Vascularized pedicle dorsal distal radius graft in management of scaphoid nonunion
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Abstract:
Background: Many studies have demonstrated superiority of vascularized graft over non-vascularized in management of scaphoid nonunion, especially with sclerotic fracture edges with poor vascularity, and in proximal pole fractures or in presence of avascular necrosis. The aim of the current study was to assess the outcome of vascularized pedicled 1,2-ICSR A graft in management of scaphoid nonunion.

Patients and Methods: Between May 2011 and May 2014, 20 patients with scaphoid nonunion were prospectively enrolled in the current study. Exclusion criteria included radio-scaphoid arthritis. All patients were males with the non-dominant hand affected in 15 and the dominant in 5 patients. The average age was 32.5 (range, 21 to 40). Eight patients were manual workers, 5 were students, and 7 had an office based work. The mechanism of injury was fall on outstretched hand in 13 patients, and sport related injuries in the other 7. There were 15 waist fractures and 5 proximal pole fractures. All patients treated by vascularized pedicled 1,2-ICSR A graft fixed by Herbert screw.

Results: The average follow-up period was 18 months (range, 12 to 30). Union was obtained in all cases in an average of 11.3 weeks (range, 5-30). The mean time to union in proximal pole fractures was 12.3 weeks (rang, 6-30). While that of waist fractures was 10.4 weeks (range, 5-20). At the final follow up, the average pain VAS improved from 4.3 (range 2 to 6) preoperatively to 0.45 (range, 0 to 3) postoperatively. This improvement was statistically significant (p,0.0001). Seventeen of our patients (85%) became totally pain free while the remaining 3 patients had mild pain on strenuous activities. The average flexion and extension range improved from 65% and 61% to 74% and 75% respectively (p<0.01). The average Grip strength improved from 74% to 89% postoperatively (p<0.01). The average modified Mayo wrist score improved from 61.2 preoperatively to 80.75 at the final follow up (P<0.001).

Conclusion: Vascularized pedicle distal radius bone graft based on 1,2-ICSR A is effective in management of scaphoid nonunion with very high healing rate and with few complications.

Key words: scaphoid, scaphoid nonunion, vascularized graft, 1,2-intercompartmental supraretinacular artery.

Introduction
Natural history studies have demonstrated inevitable radio-scaphoid arthritis in all cases of long standing scaphoid nonunion (1). The management of nonunion of the scaphoid is a technically demanding process. The majority of patients are young and active and this disabling condition can have significant negative impact on the patient’s ability to perform his job (2).

Management of scaphoid nonunion follows general principles of management of nonunion elsewhere. Adequate debridement of interposed fibrous and sclerotic tissue is needed with adequate fixation and bone graft to fill the defect and enhance union. The bone grafts used is either non-vascularized cancellous or cortico-cancellous grafts or vascularized bone grafts. Vascularized grafts are either vascularized pedicle grafts based on a nearby artery, or free vascularized graft (2).
The latter had better reported results, however, it is much more complicated procedure that requires highly specialized microvascular centers (3).

Many studies have demonstrated superiority of vascularized over non-vascularized graft in management of scaphoid nonunion, especially with sclerotic fracture edges with poor vascularity, and in proximal pole fractures or in presence of avascular necrosis. Vascularized grafts have biological advantage in achieving a faster primary bone healing with the scaphoid, and a mechanical advantage being an alive normal structure bone tissue (4).

The 1,2-intercompartmental supraretinacular artery graft (1,2-ICSRA) is a pedicled vascularized bone graft, from distal radius based on a branch of radial artery first described by Zaidemberg et al (5). with consistent origin approximately 1.9 mm proximal to the tip of the radial styloid, and courses on top of the extensor retinaculum, between the first and second extensor compartments (6).

In a recent meta-analysis of vascularized pedicled bone grafts used in management of scaphoid nonunion (7), 1,2-ICSRA graft was the most popular among hand surgeons with results similar to other pedicled bone grafts including pronator pedicled graft and first or second intermetacarpal arteries grafts. Zaidemberg et al (5), as well as Steinmann et al (8), reported 100% union rates in scaphoid nonunion treated with the 1,2-ICSRA graft. However, consequent studies showed far less union rates and high complication rates. The aim of the current study was to assess the outcome of vascularized pedicled 1,2-ICSRA graft in management of scaphoid nonunion.

