

Results of Iliac Bone Graft with Kirschner Wire Fixation for Scaphoid Nonunions

Byoung Jin Kim¹, Gil Hwan Lim²,
Myung Sun Kim²

¹Department of Orthopedic Surgery, Sunhan Hospital, Gwangju, Korea

²Department of Orthopedic Surgery, Chonnam National University Hospital, Chonnam National University Medical School, Gwangju, Korea

Received: March 22, 2017

Revised: [1] May 3, 2017
[2] June 4, 2017

Accepted: June 24, 2017

Correspondence to: Myung Sun Kim
Department of Orthopedic Surgery, Chonnam National University Hospital, Chonnam National University Medical School, 42 Jebong-ro, Dong-gu, Gwangju, 61469, Korea
TEL: +82-62-227-1640
FAX: +82-62-225-7794
E-mail: mskim@jnu.ac.kr

This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/3.0/>) which permits unrestricted noncommercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

Purpose: To determine clinical and radiographic results of iliac bone grafting with Kirschner wire fixation for treatment of scaphoid nonunions.

Methods: A total of 13 patients who had scaphoid nonunion treated with iliac bone grafting and Kirschner wire fixation between October 2007 and January 2016 were enrolled as subjects of this study. Their clinical results were evaluated, including range of motion of the wrist joint and modified Mayo wrist score. Radiographic results including lateral intrascaphoid angle and scapholunate angle were also assessed.

Results: Bony union was achieved in 11 (84.6%) of 13 cases. Modified Mayo wrist score was improved from 64.0 preoperatively to 87.5 postoperatively. Average intrascaphoid angle was improved from 39.5° preoperatively to 27.2° postoperatively while scapholunate angle was improved from 66.0° preoperatively to 55.1° postoperatively.

Conclusion: Iliac bone graft with Kirschner wire fixation provided good clinical and radiographic results. Therefore, iliac bone graft with Kirschner wire fixation can be considered as a good treatment option for scaphoid nonunion.

Keywords: Scaphoid, Nonunion, Kirschner wire, Bone graft

INTRODUCTION

Despite scaphoid fractures are primarily recognized and treated appropriately, nonunion may occur in 5% to 15% of scaphoid fractures¹. Scaphoid nonunion can be predisposed to premature carpal arthrosis and long-term disability^{2,3}. And long-term follow-up after untreated scaphoid nonunion has shown radiological osteoarthritis⁴.

Various surgical methods have been presented for

scaphoid nonunion. However, the ideal treatment for scaphoid nonunion remains uncertain⁵⁻⁷. Usually, bone graft and internal fixation are conventional treatment for scaphoid nonunion. Commonly used internal fixation devices include Kirschner (K) wires and compression screws⁸⁻¹⁰. While compression screw can achieve a high predictability of bone union (80%–90%)⁷, some disadvantages were described in previous report. When scaphoid nonunion is treated with corticocancellous bone graft

and screw fixation, there is difficulty in dealing with cavitory defects in established scaphoid nonunions¹¹. Because compression screw devices can further split the graft material or cause the graft to displace, it can result in malreduction, graft failure, and finally union failure.

Although compression screw showed more stable than K-wires fixation on biomechanical study¹², several studies showed similar clinical results between compression screw and K-wires¹³⁻¹⁵.

The purpose of this study was to evaluate the clinical and radiographic results of iliac bone grafting with K-wire fixation for treating scaphoid nonunion.

MATERIALS AND METHODS

Of 98 patients who underwent surgical treatment because of scaphoid nonunion between January 2007 and January 2016, 13 patients with scaphoid nonunion who were treated with iliac bone graft and K-wire fixation were retrospective reviewed. We usually use the iliac bone graft and compression screw fixation for scaphoid nonunion. When the nonunion site showed large cavitory defect or failure after screw fixation, we considered the use of K-wire fixation. Medical records of patients including gender, age, symptoms, follow up duration, and operative and radiological data were reviewed. The inclusion criteria were: (1) a nonunion of the scaphoid with duration of at least six months, (2) patient with followed up of more than 12 months. All patients had plain radiographs, preoperative computed tomography (CT) scans, and postoperative CT scans. The exclusion criteria were: (1) patient treated with compression screw or combination of compression screw and K-wire, (2) patient that treated with vascularized bone graft because of avascular necrosis.

Functional evaluation was performed using the modified Mayo wrist scoring system. Range of motion (ROM), grip strength, and pain were measured. Range of motion was measured using goniometer. It was compared to that of the contralateral side. Maximal grip strength of the injured side was measured and reported as a percentage of maximal strength of the contralateral side. Pain scale was

self-reported and graded using a questionnaire. In addition to satisfaction score, a medication of the Mayo Wrist Scoring Chart was used for functional assessment, allowing for a total of 100 points for four categories.

