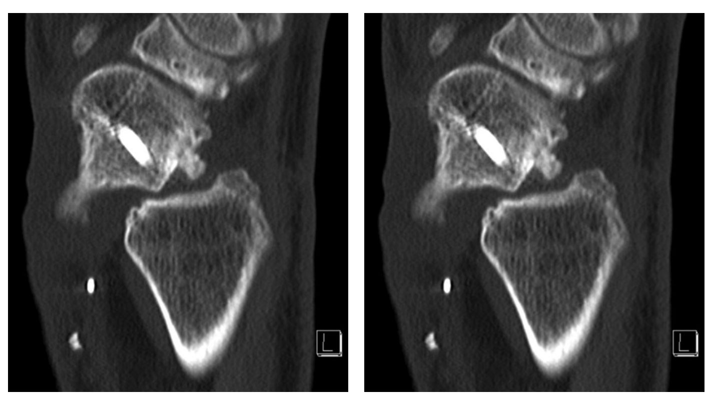

Figure 6. CT right wrist four months status post medial femoral condyle vascularized bone flap to the right scaphoid.

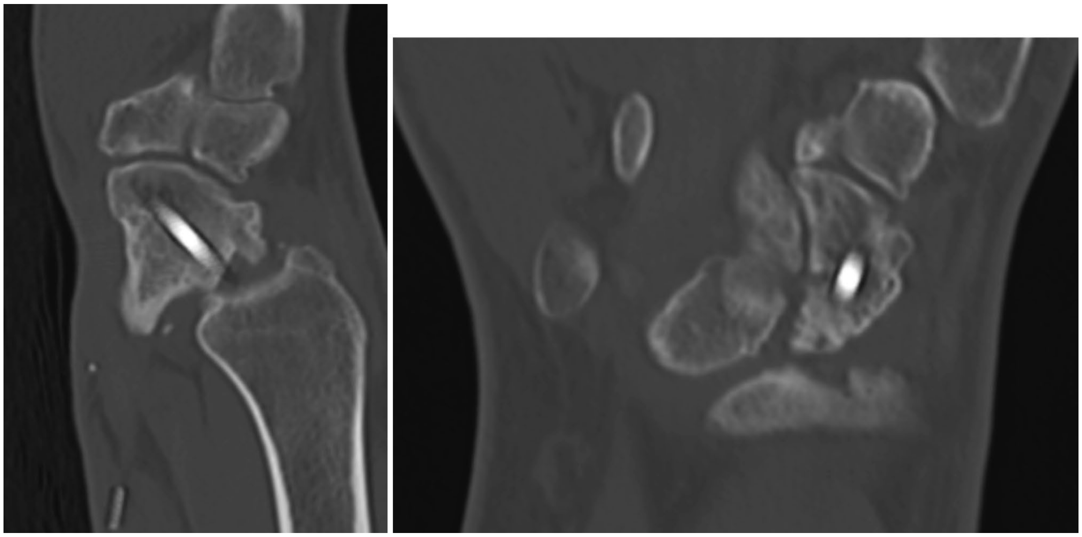

Figure 7. CT right wrist eight months status post medial femoral condyle vascularized bone flap to the right scaphoid.

was notably extended from the scaphoid into the volar soft tissues. Repeat CT right wrist performed eight months post-operatively demonstrated increased healing and callus formation across the fracture site and hardware in place. No evidence of nonunion.

At one year follow-up patient was doing well and had returned to athletic activities including playing football. He denied pain in the wrist but endorsed occasional crepitus. Radiographs demonstrated increased bony bridging of the scaphoid fracture site and a large volar scaphoid osseous prominence (Figure 8). He had a persistent volar wrist excrescence for which he will electively undergo excision of right scaphoid prominence.