**Patients and methods**

A prospective study done in Benha University hospital between May 2011 and May 2014. Twenty patients with scaphoid nonunion were included. Exclusion criteria included radioscaphoid arthritis or associated wrist or distal radius fractures. All patients were males with the non-dominant hand affected in 15 and the dominant hand in 5 patients. The average age was 32.5 years (range, 21 to 40). Eight patients were manual workers, 5 were students, and 7 had an office based work. The mechanism of injury was fall on outstretched hand in 13 patients, and sport related injuries in the other 7. There were 15 wrist fractures and 5 proximal pole fractures. Nine patients received no initial immobilization while the remaining 11 had a short-arm thumb spica cast immobilization for variable periods with the longest was about 3 months. None of the patients had a previous attempt at surgical management of the scaphoid fracture. The time from injury to vascularized bone grafting averaged 23.1 months (range, 9 to 46).

A detailed history and a thorough clinical examination were done for all patients; range of motion was measured using goniometer and grip strength using hand held dynamometer. Both were calculated as percent from the normal contralateral side. Visual analogue scale (VAS) for pain and modified Mayo wrist score were recorded, Radiographic evaluation included wrist anteroposterior (AP), lateral and scaphoid views. MRI were obtained for all patients to assess viability of the proximal pole. All patients were consented and the study was approved by Benha University review board.

**Surgical technique**

All operations were done under general anaesthesia with the use of pneumatic tourniquet without exsanguinating the arm to allow visualization of the small vessels. A dorsal curvilinear incision was made centered over the interval between the first and second intermetacarpal arteries grafts. Zaidemberg et al (5), as well as Steinmann et al (8), reported 100% union rates in scaphoid nonunion treated with the 1,2-ICSRA graft. However, consequent studies showed far less union rates and high complication rates. The aim of the current study was to assess the outcome of vascularized pedicled 1,2-ICSRA graft in management of scaphoid nonunion.
size. A dorsal distal radius wedge graft (with the distal surface wider than the proximal) was obtained with careful protection of the vascular pedicle containing the 1.2 ICSRA vessels with surrounding retinaculum. The tourniquet is deflated, and vascularity of the graft as well as of the scaphoid were checked. Once satisfactory bleeding occurs, the graft was gently press-fit into the prepared bed in the scaphoid nonunion site. In proximal pole fracture cases and waist cases without malalignment, this inlay graft was then fixed by headless Herbert screws. In unstable fractures with humpback deformity (5 cases), after correcting humpback deformity using temporary joy-stick k-wires, one k-wire in the lunate bone to obtain flexion of the proximal pole and the other wire in distal scaphoid pole for its extention. Then the wedge grafts were positioned and the remaining defect filled with cancellous bone graft. Fixation of the scaphoid was then achieved using headless Herbert screws.

Fig 1 A: skin incision, B: Identification of the 1,2- ICSR artery over septum between the 1st and 2nd extensor compartments, C: opening retinaculum to expose graft site and scaphoid, D, E: Osteotomy the distal radius graft with preservation of the attached vascular pedicle, E: completion of vascularized pedicle graft F: preparation of scaphoid nonunion site.
Postoperative follow-up

A compressive dressing with a bivalved short-arm scaphoid cast was applied and maintained till suture removal 2 weeks postoperatively. New short-arm scaphoid cast was applied to the patients for four weeks. Then, the cast was replaced with a short arm brace including thumb which was continued till union was obtained. Physiotherapy program began once cast was removed. Patients were allowed to use computer keyboard and to perform non-strenuous activities under the protection of the plastic brace. Strenuous manual labor and sports activities were allowed only after solid union. Follow up radiographs were obtained postoperatively, after 6 weeks then every 2 weeks till union (fig2&3). At final follow up, patients were assessed as regard pain VAS, range of motion, grip strength and modified Mayo wrist score.

Data were analyzed by means of the SPSS statistical package (SPSS version 16; SPSS, Inc.,Chicago, Ill.). Statistical analysis was done using paired-samples Student t-test. The level of significance was set at p< 0.05.

Results

The average follow-up period was 18 months (range, 12 to 30). Union was obtained in all cases as proved by plain radiographic evaluation and CT. The mean time to union was 11.3 weeks (range, 6-30). The mean time to union in proximal pole fractures was 12.3 weeks (range, 6-30). While that of waist fractures was 10.4 weeks (range, 6-20).

