Lateral Closing Wedge Osteotomy of the Radial Styloid in Treatment of Scaphoid Proximal Pole Nonunion with AVN

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Abstract: Nonunion is the most common complication after scaphoid fracture treatment especially proximal pole fracture. Because the vascular supply of the proximal pole primarily relies on vessels entering the scaphoid more distal, thereby making the proximal pole particularly susceptible to ischemic changes placing it at risk for avascular necrosis (AVN). Furthermore the radial styloid essentially functions as a fulcrum against the center of the scaphoid, resulting in the predominance of fracture. Over long time, patients may then experience pain, instability, and eventual collapse of the proximal pole that leads to intercarpal or radiocarpal arthritis. Eight patients with symptomatic nonunion of the proximal pole fracture of the scaphoid with AVN had been treated by excision of the proximal pole and lateral closing wedge osteotomy of the radial styloid. The average age was 37 years. The average time of delay before the operation was 27 months. The average duration of follow up period was 10 months. The radial deviation, grip strength and the resting pain improved and the changes were statistically significant. This technique is a simple procedure and effective technique for management of scaphoid proximal pole nonunion with AVN.

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1. Introduction

The unique anatomy of the scaphoid predisposes its fractures to delayed union or nonunion and to disability of the wrist. The proximal pole is vascularized nearly exclusively from intraosseous vessels. Fractures through the proximal third of the scaphoid have a high rate of devascularizing the proximal fragment[1]. Non-union of the scaphoid ranges from 5% to 50% and it usually causes pain and weakness, also it would result in carpal osteoarthritis[2].

Treatment of scaphoid nonunion remains a challenging problem, especially in the setting of proximal pole avascular necrosis. The options for treatment of nonunion of proximal pole fractures depend on the blood supply to the proximal pole and the size of the fragments[3].

Despite the best efforts in diagnosis and treatment, failure of the persistent scaphoid nonunion to heal may occur. Theoretically, the use of pedicled vascularized bone grafts (VBG), which help revascularize ischemic bone, should improve the union rate and time to union[4], but, unfortunately, not all reports on the use of VBG have been favorable[5].

A metaanalysis of treatment of scaphoid nonunion with osteonecrosis of the proximal pole indicated an 88% union rate with a VBG[6]. Pedicled dorsal distal radius VBG has been reported to have nearly a 50% failure rate when used in scaphoid nonunion with proximal pole AVN[7]. Straw etal at 2002 reported on Zaidemberg's technique, only 2 of 16 nonunions with avascular proximal poles (12.5%) united[8]. They concluded that pedicled vascularized bone grafting may not improve the union rate for scaphoid fracture nonunion with avascular proximal pole fragments[6].

To avoid collapse of the carpus and painful arthritis, a salvage procedure is likely to be necessary[9]. Many salvage procedures can be done one of them is radial styloidectomy with partial scaphoid excision[10]. Partial scaphoid excision can be performed without disrupting wrist biomechanics if the proximal pole fracture fragment is small[11, 12].

The main risk following a radial styloidectomy is ulnar translocation of the carpus[13]. Nakamura et al observed significantly increased radial translation with ulnar and palmar carpal displacement after radial styloidectomy. Excessive styloid resection may result in scaphoid instability by transection the origin of the radioscaphocapitate ligament and loss of the radial buttress of the articular surface toward the carpus[14].

