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The Role of Vascularized Bone Graft in the Treatment of Kienbock's Disease

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Abstract

Background: Kienbock's disease, also known as avascular necrosis of the lunate, is characterized by a sequence of lunate collapse, carpal changes, and degeneration resulting from a combination of anatomic, vascular, and traumatic insults. The methods of treatment of Kienbock's disease vary according to the stage of the disease.

Objectives: Evaluate the clinical and functional outcome of the pronator quadratus pedicled bone graft in the treatment of avascular necrosis of the lunate bone.

Patients and Methods: A prospective case-series study was conducted at Al-Wasity Teaching Hospital from September 1, 2023, to October 1, 2024. The follow-up period was approximately six months for eight patients, whose ages ranged from 22 to 36 years (mean age, 29). Five males and three females among those patients were affected in the right hand, and three were affected in the left hand; all affected hands were the dominant ones. They presented with a history of vague wrist pain and restriction of wrist movement. These patients were later diagnosed as Kienböck disease; all of them were stage two and stage three-A. Patients were surgically treated at Al-Wasity teaching hospital by vascularized bone graft (distal radius transfer on pronator quadratus pedicle).

Results: The patients included in this study were followed for a period of six months. The clinical assessment was good, as indicated by the DASH scoring system, the Mayo scoring system, and the patient's clinical and functional outcomes. Functional improvement in power grip strength was evident, with the patients' mean grip strength increasing from 147.5 mmHg preoperatively to 163.75 mmHg postoperatively. Regarding the range of motion, mean flexion-extension preoperatively was 64.37-60.62, and postoperatively, it was 71.87-65.

Conclusion: The pronator quadratus pedicle bone graft is a beneficial procedure for treating patients with stage two and stage three (A) Kienbock's disease.

Keywords: Kienbock's disease, Stage 2, Stage 3-A, Vascularized bone graft.

Introduction

Kienbõck disease is defined as avascular necrosis of the lunate, characterized by lunate collapse, carpal change, and degeneration, resulting from a combination of anatomic, vascular, and traumatic insults. Kienbõck disease was described in 1983 by Peste through his cadaveric work, by observations of lunate collapse (1). The lunate is initially cartilaginous at birth, and the ossification center begins during

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the fourth year (2, 3). Several accessory bones are associated with the lunate. These are associated with the lunate: the os epilunatum (os centrale II), the os hypolunatum (os centrale III), the os hypotriquetrum, the os epitriquetrum (epipyramis, os centrale IV), the os triangulare (os intermediumantebrachii, os triquetrum secundarium) (4). The location of the lunate is never followed by lunatomalacia (2). The cause of Kienbõck disease is multifactorial, resulting from different degrees of anatomic factors, traumatic insult to the lunate bone, and interrupted vascularity (1). The extraosseous and intraosseous vascular anatomy has been studied. The carpal bones with type 1 vascularity are at risk; these bones are supplied mainly by a single vessel without additional anastomosis, so occlusion of this vessel will probably lead to necrosis. It was reported that all scaphoids, capitate, and 8-20% of lunate have this pattern of vascularity. Additionally, venous stasis, in conjunction with arterial insufficiency, has been studied in carpal bone necrosis. Other factors, such as repetitive minor trauma and fractures, may lead to damage to the intraosseous blood supply, which will lead to osteonecrosis. However, the fracture may result from a consequence of necrosis. Most patients with Kienbõck disease are young and active, between 20 and 40 years of age. The male-female ratio is about 3:1 to 7:1. It is rarely bilateral. More than 95% of patients are engaged in heavy manual labor, regardless of gender (5). The most common complaints of patients are dorsal central wrist pain, significant weakness of grip, which is often reduced to 50% of the opposite hand, and stiffness. The intensity of the pain varies from mild discomfort to constant pain. It is usually related to activity and improves with rest and immobilization. The history of trauma is variable. The wrist is typically swollen dorsally, with consistent synovitis and tenderness over the lunate; both flexion and extension are diminished. Wrist flexion is more reduced than extension because the volar pole of the lunate is often extruded. Therefore, it impinges against the volar rim of the distal radius (6). Plain radiographs have been used to diagnose Kienböck disease and to monitor its progression (7).