At the final follow up, the average pain VAS improved from 4.3 (range 2 to 6) preoperatively to 0.45 (range, 0 to 3) postoperatively. This improvement was statistically significant (p<0.001). Seventeen of our patients (85%) became pain free at the final follow-up evaluation while the remaining 3 patients had mild pain on strenuous activities. The average flexion and extension range improved from 65% and 61% preoperatively to 74% and 75% respectively (p<0.01). The average grip strength improved from 74% (range, 70 to 77) to 89% (range 83 to 94) postoperatively (p<0.01). The average Modified Mayo wrist score improved from 61.2 (range, 54 to 67) to 80.75 (range, 74 to 87) at the final follow up (P<0.001).

As regard complications, 2 cases developed tingling and numbness around the base of the thumb from injury of one of the branches of the superficial radial nerve that improved after 6 months. One case had superficial wound infection that improved by daily dressing and antibiotics. At final follow up, no reported AVN or arthritic changes were reported.

Figure 2 :A: Preoperative radiographs showing ununited proximal pole scaphoid fracture with cyst formation, B: follow up x-ray after 4 weeks C: x-ray after union
Discussion

Management of scaphoid non-union remains a challenge to hand surgeons with high failure rates. Addressing both mechanical and biological aspect of the nonunion by headless compression screw fixation and bone graft respectively have shown improvement in the rate of union. In the current study of 20 cases of scaphoid nonunion, union was achieved in all cases at an average time of 12.3 weeks (range, 6-30) in proximal pole fractures, and 10.4 weeks (range, 6-24) in waist fractures. This union rates is the same obtained by Zaidemberg et al(5) who reported 100% union rates in 11 patients with average union time of 6.2 weeks, and by Steinmann et al(8) in 14 patients with average time 11.1 weeks (table 1). Chang et al(9), reported union in only 71% of cases (34 of 48), and in only 50% of cases with AVN. Our high rate can be explained by using a large wedge shaped graft and correcting any humpback deformity of the scaphoid while such deformity is present in most failed cases of Chang study.

<table>
<thead>
<tr>
<th>Study</th>
<th>Year</th>
<th>No of cases</th>
<th>Union rate</th>
<th>Union time</th>
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<tbody>
<tr>
<td>Zaidemberg et al(5)</td>
<td>1991</td>
<td>11</td>
<td>100%</td>
<td>6.2 weeks</td>
</tr>
<tr>
<td>Steinmann et al(8)</td>
<td>2002</td>
<td>14</td>
<td>100%</td>
<td>11.1 weeks</td>
</tr>
<tr>
<td>Malizos et al(10)</td>
<td>2001</td>
<td>22</td>
<td>100%</td>
<td>6-12 weeks</td>
</tr>
<tr>
<td>Chen et al(11)</td>
<td>2006</td>
<td>11</td>
<td>100%</td>
<td>13 weeks</td>
</tr>
<tr>
<td>Chang et al(9)</td>
<td>2006</td>
<td>48</td>
<td>71%</td>
<td>13.3 weeks</td>
</tr>
<tr>
<td>Dehghani et al(12)</td>
<td>2014</td>
<td>16</td>
<td>100%</td>
<td>8-12 weeks</td>
</tr>
<tr>
<td>Current study</td>
<td>2017</td>
<td>20</td>
<td>100%</td>
<td>11.3 weeks</td>
</tr>
</tbody>
</table>

Seventeen of our patients (85%) became pain free at the final follow-up evaluation while the remaining 3 patients had mild pain on strenuous activities. Similar results were obtained by Chen et al(11), after 4 years follow-up of 11 scaphoid nonunion managed by vascular bone grafts pedicled on the dorsal supra-retinacular artery of the distal radius. Nine patients became pain free and the remaining 2 patients complained of mild pain with vigorous activities or weather changes.

In a recent meta-analysis (13) including 54 articles using 9 different vascularized bone grafts in management of scaphoid nonunion, the most commonly used graft was 1,2-ICSRA graft making the procedure results more reproducible. However, they reported less favorable results in some case series and concluded that dorsal grafts are not suitable for correction of humpback deformity. We think that the key is in the proper shaping of the graft as a wedge with wider volar surface together with manipulative joy-stick...
correction of the deformity before graft insertion can correct the humpback deformity. This can explain 100% union rates in our series and in many other series using the same technique (5, 8, 10-12) (table 1). The main limitation of the current study was the relatively small number of cases and the lack of control group.

**Conclusion**

Vascularized pedicle distal radius bone graft based on 1,2-ICSRA is effective in management of scaphoid nonunion with very high healing rate and with few complications.

**References**