

Is Bone Grafting Unnecessary in the Treatment of Cystic Scaphoid Pseudoarthrosis?

Je kostní štěp nezbytný při léčbě cystické pseudoartrózy skafoidea?

E. C. ZENGİN¹, H. ERTEM² MD, S. SARUHAN³, T. ÖZTÜRK¹, M. SENER⁴

¹ Department of Orthopaedics and Traumatology, Tokat Gaziosmanpaşa University, Tokat, Turkey

² Department of Orthopaedics and Traumatology, Mus State Hospital, Mus, Turkey

³ Department of Orthopaedics and Traumatology, Bozyaka Training and Research Hospital, İzmir, Turkey

⁴ Private Clinic, İzmir, Turkey

ABSTRACT

PURPOSE OF THE STUDY

The basic aim of the treatment of cystic nonunion is to provide stable fixation and mechanical compression to increase union, but there is no consensus on whether to perform bone grafting in the cystic area or not. The aim of this study was to compare the clinical and radiological results of patients with cystic scaphoid non-union who received open grafting, and internal fixation and those treated with percutaneous fixation without grafting.

MATERIAL AND METHODS

A retrospective evaluation was made of patients included those determined radiologically with Slade and Dodds grade IV scaphoid cystic non-union. Two different surgical procedures were performed. Percutaneous screw fixation was carried out on the patients in group 1. Open curettage-grafting and screw fixation were performed on the patients in group 2. Group 1 was comprised of 16 patients treated with percutaneous screw fixation, and group 2 was comprised of 17 patients who had open curettage-grafting and screw fixation.

RESULTS

In the radiological evaluation at the final follow-up examination, union was determined in 12 of the 16 (75%) patients in group 1 and 15 of the 17 (88%) patients in group 2. There was no statistically significant difference between the two groups in terms of union, functional outcomes and complication rates.

DISCUSSION

In the current study, the union rate was higher in the patients who had open curettage-grafting and fixation with a headless screw (88%) than in those with percutaneous screw without grafting (75%), but the difference was not determined to be statistically significant. The union rate of the group that received grafting was similar to the rates reported in the literature.

CONCLUSIONS

We think that both of these techniques may be successfully used for cystic scaphoid nonunions but percutaneous technique should be preferred as it is minimally invasive. Nevertheless, there is a need for further prospective, randomised studies with larger series to have better comparisons.

Key words: scaphoid bone, nonunion, fracture fixation, internal, bone grafting, bone screws.

INTRODUCTION

Approximately 10% of all scaphoid fractures result in nonunion, which is associated with factors such as the localisation of the fracture, degree of displacement, and time of starting the treatment (5). The scaphoid is a bone predisposed to nonunion because of its anatomical characteristics (14). These factors are that the blood flow necessary for feeding is retrograded to a high degree; secondary bone healing does not occur, as it is mostly covered in cartilage; there are greater deforming forces because of localisation; and there is a negative effect of joint fluid on fracture healing (14). The treatment of scaphoid fractures, which is always difficult, is further complicated when there is

non-union (14). The failure rate in patients undergoing operation for nonunion varies between 25% and 45% (2, 8, 12).

Scaphoid nonunions are classified in different categories. In the literature, classification according to anatomical location or specific clinical terms such as stable, unstable, fibrous, sclerotic, pseudoarthrosis, avascular, and humpback deformity has been used (6, 15). Slade and Dodds graded scaphoid nonunions from I to VI according to the amount of bone resorption in the fracture interface. This classification is extremely useful in guiding the treatment of scaphoid nonunion. According to this, patients with bone resorption of 1 to 5 mm in the fracture line, cyst formation, and preserved scaphoid alignment are classified as grade IV (14).

The basic aim of the treatment of cystic nonunion is to provide stable fixation and mechanical compression to increase union, but there is no consensus on whether to perform bone grafting in the cystic area or not. Slade and Dodds stated that fixation with a compressive screw alone is not sufficient in patients with cystic nonunion, and grafting is necessary, as there is a wide devitalised bone area. They reported that open, percutaneous, or minimally invasive techniques can be used for grafting (14). In contrast, there are also views that union can occur in patients with cystic nonunion receiving mechanical stabilisation only, without grafting around the nonunion line (4, 10). There is no clear information in the literature about how much bone resorption in the fracture line requires grafting.