Patients and Methods

Study design: The study is a prospective case series study conducted at Al-Wasity Teaching Hospital from September 2023 to October 2024. Follow-up period was about six months for eight patients, their ages ranging between 22 and 36 years (mean age 29). There are five males (62.5%) and three females (37.5%) among those patients; five right hands (62.5%) and three left hands (37.5%) are affected, and all affected hands are the dominant ones. They presented with a history of dorsal wrist pain and restriction of wrist movement, and a decrease in grip strength, all of them stage two and stage three-A. Those patients were treated at Al-Wasity Teaching Hospital with a vascularized bone graft (distal radius pronator quadratus pedicled graft). Upon examination, tenderness was noted in all patients on the dorsum of the wrist. Five of the patients had moderate limitation in flexion and extension of the wrist joint, and five patients had weakness of grip strength. Three of the patients were diagnosed as stage three (A), and five were diagnosed as stage two. Grip strength was assessed by asking the patient to press the inflated sphygmomanometer cuff and comparing the reading of the abnormal hand with that of the normal hand.

Inclusion criteria: include patients with neutral ulnar variance, stage 2 Kienbock's disease, and stage 3a Kienbock's disease.

Exclusion criteria: include patients with negative ulnar variance, positive ulnar variance, stage 3b Kienbock's disease featuring a collapsed lunate and proximal migration of the capitate, as well as decreased carpal height, and stage 4 Kienbock's disease with advanced radiocarpal arthritis.

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Statistical Analysis

Each questionnaire was given an identity number before data entry and analysis. The study questions were coded, and the data were entered into a Microsoft Excel spreadsheet. This study is represented in frequency and percentage.

Results

Demographic characterization of patients: The follow-up period was about six months for eight patients whose ages ranged between 22 and 36 years (mean age 29). There were five males (62.5%) and three females (37.5%) of those patients; five right hands (62.5%) were affected, and three left hands (37.5%) were affected, and all affected hands are the dominant ones. Those patients presented with a history of dorsal wrist pain, restriction of wrist movement, and weakness in grip strength.

The preoperative and postoperative assessment of the Mayo scoring system: The Mayo scoring system for the wrist improved postoperatively compared to the preoperative assessment, as shown in Table 1. The Mean Dash score preoperatively was 32, while postoperatively it was 4.1, which indicated that our patients' disabilities decreased. Additionally, power grip in patients with weak power grip showed excellent improvement when compared to the preoperative mean of 147.5 and the postoperative mean of 163.75, as shown in Table 2, for patients who had restriction of flexion and extension, postoperatively, the range of motion of the wrist joint was significantly improved, with a mean flexion/extension of 64.37/60.62 preoperatively and 71.87/65 postoperatively, as shown in Table 3. One out of eight of our patients showed a slight improvement in the result compared to their preoperative state. He still had slight pain and restriction of movement. This one patient is stage IIIa Kienböck disease with a long duration of symptoms before presentation to us. The results of this study showed that six out of eight of our patients are satisfied with the postoperative results, and they can return to their daily job tasks without any complaints. X-rays of patients showed no collapse of the carpal bones and also did not show arthritic changes or ossification. The Mayo scoring system is an online assessment tool that evaluates the function of the hand both preoperatively and postoperatively. Table 2 shows an improvement in the DASH scoring system when compared preoperatively and postoperatively, as well as an improvement in the power grip when compared between them. The power grip of the patients was measured by a sphygmomanometer by asking the patient to press the inflated cuff and compared to the unaffected one preoperatively and postoperatively when measured by a sphygmomanometer.

Table 1. The preoperative and postoperative assessment using the Mayo scoring system. The underlying table presents a comparison of the preoperative and postoperative myoscoring systems, which assess hand function preoperatively and postoperatively.

Degree of score preoperative	Excellent	Good	Satisfactory	Poor
No of cases	0	2	3	3
Degree of score postoperative	2	3	2	1

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Table 2. Preoperative and postoperative DASH score and power Grip results. The underlying table compares preoperative and postoperative DASH scores, which include items such as shoulder pain, carrying a shopping bag, washing your back, tingling, difficulty sleeping, using a knife to cut food, and turning a key.

