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Treatment of non union scaphoid fractures using pronator quadratus pedicle graft

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Abstract
AIM: The aim of the study was to evaluate the outcomes in a series of scaphoid non-unions to determine if the pronator quadratus pedicle bone graft is effective in the treatment of these fractures.
Objectives: The ideal treatment of scaphoid nonunions remains controversial. The purpose of the study was to evaluate the outcomes in a series of fracture scaphoid nonunions to determine if the pronator quadratus pedicle bone graft is effective in the treatment of these fractures. We report our experience with the operative treatment of five non-united scaphoid fractures with pronator quadratus pedicle bone graft and Herbert-screw.

Keywords: scaphoid fracture, non-union, proatus quadratus pedicle 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. 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. In this paper we present our experience of pedicled pronator quadratus bone graft for treatment of scaphoid fracture non-unions [1].

Mechanism of Injury
Fall on outstretched had with Axial load over hyperabducted and radially deviated wrist.

Materials and Methods
A prospective study was done on five patients who came to our hospital with old non-united scaphoid fractures and treated with pronator quadratus pedicled bone graft, Herbert-screw and K-wire. Postoperatively below elbow slab was given for 3 weeks. K wire was removed after third week in order to mobilize early.All the patients had symptoms for minimum 8 months before the surgery. There were recorded patient demographies: age, sex, etiology, the location of fracture, time from fracture to diagnosis of nonunion, initial treatment, operative details, type of fixation, time to union, range of wrist motion, subjective complains, complications, grip strength, Mayo clinical wrist score, duration until return to work.
The dominant hand was affected in four patients and the average duration of the nonunion of the scaphoid was 8 month. Minimum follow up was taken upto 12 months after surgery.
2 patients had sustained the fracture in a simple fall, 2 in a traffic accident with motor bike and 1 during sports activity. In 2 cases the fracture was missed on initial radiographs and 3 cases was managed conservatively.

Surgical Procedure
A linear or a zig-zag incision was made over the scaphoid tuberosity and the distal radius. The radio scaphocapitate ligament is splitted by incision and later is repaired. The site of the nonunion was exposed and the fibrous material was curetted until normal bone is visible. The surface of the proximal fragment is carefully inspected for bleeding points with use of a loupe magnification. The bleeding points are seen even with the tourniquet inflated. Then, at the level of distal radius, the pronator quadratus. Along the margin of the graft were made holes with Kirschner-wire to facilitate separation with a fine osteotome. It must be take care that the pronator quadratus is not detached from the bone graft and the muscle is dissected towards the ulna to secure a pedicle 20mm thick. If the muscle is too tight to allow easy transfer of the pedicled bone, the ulnar origin of the pronator quadratus is dissected subperiostally from the ulna through an additional incision over the distal ulna. The proximal and distal segments of the scaphoid are aligned as a traction force is applied to the thumb. This allows the bone graft to be inserted firm, into the space between the two fragments. The scaphoid with the bone graft inserted are firmly fixed with a Herbert-screw or with two 1, 2 mm Kirschner wires introduced at the scaphoid tuberosity.

The bone graft is inserted volarly and is placed as a wedge in the scaphoid nonunion site. Screw fixation is preferred, but occasionally Kirschner wires are used if the bone fragments are too small [6]. The supply of blood to the bone graft is verified by inspection of bleeding from the graft after the tourniquet is deflated.

The skin incision was closed without tension and a glass holding cast is applied for one month, followed by a short cast for a next month, then the union is evaluated radiographically. The wrist is braced in a functional position for another one month and physiotherapy and active exercises are then started. We were little cautious in deciding when the fracture has healed, believing that is better a longer immobilization than to risk an unsatisfactory result. Kirschner-wires used for additional support were removed at 3 weeks The Herbert-screw doesn't need to be removed [7].