The aim of this study was to compare the clinical and radiological results of patients with Slade and Dodds grade IV scaphoid nonunion who received open grafting, and internal fixation and those treated with percutaneous fixation without grafting.

MATERIAL AND METHODS

This study was approved by the Local Ethics Committee. A retrospective evaluation was made of patients who presented with scaphoid nonunion between 2013 and 2018. The patients included those determined radiologically with Slade and Dodds grade IV scaphoid nonunion (bone resorption in nonunion interface $5 > \text{mm}$, cyst formation, and maintained scaphoid alignment), and no arthritis despite having at least 6 months passed since the injury (2). All the patients were evaluated preoperatively in terms of the amount of bone resorption, presence of cyst formation, and presence of scaphoid alignment using computed tomography (CT) scans taken with 1 mm slice thickness together with posteroanterior (PA), lateral, and ulnar deviation radiographs. The patients were examined for the presence of avascular necrosis (AVN) in the scaphoid fragments via magnetic resonance imaging (MRI). All radiological examinations were interpreted by a radiologist and a specialist hand surgeon. No AVN was confirmed with MRI in the patients. There was no concomitant ligament injury noted in any patient. Patients were excluded

from the study if they had a history of hand surgery, AVN in the scaphoid, or follow-up of less than 1 year. Proximal pole fractures were not included in the study to avoid a misleading result in union rates.

The operations were performed by two different surgeons. The first surgeon was carried out percutaneous screw fixation was carried out on the patients in group 1. The operation was performed under fluoroscopy. The volar or dorsal approach was preferred according to the fracture localization. A headless compression screw (Acutrak Mini; Acumed, Hillsboro, OR) 3.6 mm in width was applied to the scaphoid for fixation.

The second surgeon was carried out open curettage-grafting and screw fixation were performed on the patients in group 2. Debridement was carried out on the pseudoarthrosis line with volar approach. In all the patients, the space remaining after debridement was filled with a cancellous graft taken from the iliac wing with a mini-incision. Then, screw fixation was performed in the same way as for the patients in group 1.

Patients in group 1 were followed up for 4 weeks with splint, and patients in group 2 were followed up for 6 weeks with a thumb-supporting brace, and then a splint was applied for 4 weeks.

Radiographic evaluation was made at 4 weeks postoperatively and then at 1-month intervals until union was observed. Union was evaluated as the occurrence of trabeculae crossing the fracture line and absence of sensitivity. The patients considered to have radiological union were confirmed on CT.

At the final follow-up examination, functional evaluation of the patients was made by an independent researcher. Flexion-extension and ulnar-radial deviation were measured by a goniometer. Grip strength was measured with a Jamar hand dynamometer (model SH 5001; Saehan Corporation, Masan, South Korea). By measuring the operated and healthy hand in the same position, the comparative percentage was recorded. The functional results were assessed with the Disabilities of Arm, Shoulder, and Hand (DASH) score. The DASH scale consists of 30 multiple-choice questions with 5 possible responses per question. Of these items, 21 are related to the degree of difficulty in performing different physical activities, 6 to symptoms, and 3 to psycho-