2. Material and Methods

From October 2009 to April 2012, a group of eight patients with symptomatic scaphoid nonunion and AVN of proximal pole refused treatment options involving prolonged immobilization so I offered resection of the proximal pole of the scaphoid and lateral closing wedge osteotomy of radial styloid (instead of styloidectomy) at the Department of Orthopedics and Traumatology of the Minia university Hospital, Egypt. The patients presented with pain, limited range of wrist motion and weak grip strength, all patients had not been surgically treated before. There were one woman and seven men with average age 37 (24–57) years. The dominant wrist was involved in 6 cases, and the non dominant wrist was involved in 2 cases. The mean delay from the recalled time of injury to start of management was 27 months with range from 3 to 60 months. The minimum follow-up was six (6–24) months. We compared the flexion-extension arch, palmar flexion, dorsal flexion, radial and ulnar deviations, grip strength, radiolunate angle, resting pain and pain during physical activities before surgery and during re-examination. The flexion-extension arch was measured in degrees. Preoperative and postoperative wrist radiographs were obtained in all patients in standard fashion (Figure1). Radiographs were evaluated for changes in radiolunate angle. All patients also had magnetic resonance imaging (MRI) scans before surgery for detection of AVN of the proximal pole (Figure2). The flexions, deviations and grip strength (Grip strength measurement performed for every patient using a sphygmomanometer. The cuff was inflated up to 20mm Hg and the patient was asked to squeeze it as hard as he can. A reading of 200 mm Hg or over should be achievable with normal hand compared with the other hand [15]).

The differences between the results evaluated pre- and postoperatively were tested by the Student's t-test and the Chi-square test. The results were considered to be significant if $p < 0.05$.

Surgical technique:

All operations were performed under general anesthesia. The patient is positioned supine with the extremity on a radiolucent arm table. The arm is cleansed with antimicrobial solution and draped sterilely. Exsanguination is performed with an Esmarch bandage with a pneumatic tourniquet applied to the upper arm. A fluoroscopy unit is used to confirm the position of the guide wires and screw.

A 3 cm a straight incision is made between the first and second extensor tendon compartments. The incision is made centered over the radial styloid (Figure3). The branches of the superficial radial nerve and the radial artery are identified and protected[15]. The capsule is incised longitudinally to expose both parts of the scaphoid as well as radial styloid. The proximal fragment is excised while the wrist in maximum ulnar deviation to bring it in the wound.

Three K wires are inserted to delineate the fragment for osteotomy, 1st is just flushing and parallel to the distal articular surface of the radius, 2nd is just flushing and parallel to the articular surface of the radial styloid, 3rd is proximal to the 1st one and making with it an angle smaller than that between the 1st and 2nd wires (Figure 4).

A fine oscillating saw, with constant irrigation, is used to cut the two sides of the osteotomized bone between the 1st and 3rd wires. The osteotomy site is closed by reduction clamp and 4mm partially threaded cancellous screw is inserted (Figure5&6)

The procedure was completed by repairing the capsule, soft tissue closure and skin suture. The patients were immobilized in a short arm thumb spica splint for 2–3 weeks, after which all patients participate in a supervised hand therapy program during postoperative rehabilitation. Motion is the early goal followed by graduated strengthening. Late postoperative radiographs were done to detect bone healing at the osteotomy site (Figure 7).

3. Results

The average length of the follow-up period was 10 months (range 6–24 months). The changes of flexion extension arch, palmar flexion and dorsal flexion, ulnar deviation, radiolunate angle and pain during physical activity were statistically insignificant. The change in dorsal flexion was of borderline significance ($p = 0.050$). The radial deviation, grip strength and the resting pain improved and the changes were statistically significant ($p < 0.05$). All results are shown in table 1.

Table 1. Results evaluated preoperative and postoperative (after a minimum follow-up of 21 months) and statistical analysis.

	Preoperative	Postoperative	Statistical analysis
	N = 8	N = 8	
Flexion extension arch	101° ± 12°	113° ± 22 °	*P* = 0.17
Palmar flexion	68 ± 15.5	72.5 ± 18.5	*P* = 0.9
Dorsal flexion	78 ± 10	83 ± 13.5	*P* = 0.050
Radial deviation	56.5 ± 20.5	85 ± 30	* *P* = **0.013**
Ulnar deviation	68 ± 18.5	66.5 ± 17.5	*P* = 0.72
Grip strength (%)	61 ± 12	80 ± 18.5	* *P* = **0.001**
Radiolunate angle	– 22°± 11°	– 23°± 10°	*P* = 0.289
Resting pain	6	0	* *P* = **0.007**
Pain during physical activities	8	4	*P* = 0.077

(*)Significance values.

