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The results of pedicled vascularized bone grafts in the treatment of scaphoid nonunion

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ABSTRACT

Objectives: Scaphoid nonunion still creates a big challenge for hand surgeons due to high failure rates after surgery, particularly in proximal pole fractures. The pedicled vascularized bone graft (VBG) is a valuable option to achieve union and good outcomes. This study aimed to analyze the clinical and radiological results of patients who underwent scaphoid fixation with pedicled VBG due to non-union of a scaphoid fracture.

Methods: The patients who were operated due to scaphoid non-union and underwent fixation with pedicled VBG between 2017 and 2018 were reviewed retrospectively. The patients were evaluated both preoperatively and postoperatively. The clinical assessments included; the range of motion, grip strength, Mayo wrist score, and visual analogue scale (VAS) pain score. The presence of bony union was evaluated with direct radiographs.

Results: Eight patients were included in the final analysis. Four patients who had waist non-union were reconstructed with volar pedicled VBG, while the other four patients with proximal non-union were reconstructed with dorsal 1,2 ICSRA pedicled VBG. The average age was 28.7 and the average follow-up was 12.3 months. The bony union was achieved in 7 patients at average 3.1 months with gain of both range of motion and grip strength. The average VAS pain score was improved from 6.8 to 2. The average Mayo wrist score was improved from 52.2 to 80.4.

Conclusion: The application of pedicled VBGs harvested from the distal radius provides good clinical and radiological outcomes in the treatment of scaphoid non-unions.

Key words: *Scaphoid fracture, scaphoid nonunion, pedicled vascularized bone graft, clinical outcome*

Introduction

The non-union of scaphoid fractures is reported between 5% and 15% but when proximal fractures were particularly considered, the nonunion rate can go up to 30%, and even to 60% in the presence of avascular necrosis [1–4]. The nonunions can lead to wrist osteoarthritis if they are not managed appropriately. Different treatment techniques are defined to obtain bony union and normal carpal anatomy but there is no consensus on which method yields the best result [5]. The conventional methods include non-vascular bone grafting (NVBG) with internal fixation but the diminished blood supply might prevent obtaining successful clinical results. In search of better vascularity to achieve

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higher union rates, pedicled vascularized bone grafts (VBG) are started to be used increasingly in the management of scaphoid nonunions.

The studies comparing NVBGs and VBGs reported conflicting results and it is not possible to make certain conclusions based on the literature due to various reasons including heterogeneous & low-sample-sized patient groups and uncertainty of preceding avascular necrosis or arthritis [6,7]. Several studies reported higher union rates with VBGs in the presence of proximal pole avascular necrosis [8–10]. However, there are also studies reporting less promising results [11,12]. The most commonly applied pedicled VBGs for scaphoid nonunions are obtained from the distal radius and based on whether dorsal or volar pedicles. This study aimed to analyze the clinical and radiological results of pedicled VBGs in the treatment of scaphoid nonunions.

Patients and Methods

Eight patients who underwent pedicled vascularized bone grafting due to scaphoid nonunion between 2017 and 2018 were reviewed retrospectively. The presurgical and postsurgical evaluation included the range of motion, grip strength, Mayo wrist score. Visual analogue scale (VAS) pain score was used to assess the pain difference between the preoperative and postoperative periods. The nonunions were classified according to Filan and Herbert (FH) Classification (D1: fibrous union, D2: pseudarthrosis, D3: sclerotic pseudarthrosis, D4: avascular necrosis)[13]. All patients were evalu-

