

Long-term results of vascularized os pisiform transfer for advanced Kienböck disease after follow-up for at least 15 years

A case series

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Abstract

No surgical procedure perfectly treats advanced Kienböck disease. Although vascularized os pisiform transferring (VOPT) is one of the main therapeutic approaches, reports on long-term follow-up and case series for this technique are scarce.

We collected postoperative results in 11 patients with advanced Kienböck disease who underwent VOPT between 1986 and 2001 in our Hospital. Follow-up durations ranged from 15 to 26 years.

At the last follow-up, excellent and good results were found in 81.8% according to the Modified Green and O'Brien score. Postoperative imaging revealed significantly reduced pisiform bone; carpal height ratio and Nattrass index were decreased, while the radioscapoid angle was increased, compared with preoperative and mid-term follow-up results.

The favorable long-term results demonstrated that VOPT is a dependable and durable procedure for the treatment of advanced Kienböck disease, with pain relief and functional improvement despite some radiographic findings such as wrist osteoarthritis occurrence.

Abbreviations: CT = computed tomography, MRI = magnetic resonance imaging, PRWE = Patient-Rated Wrist Evaluation, ROM = range of motion, SC = Scaphoid-Capitate fusion, SPSS = Statistic Package for Social Science, STT = Scaphoid-Trapezium-Trapezoid fusion, VAS = Visual analogue scale, VOPT = vascularized os pisiform transferring.

Keywords: clinical result, Kienböck disease, long-term follow-up, vascularized

1. Introduction

Avascular necrosis of the lunate bone was first described in detail by Kienböck based on X-ray manifestations and clinical symptoms in 1910, and coined Kienböck disease accordingly.^[1] Although Kienböck disease has been intensely assessed for diagnosis and treatment for more than a century, its etiology remains currently unclear. Kienböck disease is a continuous process, and the treatment difficulty lies in late pathological changes. The current techniques for regenerating vascular flow, termed vascularized bone grafting methods, are the mainstream therapies for advanced Kienböck disease.^[2,3] Multiple short-term^[4] or mid-term^[5] clinical trials have reported the usefulness

of vascularized bone grafting in patients with advanced Kienböck disease; meanwhile, few long-term clinical results are available,^[6] with follow-up no longer than 15 years. Since the first report of Saffar^[7] on Kienböck disease treatment with vascularized os pisiform transferring (VOPT), the procedure has become a useful approach for treating Kienböck disease affecting the wrist, due to its ability to relieve pain, improve grip strength, and enhance the range of motion. We have been leaders in treating Kienböck disease with VOPT since 1986, with good short-term and mid-term results. As an important part of a case series, the purpose of this study was to assess long-term clinical results of VOPT in patients with Lichtman stage IIIb-IV Kienböck disease.

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2. Materials and methods

2.1. Basic information

We performed a retrospective review of 13 patients who underwent VOPT for stage IIIb-IV Kienböck disease in our hospital between 1986 and 2001. Of the 13 patients, 1 died in an accident 12 years after surgery; 1 case was lost to follow up. The 11 cases who were followed up successfully for at least 15 years were enrolled in this study. The patients included 7 men and 4 women, with a mean age of 35 years (range, 19–56 years) at the time of surgery. Four patients had a history of wrist sprain, while the remaining 7 had unknown origins. There were 8 and 3 cases of dominant and nondominant hand, respectively. According to Lichtman^[8] staging, 9 patients were stage IIIb and 2 were stage IV; all of them complained of wrist pain, and decreased range of motion and grip strength (Table 1). This study was approved by the Human Ethics Committee of West China Hospital of Sichuan University.

