

Cannulated Screw Fixation for Scaphoid Nonunion Without Bone Grafting

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ABSTRACT

This study aimed to evaluate radiological union and clinical outcomes of patients with Slade Grade III–IV scaphoid nonunion treated with open reduction and internal fixation using a cannulated compression screw without autologous bone grafting.

A retrospective cohort of patients who underwent first-time surgery for Grade III–IV scaphoid nonunion between January 2017 and May 2024 was reviewed. Union was assessed radiographically, and clinical outcomes were evaluated using the Mayo Wrist Score.

Twenty-two patients (20 men, 2 women; mean age 28 years, range 18–41) were included. Union was achieved in all patients, with a mean union time of 17 weeks. The median Mayo Wrist Score improved from 70.5 preoperatively to 90.5 at 12 months. Outcomes were excellent in 13 (59.1%), good in 6 (27.3%), and fair in 3 (13.6%) patients.

Open reduction and cannulated screw fixation without bone grafting may be an effective option for selected patients with Slade Grade III–IV scaphoid nonunion.

Keywords: Scaphoid; Nonunion; Fracture Fixation; Osteosynthesis; Wrist

Introduction

Scaphoid fractures are the most prevalent type of fracture in the carpal region, particularly among young people. Approximately 5–10% of these fractures result in non-union over time (1). The incidence of non-union in scaphoid fractures is 5–12%, and if there is displacement of more than 1 mm at the fracture site, this can rise to as high as 55% in the long term, accompanied by complications such as carpal misalignment, scaphoid non-union-associated collapse (SNAC), and progressive radiocarpal and midcarpal arthritis (2). It is imperative to restore normal carpal kinematics to prevent this progression (3).

The management of scaphoid non-union remains a subject of considerable controversy and heterogeneity. The extant literature describes a wide range of surgical techniques, from microsurgical vascularized bone grafts to shockwave therapy (4). However, given the current plethora of graft and fixation methods, a consensus on optimal treatment strategies remains elusive (5). Despite the advances in treatment methods that have been witnessed in recent decades, leading to enhanced patient outcomes, the heterogeneity of patients' symptoms, the challenges associated with standardizing diagnosis and outcomes,

and the extensive range of available treatment techniques, the selection of the most suitable surgical intervention remains a complex undertaking (6,7). In 2003, Slade et al. proposed a classification of scaphoid pseudarthrosis to evaluate the characteristics of scaphoid non-union (8).

At present, the percutaneous screw fixation strategy is considered effective in the treatment of Grade I–III SNU, but it cannot be used in the treatment of Grade VI SNU, and its therapeutic effect on Grade IV and V SNU remains controversial (9,10).

Recent studies have focused on percutaneous screw fixation without the use of grafts; in this study, the objective was to present the radiological and clinical outcomes of patients diagnosed with Grade III and IV scaphoid non-union who were treated with open reduction surgery and internal rigid fixation without the use of autologous bone grafts.

Materials and Methods

The present retrospective study was approved by the ethics committee of our hospital. Prior to undergoing surgery, all patients provided written consent by signing an informed consent form. The study included patients who underwent their first surgery for grade III–IV SNU between January 2017 and May

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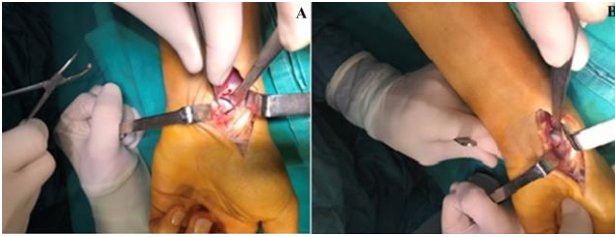


Fig. 1A and Fig. 1B. Volar approach to the scaphoid Volar approach described by Russe was used to reach the pseudoarthrosis region (13). After seeing the fracture line, the fractured poles were cleaned with fine tip curette (Figure 2).

