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Case Series

Pronator quadratus pedicled bone graft for scaphoid non-unions

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ABSTRACT

Scaphoid fractures frequently present with nonunion and proximal pole necrosis, the treatment of which is bone grafting. Pronator quadratus pedicled vascularized bone graft is an option especially in the setting of proximal pole necrosis. We describe our experience of managing such scaphoid non-unions using pronator quadratus pedicled vascularized bone graft. Six patients were managed using pronator quadratus pedicled vascularized bone graft following scaphoid fracture nonunion with proximal pole necrosis. All patients had good fracture healing and symptom resolution. Mild deficit in wrist extension was noted in all patients. Pronator quadratus pedicled vascularized bone graft is an attractive option for managing scaphoid nonunion. Lying adjacent to the fracture site, bone can be harvested and transferred without making any other incisions. This procedure introduces another source of blood supply to the fracture site and hence improves fracture healing.

Keywords: Scaphoid, Non-unions, Pedicled pronator quadratus, Vascularised bone graft

INTRODUCTION

Scaphoid fractures frequently present to a hand surgeon's clinic usually as an undiagnosed wrist pain or a problem fracture following trauma. Due to the unique blood supply of the scaphoid, periscaphoid arthritis and proximal pole necrosis are common sequalae, with upto 30% progressing to non-union.[1-3] Although conservative methods have been described in literature for the treatment of non-unions, the management is usually surgical. Bone grafting is the procedure of choice, which can be non-vascularised or vascularised.

Braun in 1983 first reported good healing using the pronator pedicled bone graft for scaphoid non-union.[4] In this paper we present our experience of pedicled pronator quadratus bone graft for treatment of scaphoid fracture non-unions.

CASE SERIES

The study included cases of six patients. All patients had history of previous trauma to the hand. The earliest surgery was performed six months post injury, while the latest was three years after injury. All patients had fracture through the waist. A radiograph of the wrist is taken to confirm the diagnosis.

The procedure is performed under regional anaesthesia, with an arm tourniquet. A longitudinal incision, centred over the radial styloid, is made over the lateral border of the flexor carpi radialis (FCR) muscle.

The incision is made on the dotted line. Other structures marked are the FCR, the palmaris longus (PL) and the radial artery (RA).

Figure 1: Pre-operative radiograph showing non-union of a fracture through the waist of the scaphoid.

Figure 2: Pre-operative markings shown in the photograph.

This provides exposure to the site of nonunion as well as the donor area. The incision is made and deepened, incising the deep fascia and the FCR is retracted ulnarly. The nonunion is approached by incising the extrinsic ligaments of the wrist. The radio-scapho-capitate (RSC) ligament is divided and the radio-luno-triquetral (RLT) ligament may also be divided to gain adequate exposure. The nonunion site is exposed and the unhealthy fibrous ends are curetted. A burr may also be used to aid this debridement. Thus, a cavity is created, which will be filled by the bone graft. A distractor is placed across this gap to stretch the gap and allow the graft to be placed easily. This distractor is removed after graft placement, which collapses the cavity, snugly fitting the graft into the defect. The three-dimensional bony defect is measured, which will be the dimensions of the bone graft harvested. Proximally in the incision, the pronator quadratus muscle is identified. Deep to the proximal edge of this muscle the anterior interosseus vessels along with the anterior interosseus nerve are seen, running volar to the interosseus membrane. This vessel forms the vascular basis of this bone graft. A piece of distal radius, equal to the dimensions of the defect, is harvested from the site where the pronator quadratus inserts into the radius. Care is taken not to disturb the connection of the anterior interosseus vessels to the pronator quadratus muscle, as well as the muscle to the harvested graft. The insertion of the muscle on the ulna needs to be divided to allow the movement of the bone graft to take place. The tourniquet is released at this point and hemostasis attained. The bleeding from the harvested bone is noted. The bleeding from the distal scaphoid segment indicates adequate debridement. Proximal segment bleed may or may not be present. The bone graft is introduced into the defect and the muscle is sutured to the distal remnant of the RSC ligament. The wrist is kept in extension during this transfer to ensure adequate mobilization. If the bone graft is small for the dimensions of the defect, additional bone graft may be harvested from the distal radius. The graft is fixed with a Kirschner wire with the help of an image intensifier. The distractor is removed and the wound is closed over a suction drain. The wrist is immobilised in a splint with the wrist held in neutral. The drain is usually removed on the second post-operative day. The sutures are removed at two weeks. Radiographs are taken at twelve weeks and the K wire is removed then.