Table 1**Preoperative basic characteristics on the study patients.**

Patient	Sex/age, y	Occupation	Lichtman Stage	Dominant hand	Injury history
1	M/34	Factory worker	IIIB	Yes	Yes
2	F/56	Housewife	IIIB	Yes	No
3	M/33	Trucker	IIIB	Yes	No
4	M/42	Baker	IIIB	No	No
5	F/24	Self-employed	IIIB	No	Yes
6	M/19	Military	IIIB	Yes	No
7	F/40	Housewife	IIIB	No	No
8	F/37	Laborer	IIIB	Yes	No
9	M/26	Teacher	IV	Yes	Yes
10	M/24	Factory worker	IV	Yes	Yes
11	M/51	Company employee	IIIB	Yes	No

2.2. Surgical approach

The operations were performed 13.5 months (range, 1–33 months) after symptom onset. Surgery was performed under brachial plexus block or general anesthesia. The wrist, palm, and distal forearm were incised, completely clear of the pisiform bone, retaining the vessel pedicle and the flexor carpi ulnaris. Then, a cut was made through the transverse carpal ligament to expose the volar wrist capsule; this was followed by complete removal of the lunate bone. The pisiform bone with the vascular pedicle and flexor carpi ulnaris were placed in the gap after resection of the lunate bone. When the vascularized pisiform bone was transferred, the articular surface of pisiform bone was articulated with that of capitate bone and the ulnar surface of pisiform bone faced to the dorsal wrist. The pisiform bone was cross-fixed with 2 Kirschner wires from the triangular bone at the lateral ulnar and radial sides of the wrist scaphoid needle, respectively. Scaphoid–Trapezium–Trapezoid (STT) fusion was used in 2 patients and Scaphoid–Capitate (SC) fusion was used in 1 patient.

These operations were completed by the second, third, and corresponding authors, who were orthopedics professors with surgical experience of more than 20 years each.

2.3. Follow-up

2.3.1. Pain and subjective assessment. The visual analogue scale (VAS, 0–10 points) was used to assess the degree of subjective pain in the operative side. Recovery of working and living conditions, subjective assessment, and the satisfaction degree were evaluated through questionnaire by the first and fourth authors, impartially and without induction. The PRWE (Patient-Rated Wrist Evaluation) was evaluated by the first author.

2.3.2. Clinical efficacy evaluation. The first and fourth authors used the same goniometer to measure the range of motion (ROM) of the wrist joint, including flexion, extension, ulnar deviation, radial deviation, pronation, and supination of the forearm. Grip strength was measured with the same Jamar meter 3 times for the affected and opposite hands, by the first and fourth authors. The ROM and grip strength of the injured wrist at final follow-up were compared with results of the opposite side and mid follow-up values. ROM and grip strength data for the injured wrist at mid follow-up were obtained at 3 to 5 years after surgery. Clinical assessment was performed with the modified Green and O'Brien system,^[9] which ranks according to points attributed to 4 indicators (25 points each), including pain, functional status,

range of motion, and grip strength: 90 to 100 points, excellent; 80 to 89 points, good; 65 to 79 points, fair; less than 65 points, poor.

2.3.3. Imaging evaluation method. Postoperative anteroposterior (AP) and lateral X-ray films were obtained and evaluated for all patients; 3-dimensional computed tomography (CT) and magnetic resonance imaging (MRI) scans were performed in 9 patients to observe the shape, size, position, and existence of ischemic necrosis of the pisiform bone more accurately (1 patient refused to undergo CT scan, and another patient did not undergo MRI examination because of the presence of a metal pacemaker in his body). The carpal height ratio, Nattrass index, and radioscapoid angle were measured and compared with preoperative and mid-term follow-up results. The size, shape, and position of the pisiform, and osteoarthritis occurrence, as well as vascularization of pisiform bone were carefully assessed by the first and the fourth authors.

2.4. Statistical analysis

Paired *t* test was applied to compare preoperative and postoperative values for continuous parameters. The Wilcoxon test for paired samples was used to assess nonparametric preoperative and postoperative variables. Comparison of unpaired continuous variables was performed by unpaired Student *t* test; Pearson Chi-square test was employed to compare unpaired nonparametric variables. Two-tailed *P* < .05 was considered statistically significant. All tests were performed without adjustment. Data analysis was performed with the SPSS software.