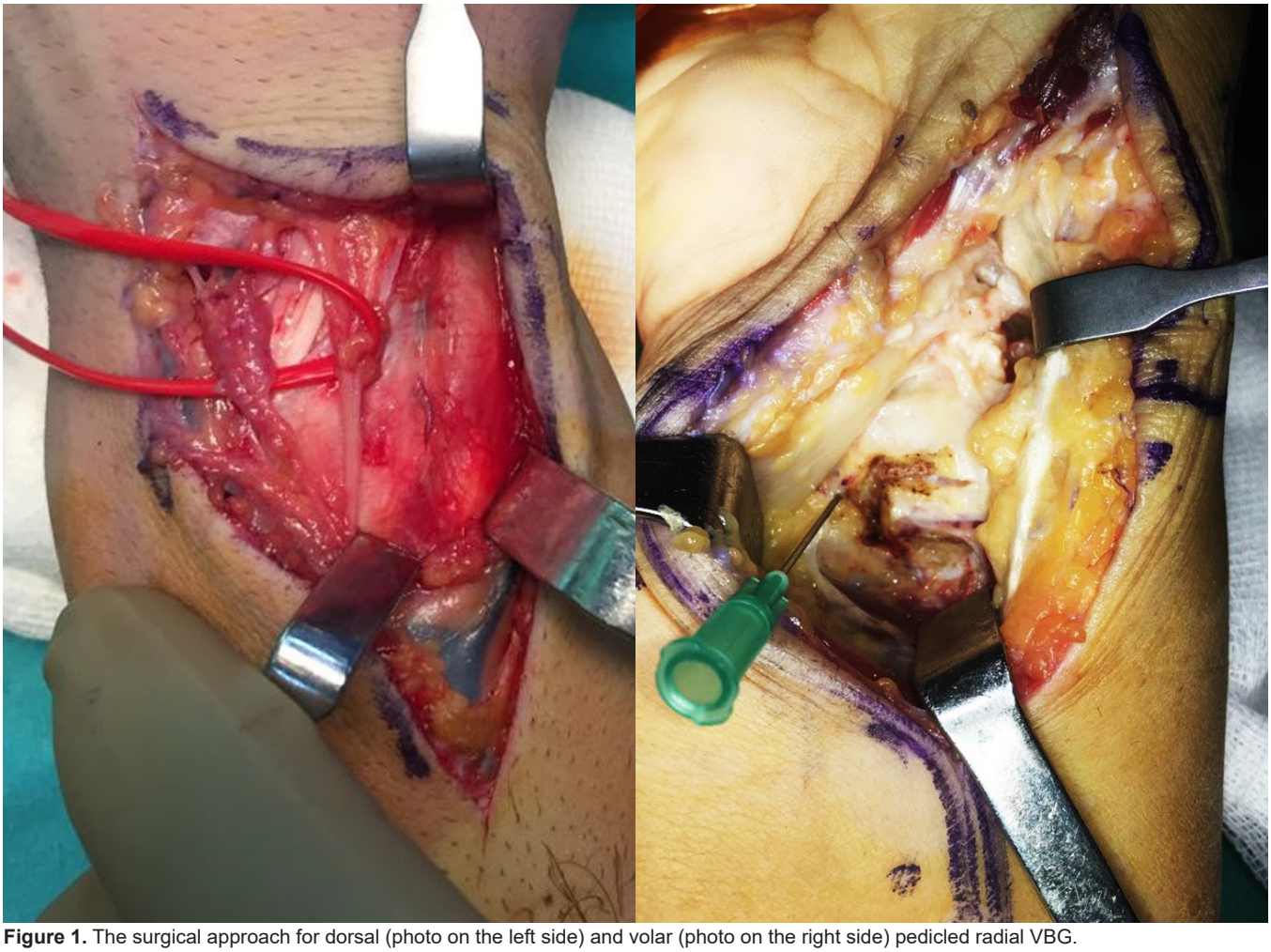

Figure 1. The surgical approach for dorsal (photo on the left side) and volar (photo on the right side) pedicled radial VBG.

