

Research Article

Our Experience of 1,2 Intercompartmental Supra Retinacular Artery Pedicle Vascularized Bone Graft for Scaphoid Nonunion

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Abstract |

Background: The aim of this study was to observe efficacy and outcomes of 1,2 inter compartmental supraretinacular artery(ICSRA) pedicle vascularized bone graft in scaphoid non-union at our center.

Methodology: This retrospective study was conducted over a four-year period from January 2015 till January 2019. All patients who underwent 1,2 ICSRA pedicle vascularized bone graft for scaphoid non-union were included in the study. The vascularized grafts were fixed with k-wires and compression screws. The outcome was measured by radiological healing time, range of motion at the wrist joint, and grip strength of hand, and the DASH (Disability of the Arm, Shoulder and Hand) score.

Results: 13 patients underwent 1,2 ICSRA pedicled vascularized bone graft for scaphoid non-union. According to the topography of fracture, 9 were proximal pole fractures and 4 were waistline fractures. 11 out of 13 patients achieved radiological healing by a mean time of 9.8 weeks. There was a significant decrease in the DASH score from 77.3 to 25.1. All scaphoid unions were pain-free. The range of movement at the wrist joint was comparable to the contralateral hand.

Conclusion: Treatment of scaphoid non-unions with 1,2 ICSRA pedicled vascularized bone grafts has favorable outcomes in terms of quicker healing and better hand function.

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Introduction

Scaphoid fractures account for 50 – 70 % of all carpal fractures and almost 11% of all hand fractures.¹ The challenging complications are non-union and avascular necrosis of the proximal segment, which are difficult to manage. Rate of non-union after surgical fixation of scaphoid fracture is as high as 10%. Delay in diagnosis and treatment, compromised blood supply, proximal pole fracture, smoking, and type of fixation technique, all contribute to nonunion of the scaphoid.² Clinically, nonunion renders patients in pain, deformity, and restricted range of motion.³

Bone graft has remained the mainstay of treatment of scaphoid non-union. Though conventional bone grafting has been successfully used for scaphoid

nonunion⁽⁴⁾, it has been challenging with proximal fractures and avascular necrosis. Zaidenberg et al,⁵ in 1991 described the use of pedicled vascularized bone graft for scaphoid non-union. More recent studies report significantly higher union rates of scaphoid fractures with vascularized graft,⁶⁻⁸ even though previous studies showed contrary results.^{9,10} This variability might depend on variable presentation of scaphoid nonunion, patient selection, and factors affecting its union.

In our center, we have been treating scaphoid fractures for more than a decade based on Zaidenberg's technique.⁵ 1,2 inter compartment supra retinacular artery (ICSRA), Pedicled vascularized graft has been our mainstay of treatment in scaphoid non-union, as it

demonstrated satisfactory results with less morbidity. The purpose of this study was to measure the outcome and efficacy of 1,2 ICSRA pedicle vascularized bone graft in all scaphoid nonunion at our center.

Methodology

The study was conducted over a 4-year period from January 2015 – January 2019. This was a retrospective review of prospectively maintained data. Approval from the hospital ethical committee was taken (Ref: APP # 0568-2020 LNH-ERC). Data were extracted from the hospital information management system (HIMS) and OPD register.

All the patients who were operated on with 1,2 ICSRA pedicle vascularized radial bone graft for scaphoid nonunion were included in this study. Exclusion criteria were age less than 14 years and above 60 years, any other associated fracture, and previous history of scaphoid surgery. All patients were called and requested to visit the clinic for last follow up, where they were examined for the functional outcomes in terms of pain, range of motion at wrist joint, pre and post-op DASH (Disability of the Arm, Shoulder and Hand) scores, and grip strength of hand.

Range of motion at wrist joint was measured by two arm goniometer, as the angle at radial deviation, ulnar deviation, wrist flexion and ulnar flexion, and compared with the contralateral hand.

The grip strength of the affected hand was measured and compared with the contralateral hand by using sphygmomanometer.

Pre and postop DASH SCORE were calculated on last visit as outpatient and recorded. Time of radiologic healing was extracted from hospital follow up records. Any tenderness and pain was also noted.