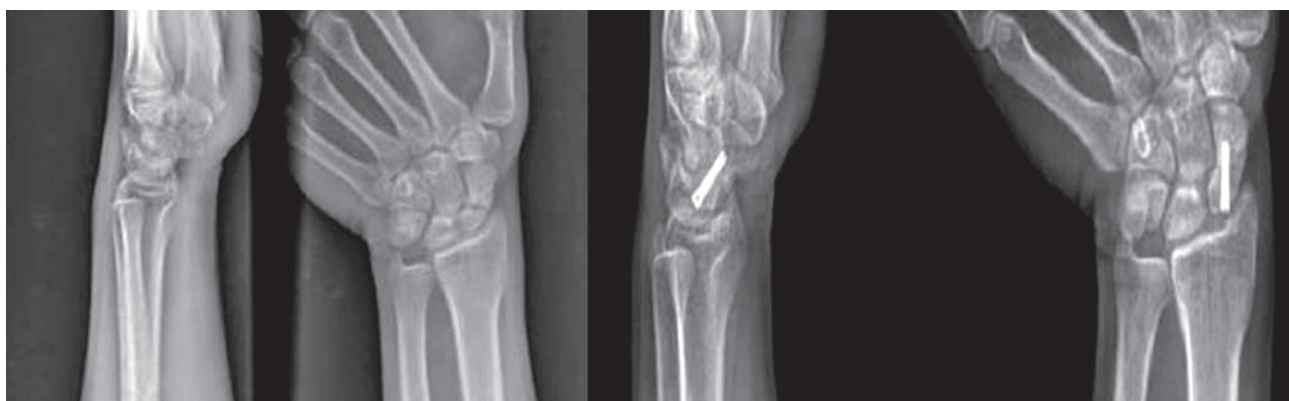


Fig. 1. Preoperative (left) and 14th week follow-up radiographs (right) of the patient treated with percutaneous screw.

social effects. The DASH score is measured on a scale of 0 to 100, with higher scores indicating greater disability.

Statistical evaluation

All of the statistical analyses were performed using SPSS Statistics for Windows version 15.0 (IBM Inc, Armonk, NY, USA). The categorical data were presented as the frequencies and percentages; with the normally distributed continuous data presented, as the mean with minimum and maximum values. The differences in the groups and fracture configurations were evaluated with chisquared tests, and the differences in the ages, ranges of motion, grip strengths, and DASH scores were assessed with Student's t-tests. In all of the analyses, $p < 0.05$ was set as statistically significant with a 95% confidence interval.

RESULTS

A retrospective evaluation was made of 33 patients who met the inclusion criteria of this study. Group 1 was comprised of 16 patients treated with percutaneous screw fixation, and group 2 was comprised of 17 patients who had open grafting and screw fixation. The fracture was in the dominant hand in 10 patients in group 1 and 7 patients in group 2. No significant difference was noted between the groups in terms of demographic characteristics (Table 1).

In the radiological evaluation at the final follow-up examination, union was determined in 12 of the 16 (75%) patients in group 1 and 15 of the 17 (88%) patients in group 2 ($P = 0.34$) (Figure 1,2). The mean time to union was 11.8 weeks (range, 8–17 weeks) in group 1 and 12.5 weeks (range, 9–17 weeks) in group 2 ($P = 0.41$). Union did not occur in 4 patients in group 1 and, 2 patients in group 2. No statistically significant difference was found between the groups with respect to the pre- and postoperative mean flexion range, extension range, grip strength, and DASH score (Table 2). The 4 patients in group 1 with nonunion had no complaints, so no second intervention was required. In two patients with nonunion in group 2, the screw was removed because of irritation after 16 and 24 months respectively.

No new surgery was planned as the patient's complaints regressed after screw removal. No infection developed in any patient, and no complications developed in the iliac wing related to graft harvesting.

DISCUSSION

In this study, a comparison was made between open grafting and screw fixation and closed percutaneous fixation without grafting in patients with cystic scaphoid nonunion. The results showed that union rates were higher in the group that received grafting, but the difference was not found to be statistically significant.

In the treatment of cystic scaphoid nonunion, "whether or not there is a need for grafting or for what size of cyst it is necessary" remains controversial. Another subject of debate is whether grafting should be applied closed (minimally invasive) or open (3, 4, 10, 14). In scaphoid nonunion where there is no evident bone resorption with sufficient perfusion, rigid fixation alone is sufficient. In the literature, there is agreement on percutaneous fixation in such patients (4, 10). These are patients with stable nonunion who present late (grade I), those with fibrous nonunion (grade II), or those with minimal sclerosis (grade III). There are studies in the literature that have reported union rates of 100% with percutaneous screw fixation only, using the dorsal or volar approach (4, 10, 14). Kim et al. obtained union with percutaneous screw fixation in all 12 patients with grade I nonunion and in all 21 patients with Hegazy grade II to III non-union (7, 9).