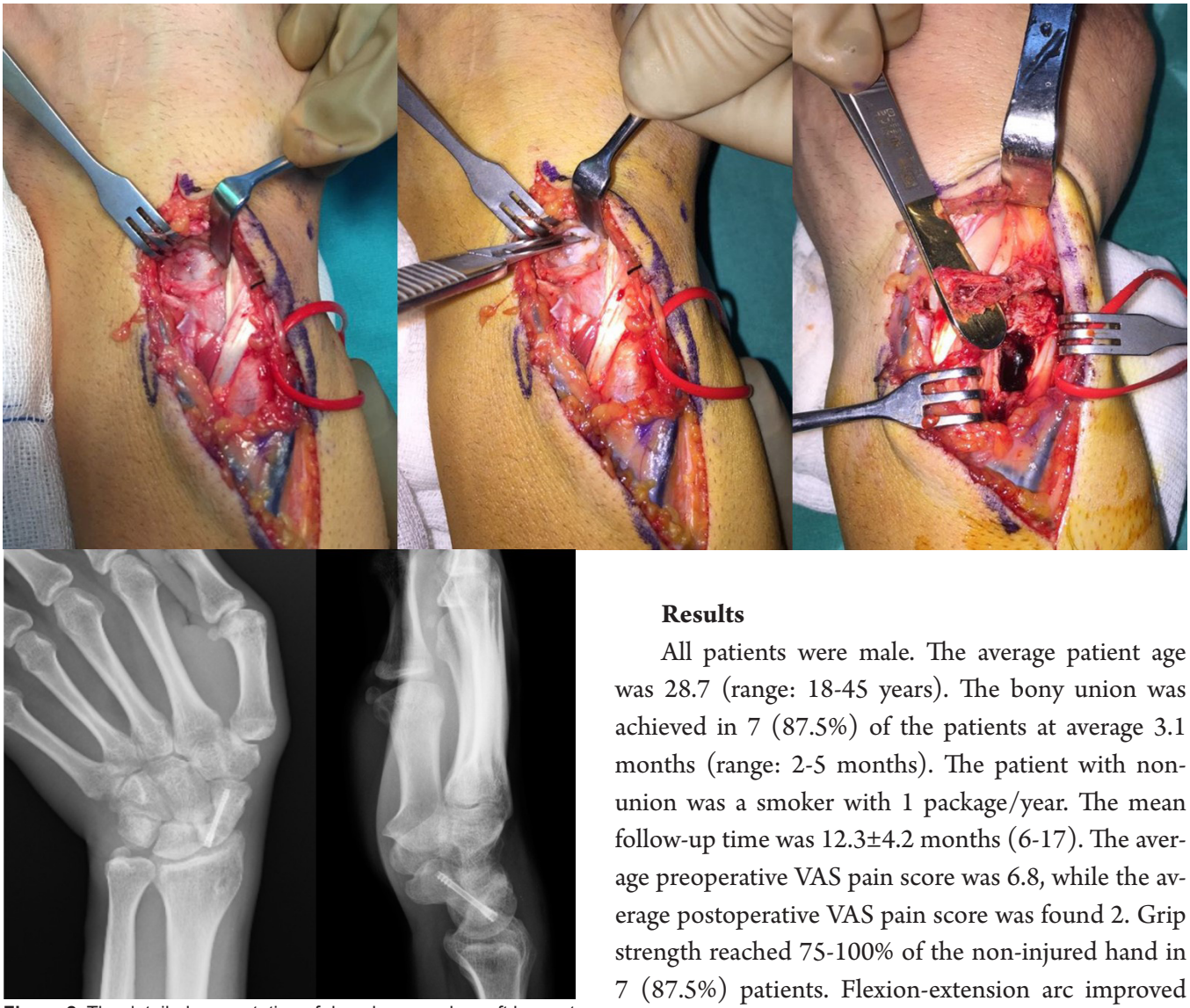

Figure 2. The detailed presentation of dorsal approach, graft harvest and the position of inserted screw.

ated with magnetic resonance imaging before surgery. Four patients had avascular necrosis while the other patients did not. No humpback deformity was detected.

The surgical technique included volar pedicled VBG application for waist non-unions and dorsal 1,2 intercompartmental supraretinacular artery (ICSRA) pedicled VBG application for proximal pole non-unions (Figure 1, 2). The fixation of the graft and scaphoid was provided with a screw or K-wires. Direct radiographs were obtained to verify ossification (Figure 3, 4). The immobilization period was 6 weeks via spica cast or splint.

Results

All patients were male. The average patient age was 28.7 (range: 18-45 years). The bony union was achieved in 7 (87.5%) of the patients at average 3.1 months (range: 2-5 months). The patient with non-union was a smoker with 1 package/year. The mean follow-up time was 12.3±4.2 months (6-17). The average preoperative VAS pain score was 6.8, while the average postoperative VAS pain score was found 2. Grip strength reached 75-100% of the non-injured hand in 7 (87.5%) patients. Flexion-extension arc improved from 83.2° to 103.4°. The average Mayo wrist score was improved from 52±7.4 to 80±9.2 (Table 1).

Four patients who had waist non-union were reconstructed with volar pedicled radial VBG, four patients with proximal non-union were reconstructed with dorsal 1,2 ICSRA pedicled VBG. Two of the patients had FH type D2, two of them had FH type D3 and four of the patients had FH type D4 nonunion. The fixation method was headless cannulated screws in seven patients and K-wire in one patient. None of the patients had previous history of surgery for scaphoid non-union and was firstly treated with spica casting.