Measurements of both preoperative and postoperative radiographs and CT scans were comparatively reviewed. Assessments were made on posteroanterior (PA) views of neutral and deviation position and lateral views with the forearm in neutral rotation. Severity of collapse was measured based on intrascaphoid (IS) angle¹⁶ and scapholunate (SL) angle¹⁷ on CT. Fracture union was defined according to the criteria described by Dias¹⁸ and assessed at final follow-up from radiographs or with CT scans if the radiological appearances were inconclusive.

1. Surgical technique and postoperative management

Surgical procedure was carried out under general anesthesia. The scaphoid was approached through the volar aspect by a longitudinal incision along the radial border of the flexor carpi radialis. Longitudinal capsulotomy was done to expose the scaphoid. The fibrous nonunion of the scaphoid was debrided and the necrotic tissue was removed. The distal part of the scaphoid was curetted to obtain a vascularized bed. The scaphoid humpback deformity was realigned by insertion of a wedge-shape bone graft from the iliac crest. Two or three of 1.4 mm K-wire s were drilled from the scaphoid tubercle through the bone block and into the proximal pole. Reduction and the position of the pin were controlled with a fluoroscope. The wrist was immobilized for two weeks in a below-elbow thumb spica splint with the thumb in abduction, leaving the interphalangeal joint free. After that, short-arm thumb spica cast was worn for an additional of eight weeks. At postoperative 10 to 12 weeks, if radiographs looked satisfactory, then K-wire s were removed under local anesthesia in the theater. Patients were permitted to resume normal activities for daily living at 12 weeks postoperatively.

2. Statistical analysis

All statistical analysis was performed using IBM SPSS ver. 21.0 (IBM Corporation, Somers, NY, USA). Descriptive

statistics were reported as mean and standard deviation (SD) for continuous variables and number (and percentage where possible) for discrete assessments. Comparisons between preoperative and postoperative outcomes were analyzed using paired t-test. A p-value of less than 0.05 was considered statistically significant.

RESULTS

There were 13 males with a mean age of 30.2 years (range,

13 to 57 years). The mean time from injury to operation was 22.2 months (range, 7 to 72 months). Mean follow-up duration was 15.6 months (range, 12 to 24 months).

Bony union was achieved in 11 (84.6%) of 13 patients. The mean preoperative ROM was 62.5° (SD, 11.5°) for extension and 72.5° (SD, 12.7°) for flexion. Postoperative ROM was improved to a mean of 64.0° (SD, 13.5°) for extension and 74.2° (SD, 15.7°) for flexion. However, there was no statistical difference between preoperative ROM and postoperative ROM. The modified Mayo wrist score

Table 1. Clinical and radiological results

Clinical and radiological result	Preoperative	Postoperative (last follow-up)	p-value
Wrist flexion	72.5±12.7	74.2±15.7	>0.05
Wrist extension	62.5±11.5	64.0±13.5	>0.05
Modified Mayo score	64.0±8.3	87.5±9.7	<0.05
Intrascaphoid angle	39.5±12.5	27.2±5.9	<0.05
Scapholunate angle	66.0±8.5	55.1±7.8	<0.05



Fig. 1. (A) Preoperative radiograph showing nonunion of the distal third of the scaphoid. (B) Postoperatively radiograph after bone graft and fixation with K-wires. (C) Radiograph at 3 months after surgery showing complete bony union and K-wire migration. (D) Radiograph showing complete bony union after K-wires removal.

was significantly ($p < 0.05$) improved from 64.0 (SD, 8.3) preoperatively to 87.5 (SD, 9.7) postoperatively. Excellent results were obtained in 6 (46.2%) patients, good results were achieved for 5 (38.5%) patients, and fair results were obtained for 2 (15.3%) patients. The lateral intrascaphoid angle measured on follow-up CT was significantly improved from 39.5 (SD, 12.5) preoperatively to 27.2 (SD, 5.9) at the final follow up (normal, $< 35^\circ$). The scapholunate angle was also significantly improved from 66.0 (SD, 8.5) preoperatively to 55.1 (SD, 7.8) at final follow up (normal, $< 35^\circ$) (Table 1).

Complications occurred in six patients. Nonunion after treatment was occurred in two patients. Although they complain the pain and functional discomfort, they did not want to another operation and follow up was loss. In three patients, K-wire migration was found on radiograph. Although K-wire migration was shown, these patients obtained bony union of the nonunion site. After K-wire removal, there was no discomfort at the operation site (Fig. 1). One patient showed refracture after slip down.

