Partial Capitate Shortening Osteotomy and Its Impact on Lunate Revascularization: Mid-Term Results

Les résultats à moyen terme de l'ostéotomie partielle de raccourcissement du capitatum et ses résultats sur la revascularisation : de l'os semi-lunaire

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Abstract

Background: Treatment of Kienböck disease is still a clinical challenge. The treatment used in each instance is decided according to stage of the disease at presentation. Good clinical and radiological results could be obtained with partial capitate shortening osteotomy. However, mid-term results of this technique and its effect on lunate revascularization are not well known.

Objectives: The aim of this study was to report our results of partial capitate shortening osteotomy in the treatment of stage II and IIIA Kienböck disease. **Methods:** Ten patients were enrolled in the study with a mean age of 37.7 years old (standard deviation [SD] = 9.6). Patients were evaluated clinically in terms of range of motion, DASH and VAS scores, satisfaction with the outcome, and grip/tip/palmar/key pinch strength compared to the contralateral side. Radiological evaluation consisted of Lichtman staging on plain radiographs and lunate revascularization on magnetic resonance imaging (MRI) at both preoperative and post-operative evaluations. **Results:** The mean duration of follow-up was 55.2 (SD = 24) months. The mean DASH and VAS scores were 14.3 (SD = 6.7) and 1.5 (SD = 1.3), respectively. For patient satisfaction, the mean score was 3.6 (SD = 0.6). The Lichtman stage of 7 patients remained unchanged. Lunate revascularization was detected with MRI in 6 patients.

Conclusions: Although the number of patients in the study prevents more strict conclusions, our results are promising, and the technique presented offers minimally but observable lunate revascularization and high success rates in preventing the progression of the disease.

Résumé

Historique : Le traitement de la maladie de Kienböck demeure un défi clinique. Dans chaque situation, le traitement dépend de la phase de la maladie à la consultation. On peut obtenir de bons résultats cliniques et radiologiques grâce à une ostéotomie partielle de raccourcissement du capitatum. On connaît toutefois mal les résultats à moyen terme de cette technique et ses effets sur la revascularisation de l'os semi-lunaire. **Objectifs :** La présente étude visait à rendre compte des résultats de l'ostéotomie partielle de raccourcissement du capitatum dans le traitement de la maladie de Kienböck de stade II et IIIA. **Méthodologie :** Dix patients d'un âge moyen de 37,7 ans (ÉT 9,6) ont participé à l'étude. Les chercheurs ont évalué l'amplitude de mouvement de ces patients, leurs scores DASH et VAS, leur satisfaction envers les résultats et leur force de préhension des doigts, de la paume et de la pince sub-termino-latérale par rapport au côté controlatéral. Ils ont procédé à une évaluation radiologique préopératoire et post-opératoire au moyen de la classification de Lichtman par radiographie classique et de la revascularisation de l'os semi-lunaire par

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imagerie par résonance magnétique (IRM). **Résultats :** Le suivi avait une durée moyenne de 55,2 mois (ÉT 24). Les scores DASH et VAS moyens s'élevaient à 14,3 (ÉT 6,7) et à 1,5 (ÉT 1,3), respectivement. Le score moyen de satisfaction des patients était de 3,6 (ÉT 0,6). Le stade de Lichtman de sept patients est demeuré stable. Chez 6 patients, l'IRM a révélé une revascularisation de l'os semi-lunaire. **Conclusions :** Même si le peu de patients à l'étude empêche les auteurs de tirer des conclusions plus rigoureuses, les résultats sont prometteurs. La technique utilisée entraîne une revascularisation de l'os semi-lunaire minime, mais observable, et empêche l'évolution de la maladie dans une grande proportion des cas.

Keywords

capitate, Kienböck, lunate, lunatum, partial, shortening

Introduction

Treatment of Kienböck disease is still a clinical challenge with over 20 treatment modalities of varying efficacy available.¹ Although the exact etiology is uncertain, vascular, anatomic, or traumatic insults seem to cause lunate collapse, carpal migration, and wrist degeneration.² The proper treatment is decided according to the stage of the disease at presentation.^{3,4}

Most surgical procedures are based on decompression of the lunate, and such decompression seems to be achieved by redistributing the load to adjacent normal structures.⁵ In this context, radial shortening or ulnar lengthening osteotomies, revascularization procedures with or without stabilization, capitate shortening osteotomy, radial wedge or dome osteotomies, core decompression, or combined procedures were proposed in the treatment of Lichtman stages II and IIIA.⁶ Partial capitate shortening osteotomy, first described by Moritomo et al, is another treatment option that aims for lunate decompression.⁷ Early results have been reported by Citlak et al in patients with stages II and IIIA of Kienböck disease.⁸ With this procedure, good clinical and radiological results could be obtained, carpal alignment could be preserved, and better joint congruency could be provided around the scaphoid. However, mid-term/long-term results and the effects of this technique on lunate revascularization are not well known.