Fracture healing was seen in all six patients at twelve weeks. No deficit in pronation was noted in any of the patients. Limitation in wrist extension was seen in all patients postoperatively. Six patients with non-union scaphoid were operated upon by the senior author.

Table 1: Patient information table.

Age	G	Time after injury	Site	Union at 12 weeks
25	M	2 years	Waist of scaphoid	Present
25	M	6 months	Waist of scaphoid	Present
21	M	3 years	Waist of scaphoid	Present
30	M	1 year	Waist of scaphoid	Present
41	M	1.5 years	Waist of scaphoid	Present
35	M	1.5 years	Waist of scaphoid	Present

Figure 3: Twelve weeks post-operative photograph demonstrating limitation in wrist extension.

Figure 4: A twelve weeks post-operative radiograph showing union of the scaphoid and rarefaction of the distal radius.

DISCUSSION

Scaphoid fractures frequently present with the sequala of non-union and proximal pole necrosis. The key to this lies in the unique anatomy of the scaphoid bone. The blood vessels supplying the scaphoid enter the dorsal and the volar surfaces from the distal part and run retrogradely to supply the proximal pole. Hence fractures of the scaphoid can compromise the blood supply of the proximal pole. This clinically results in nonunion and avascular necrosis. Although conservative methods have been tried, the treatment of scaphoid non-unions is usually surgical.[5] The old fracture site is exposed and a cavity is created at the nonunion site which is filled by bone grafts. Bone grafts can be vascularised or non-vascularised.

Vascularised bone grafts provide an additional source of blood supply and hence aid healing, replace deficient bone and re-vascularise ischemic bone.[6] Tu et al in an experimental study determined the bone blood flow following vascularised and non-vascularised bone grafts.[7] They found that the blood flow 2 weeks following a pedicled bone graft was 200% of the normal blood flow as compared to 3% of normal in case of a non-vascularised bone graft. In a meta-analysis of scaphoid fractures by Munk and Larsen, 80% patients had fracture healing following non-vascularised bone grafts and 91% of patients following vascularised bone graft, in the setting of simple non-unions.[8] The difference was stark in the setting of non-unions with proximal pole necrosis. Good union was reported in 85% of patients with vascularised bone grafts, but in <50% of patients in non-vascularised bone grafts.

Braun in 1983 had described the Pronator Quadratus pedicled bone grafting technique for a variety of indications, including scaphoid non-unions. He reported 100% healing with this technique. Other techniques of harvesting vascularised bone grafts are based on the 1, 2 intercompartmental supra-retinacular artery, volar carpal artery and from the metacarpal.[9-12] Hemi-hamate has also been reported to be used for scaphoid non-unions.[13] Free microvascular transfer of the medial femoral condyle has also emerged as an option for correction of this deformity.[14]

The pronator quadratus muscle is supplied by the anterior interosseus vessels. Bone graft harvested from the distal radius is supplied through the insertion of the muscle on the radius bone. The advantage of this pedicled transfer over other transfers is that this is a safe and easy procedure, with a robust blood supply. Microsurgical expertise or delicate dissection of vessels is not required during the flap and hence does not need a microvascular expert or a multi-speciality hospital. One limitation of this procedure is that the extrinsic volar ligament, like the RSC and the RTL are divided permanently. The muscle is sutured across the wrist joint which may limit the wrist movement post operatively.[15]

The understanding of scaphoid non-unions and proximal pole necrosis has undergone a change. Gras and Mathoulin used vascularised bone graft based on the volar carpal artery and suggested the use of vascularised bone graft even for simple scaphoid non-unions.[16] In a metanalysis in 2001, Merrell et al supported the use of vascularised bone graft for scaphoid non unions in cases of proximal pole necrosis. They suggested removal of necrotic bone and filling the subsequent cavity with vascularised bone. Another article published twenty years later by Rancy et al reviewed the need of vascularized bone grafting.[17] Absence of punctate bleeding was considered an unreliable sign of avascular necrosis. As the presence of avascular necrosis was difficult to establish, the basis of vascularised bone grafting was unclear. They summarised that there was no evidence supporting the use of vascularized bone graft, with even established proximal pole necrosis successfully treated with non-vascularised bone graft after debridement.

CONCLUSION

Pronator Quadratus pedicled bone graft is a time-tested method of vascularised bone grafting for scaphoid non-unions. Although this procedure has its limitations, its attraction is its simplicity. It is an easy and robust flap, with a short learning curve, not requiring microvascular expertise. It can be performed by anybody armed with basic surgical skill and instrumentation.

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