3. Results

The last follow-up occurred in November 2016, with a follow-up rate of 84.6% (11/13). The mean follow-up duration was 19 years and 5 months, ranging from 15 years and 4 months to 26 years and 2 months.

3.1. Pain and subjective assessment results

At the last follow-up, VAS scores were 1–4, with an average of 2.1 (SD=1.8), and all patients reported having wrist pain only during heavy manual labor or after weight-bearing. Only 3 patients complained of slight wrist pain at rest, which was aggravated during daily activities; none of them experienced severe pain. Wrist function in 8 patients could meet all needs of

Table 2
ROM and grip strength of injured wrist at final follow-up compared with the opposite side and mid follow-up.

Items	Uninjured side	Mid follow-up	Final follow-up	P1	P2
Dorsal extension	64.3±7.3	55.2±7.8	54.3±8.2	<.05	>.05
Palmar flexion	71.1±4.3	61.5±6.9	59.8±7.3	<.05	>.05
Ulnar deviation	37.8±3.5	32.0±4.1	31.5±5.5	<.05	>.05
Radial deviation	20.1±1.5	17.7±3.5	17.1±4.1	<.05	>.05
Pronation of forearm	76.3±6.2	85.2±3.3	86.0±3.5	<.05	>.05
Supination of forearm	83.3±4.8	83.3±4.8	89.8±2.1	<.05	>.05
Grip strength (kg)	27.8±7.2	25.9±7.9	26.1±6.4	>.05	>.05

P1= t test uninjured side versus follow-up (P value); P2= t test mid follow-up versus follow-up (P value).

daily life; daily needs were only partially met in the remaining 3 patients. A total of 7 cases recovered physical work, while 2 could not perform their original tasks and changed to light physical work; 2 cases retired from work due to age. According

to the results of the last follow-up, the PRWE score was 5~23, with an average of 15.4 (SD=6.6). All the patients reported a significant improvement in pain relief and wrist function at final follow-up in comparison with the preoperation condition,



Figure 1. A female patient who underwent VOPT in the right wrist (dominant side) at the age of 19, with utmost motions of wrist on both the healthy and affected sides 25 years after the operation. (A) Dorsal extension. (B) Palmar flexion. (C) Radial deviation. (D) Ulnar deviation. (E) Supination of forearms. (F) Pronation of forearms.

Table 3

Modified Green and O'Brien scores and clinical assessment results of the 11 patients at final follow-up.

Item	Score	Patients' score by number										
		1	2	3	4	5	6	7	8	9	10	11
Pain												
Absent	25	25		25	25	25	25	25	25			25
Occasional	20		20								20	
Moderate, tolerable	15											15
Severe, intolerable	0											
Functional status												
Resumed work	25	25	25	25	25		25	25	25			25
Constrained work	20					20						20
Able to work but failed to be employed	15										15	
Unable to work due to pain	0											
Range of motion (percentage of normal status)												
100%	25			25		25			25			
75–99%	15	15	15		15		15	15		15	15	15
50–74%	10											
25–49%	5											
0–24%	0											
Grip strength (compared with healthy side)												
100%	25		25	25	25		25		25	25		
75–99%	15	15				15		15			15	15
50–74%	10											
25–49%	5											
0–24%	0											
Total score	100	80	85	100	90	85	90	80	100	75	65	80

but the changes were not obvious between the mid and final follow-ups.

3.2. Clinical efficacy

Range of motion assessment showed that 75% to 100% wrist motion was recovered compared with the normal range in all patients, with 154.5 (SD = 31.5) degrees in the affected wrist joint and 184.5 (SD = 36.5) degrees in the contralateral one (Table 2, Fig. 1). Meanwhile, 80% to 100% of grip strength was restored, with 25.9 (SD = 7.9) kg obtained for the operated side and 27.8 (SD = 7.2) kg for the healthy one (Table 2). Range motion and grip strength changes in the affected sides were not significantly different between mid and final follow-ups. According to the Modified Green and O'Brien score, results at final follow-up were excellent in 4 cases, good in 5 patients, and fair in 2 individuals; none showed poor results. Therefore, the rate of excellent and good results was 81.8% (Table 3). No patient needed further surgery for procedure failure.