Discussion

Scaphoid nonunion is a relatively common but difficult to predict complication of scaphoid fracture and can be a challenging issue to treat. It is essential to recognize scaphoid nonunion early in its course so the appropriate intervention can be completed. As with our patient, CT scan can be used to identify nonunions promptly and allow for operative planning and decreased delays in intervention. In 2009, Geoghegan et al followed scaphoid fractures for four weeks in a thumb spica cast followed by CT scan at the four-week mark. They determined that all scaphoid fractures which appeared nondisplaced and united at four weeks went on to union.[11] In 2018, Bhat et al proposed their own protocol in which nondisplaced and minimally displaced scaphoid fractures were treated conservatively in a cast for six weeks at which time radiographs were obtained to assess fracture healing. Fractures with doubtful union then underwent CT imaging for assessment of healing at the fracture site. Those fractures will more than a 2mm gap were indicated for percutaneous screw

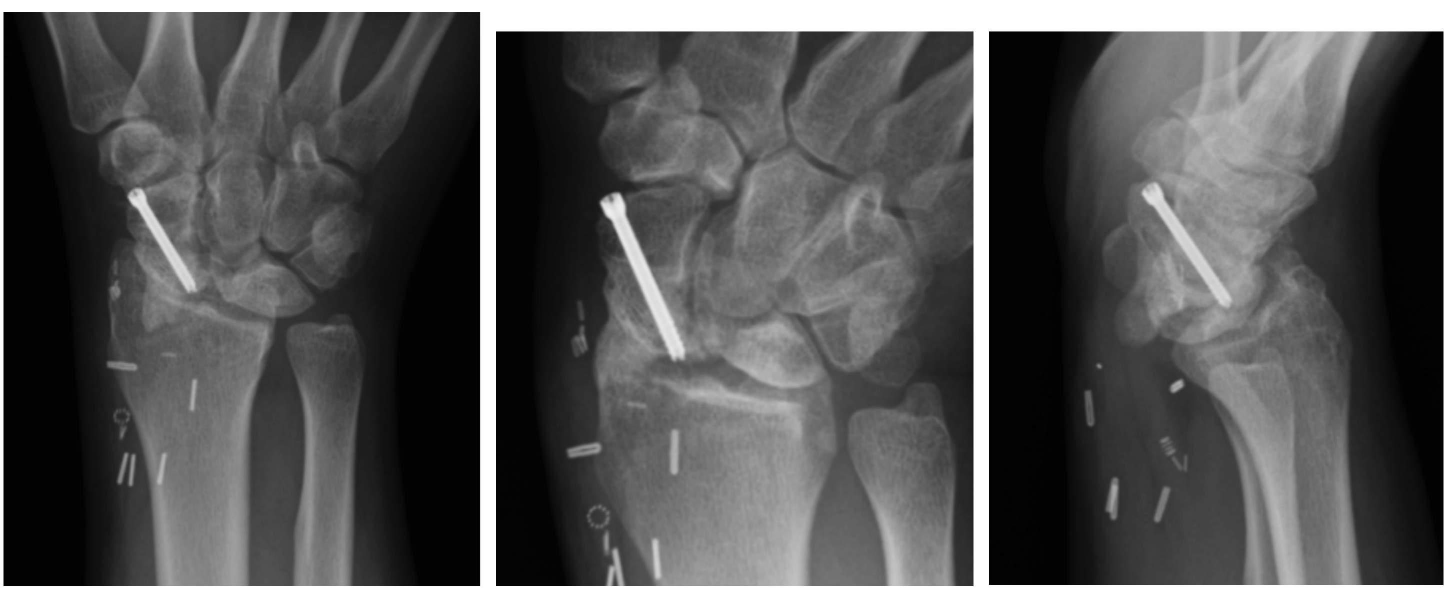

Figure 8. XR right wrist one year status-post medial femoral condyle vascularized bone flap to the right scaphoid.

fixation of the scaphoid whereas those with less than 2mm gap continued immobilization in a cast for an additional two to four weeks.[12] By following this protocol they achieved a 100% union rate at one year. CT imaging at four to six weeks of planned non-operative management of scaphoid fracture may help predict which fractures will ultimately progress to nonunion. These patients can then be assessed for which operative intervention would be most appropriate based on CT findings. Patients with concern for impending or present proximal pole collapse would benefit from early consideration for a vascularized medial femoral condyle bone graft which would decrease their time to definitive union.

Conclusion

The vascularized medial femoral condyle is a reliable option for repair of scaphoid nonunion that allows for treatment of small proximal pole defects. It has particularly dependable blood supply which reduces the risk of bone graft reportion, a common obstacle when treating scaphoid nonunion. We anticipate that our patient will regain full range of motion and grip strength. The use of the medial femoral condyle vascularized bone graft provided our patient with a superior option for definitive surgery to treat their scaphoid nonunion.

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