Unlike stable nonunions, there is no consensus in the literature in the treatment of cystic nonunions. If the scaphoid nonunion fragment is well perfused but there is substantial bone loss (2–10 mm) without substantial flexion deformity (grades IV and V), then bone grafting is recommended in addition to rigid fixation to achieving union. It has been reported that when grafting is performed on patients with Slade and Dodds cystic nonunion, bridging develops in the trabecular bone as a result of healing occurring towards the graft from the bone fragments, which are vitalised with vascular penetration (14). In a study by Mani and Acharya, 31 patients with cystic nonunion were treated with cancellous



Fig. 2. Preoperative (left) and 12th week follow-up radiographs (right) of the patient treated with open grafting and screw fixation.

grafts from the distal radius and fixation with a headless screw. Union was obtained at the rate of 93.3%, and it was reported that the key factors for successful union were the excision of sclerotic bone tissue and application of rigid fixation after grafting with a matrix that had both osteoinductive and -conductive properties (11).

In contrast, there are also studies that have reported that union can occur in cystic scaphoid (grade IV–V) nonunion by reducing the stress in the nonunion line with mechanical stabilisation only without grafting. Capo et al. reported that fixation alone could be sufficient in grade IV non-union (4). In a study by Mahmoud et al. of 13 grade IV (<5 mm) and 14 grade V (>5 mm) patients, percutaneous screw fixation was performed using the volar approach without grafting, and union was obtained in all patients at means 12.5 and 10.8 weeks, respectively. It was also stated that union could be obtained in cystic nonunion without the need for grafting, independently of the gap size. However, although high union rates were reported in this study, only fractures in the waist region were included, not proximal pole fractures (10).

Ikeda et al. categorised scaphoid nonunions into three groups: linear, cystic, and sclerotic or displaced. According to this classification, the cystic type was the equivalent of Slade IV to V. In 24 patients with cystic nonunion in the study, union was obtained in 85% of 7 patients who had open curettage and cancellous grafting and in 82% of 17 patients who received percutaneous screw fixation without grafting. Ultrasound wave therapy was performed on patients who received percutaneous screw fixation to accelerate union. As there was no statistically significant difference found between the groups, it was reported that grafting was not necessary in cystic non-union (8).

In the current study, the union rate was higher in the patients who had open curettage–grafting and fixation with a headless screw (88%) than in those with percutaneous screw without grafting (75%), but the difference was not determined to be statistically significant. The union rate of the group that received grafting was similar to the rates reported in the literature.

Open curettage–grafting has been in use for many years in the treatment of scaphoid non-union. The advantages of this technique are that fracture fragments can be directly visualised, debridement of the nonunion line can be applied comfortably, and if there is a deformity, it can be directly corrected. However, there are also disadvantages of increased morbidity related to the graft taken from the iliac wing, prolonged operating time, ligament injury, and greater soft tissue dissection leading to decrease vascular perfusion of the scaphoid, which is already weak (11, 17). The treatment of scaphoid nonunion with a minimally invasive approach has become more popular in recent years (1, 2, 13, 16). The advantage of this approach is that because of the minicision, less stiffness develops in the joint postoperatively, and more aesthetic scar tissue is obtained with-

out devascularisation of the scaphoid. However the use of the closed grafting technique in patients with cystic nonunion is limited because only a part of the pseudoarthrosis line can be cleaned and the cyst cannot be sufficiently filled with graft. Also the technique requires the frequent use of fluoroscopy and the learning curve is long (13,16). When the open and closed groups in the current study were compared in terms of grip strength and joint movement range, the results of the closed group were found to be better, but the difference was not statistically significant. In addition, no statistically significant difference was noted between the groups in terms of the DASH score. When the time to union was examined in a series of 27 cases of cystic nonunion, Mahmoud et al. reported mean 11.6 weeks following percutaneous screw fixation. Similarly, Capo et al. obtained a radiological union at mean 12 weeks in a series of 12 patients (4, 10). Consistent with these findings in the literature, the mean time to union was 12.1 weeks in the current study.