Surgical Technique

All Patients were operated under general anesthesia with loupe magnification and tourniquet by a single senior surgeon. Lazy S-shaped incision was centered over the styloid process of radius allowing exposure of scaphoid dorsoradially. While preserving the cephalic vein and superficial radial nerve, extensor retinaculum was incised over the 1st and 2nd compartment, and 1,2 ICSRA visualized (Fig 1a). Corticocancellous bone graft from radial bone was marked along with pedicle. Pedicle dissection was carried out with a perivascular soft tissue cuff (Fig 1b). The scaphoid capsule was opened under wrist extensors, fracture visualized and the

scaphoid bone prepared for graft placement. Radial bone graft was harvested with a fine osteotome. Tourniquet was released to see the viability of graft and punctate bleeding of the scaphoid. The vascularized graft was then placed and fixed with k wire or compression screws under c arm.

Patients were discharged when stable, on the 1st or 2nd post-op day. They were followed weekly. Back-slab was removed at 6 weeks, and rehabilitation started with active and passive range of motion of fingers with continuation of wrist brace and thumb spica up to radiological healing. K-wires were removed once signs of healing were achieved on x-rays.



Figure 1(a)1, 2 ICSRA pedicle (yellow arrow), and (b) pedicle with radius bone graft (yellow arrow)

Data Analysis:

Patient data was compiled and analyzed through the statistical package for Social Sciences (SPSS) Version 25. Frequency and percentage were computed for qualitative variables. Means were calculated for the quantitative variable. The mean comparison was done by dependent and independent t-test. Association was checked by using the chi-square test and Fisher exact test as appropriate. $P \leq 0.05$ was considered as significant.

Results

There were 13 patients with scaphoid non-union. Majority of the patients were male. The mean age was 35.2 years. Fracture patterns were 69.2 % (n=9) proximal pole fractures and 30.8 % (n=4) waistline fractures. The mean time period between injury and surgery was 6.5 months. All patients had 1,2 ICSRA pedicle vascularized bone graft which were fixated with either k – wire (n=8) or compression screw (n=5). Table 1 shows the demographic and clinical details of the patients.

11 out of 13 patients (84.6%) achieved radiological healing, with an average time of 9.8 weeks (range 8 to

12 weeks). Union rate of proximal pole fracture were 88% and waistline fracture was 75% with radiological healing times as shown in Table 2. Out of two non-united cases, one was proximal and the other was waistline fracture along with humpback deformity.

All the cases that achieved radiological healing were pain-free. Outcomes were assessed with DASH scores, which declined significantly from a pre-operative value of 77.3 to 25.1 post-operatively. Range of motion of the affected wrist was recorded on the last follow-up

Table 1: demographic and clinical characteristics of the patients (n=13)

| | |
|--------------------------------|-------------|
| Mean age (years) | 35.2 |
| Gender (n,%) | |
| Male | 12 |
| Female | 1 |
| Fracture patterns (n,%) | |
| Proximal pole | 9 (69.2) |
| Waistline | 4 (30.8) |
| Fixation method (n,%) | |
| K wires | 8 (61.5) |
| Compression screws | 5 (38.5) |

Table 2: Union rate and healing time of different fracture types

| Fracture pattern | Union rate | Mean readiological healing time |
|------------------|------------|---------------------------------|
| Proximal pole | 88% | 10 weeks |
| Waist | 75% | 9 weeks |

and compared with the non-affected side (Table3). Wrist flexion in the affected hand was 92%, extension 95%, radial deviation 81%, ulnar deviation 85% and grip strength 92% as compared to unaffected hand.

Discussion

Scaphoid fractures are common injuries accounting for 80% of all carpal fractures.¹¹ If missed at initial evaluation, they result in malunion, nonunion or avascular necrosis, consequently leading to advanced collapse arthritis.¹ Treatment depends on the type of fracture

encountered. Conservative treatment with cast immobilization is a valid choice in stable fractures, but at the cost of longer immobilization.¹¹ Unstable fractures including displaced waistline fracture and proximal pole fractures are more prone to its scaphoid nonunion leading to avascular necrosis and arthritis, with the latter having a higher risk due to its tenuous blood supply.¹²⁻¹⁴ Scaphoid nonunion is defined as no signs of healing on radiology by 12 weeks with symptoms of persistent pain and decreased range of movements.¹ The goal of treatment for Scaphoid nonunion is to achieve consistent union, reduction in pain, better range of movement and prevent progression to osteoarthritis.¹⁵ Bone grafting is the mainstay of treatment in scaphoid nonunion. To achieve early and better consolidation vascularized or non-vascularized bone grafts are both options, but there is little evidence as to which method is superior. A systematic review of existing evidence showed 95-100% scaphoid union rate with vascularized bone grafts.¹⁶ However this result varies, as another systematic review concluded mean union rate of 84% and 80% in vascularized and non-vascularized bone graft respectively.⁶ This difference in success rate in literature might be attributed to differences in the expertise of the surgeon, patient factors and post-operative management. Union rate with pedicled vascularized grafts in this study was 84% which is comparable to our study.

