The Proposal and Early Results of Capitate Forage as a New Treatment Method for Kienböck's Disease

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Abstract Kienböck's disease is a type of avascular necrosis which disrupts the biomechanics of the wrist as a result of the changes it creates in the lunate bone. Its treatment generally consists of osteotomies intended to relieve the pressure on the bone, pedicle bone grafting applications aiming to increase bone blood supply, and salvage procedures. Capitate forage is a safe and simple-to-apply surgical treatment method which is intended to enhance neovascularization of the lunate much like a radius osteotomy or core decompression

Keywords Kienböck's disease · Lunate

Kienböck's disease is the most interesting and complicated disease of the wrist with regard to its etiology and choice of treatment. Since the day it was defined as traumatic malacia of the lunate bone by Viennese radiologist Robert Kienböck in 1910, inconsistencies between radiologic findings and clinical symptoms and local vascular and osseous anatomical differences in its etiology have been the topic of many scientific articles [1–6].

As with femoral head avascular necrosis, the etiology of Kienböck's disease is not yet fully understood. There are also controversial issues with regard to the surgical treatment of the disease. Since the etiology of the disease is yet to be agreed upon, the surgical interventions applied illustrate the main differences between the points of view. While some authors, Nakamura, Rouillet, and Weiss, aim to relieve the pressure on the lunate, some others, such as Elhassan and Leung, propose techniques for increasing blood supply to the bone [4, 7–13].

In this study, the “capitate forage” technique and early results for nine patients to whom this technique was applied are discussed as a new treatment method for Kienböck's disease.

Material and Methods

Capitate forage was applied to nine patients who were diagnosed with Kienböck's disease following wrist radiographies and MRI examinations. The main complaint was pain in the wrist. The average age of the six male and three female patients was 30 (between 20 and 40); seven of the patients were defined as stage 2, one of them as stage 3a, and the last as stage 3b, according to the Lichman/Stahl classification system. Wrist range of motion, grip strength, and pain of the patients were examined pre- and postoperatively. The patients were evaluated according to the Mayo wrist score (Table 1). The measurements of wrist motion were obtained with a goniometer, and grip strength was measured with a Jamar dynamometer. Pain and functional status were evaluated; the patients were asked to give a verbal categorical rating of their pain as “severe to intolerable,” “pain after activities and rest,” “pain after strenuous activities,” or “no pain.” They were also asked to mark the level of pain on a scale of 0 to 20 and their function as severe to no disabilities.

Following site cleaning and wrapping procedures, supraclavicular nerve block preparation was performed for six patients, and general surgical preparation done under general anesthesia was performed for three of the patients. The wrist was placed on a radiolucent hand table, keeping the lunate in the center. The central area of the capitate bone not covered by cartilage was detected under fluoroscopy control. The skin over it was marked using a 1.5-mm Kirschner wire. A mini skin incision was followed by a deep blunt dissection performed with a hemostatic clamp, preventing the extensor tendons from being damaged. The

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Table 1 Modified Mayo wrist score

Grip strength percent of contralateral side			Points
0–25			0
>25–50			10
>50–75			20
>75–100			30
Range of motion (ROM)			
Ex/Flex	Rad/Uln	Pro/Sup	Points
≤30°	≤10°	≤80°	0
>30–60°	>10–35°	>80–110°	10
>60–100°	>35–50°	>110–140°	15
>100°	>50°	>140°	20
Pain			Points
Severe to intolerable			0
Pain after activities and at rest			10
Pain after strenuous activities			15
No pain			20
Functional status points			
Severe disability			0
Moderate disability			10
Limited only in special situations			20
Normal no disability			30
Ranking points			
Excellent, >80–100			
Good, >65–80			
Moderate, >50–65			
Poor, 0–50			

edge of the K wire was forwarded through the capitate bone. Four to five drillings (forage) were applied to the bone under fluoroscopy control (Fig. 1).