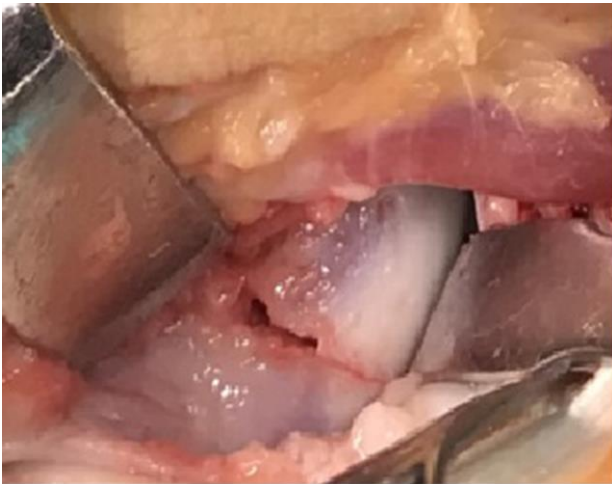


Fig. 2. Scaphoid Pseudoarthrosis Line After Curettage

2024, and who had initially been misdiagnosed, had their diagnosis missed, or whose initial non-surgical treatment had failed. The exclusion criteria comprised the following: radiographic evidence of osteonecrosis, kyphosis or displacement; other fractures or dislocations of the wrist; reoperation within one year of the initial surgery; or patients without complete follow-up data. In accordance with the Slade classification system, the grades were assigned by two senior doctors. This process involved the assessment of the degree of bone resorption at the fracture ends, utilizing preoperative CT scans as a diagnostic tool. Disagreements among the assessors resulted in the exclusion of the case from the study.

The sample comprised 20 male and 2 female patients, with a mean age of 28 years (range 18–41 years). The fracture was located on the right side in 13 patients and on the left side in 9 patients. The etiology of the scaphoid fracture was categorized into the following: falls ($n = 19$), sports injuries ($n = 7$), road traffic accidents ($n = 3$) and workplace accidents ($n = 2$). The dominant hand was affected in 60% of patients. According to the Slade classification, 15 patients were Grade III and 7 patients were Grade IV. A total of 18

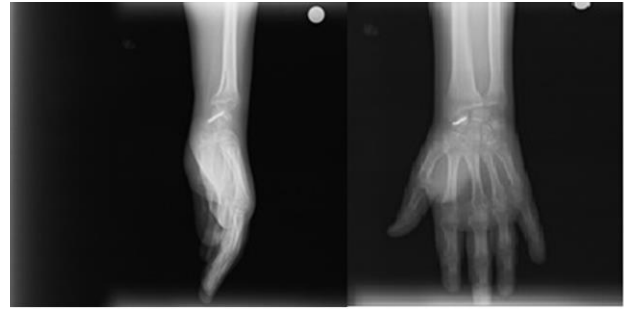


Fig. 3. Postoperative 6 months X-ray images of the same patient

patients sustained a scaphoid shaft fracture, while 4 patients sustained a distal pole fracture. (Table 1)

Post-surgical routine radiographic images were obtained for the patients. The radiological union criteria for the patients were as follows: the absence of radiolucency at the fracture line, the disappearance of the pseudoarthrosis line, the presence of trabeculation across the fracture, and no implant failure (11). The Mayo wrist scoring system was utilised for the purpose of conducting a functional assessment of the wrist (12).

Surgical Procedure: All patients were treated with the same standard surgical method (Figures 1A and 1B).

The fracture line was reduced to prevent the humpback deformity and to obtain the scaphoid length. A guide wire was inserted under fluoroscopy to control the position of the wire. The scaphoid was drilled under fluoroscopic control to determine the length of the screw to be inserted and one cannulated compression screw was inserted. The wound site was closed after the screw insertion. A short-arm cast covering the thumb was used to immobilize the hand after surgery. After 6 weeks, the cast was removed, followed by wrist splinting. The wrist joint was allowed to move.

The image of the same patient at the postoperative 6 months is shown in Figure 3.

Statistical Analysis: Descriptive statistics for the continuous variables were presented as Mean and Standard deviation, while count and percentages for categorical variables. Z test was used for comparison of two proportions of the groups. Statistical significance level was considered as 5% and MINITAB for windows (ver: 14) statistical program was used for all statistical computations.

Results

The mean interval between injury and surgery was 11.9 months (range 8–19 months). The mean postoperative follow-up was 14 months (range 12–18 months).

Radiographic union was achieved in all 22 patients. The mean time to union was 17 weeks.