The limitations of this study are that it was retrospective in design; the number of patients was low and the operations were performed by two different surgeons.

CONCLUSIONS

In conclusion, there is no difference between open grafting and fixation and percutaneous fixation without grafting in the treatment of cystic scaphoid non-union. We think that both of these techniques may be successfully used for cystic scaphoid nonunions but percutaneous technique should be preferred as it is minimally invasive. Nevertheless, there is a need for further prospective, randomised studies with larger series to have better comparisons.

References

1. Aydin U, Thirkannad SM. Internal bone grafting for the treatment of scaphoid nonunions. *Tech Hand Up Extrem Surg.* 2017;21:18–21.
2. Bokhari S, Hadi S, Hossain F, Ketzer B. The outcome of using a jamshidi biopsy trocar needle in a novel technique for bone grafting in percutaneous internal fixation of scaphoid nonunion. 2018;12:506–510.
3. Barton NJ. Experience with scaphoid grafting. *J Hand Surg Br.* 1997;22:153–160.
4. Capo JT, Orillaza NS Jr, Slade JF 3rd. Percutaneous management of scaphoid nonunions. *Tech Hand Up Extrem Surg.* 2009;13:23–29.
5. Dias JJ, Brenkel IJ, Finlay DB. Patterns of union in fractures of the waist of the scaphoid. *J Bone Joint Surg Br.* 1989;71:307–310.
6. Filan SL, Herbert TJ. Herbert screw fixation of scaphoid fractures. *J Bone Joint Surg Br.* 1996;78:519–529.
7. Hegazy G. Percutaneous screw fixation of scaphoid waist fracture nonunion without bone grafting. *J Hand Microsurg.* 2015;7:250–255.
8. Ikeda K, Osamura N, Tomita K. Percutaneous screw fixation without bone graft for cystic-type scaphoid fractures. *J Trauma.* 2008;65:1453–1458.

9. Kim JK, Kim JO, Lee SY. Volar percutaneous screw fixation for scaphoid waist delayed union. *Clin Orthop Relat Res.* 2001;468:1066–1071.
10. Mahmoud M, Koptan W. Percutaneous screw fixation without bone grafting for established scaphoid nonunion with substantial bone loss. *J Bone Joint Surg Br.* 2011;93:932–936.
11. Mani KCK, Acharya P. Scaphoid nonunion: does open reduction, bone grafting and Herbert screw fixation justify the treatment? *Int Orthop.* 2018;42:1099–1106.
12. Merrell GA, Wolfe SW, Slade JF 3rd. Treatment of scaphoid nonunions: quantitative meta-analysis of the literature. *J Hand Surg Am.* 2002;27:685–691.
13. Ohta S, Ikeguchi R, Noguchi T, Kaizawa Y, Oda H, Yurie H, Matsuda S. Percutaneous fixation for scaphoid nonunion with bone grafting through the distal insertion hole of fully threaded headless screw. *J Hand Surg Asian Pac Vol.* 2016;21:357–363.
14. Slade JF 3rd, Dodds SD. Minimally invasive management of scaphoid nonunions. *Clin Orthop Relat Res.* 2006;445:108–119.
15. Slade JF 3rd, Geissler WB, Gutow AP, Merrell GA. Percutaneous internal fixation of selected scaphoid nonunions with an arthroscopically assisted dorsal approach. *J Bone Joint Surg Am.* 2003;85:20–32.
16. Somerson JS, Fletcher DJ, Srinivasan RC, Green DP. Compression screw fixation without bone grafting for scaphoid fibrous nonunion. *Hand (N Y).* 2015;10:450–453.
17. Stark A, Brostrom LA, Svartengren G. Scaphoid nonunion treated with Matti-Russe technique. Long-term results. *Clin Orthop Relat Res.* 1987;214:175–180.

Corresponding author:

Eyup Cagatay Zengin, MD
Department of Orthopaedics and Traumatology
Izmir Katip Celebi University
Basin Sitesi 35160
Izmir, Turkey
E-mail: zengincagatay@hotmail.com