BMC Musculoskeletal Disorders

CASE REPORT

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Free medial femoral condyle osteocutaneous flap for repairing stage IIIB osteonecrosis of the lunate: a case report

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Abstract

Background There are several surgical options for osteonecrosis of the lunate, and confirming the effectiveness of various surgical methods remains challenging. Here, we present a case of stage IIIB osteonecrosis of the lunate repaired with a free medial femoral condyle osteocutaneous flap.

Case presentation A 43-year-old male construction worker was admitted to our hospital due to right wrist pain, impaired mobility, and pain aggravated by activity for 10 months. The patient was diagnosed with stage IIIB osteonecrosis of the lunate based on the orthopantomogram and magnetic resonance imaging of the right wrist. Considering the patient's medical history, physical examination, auxiliary examination, and wishes, reconstruction was performed using a free medial femoral condyle osteocutaneous flap. After the flap survived completely, the K-wires were removed one month after the operation, the external brace was removed two months after the operation, and functional wrist rehabilitation was initiated. After six months of follow-up, the wrist swelling and pain resolved, and the reconstructed lunate bone was viable. Additionally, the last follow-up was conducted in the sixth month after surgery; the affected hand grip strength improved from about 70% (28 kg) to 80% (32 kg) compared with the healthy side (40 kg); the visual analog scale score decreased from 6.5 points before the operation to 1 point; and the MAYO score increased from 60 points before the operation to 85 points.

Conclusions The success of this case reinforces the potential of the free medial femoral condyle osteocutaneous flap as a new treatment option for stage IIIB osteonecrosis of the lunate and further expands the existing treatment options. Using a free medial femoral condyle osteocutaneous flap to reconstruct the lunate and restore the carpal anatomy may.

Keywords Osteonecrosis of the lunate, Medial femoral condyle osteocutaneous flap, Hand surgery, Case report

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bring us new hope for a new treatment modality for osteonecrosis of the lunate.

Background

Osteonecrosis of the lunate was first described by Peste in 1843 and was later described by the Austrian radiologist Robert Kienböck in 1910, also known as Kienböck's disease [1]. The lunate is located in the center of the proximal row of carpal bones and has high mobility and poor stability compared to the other joints. Its blood supply depends mainly on small blood vessels on the surface of the radiocarpal joint capsule and within the intercarpal ligament. For people with frequent and repetitive use of the wrist such as hammering, repetitive shock and its impact on the lunate bone can cause damage and occlusion of small blood vessels in the joint capsule and ligaments, leading to a lack of blood flow to the lunate bone. This lack of blood flow causes necrosis of the lunate bone. Furthermore, the increased pressure in the marrow cavity of the necrotic lunate bone obstructs circulation and aggravates ischemic necrosis [2]. The main symptoms of osteonecrosis of the lunate include pain in the wrist joint, synovitis and osteoarthritis, reduced hand grip strength, persistent wrist pain, and loss of function [3]. This disease can be distinguished from navicular osteonecrosis, wrist tenosynovitis, wrist ligament injuries, and rheumatoid arthritis based on the patient's history, physical examination, and auxiliary examination.

The treatment of osteonecrosis of the lunate depends on the stage of the disease and is mainly divided into conservative and surgical treatments. Conservative treatment is recommended for the early stage of osteonecrosis of the lunate. A previous study showed that 50% of the patients showed improvement or complete resolution after two months of conservative treatment [4]. Surgical treatment is recommended for the middle and late stages of osteonecrosis of the lunate and includes four main categories: core decompression, joint leveling/lunate unloading, lunate revascularization, and salvage procedures. According to the literature retrieved so far, there has been no report on the use of a free medial femoral condyle osteocutaneous flap in the treatment of stage IIIB osteonecrosis of the lunate. The advantages of this procedure include the normal anatomical structure of the carpal joint, avoiding further loss of carpal joint height, better blood flow, superficial vessels that are easily dissected, and minor damage to the donor flap site [5–9]. Here, we report a case of stage IIIB osteonecrosis of the lunate treated surgically with a free medial femoral condyle osteocutaneous flap, and good results were achieved.