Two patients developed complex regional pain syndrome and were treated accordingly. No implant loosening, loss of reduction, or hardware failure was observed.

After union, the mean scapholunate angle was 44° (range 38–49) and the mean radiolunate angle was 8° (range 5–11). Mean wrist range of motion was 66° (range 50–80) for extension and 71° (range 55–90) for flexion.

The median preoperative Mayo Wrist Score was 70.5 (range 50–85). At 12 months postoperatively, the median Mayo Wrist Score was 90.5 (range 72–95). According to Mayo categories, results were excellent in 13 (59.1%) patients, good in 6 (27.3%), and fair in 3 (13.6%); no patients had poor outcomes (Table 2).

Discussion

The aim of delayed union and nonunion treatment after scaphoid fracture is to improve nonunion fracture site, prevent carpal collapse and stabilize fracture line. Proper treatment improves joint movement and prevents the progression of osteoarthritis (14). Currently available techniques include non-vascular bone graft, vascularized bone grafting and open internal fixation and percutaneous internal fixation methods. Any surgical treatment for scaphoid should be approached carefully and patients should be informed about potential risks such as preoperative infection, ankylosis and persistent nonunion. In recent studies, stable percutaneous fixation methods have become popular without the need for grafts in patients with scaphoid delayed union and nonunion. In order to apply this method, the scaphoid cartilage surface must

be intact, the fracture line must be in the waist or distal pole of the scaphoid, there must not be any advanced level of sclerosis and cystic formation, avascular necrosis must be zero or minimum or the scapholunate angle must be close to normal (15,16). The advantages of the percutaneous fixation method are continuous blood flow to the scaphoid, the aesthetics of scar tissue and shorter union time (15). Since we had no experience in

percutaneous fixation, we performed open reduction and screw fixation in Grade III and Grade IV patients and found that all patients were fully recovered (Table 3).

When compared to percutaneous fixation, the worst disadvantage was the presence of a scar. Scaphoid pseudoarthrosis rates cannot be determined precisely because of the patients who are asymptomatic or have few symptoms. In symptomatic patients, treatment is essential for preventing scaphoid collapse and arthrosis of the wrist (17,18). Immobilizing the scaphoid with a cast for acute scaphoid fractures for a long term, percutaneous or open-screw osteosynthesis treatment for young and active athletes are still very common and researchers have published promising results (19-22).

When we look at the history for the treatment of scaphoid pseudoarthrosis, many different methods are presented. In 1928, Adams and Leonard have been the first researchers who have used and suggested the use of bone grafting in scaphoid pseudoarthrosis. In their study, they have only used autografts and have not performed internal fixation (23). In 1935, Cole and Williamson have suggested that treatment with bone grafting without any internal fixation can help recovery but it is not recommended for routine procedure (24). Since 1943, bone grafting and internal fixation have been used for scaphoid pseudoarthrosis. In 1940s and 1950s, Matti and Russe have developed surgical methods for scaphoid fractures and have had important improvements in bone grafting with internal fixation (25,26). In 2001, Shin and Bishop have reported successful results for proximal pole scaphoid fractures by using vascularized bone grafts which still remain popular today (27). Despite all these developments, there are still some contradictions in treatment of scaphoid pseudoarthrosis about the graft donor site, nonunion, immobilization time, complete union time and full recovery. In our study, two patients who admitted to our clinic did not permit for harvesting bone grafts, so only curettage of the scaphoid and internal fixation were performed. After 6 weeks of immobilization, a significant improvement in scaphoid was observed at 12th week control. We used this method in Grade III and IV scaphoid fractures and observed complete union in all patients. To our knowledge, there are no studies in the literature that has performed osteosynthesis with only debridement-cannulated compression screw without the use of bone grafts in the pseudoarthrosis area.