Application of sutures was mostly not required, but when it was needed, the skin was closed with 4-0 polypropylene

Fig. 1 Four to five drillings (forage) were applied to the capitate bone under fluoroscopy control

sutures. A volar wrist splint was applied for a month. The splint was used only for patient comfort, during daily routine, and removed two times daily for wrist movement. To encourage the patients to move their fingers, it was recommended that they use their hands actively. Wrist radiographies were taken the day after the surgery, and the quantity of the forage was documented. At the post-operative 1st, 3rd, and 6th months, in the clinical evaluation of our patients, Mayo wrist scoring was preferred. For each patient, at the 3rd month, MRI examinations of the wrist were performed in order to detect the vascular supply of the lunate (Fig. 2).

Results

We thought that the main scope of the treatment was the daily satisfaction of the patients in being able to use their hands without pain complaints; thus, Mayo scoring is the most suitable scoring system. In the 6th month evaluation of our patients, five good and four excellent results were reached. At the 6th month, only one of our patients had any decrease in his/her grasping strength (Table 2). It was also noted that the range of motion was preserved. Five of the patients had a

Fig. 2 MRI examinations of the wrist were performed at the 3rd month

full range of motion at the wrist joint, while comparing to the unaffected side, four patients had only a 20 % loss detected especially at flexion and extension (Table 3). We found that all our patients were moderately satisfied. While doing forceful motions, slight (six patients) or moderate (one patient) pain occurred. One of our patients stated that pain was present during daily activities.

Discussion

The lunate bone is the keystone of the wrist's biomechanics. In addition, it is located at the center of the proximal row, and

its main characteristic is to provide balance. Scaphoid flexion and triquetrum extension are balanced by the lunate bone. A change which occurs in the lunate or in the ligaments which connect it to the scaphoid or the triquetrum may cause instabilities, such as SLAC, DISI, VISI, or osteoarthritis caused by damaged wrist mechanics.

The resection of the lunate has been recommended by Roca [14]. But, Takase and Imakiire suggest that lunate bone excision may only be applied by means of an arthrodesis which forms a bridge between the scaphoid, lunate, and triquetrum [15]. According to Takase, osteotomy of the capitate requires the resection of the lunate bone and intercarpal arthrodesis; this technique is called the modified Graner procedure. Takase states that palmar flexion of the scaphoid cannot be prevented in the original Graner procedure. A scaphoid not supported by the scapholunate ligament will flex. Since scaphoid flexion inevitably causes arthritis in the wrist, the natural result of this treatment must be prevented by not performing this surgery.

The impact of the negative ulnar variant for the Kienböck occurrence is controversial [3, 16]. Some authors suggest that a decrease in radial inclination causes the disease [5, 6, 17]. It has been suggested that the lunate is not covered sufficiently by the radius due to an ulna minus deformity or change in the radial inclination. The pressure on the lunate increases when the contact surface decreases (pressure = force/area); this is similar to acetabular dysplasia of the hip. An increase in load causes the breakdown of the vascularity of the bone. The aim of radial or ulnar osteotomy is to decompress the lunate by reducing the axial pressure load on the bone. This theory, in our opinion, must be reevaluated. The similar surface insufficiency seen in acetabular dysplasia never causes avascular necrosis of the hip, but rather chondral pathologies. Avascular necrosis of the hip occurs for totally different reasons. If the lunate is under compression, the effect should be

Table 2 Cases according to modified Mayo wrist score at the 6th month

	Side	Lichtman stage	Pain points	Functional status points	ROM points	Grip strength of the contralateral wrists	Grip strength of the affected wrist	Grip strength percent of the contralateral side	Grip strength point	Points
31/M	Right	2	20	20	20	48.3 kg	38.4 kg	79 %	30	90, excellent
30/M	Right	2	15	20	15	51.3 kg	31.9 kg	62 %	20	70, good
40/M	Left	2	15	20	15	43.2 kg	23.7 kg	54 %	20	70, good
33/F	Left	2	20	30	20	28.1 kg	14.8 kg	52 %	20	90, excellent
26/F	Left	3a	20	20	15	31.4 kg	19.7 kg	62 %	20	75, good
32/M	Right	2	20	20	20	45.6 kg	25.3 kg	55 %	20	80, good
20/M	Right	2	20	30	20	48.7 kg	28.4 kg	58 %	20	90, excellent
26/F	Right	2	20	30	20	24.5 kg	32.7 kg	60 %	20	90, excellent
42/M	Right	3b	20	20	15	44.6 kg	30.1 kg	62 %	20	75, good