Case No.	DASH before	DASH after	Power Grip In mmHg
1	40	6	150/180
2	27	3	140/160
3	40	8	180/200
4	35	5	120/150
5	25	2	130/130
6	33	3	145/150
7	30	4	135/140
8	26	2	180/200
Mean	32	4.1	147.5/163.75

Preoperative and postoperative range of motion of the wrist joint: For patients who had restriction of flexion and extension, postoperatively, the range of motion of the wrist joint was significantly improved, with a mean flexion/extension of 64.37/60.62 preoperatively and 71.87/65 postoperatively, as shown in Table 3. A sphygmomanometer measured the power grip of the patients by asking the patient to press the inflated cuff and comparing it to the unaffected one. MRI findings of revascularization can be assessed after one to three years postoperatively. Otherwise, during the first year, we depend on the clinical and functional outcomes of the patient, so we didn't perform an MRI due to the short-term nature of the study.

Table 3. Preoperative and postoperative range of motion of the wrist joint. The underlying table displays the range of motion between flexion and extension in patients before and after surgery, illustrating the improvement in range of motion.

Case No.	Range of motion preoperatively (Flexion/Extension)	Range of motion postoperatively (Flexion/Extension)
1	60/60	75/65
2	70/65	75/65
3	65/65	70/70
4	60/50	75/60
5	65/60	75/65
6	80/75	80/75
7	65/55	75/65
8	50/55	50/55
Mean	64.37/60.62	71.87/65

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Discussion

Kienbock disease, also known as avascular necrosis of the lunate bone, results in carpal collapse and subsequently leads to osteoarthritis of the wrist (8). The lunate is the prominent bone of the wrist joint. The disease is idiopathic osteonecrosis of the lunate bone, resulting in a lunate fracture and carpal collapse (9, 10). The pronator quadratus pedicled bone graft was approved as one of the pedicled bone graft options in the treatment of lesions of the lunate (11). Many cadaver studies showed that the pronator quadratus muscular branches of the anterior interosseous artery form a good periosteal plexus on the distal radius volar surface, while a branch from the anterior interosseous artery supplies the radial corner of the distal radius (12). In this study, we harvested grafts from the distal radius as far as possible radially to the cortical window in the volar aspect of the lunate. We fixed the harvested graft with a K-wire (scaphoid transfixing), with a follow-up period of about six months. Christophene Mathoulin et al operated on 22 cases, involving 18 patients, of whom were completely pain-free (11). In contrast, in our study, we operated on eight cases, of which seven were pain-free. Christophe mathoulin et al. harvest a vascularized bone graft based on the volar transverse carpal artery, that lies on the volar aspect of the radius (10, 11) while in our study we do pronator quadratous vascularized pedicled graft without doing shortening osteotomy to the distal radius Christophe mathoulin et al The average time to return to the normal activities was 3.5 months (range from 1–6 months) (9, 11). In our study, the duration was approximately 4 months. Daecke et al implanted the dorsal metacarpal vascular pedicle into the lunate of nine patients, then found evidence for revascularization of the lunate. While in this study, the harvested graft was used from the volar aspect of the distal radius. Daecke et al reported the results of long-term follow-up on 23 patients with different stages 2 and 3 disease who were treated with a pedicled pisiform vascularized graft. 15 out of the total 22 patients have no disease progression. They concluded that vascularized bone grafts obtained good functional outcomes (13). Fujiwara et al. showed the results of vascularized bone grafts in 18 patients with stage 3A disease who were followed up for approximately 10 years (14). A total of 11 patients underwent transplantation from the metacarpal base, and 7 had a graft from the distal radius The associated procedure of capitate shortening or radial shortening was performed. In our procedure, we don't perform capitate shortening osteotomy or radial shortening osteotomy. The treatment of the disease includes many options. For optimal results, the first step is proper staging of the disease. Revascularization of the lunate remains a viable option for the treatment of Lichtman stage II or IIIA Kienböck's disease (15, 16). Christophene Mathoulin et al. reported that the Mayo Clinic Wrist Score had eight excellent, seven good, four average, and 2 poor results (11). The Mayo wrist scoring system in our study was rated as excellent in two cases, good in three, satisfactory in two, and poor in one. In addition, Christophene Mathoulin et al reported that there was no correlation between the sex of the patient and the functional result (11). In our results, we have a limited number of cases, so we did not find a correlation between sex and healing rate. Frantzeska Zampeli et al. The patient showed improvement in the Mayo wrist score, pain, as well as grip strength (from 60 to 80% of the unaffected side) and wrist range of motion from 70 to 90% of the unaffected side at 15 months follow-up. In our study, there is an improvement in grip strength from 65 to 85% of the unaffected side, and there is also an improvement in the Mayo scoring system (17). Frantzeska Zampeli et al. showed a good improvement limited to some patients after vascularized bone graft in 0-15% of patients, while in our study, there is radiological

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progression in one case (17). Sara p shows no difference between male and female predominance in our study, not a lot of cases, and cannot reveal the gender predominance (18-20).