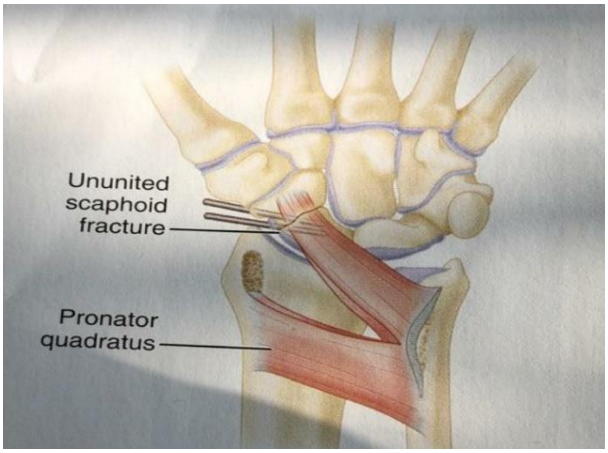


Fig 1

Table 1: Preoperative data on 5 patients

Case	Sex/Age	Side	Initial Treatment	Site of Non-Union	Duration of Non-Union
1	M/25	Right	Glass Holding Cast	Waist	8 Moths
2	M/52	Right	B/E Cast	Waist	8 Months
3	M/22	Left	None	Waist	9 Months
4	M/34	Right	B/E Cast	Proximal 3RD	9 Months
5	M/30	Right	B/E Cast	Proximal 3RD	9 Months

Table 2: Postoperative data on 5 patients

Case	Osteosynthesis/ herbert Screw	Time to Union (Weeks)	Duration Until Returns to Work (Weeks)	Mayo-Clinic Wrist Score (Points)	Results
1	HERBERT SCREW	8	12	100	Excellent
2	HERBERT SCREW	12	14	80	Good
3	HERBERT SCREW	9	13	90	Excellent
4	HERBERT SCREW	10	12	90	Excellent
5	HERBERT SCREW	9	14	80	Good

Mayo Modified Wrist Scoring System

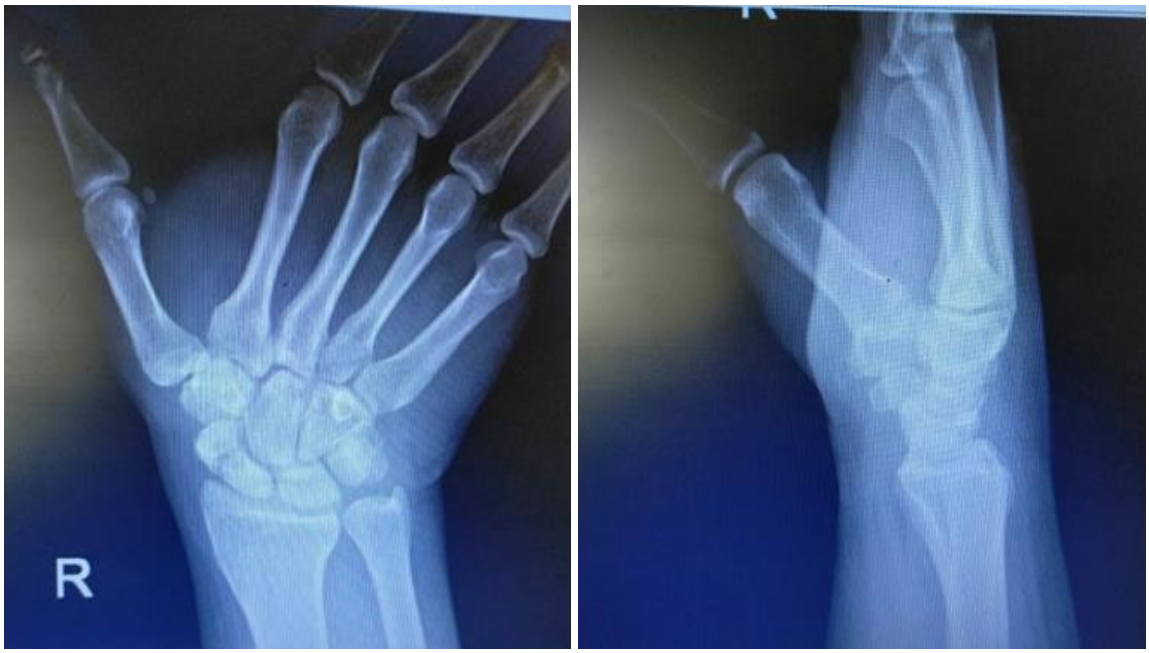
Pain	Points		
	25	No pain	0
	20	Mild, occasional	1–4
	15	Moderate, tolerable	5–7
	0	Severe to intolerable	8–10
Functional Status	**Points**		
	25	Return to regular employment	
	20	Restricted employment	
	15	Able to work, unemployed	
	0	Unable to work, pain	
Range of Motion	**Total Motion**	**Percentage of Normal (%)**	
25	≥ 20°	90–100	
20	100°–119°	80–89	
15	90°–99°	70–79	
10	60°–89°	50–69	
5	30°–59°	25–49	
0	0°–29°	0–24	
Grip Strength		**Percentage of Normal (%)**	
25		90–100	
15		75–89	
10		50–74	
5		25–49	
0		0–24	
91–100 — Excellent; 80–90 — Good; 65–79 — Fair; <65 — Poor.			