Table 3 Range of motion

Patients	31 M	30 M	40 M	33 F	26 F	32 M	20 M	26 F	42 M
Pronation/preop	70°	59°	50°	61°	58°	60°	61°	70°	58°
Pronation/postop 6th month	75°	63°	58°	68°	59°	72°	69°	76°	63°
Supination/preop	71°	50°	60°	81°	50°	68°	71°	77°	45°
Supination/postop 6th month	79°	54°	67°	83°	57°	81°	74°	85°	51°
Flexion/preop	55°	30°	36°	51°	32°	59°	54°	62°	37°
Flexion/postop 6th month	60°	35°	40°	54°	37°	64°	61°	72°	42°
Extension/preop	40°	24°	25°	41°	29°	42°	41°	45°	24°
Extension/postop 6th month	43°	27°	31°	47°	34°	47°	48°	51°	29°
Radial deviation/preop	20°	16°	15°	20°	13°	17°	24°	21°	10°
Radial deviation/postop 6th month	26°	16°	20°	24°	18°	20°	30°	25°	15°
Ulnar deviation/preop	29°	16°	21°	30°	21°	29°	35°	34°	24°
Ulnar deviation/postop 6th month	35°	20°	26°	39°	27°	33°	41°	37°	30°
ROM according to mod. Mayo wrist score	20°	15°	15°	20°	15°	20°	20°	20°	15°

seen first of all on the cartilage surface, and arthritis should be observed in the first stage, not the final stage, as in the case of damaged wrist biomechanics.

On the other hand, radial shortening and ulnar extension osteotomies are recommended and acknowledged to be successful. In patients with no negative ulnar variant, radial inclination is found to be responsible, and radial closing wedge osteotomy is applied. This treatment approach may be defined as osteotomy in any condition.

We think that ulnar variant and radial inclination-oriented treatments are wrong, but the radial and ulnar osteotomy is correct because it is successful. The reason for the success is the osteotomy. Osteotomy is a created fracture, which causes changes, not only to the bone to which it is applied, but also in peripheral bones. The most basic regional change is an increase in the vascularity. Increased vascularity facilitates recovery in avascular necrosis.

Radial and ulnar osteotomies damage the front arm biomechanics while benefiting the recovery of Kienböck's disease. After osteotomies, bone union difficulty and DRUJ dysfunctions are encountered [16, 18]. Core decompressions of the distal radius and lunate for the treatment of Kienböck's disease represent two less invasive procedures with potentially fewer complications [19, 20].

We believe that the osteotomies used in this treatment are applied in the wrong locations. Osteotomies should be applied not to the forearm, but to the capitate bone. It is easy to reach, it is closer to the lunate, and it is safer to perform forage on its noncartilage-covered surface. The blood supply of the capitate is from the same vascular network as for the lunate. When forage is applied to the capitate bone, an osteotomy effect is created in the bone. Changes occurring in the capitate and lunate as a result of forage can be detected in MRI images.

The low degree of strength loss and motion limitations suggests that the treatment is well tolerated by patients. The decrease in pain and high satisfaction suggest the effectiveness of the treatment. We think that the osteotomies applied in the treatment of Kienböck's disease help recovery not by relieving the pressure, but through the vascularity-enhancing effect of the osteotomy. With capitate forage, these positive effects are produced with fewer negative impacts; this method should be of interest to surgeons investigating treatment methods for Kienböck's disease.

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