Case presentation

A 43-year-old man was admitted to our hospital with a chief complaint of recurrent right wrist pain, impaired mobility, and pain aggravated by activity for 10 months. His pain was relieved by rest. He had no radiating pain, limb numbness, skin breakdown, redness, or swelling. He had no history of trauma. Anti-inflammatory and analgesic drugs did not significantly improve symptoms. His symptoms persisted and worsened, affecting his quality of life. He visited a local hospital one month ago, and the right wrist X-ray showed necrosis and collapse of the carpal lunate. His past medical history was unremarkable.

During the consultation, it was revealed that the patient was working in the construction industry and had to use hammers and carry weight on his wrist for a long time. The patient did not drink alcohol and smoked an average of one pack of cigarettes a day. He had a BMI of 23.8 and was previously in good health. A physical examination revealed a slightly swollen right wrist without redness and swelling, and the pressure and pain at the dorsum of the wrist in the middle of the lunate were obvious. There was no numbness or weakening of skin sensation in the wrist and hand. Additionally, limitations in wrist joint mobility and dorsal extension were observed. Percussion of the third metacarpal head revealed obvious pain in the longitudinal direction. Active and passive movements of the wrist joint were limited, with dorsiflexion of 25°, palmar flexion of 35°, ulnar deviation of 15°, and radial deviation of 10° in the active range of motion. The grip strength decreased, equivalent to 70% of that on the healthy side. The preoperative VAS score [10] was 6.5 points and the preoperative MAYO score [11] was 60 points. The VAS consists of a 10 cm line, with two endpoints representing 0 ('no pain') and 10 ('pain as bad as it could possibly be'). The total MAYO score ranges from 0 to 100 points, with higher scores indicating a better result. An excellent result is defined as 90–100 points, good is 80–89, fair is 65–79 points, and poor is less than 65 points.

On admission, routine blood, urine, and stool tests, biochemical tests, and coagulation tests did not show any obvious abnormalities. Frontal and lateral views of the right wrist showed that the bone density of the right lunate was uneven, with multiple patches of low-density bone destruction and patches of osteosclerosis (Fig. 1a-b). Magnetic resonance imaging of the right wrist showed abnormalities in the morphology and signal of the lunate, small cystic changes in the right carpal triangle, and damage to the carpal triangular fibrocartilage complex (Fig. 2a-b). Based on these findings, the patient was diagnosed with stage IIIB osteonecrosis of the lunate and treated surgically.

A 4 cm curved incision was made in the middle of the metacarpal side of the carpal joint to open the carpal