Fig 2

Table 3: Postoperative clinical results

Case	Pain		Last Follow-UP (Degrees)			Grip Strength (Affected/ Normal)
		Flexion (65-85)	Extension	Radial Deviation	Ulnar Deviation	(KG/F)
1	-	70/75	65/70	10/1O	30/30	37/35
2	Mild	50/70	65/70	15/15	25/25	40/40
3	-	70/70	65/70	20/20	25/25	35/38
4	-	65/70	70/80	10/20	20/30	42/52
5	Mild	65/70	50/60	10/20	35/35	42/45

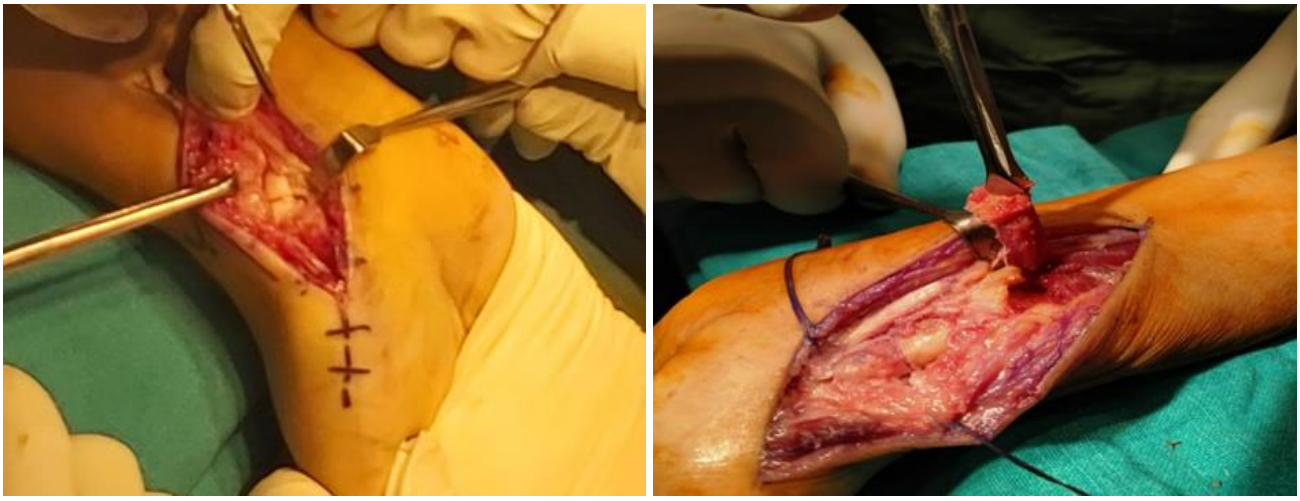
Preoperative X-Ray



Scaphoid View Lateral

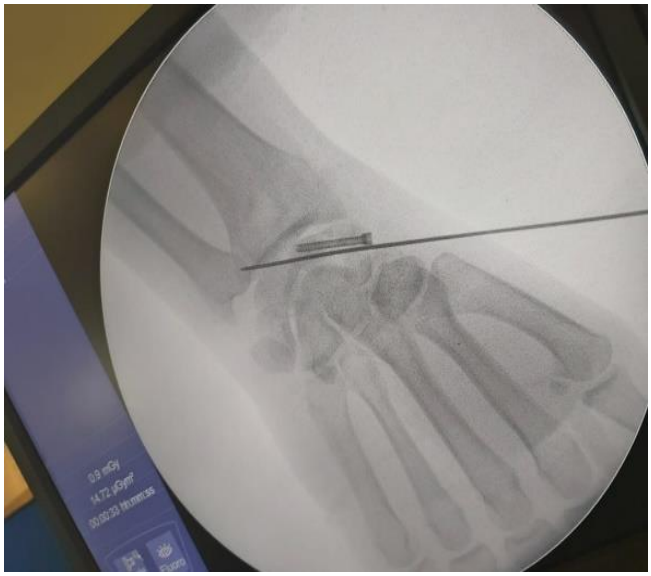
Fig 3

Intraoperative Images

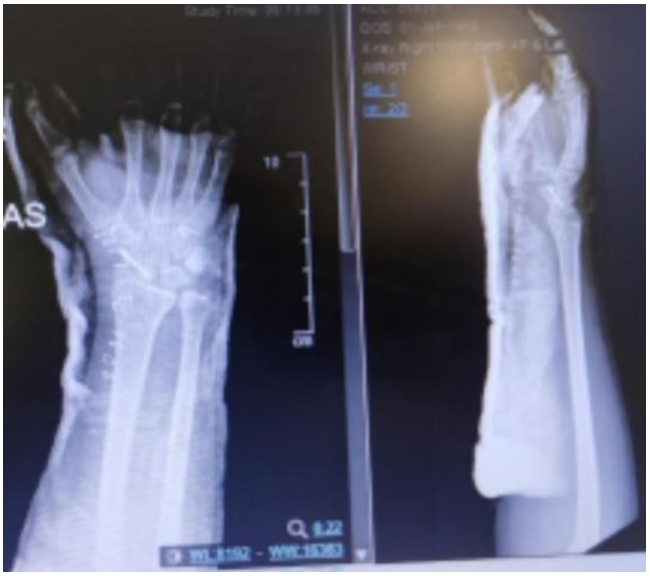


Non-United Scaphoid Pronator Quadratus Pedicle Graft

Fig 4



Fluoroscopic Image



Post-Operative X-Ray

Fig 5

12 months follow up

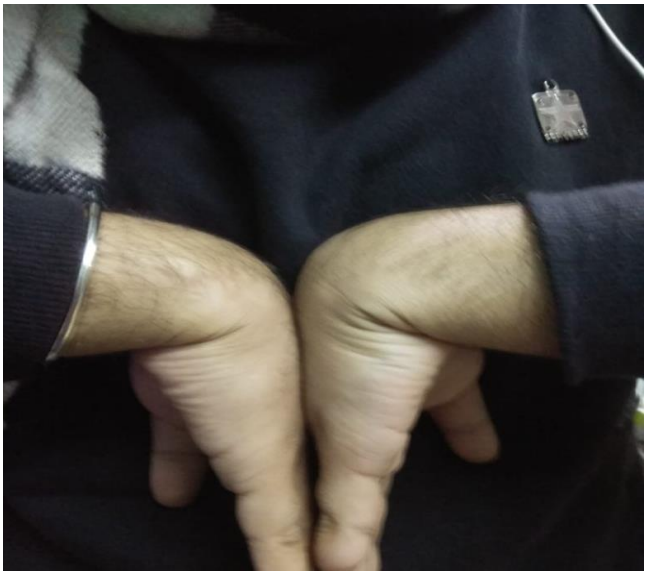


Fig 6

Results

The final evaluation was made using radiological, subjective and objective criteria, the patient satisfaction, chronic pain, active range of motion, grip strength and ability to work. The patient's satisfaction was assessed by asking if the status of wrist was better than before the operation. Fracture union was confirmed by absence of fracture line radiologically averaging at 3-6 months and by absence of tenderness in anatomical snuff box and scaphoid tubercle. Pain was considered mild if it occurred at the extremes of active range of motion of the wrist, but the patient wasn't disturbed. The pain was considered severe if it appear during daily activities and at rest. The range of motion was measured using a goniometer and was compaired with the contralateral hand. The final functional result according to Mayo Clinic Wrist Score was excellent in 3 cases and good in 2 cases.