DISCUSSION

The goal of surgical management of scaphoid nonunion is to improve wrist function. This includes bony union and restoring scaphoid alignment for functional improvement. It is known that re-establishment of the scaphoid length can relieve pain, improve grip strength and prevent degenerative changes¹⁷. To achieve these goals, a number of surgical approaches are available, including bone grafting, internal fixation, or a combination of both¹¹.

Commonly used internal fixation devices include K-wires and variable compression screw⁸⁻¹⁰. K-wires are easy to insert and remove. It can provide satisfactory stability. However, K-wires are unable to provide compression at the fracture site. In addition, there is a need for extended postoperative immobilization which may lead to wrist stiffness. There are many different compression screws available to help achieve stable fixation when treating scaphoid nonunions. Usually, compression

screws are cannulated, and headless screw. The cannulated aspect allows for easy insertion. Since the screw is headless, it may be buried under the articular surface. However, compression screw can further split the graft material or cause the graft to displace. Also, compression devices can cause the scaphoid shorten, which is undesirable for subsequent wrist mechanics.

Based on biomechanical stability study, compression screw can increase the strength of fixation and stiffness when compared to K-wires. Panchal et al.¹² have studied the relative biomechanical stability of three types of internal fixation (Standard Acutrak screw, Mini-Acutrak screw, a pair of parallel 0.045-inch K-wires) with cancellous bone graft in a cadaveric scaphoid nonunion model. They concluded that Standard Acutrak screw might be a better option followed by the Mini-Acutrak screw and a pair of parallel 0.045-inch K-wires when treating scaphoid nonunions. Although compression screw was more stable than K-wires fixation in the biomechanical study, several clinical studies have shown similar results between compression screw and K-wires with union rates ranging from 55% to 97%¹³⁻¹⁵. The overall union rate of scaphoid nonunion treated by Herbert screw and bone grafting was 84%¹⁹. Our result (84.6%) are comparable with those of other studies of both K-wire and screw.

K-wire fixation technique has several advantages. K-wires occupy less of uniting surface area than a compression screw. This is a significant advantage in the context of difficult fracture healing seen in cavity scaphoid nonunions. In addition, inadequately placed K-wires can be easily repositioned with minimal removal of bone. Moreover, two or three K-wires can increase the rotational stability on nonunion site when compared to one compression screw. Because of these advantages, K-wire fixation is considered a useful method for scaphoid nonunion. However, K-wire has also several disadvantages when we comparing with compression screw. It can be unable to provide compression at the fracture site. In addition, there is a need for extended postoperative immobilization which may lead to wrist stiffness.

This study has several limitations. First, the number of patients included in this study was small. In addition, the

follow up period was relatively short. Moreover, we did not perform MRI to identify cases with avascular necrosis, which might affected the pathogenesis of nonunion and how to treat it. In addition, our study was a retrospective study. Nonetheless, this study revealed that iliac bone graft with K-wire fixation could provide good clinical and radiographic results for scaphoid nonunion.

CONCLUSION

In conclusion, when there is difficulty in dealing with cavitory defects and small fragment in established scaphoid nonunion, bone graft from the iliac crest and internal fixation with K-wire is a good treatment option. And the result is comparable with compression screw.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