Fig. 1 Preoperative X-ray. (**a**) Frontal view (**b**) Lateral view

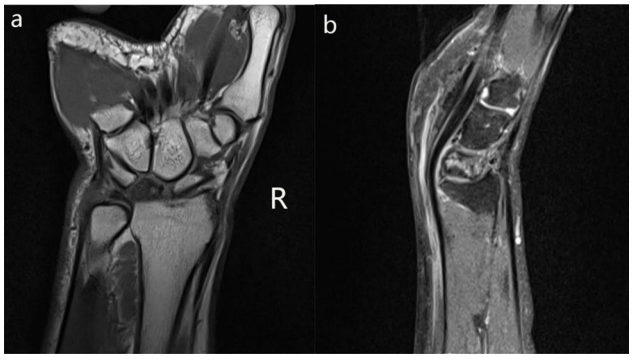

Fig. 2 Preoperative MRI. (**a**) Frontal view (**b**) Lateral view

tunnel and protect the median nerve. The lunate was exposed and completely excised. The carpal joint was repeatedly rinsed with saline, and the lunate was measured (approximately 1×2×1.5×2.2 cm) (Fig. 3a-b). With the medial epicondyle of the femur being the central reference point, a 12 cm longitudinal incision was made within the gap between the rectus femoris and the sartorius muscles. The descending artery of the knee was exposed and isolated, the branch of the saphenous artery and the articular branch were isolated, and the distribution zone of the terminal branch of the descending blood vessel of the knee on the medial epicondyle of the femur was fully exposed. According to the branch of the saphenous artery, an area of skin and soft tissues of 2×2 cm was cut, and according to the articular branch, a bone flap of about 1×2×1.5×2.2 cm was cut. Care was taken not to separate the periosteum from the bone, and the vascularity of the flap was cut off close to the femoral artery after confirmation of the normal blood flow of the flap (Fig. 3c–h). After the removal of the lunate, the flap was embedded in the cavity and fixed with two K-wires. The vascularized tip of the flap was guided through the subcutaneous tunnel and placed in the distal radial artery of the forearm. Under the microscope, the artery of the flap tip was anastomosed with the radial artery in an end-to-end fashion, and the vein was also anastomosed with the accompanying vein of the radial artery in an end-to-end fashion. After the blood supply of the flap was confirmed, the skin was sutured. The donor area was sutured directly. Two screws were inserted into the third metacarpal and distal radius, respectively. The wrist joint was fixed in the functional position using an external fixator (Fig. 3i). Postoperative treatment included the administration of antibiotics, vasodilators, and anticoagulants, complete bed rest for one week, and wound cleaning and dressing change.

The patient's X-rays were reviewed monthly after surgery (Fig. 4a-h). After the flap was confirmed to be completely viable, the K-wires were removed one month after surgery, and the external fixator was removed two months after surgery (Fig. 5a-b). Wrist function rehabilitation exercises were performed. After six months of follow-up, wrist swelling and pain resolved, the reconstructed lunate was viable, and the affected hand grip strength improved from about 28 kg (70%) to 32 kg (80%) compared with the healthy side about 40 kg (Fig. 5c-f). The visual analog scale score was 1 point, and the MAYO score was 85 points(Fig. 6).

Discussion and conclusions

Osteonecrosis of the lunate is characterized by fragmentation and progressive collapse of the lunate. It is prevalent among young and middle-aged manual workers, but its etiology remains unclear. The Lichtman classification is commonly used for osteonecrosis of the lunate staging [12, 13]. In stage I, X-rays show normal bone shape and density, and the T1 signal is widely reduced on magnetic resonance imaging. The bone scan is positive. Conservative plaster immobilization is required for patients with stage (I) In stage II, X-rays show sclerosis of the lunate. Furthermore, despite the bone shape and articular surface being intact and not collapsed, multiple fracture lines are seen. Patients with stage II osteonecrosis of the lunate should undergo hemorheological reconstruction and biomechanical surgical treatment to improve the blood flow to the bone, reduce the loading of the lunate, and prevent collapse. Hemodynamic reconstruction can be performed by implanting a vascular bundle and a bone flap with vascular, fascial, and muscular tips to reconstruct the hematology of the lunate. In stage IIIA, the lunate bone collapses, but the height of the carpal bones is still maintained. The correspondence between the lunate bone and the surrounding carpal bone is normal. The treatment of this stage is similar to that of stage (II) In stage IIIB, the lunate bone collapses, the navicular bone rotates, the capitate bone is displaced proximally, and the height of the carpal bone changes. The typical X - ray shows the appearance of a circular sign of navicular bone. In this stage, surgery cannot restore the collapsed