Conclusions

One of many treatment options described is vascularized bone grafting. Precise surgical technique, appropriate indications, and postoperative management can prevent disease progression. Additionally, revascularization of the necrotic lunate can lead to pain relief, along with the restoration of range of motion and grip strength. This study has a short-term follow-up; thus, we depend on clinical and functional outcomes. Proper staging of avascular necrosis of the lunate bone is important because the success rate of the type of surgery depends on the proper staging. Assessment of revascularization by MRI requires long-term follow-up.

Source of funding: No source of funding.

Ethical clearance: This study was approved by the Ethics Committee of Al-Wasity Teaching Hospital (No. 3096 in 01/06/2023).

Conflict of interest: None.

Use of Artificial Intelligence (AI): The authors state they did not use any generative AI tools for creating or editing the manuscript's language.

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دور الطُعم العظمي المُزوَّد بالأوعية الدموية في معالجة مرض كينبوك

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الملخص

الخلفية: يُعدّ مرض كينبوك، المعروف أيضًا بالنخر اللاوعائي للعظم الهلالي، حالة مرضية تتميز بسلسلة من انهيار العظم الهلالي، وتغيرات في عظام الرسغ، وحدوث تنكس، وذلك نتيجة تداخل عوامل تشريحية ووعائية ورضّية. وتختلف طرائق علاج مرض كينبوك باختلاف مرحلة المرض.

الأهداف: تقييم النتائج السريرية والوظيفية للطُعم العظمي المُوعّى المرتكز على العضلة الكابّة المربعة (Pronator Quadratus) في علاج النخر اللاوعائي للعظم الهلالي.

المرضى والطرق: أُجريت دراسة مستقبلية من نوع سلسلة حالات في مستشفى الواسطي التعليمي خلال الفترة من ١ أيلول ٢٠٢٣ إلى ١ تشرين الأول ٢٠٢٤. بلغت مدة المتابعة نحو ستة أشهر لثمانية مرضى تراوحت أعمارهم بين ٢٢ و٣٦ سنة (بمتوسط عمر ٢٩ سنة). شملت العينة خمسة ذكور وثلاث إناث؛ أُصيب خمسة مرضى في اليد اليمنى وثلاثة في اليد اليسرى، وكانت جميع الأيدي المصابة هي اليد المسيطرة. حضر المرضى بشكوى ألم مبهم في الرسغ مع تقيّد في حركة المفصل. وبعد الفحص والتقييم، شُخّصت الحالات على أنها مرض كينبوك، وكانت جميعها في المرحلتين الثانية والثالثة (**A**). خضع المرضى للعلاج الجراحي في مستشفى الواسطي التعليمي باستخدام الطُعم العظمي المُوعّى (نقل جزء من الكعبرة البعيدة على ساق العضلة الكابّة المربعة).

النتائج: تمت متابعة المرضى المشمولين في الدراسة لمدة ستة أشهر. وأظهر التقييم السريري نتائج جيدة، كما دلّت عليه مقاييس DASH ونظام تقييم مايو، إضافةً إلى التحسن السريري والوظيفي للمرضى. لوحظ تحسن وظيفي واضح في قوة القبضة، إذ ارتفع متوسط قوة القبضة من ١٤٧,٥ ملم زئبق قبل الجراحة إلى ١٦٣,٧٥ ملم زئبق بعد الجراحة. أما فيما يخص مدى الحركة، فقد كان متوسط الثني–المد قبل الجراحة ٦٤,٣٧–٦٠,٦٢، وارتفع بعد الجراحة إلى ٧١,٨٧–٦٥.

الاستنتاج: يُعدّ الطُعم العظمي المُوعّى المرتكز على العضلة الكابّة المربعة إجراءً علاجيًا مفيدًا لمرضى مرض كينبوك في المرحلتين الثانية والثالثة (A).

الكلمات المفتاحية: مرض كينبوك، المرحلة الثانية، المرحلة الثالثة (**A**)، الطُعم العظمي المُوعّى.

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