REFERENCES

1. Cooney WP, Linscheid RL, Dobyns JH. Scaphoid fractures: problems associated with nonunion and avascular necrosis. *Orthop Clin North Am.* 1984;15:381-91.
2. Mack GR, Bosse MJ, Gelberman RH, Yu E. The natural history of scaphoid non-union. *J Bone Joint Surg Am.* 1984;66:504-9.
3. Ruby LK, Leslie BM. Wrist arthritis associated with scaphoid nonunion. *Hand Clin.* 1987;3:529-39.
4. Singh HP, Taub N, Dias JJ. Management of displaced fractures of the waist of the scaphoid: meta-analyses of comparative studies. *Injury.* 2012;43:933-9.
5. Buijze GA, Ochtman L, Ring D. Management of scaphoid nonunion. *J Hand Surg Am.* 2012;37:1095-100.
6. Gabl M, Reinhart C, Lutz M, et al. Vascularized bone graft from the iliac crest for the treatment of nonunion of the proximal part of the scaphoid with an avascular fragment. *J Bone Joint Surg Am.* 1999;81:1414-28.
7. Munk B, Larsen CF. Bone grafting the scaphoid nonunion: a systematic review of 147 publications including 5,246 cases of scaphoid nonunion. *Acta Orthop Scand.* 2004;75:618-29.
8. Trumble T, Nyland W. Scaphoid nonunions: pitfalls and pearls. *Hand Clin.* 2001;17:611-24.
9. Chen CY, Chao EK, Lee SS, Ueng SW. Osteosynthesis of carpal scaphoid nonunion with interpositional bone graft and Kirschner wires: a 3- to 6-year follow-up. *J Trauma.* 1999;47:558-63.
10. Tomaino MM, King J, Pizillo M. Correction of lunate malalignment when bone grafting scaphoid nonunion with humpback deformity: rationale and results of a technique revisited. *J Hand Surg Am.* 2000;25:322-9.
11. Kirkham SG, Millar MJ. Cancellous bone graft and Kirschner wire fixation as a treatment for cavitory-type scaphoid nonunions exhibiting DISI. *Hand (N Y).* 2012;7:86-93.
12. Panchal A, Kubiak EN, Keshner M, Fulkerson E, Paksima N. Comparison of fixation methods for scaphoid nonunions: a biomechanical model. *Bull NYU Hosp Jt Dis.* 2007;65:271-5.
13. Stark HH, Rickard TA, Zemel NP, Ashworth CR. Treatment of ununited fractures of the scaphoid by iliac bone grafts and Kirschner-wire fixation. *J Bone Joint Surg Am.* 1988;70:982-91.
14. Christodoulou LS, Kitsis CK, Chamberlain ST. Internal fixation of scaphoid non-union: a comparative study of three methods. *Injury.* 2001;32:625-30.
15. Finsen V, Hofstad M, Haugan H. Most scaphoid nonunions heal with bone chip grafting and Kirschner-wire fixation. Thirty-nine patients reviewed 10 years after operation. *Injury.* 2006;37:854-9.
16. Linscheid RL, Dobyns JH, Beabout JW, Bryan RS. Traumatic instability of the wrist: diagnosis, classification, and pathomechanics. *J Bone Joint Surg Am.* 2002;84:142.
17. Braga-Silva J, Peruchi FM, Moschen GM, Gehlen D, Padoin AV. A comparison of the use of distal radius vascularised bone graft and non-vascularised iliac crest bone graft in the treatment of non-union of scaphoid fractures. *J Hand Surg Eur Vol.* 2008;33:636-40.
18. Dias JJ. Definition of union after acute fracture and surgery for fracture nonunion of the scaphoid. *J Hand Surg Br.* 2001;26:321-5.
19. Gupta A, Risitano G, Crawford RJ, Burke FD. The ununited scaphoid: prognostic factors in delayed and nonunions of the scaphoid. *Hand Surg.* 1999;4:11-9.

자가 장골 이식술과 K-강선 고정술을 이용한 주상골 불유합의 치료

김병진¹ · 임길환² · 김명선²

¹선한 병원 정형외과, ²전남대학교 의과대학 정형외과학교실

목적: 주상골 불유합에서 자가 장골 이식술과 K-강선 고정술을 이용한 치료에서 임상적, 영상의학적 결과를 평가해 보고자 하였다.

방법: 2007년 10월부터 2016년 1월까지 자가 장골 이식술과 K-강선 고정술을 시행받은 환자 중 1년 이상 추시가 가능하였던 13명의 환자를 대상으로 하였다. 임상적 결과는 손목관절의 운동범위, Modified Mayo score를 이용하여 평가하였고, 영상의학적 결과는 측면 주상골내 각 및 주상 월상 각을 평가하였다.

결과: 총 13예 중 11예(84.6%)에서 골유합이 확인되었다. Modified Mayo score는 수술 전 64.0점에서 수술 후 87.5점으로 유의하게 향상되었으며 수술 전 및 수술 후 방사선 촬영상 확인한 주상골내 각 및 주상 월상각은 각각 수술 전 39.5°, 66.0°에서 수술 후 27.2°, 55.1°로 유의한 차이를 보였다.

결론: 주상골 불유합에서 자가 장골 이식술 및 K-강선 고정술은 좋은 임상적 및 영상의학적 결과를 보였고, 이를 바탕으로 신뢰할 수 있는 치료 방법의 하나로 생각된다.

색인단어: 주상골, 불유합, K 강선, 장골 이식술

접수일 2017년 3월 22일 **수정일** 1차: 2017년 5월 3일, 2차: 2017년 6월 4일

게재확정일 2017년 6월 24일

교신저자 김명선

광주광역시 동구 제봉로 42

전남대학교 의과대학 정형외과학교실

TEL 062-227-1640 **FAX** 062-225-7794

E-mail mskim@jnu.ac.kr