3.3. Imaging data

Radiographic data at the last follow-up showed no significant change in size and morphology of the pisiform bone in 7 cases;

meanwhile, the lentiform bone had atrophy, decreased in size, or even partial sclerosis in the remaining 4 cases. The implant position of the pisiform bone had no obvious changes in 7 cases; 3 cases showed ulnar displacement and 1 patient had volar displacement. The carpal height ratio and Natrass index were significantly decreased between preoperative and final follow-up data, but similar in mid and final follow-ups. Similar findings were obtained for the radioscapoid angle (Table 4, Fig. 2).

Wrist joint osteoarthritis was detected by radiography in 4 patients, all of them showing mild to moderate disease with hardening of the joint surface and narrowing of the joint space. Two patients who progressed from stage IIIB to IV had a mild peri-pisiform osteoarthritis and wrist joint osteoarthritis, while 2 patients were stage IV, with moderate peri-pisiform and wrist joint osteoarthritis, the latter already existing before surgery. The pisiform vascularization was monitored by 2 primary MRI sequences (T1, T2) and the results showed no clear avascular necrosis in 9 patients, whereas mild avascular necrosis was found in the other 2 patients.

4. Discussion

The pathological basis of Kienböck disease is ischemic necrosis of the lunate, and the main imaging features are lunate bone collapse

Table 4

Radiologic parameters of the injured wrist final follow-up, compared with preoperative and mid follow-up features.

Items	Before surgery	Mid follow-up	Final follow-up	P1	P2
Carpal height ratio	0.45 ± 0.06	0.41 ± 0.13	0.40 ± 0.21	<.05	>.05
Natrass index	1.39 ± 0.11	1.28 ± 0.18	1.25 ± 0.14	<.05	>.05
Radioscapoid angle	67.1 ± 2.7	70.4 ± 4.2	71.2 ± 2.2	<.05	>.05

P1 = t test before surgery versus follow-up (P value); P2 = t test mid follow-up versus follow-up (P value).



Figure 2. Radiological examination at postoperative year 25 showing slight narrowing of the radiocapitate joint without overt osteoarthritis and osteonecrosis of the pisiform bone. (A) AP X-ray. (B) Lateral X-ray. (C) Three-dimensional CT. (D) Nuclear magnetic resonance.

and fragmentation; the major clinical symptoms are intractable wrist pain, dysfunction, and low grip strength.^[10] The etiology of Kienböck disease is multifactorial, and encompasses mechanical, anatomic, and constitutional factors, although the specific etiology remains unclear.^[11] By assessing the etiology of osteonecrosis, treatment of early-stage disease mainly includes conservative therapy and various surgical procedures to restore the blood supply of the lunate bone, or to balance the ulna and radius in order to reduce lunate bone stress. Examples of such procedures are use of the vascular pedicle of the distal radius of bone flap for filling of the lunate bone, radial shortening osteotomy, and osteotomy of the capitate bone at pars lumbalis.^[12–14] Litchman classified Kienböck disease into 4 stages. In the IIIb-IV stage, the features of lunate bone necrosis are observed, for example, collapse of the lunate bone, scaphoid bone rotation, proximal displacement of the capitate bone, changes of carpal bone height, and features of wrist osteoarthritis. Stage IIIb-IV is termed advanced disease traditionally; in such cases, it is not possible to vascularize the lunate bone, and reducing the lunate load has minimal effects. Therefore, the surgical procedure is

mainly based on lunate bone removal and replacement, proximal row carpectomy, and full wrist joint arthrodesis.^[15] Although proximal row carpectomy yields satisfactory results,^[16] this method significantly alters the biomechanical mechanism of the carpal bone, and is generally considered the last choice before full wrist arthrodesis.