A vascularized graft could be free or pedicled. Some studies showed better outcomes¹⁷ with free femoral vascularized graft with union rate of 88.9% as compared to 1,2 ICSRA bone graft with 79%, but those were done in complicated scaphoid non-union. However at our center we prefer 1,2 ICSRA pedicle bone graft based on Ziedenberg technique, due to its ease of execution and lower morbidity as compared to free flap surgery, with comparable overall outcomes.

Our experience with pedicle anatomy was consistent in all patients. All elevated grafts were checked for bleeding after tourniquet release. This technique requires

Table 3: Ranges of motion achieved at wrist joint of affected hand as compared to contralateral normal hand

| | Wrist Extension (Degree)(SD) | Wrist Flexion (Degree)(SD) | Radial deviation (Degree)(SD) | Ulnar deviation (degree)(SD) |
|---|---------------------------------|-------------------------------|----------------------------------|---------------------------------|
| Mean ranges of motion at wrist joint in affected Hand | 62.7(3.1) | 67.0(3.8) | 13.1(1.2) | 25.1(1.0) |
| Mean ranges of motion at wrist joint in unaffected Hand | 68.6(1.7) | 73.2(2.4) | 15.2(4.3) | 29.6(1.9) |
| P - value | 0.999 | 0.838 | 0.833 | 0.729 |

expertise to produce consistent results. Meticulous dissection of the pedicle is needed and taking a perivascular cuff of soft tissue around the pedicle is a lifesaver. We did not encounter any difficulty regarding reach of pedicle. Stable fixation of graft is important for early consolidation and union. Fixation of the vascularized graft was done by two methods in our patients: headless screw and k-wire. In our setting most of the cases performed were for proximal pole fractures. Placing a screw in a shorter proximal pole is technically difficult so k-wire was used in most of our cases. We believe that stable fixation is the cornerstone of any fracture fixation, and we were able to achieve that by both methods. Fixation techniques did not make a significant difference on union rate and DASH score in our study. Factors that define the prognosis of scaphoid nonunion include delayed treatment. Euler et al in their study showed significantly higher union rates with early scaphoid surgery before the commencement of Dorsal Intercalated Segment Instability or DISI.¹⁸ In our study average time of surgical intervention was 6.5 months. We made sure to have no further delays once diagnosis of nonunion was established. This could be one of the factor for our 84 % union rates postoperatively.

Proximal pole fractures are themselves a bad prognosis for scaphoid union, about 3% of proximal pole fractures lead to avascular necrosis (AVN) of proximal pole.² AVN is considered the worst prognostic factor in scaphoid healing. Thus, vascularized bone graft is superior to non-vascularized bone grafts as it eliminates stacking up of non-vascularized tissue. Recent systematic reviews showed excellent results of vascularized bone grafts, improving the rate and time of healing by revascularising ischemic bone.^{8,19,7} We had 9 proximal pole fractures out of a total of 13 cases, which showed an 88% union rate. None of the fractures showed pre-op signs of DISI. Generally, rapid consolidation is achieved in 6-13 weeks, with some studies showing early healing time with vascularized bone grafts. One study showed an average healing time of 9.9 weeks treated with pedicle vascularized bone graft.⁷ Our result also witnessed an average healing time of 9.6 weeks.

The present study showed significant functional outcomes with vascularized pedicle graft. All patients with united fractures returned to their respective work with a significant decrease in DASH score from 77 to 25, and grip strength and range of movement at the wrist comparable to the contralateral unaffected hand. Similar results have been demonstrated in other studies too.⁷

The presence of humpback deformity with scaphoid fracture affects the healing of fracture due to the collapsing nature of scaphoid unless wedge inlay bone graft is used.²⁰ Pedicle bone graft from distal radius is somehow unable to achieve scaphoid height,⁷ so nonunion is predicted. We studied that one out of two nonunion cases had humpback deformity.

There were certain limitations of this study. As this was a retrospective study, we faced problems with data collection. We lacked information about avascular necrosis of proximal pole of scaphoid at time of surgery, and size of bone grafts used. Height of scaphoid could not be measured as pre-and post-op CT scans were not always available. Our study was on a small number of patients. Lastly, pre-operative DASH scores were recalled by patients on their last visit.

Conclusion

1,2 ICSRA pedicle bone graft for scaphoid nonunion following proximal pole and waistline fractures has very good outcome in terms of union rate, early radiological healing, and functional status of hand.

Conflict of Interest

None

Funding Source

None

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