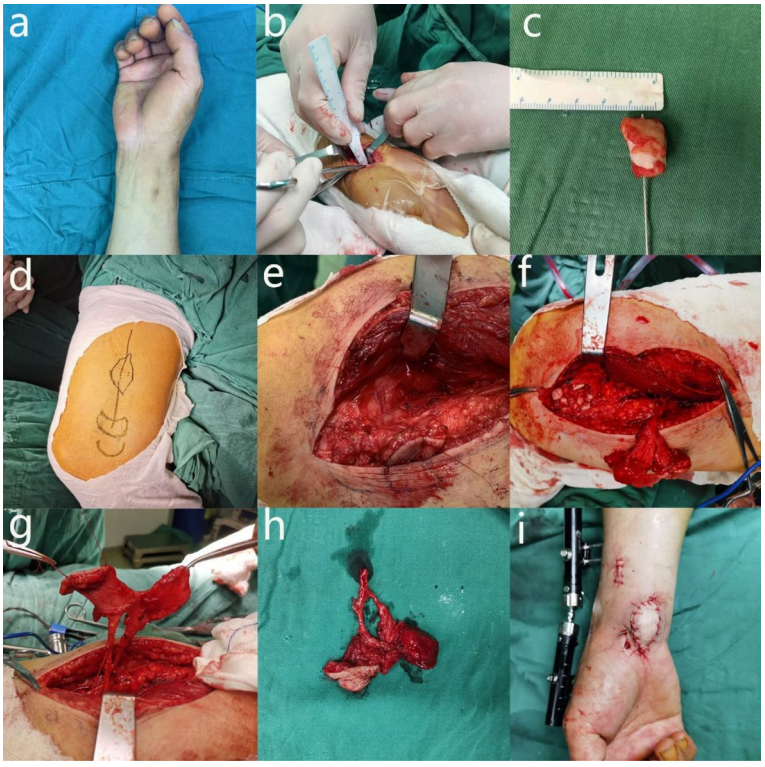

Fig. 3 Procedure of freeing medial femoral condyle osteocutaneous flap (**a**) Preoperative appearance; (**b**) Wrist incision and measurement of the lunate bone; (**c**) Measurement of the size of the fragmented lunate bone after bonding with bone wax; (**d**) Body projection of the flap of medial femoral condyle; (**e**) Separation of descending patellar artery, saphenous artery branch, and articular branch; (**f**) Cutting the osteocutaneous flap and bone grafting of the medial epicondyle of the femur; (**g**) Cutting of the osteocutaneous flap; (**h**) Free osteocutaneous flap; (**i**) Appearance of the osteocutaneous flap after freeing grafting

Fig. 4 Postoperative follow-up radiographs (**a**) Postoperative day 1 anteroposterior radiograph; (**b**) Postoperative day 1 lateral radiograph; (**c**) Postoperative 1-month anterioposterior radiograph; (**d**) Postoperative 1-month lateral radiograph; (**e**) Postoperative 2-month anterioposterior radiograph; (**f**) Postoperative 2-month lateral radiograph; (**g**) Postoperative 3-month anterioposterior radiograph; (**h**) Postoperative 3-month lateral radiograph

Fig. 5 Postoperative Follow-up Functional Diagram (**a**) Appearance of the flap at 2 months postoperatively; (**b**) Appearance of the thigh at 2 months postoperatively; (**c-f**) Functional diagram six months after surgery

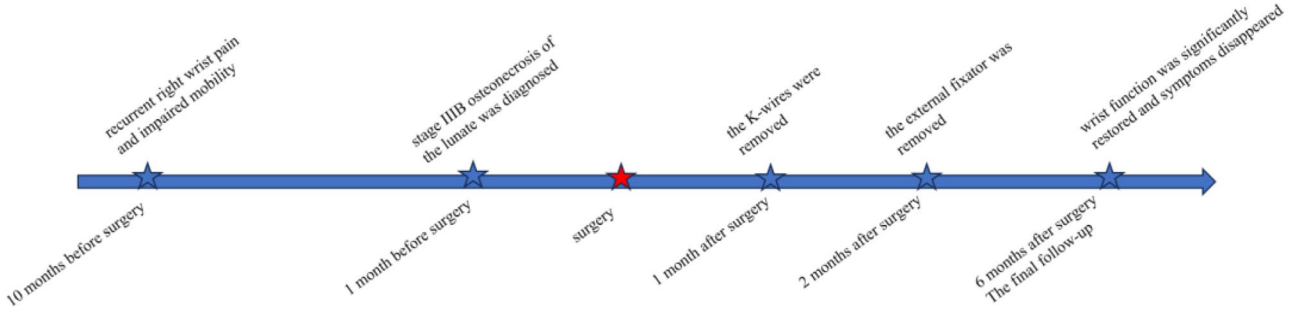

Fig. 6 Timepoint of the disease course

and fragmented lunate to its original state, and there is a risk of secondary synovitis. Therefore, the necrotic lunate should be removed, and lunate replacement should be performed in combination with biomechanical treatments to improve the symptoms and function of the carpal joint. The appearance of this operation will enrich the selection of lunate bone replacements. Stage IIIB can progress to involve arthritis of the wrist (radial wrist and mid-wrist joint). This progression leads to stage IV, which is characterized by extensive traumatic arthritis of the carpal joint, lunate necrosis, fragmentation, and loss of function of the whole carpal joint cartilage. Treatment options for patients with stage IV include proximal row carpectomy, radiocarpal fusion, lunate excision with fusion of the proximal row of carpal bones, and carpal tunnel release surgery.