In 1982, Saffar^[7] first described lunate bone replacement with VOPT, which has the advantages of preserving the approximate normal structure of the wrist joint, restoring its motor function, alleviating wrist pain, and maintaining good grip with short-term efficacy. The Department of Orthopedics in our hospital has adopted this operation and made some improvements based on a large number of anatomic features since 1986, greatly valuing postoperative rehabilitation exercise and follow-up. Our experience and improvement of the surgical technique can be summarized as follows: cutting off the abductor muscle of the little finger attached to the pisiform bone and the surrounding ligament, retaining the musculus flexor carpi ulnaris; retaining the soft tissue surrounding the pisiform bone as much as possible to protect blood supply and increase the volume of the pisiform

bone; and rotating the pisiform bone 90° to the radial side on the coronal plane, and rotating on the sagittal plane for 90° to generate joints for the pisiform bone and capitatum. We believe that in most cases, these surgical techniques allow a long-term follow-up of pisiform bone that does not have a clear size, shape, and blood supply changes. The terms of rehabilitation exercises and follow-up were formulated by the surgeons and rehabilitation therapists, with the rehabilitation training program individualized. We believe good surgical technique, postoperative functional rehabilitation, and sustained follow-up guidance are important factors guaranteeing postoperative function.

Currently, it is difficult to assess the efficacy of various surgical methods for identifying disease etiology and stage. Innes and Strauch^[17] performed a systematic study on the therapeutic effect of Kienböck disease, based on 1998 to 2008 records in PubMed, Medline, and Cochrane. They found that no surgical procedure is perfect after comparing wrist pain, mobility, grip strength, and radiographic findings. The VOPT technique also turned out to be imperfect, with radiographic findings not very good. The main reason is that the pisiform bone is prone to shift because of the absence of surrounding ligaments, while the capitate bone shifts down with a trend of carpal alignment instability because of pisiform bone volume, which is considerably smaller than that of the lunate bone.^[18] Furthermore, stage IIIB-IV Kienböck disease is characterized by scaphoid malalignment and rotation, which result in uneven stress distribution of the pisiform bone as well as greater pressure. In a study by Daecke et al,^[19] the necessity of combined carpal fusion was proposed to be controversial in the “Saffar’s Procedure.” Further studies^[20,21] showed that either fusion type (STT or SC) used in combination reduces axial pressure on the pisiform bone effectively, making the wrist stable and reducing the incidence of carpal bone osteoarthritis. In our preliminary stage of the “Saffar’s Procedure,” fusion combination was used infrequently, which may explain the high possibility of osteoarthritis in this study.

Imaging evaluation of this patient group showed that displacement as well as size and shape changes of the pisiform bone, and even bone sclerosis and osteoarthritis were observed in some patients. However, the subjective pain perception of patients was significantly improved and stabilized for a long time after the operation. This is likely because most nerve endings around the displaced pisiform bone were cut off, and pain was significantly relieved. Meanwhile, the range of motion of the affected wrist joint was significantly lower than that of the normal side, but the patients had high postoperative functional satisfaction. This may be due to the various wrist movements during rehabilitation, and the coordination with the shoulder and elbow joint, which allowed patients to meet daily and fine operation requirements. More importantly, postoperative side grip strength was greatly improved and maintained. In the 2 Lichtman stage IV patients, the joint function scores at the end of the postoperative follow-up were just fair, and a marked shift of the pisiform bone, an osteoarthritis increase, and a slight avascular necrosis of the pisiform bone were found in the postoperative imaging. These results might suggest that Lichtman stage IV patients are not very suitable for this procedure. The limitations of this study include a limited number of patients, single-center setting, and its retrospective nature.

5. Conclusion

Long-term follow-up showed that this procedure is an effective method for treating advanced stage (IIIB to IV) Kienböck disease.

Despite radiographic findings such as atrophy and degeneration of the pisiform bone, and even osteoarthritis, subjective satisfaction of the patients was high due to satisfactory pain relief, and improved wrist motion and grip strength.

Author contributions

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