Figure 3. The non-union of scaphoid waist fracture after initial cast treatment. The radiograph and magnetic resonance imaging was taken 6 months after initial trauma.

Figure 4. The union was evident at 3rd-month follow-up after the application of volar pedicled radial vascularized bone graft and screw fixation.

Discussion

The dorsal and volar pedicled VBGs harvested from distal radius provided good clinical outcomes and 87.5% union rate in our eight patients. The increased vascularity provided by the pedicle can facilitate the healing and bony union.

The characteristics and localization of the scaphoid non-union is important in choosing the best graft option. The most common indications for vascularized graft application are previous unsuccessful non-vascularized bone graft application and avascular necrosis of the proximal fragment. In selected cases, the recent literature also supports the use of VBGs as primary procedure in the treatment of scaphoid nonunion [14], while they are contraindicated in the presence of radiocarpal joint degeneration [15]. Several risk factors that can lead to scaphoid non-union are defined including; proximal pole fracture, insufficient fixation, delayed treatment, carpal deformity and avascular necrosis [16]. Dorsal pedicled VBGs are commonly preferred in proximal pole non-unions, while volar pedicled VBGs are indicated in waist nonunions, especially when a humpback deformity is present [17,18]. Scaphoid humpback deformity occurs when the scaphoid shortens volarly leading to angulation of scaphoid with the apex dorsal. It creates a gap on the dorsal side of the fracture site and can progress to carpal collapse in later stages.

The proximity to scaphoid makes the dorsal pedicled VBGs the most commonly preferred option but they are not able to correct humpback deformity and

Table 1. The preoperative and postoperative clinical situations of the patients.

Parameter	Preoperative (mean±SD, range)	Postoperative (mean±SD, range)
VAS pain score	6.8±0.83 (4-8)	2±1.7 (0-5)
Mayo wrist score	52±7.4 (42-67)	80±9.2 (65-95)
Flexion-extension (°)	83.2°±12.2 (70-100)	103.4°±16.5 (90-125)
Grip strength (% of non-injured side)	63%±8.1 (51-71)	82%±9.3 (70-92)

volar pedicled VBGs are preferred when such deformity is present [4]. 1,2 ICSRA is the most commonly preferred pedicle among the dorsal pedicles and union rates between 27% and 100% are reported in the literature [12,19]. Waitayawinyu achieved 93.3% union rate ate average 5 months with increased grip strength and functional score [19]. The studies reporting low rate of union whether included high prevalence of patients with avascular necrosis/failed surgery or used K-wire as fixation method. These parameters can be the reason behind low union rates [12]. Our study achieved 87.5% union rate with only one nonunion out of 8 patients. The patient with nonunion had avascular necrosis of proximal pole and was using 1 package/year cigarette. He underwent 1,2 ICSRA pedicled VBG and screw fixation but the union could not be achieved. In addition to avascular necrosis in this patient, it is also known that smoking can disrupt angiogenesis and lead to nonunion [19].

The volar pedicled VBGs can correct carpal geometry and humpback deformity more effectively. Satisfactory results were achieved with volar pedicled VBGs. Mathoulin and Haerle reported 100% union rate in 17 patients at average 8.6 weeks, despite more than half of the patients had a history of failed surgery [20]. However, since the volar VBGs are preferred in waist nonunions which mostly do not possess any avascular necrosis, the reason behind high union rates can be the patient groups with fewer risk factors for nonunion. Our patients who underwent volar VBG had also waist nonunions and none of them showed avascular necrosis before the surgery. The union was achieved in all of these patients.

The implant choice can also affect the union rates when adequate stabilization could not be achieved. The compression screws are reported to provide higher bony union but technically it might not possible to apply a screw to the nonunion site when the nonunion site is so close to the proximal tip of the scaphoid [4,10]. K-wires can be used when such problem is encountered. Among our patients, only one patient underwent K-wire fixation while the rest of the patients received screw fixation. The bony union was achieved in the patient with K-wire fixation at 5th month.

The two main limitations of this study is the low sample size and its retrospective design. Additionally, the surgical technique was not standardized in all patients and half of the patients received dorsal VBG while the other half received volar VBG due to the differences in the location of nonunion. Despite technical difficulties, pedicled VBGs can increase union rates and allow correction of the carpal geometry. However, larger randomized studies with more homogenous groups are needed to investigate any possible superiority of a technique.

Conflict of interest statement

The authors have no conflicts of interest to declare.

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