In this case series study, we aimed to investigate clinical and radiological results of partial capitate shortening in patients with Lichtman stages II and IIIA and to evaluate the impact of this procedure on lunate revascularization at medium-term follow-up.

Patients and Methods

We performed a retrospective study based on 10 consecutive patients who underwent partial capitate shortening osteotomy for the treatment of Kienböck disease. All patients had stage II or IIIA Kienböck disease at their initial presentation, according to the Lichtman classification system, and the diagnosis was confirmed by plain radiographs and magnetic resonance images (MRI) of the wrist joint. The patients' chief symptom was wrist pain during activity. The patients were treated between January 2010 and January 2015 in our clinic. Exclusion criteria were (1) Patients with less than 18 months of follow-up, and² patients with a history of previous wrist

fracture/dislocation/surgery (any surgery including the proximal/distal carpal rows or distal radius/distal ulna).

Of the 10 patients, 5 were male and 5 were female. The mean age of the patients was 37.7 (standard deviation [SD] = 9.6) at the time of surgery. In 7 patients, the affected side was their dominant side. None of the patients had a history of wrist trauma or previous hand surgery. Regarding staging, 3 patients had stage II and 7 patients had stage IIIA Kienböck disease at initial evaluation (Table 1). Ulnar variance was ignored.

All surgeries were performed by the same surgeon. The procedure was performed as defined by Moritomo et al.⁷ After general or regional anesthesia, the surgical procedure started with a longitudinal dorsal skin incision over Lister tubercle in line with the third metacarpal. After retraction of the extensor tendons, the capsule was incised and the capitate was exposed. We performed a "reverse L-shaped" osteotomy on the capitate bone, which is composed of 2 straight lines crossing at 90° angles. The second transverse cut was parallel and 2 mm distal to the first transverse cut. The mobile segment of capitate was then moved through the distal segment. The osteotomy line was compressed with a headless cannulated screw (Acumed, Hillsboro, Oregon; Figures 1 and 2). The position of the screw was controlled with an image intensifier. The dorsal capsule was repaired and closed in a layered fashion without imbrications, and the skin was closed in a short arm cast. After 4 weeks of immobilization, wrist motion and active finger motion was begun under the supervision of a therapist. At the end of the eight week, forced wrist movements were permitted. Hospital record data were obtained for all patients and they each were called for a final evaluation.

Final Evaluation

The functional evaluation consisted of the active range of motion of the operated and contralateral wrists with a goniometer in flexion, extension, radial, and ulnar deviations⁹; DASH¹⁰ and VAS scoring systems (0 = no pain, 10 = the most severe pain); pinch strength, which was measured through a mean of 3 attempts (with hand dominance ignored) through grip/tip/palmar and key pinch strength of both the operated and contralateral wrists measured by a Jamar dynamometer (Model SH 5001, Saehan Corporation, Masan, South Korea) and a pinch meter (Model SH 5005, Saehan Corporation). The length of time before patients returned to work was also included in

Table 1. Radiological Findings of the Patients.

Patient	Pre Lichtman	Po Lichtman	Pre Schmitt	Po Schmitt	Contr	Follow-Up
1	II	IIIB	B	B	↓	66
2	IIIA	IIIA	B	B	↑	80
3	IIIA	IIIA	B	B	↑	82
4	II	II	B	B	↑	76
5	II	IIIA	B	B	↔	52
6	IIIA	IIIA	B	B	↔	32
7	IIIA	IIIA	B	B	↑	22
8	IIIA	IIIA	B	B	↑	52
9	IIIA	IIIB	B	B	↔	18
10	IIIA	IIIA	B	B	↑	72

Abbreviations: Contr, the changes of signal intensity; Po, postoperative last follow-up; Pre, preoperative; ↓, decreased bone marrow signal intensity; ↑, increased bone marrow signal intensity; ↔, similar signal intensity to that observed on preoperative period.

the functional evaluation, as well as their satisfaction according to the Gay scale¹¹ (from 0 to 4: 0 = not satisfied, 1 = no change, 2 = slightly satisfied, 3 = satisfied, 4 = very satisfied). All measurements were done by the same author.