Discussion

There is no standard treatment of chronic nonunion of the scaphoid, but the technique we used is an accessible method to treat non-union. The main advantage of this preocedure is that it respects the normal principles of fracture-healing better than a simple placement of a non-vascularised bone graft, in an unfavorable low-vascular bed [8]. The healing potential of an ununited scaphoid depends on two factors: vascularity and stability. Because of its vulnerable blood supply and the loss of retaining ligamentous support, unstable and proximal fractures of the scaphoid have been associated with decreased rates of union

after conventional bone-graft procedures. The rate of succes with conventional grafting is lower when the proximal pole of the scaphoid is completely avascular [4, 9, 10, 11].

Viability and stability of the fragments are essential for obtaining consolidation of non-union. The base principle is to treat avascular necrosis and non-union by increasing the vascularity of the bone. It is unclear if enough osteogenic bone survives after a nonvascularised bone graft method. Laboratory studies of vascularised and nonvascularised grafts have demonstrated that the former are associated with earlier union and with greater strength and stiffness between six weeks and six month postoperatively [3].

The volar approach that was popularised by Russe provide excellent access to the volar part of the cortex of the scaphoid which can be easily reconstituted with a vascularised bone graft from distal radius and stable fixated with an implant (Herbert – screw or Kirschner wires). The osteosynthesis has been used to increase the stability of bone fragments and bone graft.The use of the Herbert-screw was initially reported by Herbert and Fischer, who also reported higher success of nonunions treatment in association with bone graft. Insertion of Herbert screw requires special equipment and high technical skills. Another disadvantages is that it violates scaphotrapezoidal joint, but the great advantage is that it provides more rigid fixation, promotes early active motion and compression than Kirschner wires [12].

We preffered the use of Kirschner-wires in case of small fragments when the use of Herbert-screw was not possible. To supplement fixation, we use a cast immobilisation for minimum 2 month.

The patients who had union did not report pain, but motion of the wrist and grip strength were slightly decreased compared with the other (normal) wrist. Incipient osteoarthritis remains limited to the radio scaphoid joint, with no significant functional implications and there was no carpal collapse. It is reported that use of a volar approach may lead to more capsular adhesions than use of a dorsal approach, but the postoperative stiffness was treated with early intensive rehabilitation, after the removal of the cast, which substantially improved the range of motion of the wrist. All the patients from our study had union and we assessed bone union according to strict criteria: trabeculation had to be visible across the site of the fracture on all three radiographic projections. Early radiographies following a scaphoid vascularised graft may be inacurrate and could show a delay union or nonunion inspite of a united fracture. Scaphoid vascularised grafts may have a markedly delayed radiographic healing time. [2]

Grafts of vascularised autogenous bone not only retain a certain amount of the cellular and mineral matrix, but they can also respond to biomechanical stress due to greater strength and rigidity. This was first pointed out by Judet and Roy Camille, who used the tubercle of the scaphoid pedicled on the lateral head of the abductor pollicis brevis [8].

Revascularisation seems to be faster promoted by the use of vascularised bone grafts than conventional autogenous graft from the iliac crest. Vascularised bone grafts obtained from the distal radius and pedicled by the pronator quadratus have been described by Braun, Leung and Hung, Kawai and Yamamoto [1, 4, 7, 13].

We think that good results in our small group of patients were due to that we achieved the two important factors that promote bone healing in nonunions: stability and vascularity in same time. The revascularisation and consolidation were obtained through two sources of capillary ingrowth: the vascular pedicle and the inlay cancellous bone graft from distal part of the radius. Stable internal osteosynthesis provides a mechanically favourable environment for the bone healing.

Conclusion

There is no standard treatment of chronic nonunion of the scaphoid, but the technique we used is an easily accessible and reproducible method to achieve scaphoid union.

The main advantage of this procedure is that it respects the normal principles of fracture healing by enhancing local blood circulation better than a simple placement of a non-vascularised bone graft, in an unfavorable low-vascular bed.

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None

Coflicts of Interest

There are no Conflicts of Interest.

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