The early diagnosis of osteonecrosis of the lunate is low, and once detected, it is mostly in stage IIIB. There is a clinical debate about the treatment of stage IIIB, whether it is necessary to perform osteotomy, fusion or replacement of the lunate. Once partial fusion of the wrist joint is performed, it will inevitably lead to partial or even total

loss of wrist joint function, which is often not accepted by patients. Recently, there has been an increasing trend among medical experts toward the use of substitute implants for lunate replacement to prevent misalignment of the carpal bones and collapse after lunate resection and maintain the.

biomechanical properties of the wrist joint. Currently, the implants studied for lunate replacement mainly include autologous tendon grafts, pisiform bone grafts, capitellum grafts, free 2nd metatarsal head grafts, or other free bone flaps as well as artificial prostheses, cemented prosthesis (Table 1). With the improvement in our understanding of this disease and the development of novel treatment options, we investigated whether the lunate bone could be reconstructed with a free bone flap that is less damaging to the donor area and easier to resect.

In 1994, Doi et al. applied free medial femoral condyle bone flap transplantation to treat 10 cases of navicular fracture combined with ischemic necrosis, and the fracture healed successfully in all cases after the operation [24, 25]. In 2007, the same operation was performed at Mayo Clinical Center, and good results were achieved [26]. Quintero et al. also used a free medial femoral condyle flap to treat upper limb deformities in osteogenesis imperfecta and bone loss-related reconstructive surgery or osteonecrosis-related reconstructive surgery, and good results were achieved [27]. Therefore, in this case, we used a free medial femoral condyle osteocutaneous flap to reconstruct the lunate, and the results were good. The preoperative evaluation showed no skin trauma or old fractures around the donor area. The patient had good bone density and no knee joint-related diseases such as osteoarthritis, and the original condition would not be aggravated by the operation. The wound at the donor site healed completely after surgery. Additionally, no numbness in the lower limb, knee pain or dyskinesia, wrist pain, or collapse were reported. No sensory loss or painful neuroma due to a saphenous nerve injury was found. The patient was able to resume activities of daily life. This approach has several advantages. First, the reconstructed lunate has a bony structure with blood flow and a cartilaginous surface. This helps restore the normal anatomical structure of the carpal joint and avoid further loss of carpal joint height to the maximum extent. Second, the anastomosed vascularized bone flap provides better blood flow, bioactivity, and conductivity. Third, the free medial femoral condyle osteocutaneous flap has stable vascular anatomy and superficial vessels that are easily dissected. The vascular tip corresponds to the knee descending artery and vein, and the caliber is close to that of the radial artery and vein, facilitating successful anastomosis. Fourth, the damage to the donor flap site is small and does not affect the strength and shape of the femur, knee joint mobility, main blood vessels, or blood supply to the distal limb. Finally, the flap includes

Table 1 Surgical methods and therapeutic effects of osteonecrosis of the lunate reported in the literature