Radiological evaluation consisted of the Lichtman staging based on plain radiographs (anteroposterior and lateral) and MRI evaluation with Schmitt classification to determine lunate revascularization and progression of the disease¹² (Table 2). Such evaluation was made by an expert radiologist at both preoperative and final control. Standard 1.5 Tesla MRI sequences were obtained for all scans. In addition, fast-spin echo (FSE) T1-weighted coronal, FSE T1-weighted FS coronal, axial, and sagittal images were obtained after an injection of gadolinium-diethylene triamine pentacetate. The revascularization of the lunate was established when high-signal intensity was detected on fat suppression images in at least one part of the lunate. An increase in signal intensity on fat suppression images suggested revascularization.¹³

Informed consent has been obtained from each patient. The authors received no financial support for the research, authorship, and/or publication of this article.

Results

Final Clinical Evaluation

Mean follow-up time was 55.2 (SD = 24) months. The mean time to return to work after surgery was 3.9 (SD = 2.1) months. The mean postoperative VAS score was 1.5 (SD = 1.3) and the DASH score was 14.3 (SD = 6.7). Mean patient satisfaction was 3.6 (SD = 0.6) of 4 points. The patient with the worst clinical outcome held a DASH score of 25.4, with a VAS score of 3 and satisfaction score of 2 of 4 points. When compared to the contralateral unaffected sides, the mean grip strength of the operated hands was 67.2%, and palmar pinch was 80.9%, tip pinch was 71.4%, and key pinch was 76.4%. The mean flexion range of the operated hands was 72%, extension range was

76.4%, radial deviation range was 79.1%, and ulnar deviation was 73.5%, when compared to the contralateral sides.

Final Radiological Evaluation

According to the plain radiographs, the Lichtman stage of 1 patient advanced from IIIA to IIIB, 1 patient from II to IIIA, and 1 patient from II to IIIB. The stages of 7 patients remained unchanged. Lunate revascularization was detected in 6 patients with MRI: Increased signal areas were observed within bone marrow of the lunate (Figure 3A and B). The enhancement pattern of the bone marrow of the lunate on MRI was similar to that observed on the initial MR images in 3 patients (2 patients with Lichtman stage progression from II to IIIA and from IIIA to IIIB; 1 patient with Lichtman stage remained unchanged). There was a regional area of decreased bone marrow signal intensity of the lunate in 1 patient (the patient with Lichtman stage progression from II to IIIB). According to Schmitt classification, the preoperative stages of all patients were B, whereas the stages of all patients at the final control evaluation were also B (Table 1). None of the patients had arthritic changes.

Discussion

The current study showed that high satisfaction rates, good clinical results, and acceptable lunate revascularization could be obtained with partial capitate shortening osteotomy on patients with stage II and IIIA Kienböck disease. To the best of our knowledge, the current study included the clinical and radiological results of partial capitate shortening osteotomy with the longest follow-up time in the English literature.

Kienböck disease is a time-dependent disease. The general opinion is that arthrosis deformans develop from 1 year to several years after the initial event. The shortest period after which it was possible to observe such signs was 4 months.¹⁴ The sequestered bone gradually becomes denser on radiographs; this process can take up to 4 years.¹⁵ The mean follow-up time in the current study was 55.2 months and, according to the Lichtman classification, the disease of 3 patients advanced while 7 remained unchanged, with the progression of the disease seemingly arrested. Although its history suggests that Kienböck disease will remain unpredictable, the revascularization of lunate in 6 patients (60%) and no change of vascularization in 3 patients (30%) suggest that partial capitate shortening could prevent progression of the disease.