Figure 1 preoperative AP radiograph

Figure 2: preoperative MRI

Figure 3: longitudinal incision centered over the radial styloid

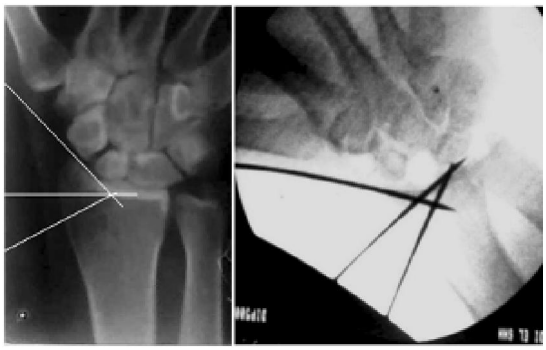

Figure 4: Three K wires are inserted to determine the osteotomy borders

Figure 5: closure of the osteotomy site by reduction clamp

Figure 6: partially threaded 4mm cancellous screw for fixation of the osteotomy site

Figure 7: late follow up radiograph showing healing of the osteotomy site

Figure 8: postoperative range of motion

4. Discussion

The ideal salvage procedure for long-standing scaphoid nonunion associated with symptomatic arthritis is to provide a pain-free, stable wrist with minimal loss of motion and it should be technically simple to perform[16].

This procedure was done to avoid excessive styloid resection and preserve the lateral supporting structures of the wrist joint that prevent scaphoid instability and loss of the radial buttress of the articular surface toward the carpus preventing ulnar translocation of the carpus

In our study we found improvement of the flexion-extension arc, palmar flexion (Figure8), dorsal flexion and radial deviation at postoperative examination but only the change of radial deviation was statistically significant. Malerich[17] presented in the group of 19 patients improvement of flexion extension arc (from 49° to 92°) and radio-ulnar deviation (from 23° to 41°) but without statistical analysis. Soejima[18] reported on 9 patients with improvement of flexion-extension arc, which was statistically significant ($p = 0.001$). In-Ho[19] found in a group of 7 patients improvement in flexion-extension arc from 81.4° to 120° and radial-ulnar deviation improved from 30° to 45°.

Assessing the grip strength we found a statistically significant improvement from 60.8 % to 79.9 % of the opposite, unaffected wrist after the surgery. Soejima[18] described a change from 40 % to 77 % and Mallerich[17] reported postoperative improvement to 75 % of the opposite wrist.

To assess the progression of carpal collapse we measured and compared the radiolunate angle on lateral X-ray of the wrist pre and post operatively. The change was statistically insignificant. Soejima[18] presented a similar outcome – change in radiolunate angle from –26° to –27° (also statistically insignificant) and Malerich[17] who found a postoperative change of radiolunate angle of only 2°. By contrast the change of radiolunate angle measured by In-Ho[19] was from –13.6° to –25.7° but without statistical analysis.

All of our eight patients were free of persistent pain during the re-examination ($p = 0.007$) and a half of them were free of pain during physical activity. Analogically, Soejima[18] reported on four of nine patients free of persistent pain and Malerich[17]

presented thirteen patients of nineteen who had complete pain relief.

Conclusion

The functional outcome in patients with scaphoid nonunion and AVN of proximal pole treated by lateral closing wedge osteotomy of the radial styloid and excision of the proximal pole after an average follow-up of 10 months after the surgery are hopeful.

This procedure preserves the lateral stabilizing structures of the wrist, avoids radial translation with ulnar and palmar carpal displacement after radial styloidectomy. It is a simple technique, economic and can be applied if the patient refused treatment options involving prolonged immobilization. Longer follow-up and a larger sample will be necessary to evaluate the real contribution of this method.

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