The most popular classifications of the scaphoid fractures are those defined by Russe in 1960 (13) and Herbert in 1984 (28). Russe has classified the

Table 1: Descriptive and Characteristic Data of Patients

Variable	Women (n = 2)	Men (n = 20)	p value
Age (Mean $\pm$ SD)	22.5 $\pm$ 2.12	28.4 $\pm$ 5.91	0.181
Fracture side (R/L)	2/0	11/9	0.338
Slade type (III/IV)	2/0	13/7	0.455
Fracture area (C/D)	2/0	16/4	0.662
Cause: Sports injury	0	7 (31.8%)	0.167
Cause: Traffic accident	0	3 (13.6%)	
Cause: Work accident	1 (50%)	1 (9.1%)	
Cause: Fall	1 (50%)	9 (45.5%)	

*R: right; L: left; C: corpus (waist/shaft); D: distal pole

Table 2: Mayo Wrist Score Categories (Preoperative vs Postoperative)

Category	Preoperative, n (%)	Postoperative, n (%)
Excellent (90–100)	0	13 (59.1)
Good (80–89)	4 (18.1)	6 (27.3)
Fair (60–79)	12 (54.6)	3 (13.6)
Poor (<60)	6 (27.3)	0

P value (overall comparison): 0.001

Table 3: Comparison With Selected Published Studies of Screw Fixation Without Graft

Study	Approach	Patients (n)	Union rate (%)	Mean union time (weeks)	Complications
Kim et al., 2010	Percutaneous	12	100	11	None
Hegazy, 2015	Percutaneous	21	100	14	None
Slade et al., 2003	Percutaneous	15	100	14	None
Somerson et al., 2015	Open	14	86	17	Two patients required revision
Present study	Open	22	100	17	None

fractures according to their plane orientation like transverse, horizontal and oblique. Herbert's classification is more popular as it is more practical and manageable in daily use. It is based on classifying the fracture according to its shape, location and union status. Slade classification is only used in scaphoid pseudoarthrosis which covers the time beginning with the first fracture nonunion, through the arthrosis of the wrist which is the worst complication of the fracture. It also classifies the severity of avascular necrosis in fracture line and the late complications (8). We think that, as a surgical guide, the Slade classification is the most useful system in scaphoid nonunions. In our study, we used the Slade classification. All patients included in the study were Grade III and IV patients and had a complete union. One of the limitations of our study is that we did not include Grade V and VI patients in the study.

Another limitation is excluding the proximal pole scaphoid fractures. Positive results have been reported on improvement in wrist functions of the patients who underwent scaphoid pseudoarthrosis surgery (29-33). In these studies, the average Mayo wrist scores were reported between 85-90. In our study, the average wrist score was 88 which is consistent with the previously published reports. According to the Mayo index, the results were excellent in 13 and good in 6 patients.

A variety of internal fixation devices are used in scaphoid fracture surgery. The initial applications of scaphoid fracture surgery have been performed with K-wire fixation. However, Stark and Fernandez have reported that K-wires cannot fix adequately and they have encountered complications due to the loss of fixation (34,35). In 1980s, Herbert invented the double threaded compression screw bearing his own

name which helped stability in internal fixation procedures and reported good results (28). In the following period, cannulated compression screws have been developed to reduce screw fixation problems. Several researchers have reported that the cannulated compression screw provides better compression and stability than the Herbert screw (36,37). In our study, we used the fully threaded cannulated compression screw and found better stable fixation and compression in the fracture line. In follow-ups, there was no loss of reduction or loosening around the screw. We suggest that cannulated compression screws can be preferred because of the successful results obtained in scaphoid fracture surgery. Langhoff et al. have reported that the treatment of scaphoid fractures after one month of immobilization (Slade Grade I) alone have resulted in poor outcomes. It has been reported that rigid fixation without the use of grafts yields better results in treatment of these types of fractures (38). Barton and Shah and Jones have shown that Slade Grade II fibrous scaphoid nonunions can heal with rigid fixation and without the use of bone grafts (14,39). Ledoux et al. and Wozasek and Moser have reported that the rate of union with rigid fixation was 70% in stable nonunions with necrosis and bone resorption below 1 mm (40). Slade et al. have reported that Grade III patients may not require bone grafts and that patients with grade IV pseudoarthrosis need to use grafts (41). In our study, we included the patients with Grade III and IV and achieved complete recovery without using any grafts. We did not find any study in literature about graft-free treatment especially in grade IV patients. In this study, open reduction and use of compression screws without bone grafts suggest that osteosynthesis may be an option for scaphoid nonunions in selected patients. Clinical and radiological healing was achieved in all 22 patients. Further studies are needed to evaluate the prognostic factors and compare them with current gold standard treatment. Thus, morbidity associated with the graft area can be avoided.

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