Authors	Year	Operation method	Result
Nakamura R et al [14]	1991	Radial wedge osteotomy	After two to five years of follow-up, all of the patients were free of pain or had only mild pain in the wrist with strenuous activity.
Minami et al [15]	1994	STT arthrodesis + interposition arthroplasty	Of the 15 patients, three were rated unsatisfactory, doing well in pain relief and grip strength, but poor in wrist range of motion. Postoperative osteoarthritis of the radiopneumonavicular joint was observed in 5 patients.
Ueba et al [16]	1999	A tendon-ball implant	Of a total of 15 patients, 9 were classified as having excellent outcomes and 6 as good. Calcification and ossification of the implanted tendon occurred frequently in the months after surgery.
Croog and Stern [6]	2008	Proximal row carpectomy	Proximal row carpectomy is a reliable and durable procedure for patients with Lichtman stage IIIA or IIIB Kienböck's disease. Caution should be exercised in performing the procedure in patients with stage IV disease because of risk of early symptomatic radiocapitate degeneration.
Ferreres et al [17]	2011	Total wrist arthroplasty	A total wrist arthroplasty should be considered as a good alternative to arthrodesis for patients who wish to preserve some degree of mobility of the wrist.
Obert et al [18]	2013	Costochondral autograft	Reconstruction of a partially destroyed articular surface using a costal graft is reliable and provides an alternative option for resurfacing the articular surface with viable cartilage.
Viljakka T et al [19]	2014	Silicone lunate arthroplasty	These very long-term results confirm that silicone lunate arthroplasty should not be used for Kienböck's disease. The incidence of silicone cysts was 78%.
Marcuzzi et al [20]	2017	Proximal row carpectomy + RCPI	It is a good alternative to carpal fusion, which leads to wrist immobility, and to total wrist joint replacement, which has a high incidence of dislocation and fracture.
Yujian Xu et al [21]	2020	Vascularized pisiform transfer	It is feasible to treat advanced Kienböck's disease by pisiform transfer with the carpal epithelial branch of ulnar artery and the descending branch.
Zhen-Jiang Ma et al [22]	2020	Varisized 3D-Printed Lunate	For patients suffering advanced Kienböck's disease, lunate excision followed by 3D printing prosthetic arthroplasty can reconstruct the anatomical structure of the carpal tunnel, alleviate pain, and improve wrist movement.
Changgui Zhang et al [23]	2023	3D printed tantalum prosthesis	The 3D printed tantalum brings us new hope, not only for hip or knee replacement, but also for joint replacement of other complex anatomical structures

RCPI = resurfacing capitate pyrocarbon implant prosthesis. STT = scaphotrapeziotrapezoid

part of the skin, facilitating blood flow monitoring after the operation. Nevertheless, this approach has a few drawbacks, including a swollen or less aesthetically pleasing appearance, and plastic surgery can be considered to solve these problems.

No one-size-fits-all treatment can be applied to all cases of osteonecrosis of the lunate, and the best treatment option should be considered based on the stage of the disease, the operator's experience, the patient's wishes, and the joint's range of motion. Among them, the surgeon must be a senior doctor with rich experience, and the learning curve is relatively long, which not only requires a long time of clinical accumulation of traumatic orthopedics and hand surgery but also requires skilled skills in vascular anastomosis. Secondly, we found that some patients with osteonecrosis of the lunate reached stage IIIB, but the joint's range of motion was still normal, so patients should be informed that there may be a slight loss of joint motion amplitude after the symptoms are resolved. Therefore, comprehensive consideration should be made according to patients' wishes and the stage of the disease.

The good results achieved using this approach further expand the available treatment options for osteonecrosis of the lunate and enrich the treatment of stage IIIB osteonecrosis of the lunate. The use of a free medial femoral condyle osteocutaneous flap to reconstruct the lunate and restore the anatomy of the wrist may bring us new hope for a new treatment modality for osteonecrosis of the lunate.

Limitations

This study has certain limitations. At present, there is only one completed case, which is not representative. At the same time, we should pay more attention to the rapid recovery of patients in the future. We need to conduct multicenter randomized controlled trials with a longer follow-up period and more surgical cases to comprehensively evaluate the feasibility of the new procedure.

Abbreviation

VAS Visual analogue scale

Acknowledgements

Not applicable.

Author contributions

X.J.W., L.G. and L.C. operated the patient. X.J.W. and L.G. designed the study. L.C. collected the data and examined the patient at the final follow-up. S.B.L. and C.C. searched the literature and compared this case with previous reports. L.G. and L.C. wrote the draft of the article. X.J.W. revised and submitted the manuscript. All authors read and approved the final manuscript.

Funding

This study was financially supported by Natural Science Foundation of Fujian Province (2022J011315) and Fujian Provincial Clinical Medical Research Center for First Aid and Rehabilitation in Orthopaedic Trauma（2020Y2014）.

Data availability

Not applicable.

Declarations

Ethics approval and consent to participate

This study has been reviewed by Medical Ethics Committee of Fuzhou Second Hospital and have been performed in accordance with the ethical standards laid down in an appropriate version of the 1964 Declaration of Helsinki.

Consent for publication

Written informed consent was obtained from the patient for publication of this case report.

Competing interests

The authors declare no competing interests.

Received: 20 July 2023 / Accepted: 19 July 2024
Published online: 30 July 2024

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