The treatment options for Kienböck disease vary. Although various procedures have been proposed, a uniform algorithm has not been organized.³ Most of the surgical procedures aim to unload the lunate in stages II and IIIA¹⁶; there are several studies in the literature that report good clinical and radiological outcomes. Afshar and Eivaziatashbeik reported reasonable long-term outcomes following both radial shortening osteotomy and vascularized bone graft techniques.¹⁷ Koh et al showed improvement of pain and grip strength after radial shortening osteotomy, but 73% of those patients had arthritic

Figure 1. Diagram of the partial capitate shortening osteotomy. A, Osteotomy lines. B, Fixation of the osteotomy with a headless screw.

Figure 2. Posteroanterior radiograph 38 months after partial capitate shortening osteotomy.

Table 2. Schmitt Classification.¹²

Stage	Pathology	T1-Weighted Images	T2-Weighted Images	Contrast Enhancement
I	Edema	Hypointensity	Variable	Homogeneous
II	Partial necrosis	Hypointensity	Variable	Patchy—inhomogeneous
III	Complete necrosis	Hypointensity	Variable	Absent

changes.¹⁸ Horii et al showed a 66% decrease in the radiolunate load and a 26% increase in the radioscapoid load through capitate shortening osteotomy combined with hamate fusion.¹⁹

Figure 3. A, Preoperative coronal MRI sequence showing stage II Kienbock disease. B, Coronal MRI sequence 48 months after partial capitate shortening osteotomy. Note the revascularization of the lunate. MRI indicates magnetic resonance imaging.

Almquist reported 83% revascularization²⁰ and Afshar showed partial revascularization in all patients after capitate shortening osteotomy¹³; Gay et al obtained 72.7% good and fair results with said technique.¹¹ Additionally, capitate shortening osteotomy reduces loading forces across the radiolunate joint.²¹ Moritomo et al proposed the usage of the partial capitate shortening osteotomy to preserve scaphotrapeziotrapezoid (STT) and scaphocapitate (SC) ligaments, unlike the capitate shortening osteotomy.⁷ They discussed that both STT and SC must remain intact for the scaphoid to move normally in the mid-carpal joint and to work effectively as the scaphoid arm in the equilibrium. They advocated that such technique is minimally invasive and technically easy, can dramatically unload lunate, and therefore allow revascularization. Additionally, Kataoka et al reported significant lunate decompression with such procedure in their biomechanical study.²² However, review of the literature revealed no study evaluating kinematics of the mid-carpal joint following partial capitate osteotomy.

Furthermore, clinical data related to this procedure are limited: Only Citlak et al reported clinical and radiological outcomes with a median 38-month follow-up, which are

comparable with our results.⁸ Our clinical results were comparable with similar studies in the literature.^{8,11,13,17,18} We obtained satisfactory results in all patients except one. This patient had a trauma after the surgery, and the surgery was revised after 18 months of follow-up. A lunate excision with limited intercarpal fusion was preferred at that time.

In accordance with Moritomo et al, we also think that partial capitate shortening does not alter carpal alignment and does not affect scapholunate or scaphocapitate articulation with lunate unloading. Moreover, our MRI evaluation showed that lunate revascularization could be obtained at mid-term follow-up. In all patients, the Schmitt classification was B both preoperatively and postoperatively, and neither the observed signal increase in the MR images of 6 patients nor the signal decrease in the MR images of 1 patient caused a progression or regression of the Schmitt stages of patients. Additionally, the signal pattern of 3 patients remained unchanged. Thus, there was no decrease of lunate vascularization of 9 (90%) patients with Kienböck disease, which is known as a progressive disorder.

The main weak points of this study are the limited number of patients, the lack of a control group, and the preoperative clinical condition of patients due to retrospective design. Additionally, no specific analysis of MRI results and patient outcomes was performed. However, it must be taken into consideration that the number of patients in related studies are similar, and those studies include shorter follow-up periods. In this technique, a step-off on the mid-carpal joint is created which can theoretically pose a risk of osteoarthritis. Nevertheless, we think that the risk of arthritis is minimal due to the 2-mm step-off created in the joint. Indeed, none of the patients had arthritic changes at their mid-term follow-up. In this context, comparative studies with larger series and longer follow-up would offer stricter conclusions. Finally, ignorance of ulnar variance may be considered as another weak point of this study. However, the causal relationship between Kienböck disease and ulnar variance is still controversial.²³⁻²⁵

Conclusion

Although the number of the patients in this study prevents more strict conclusions, our results are promising, and the technique presented offers minimal but observable lunate revascularization with high success rates in preventing the progression of the disease.

Authors' Note

Each author certifies that his or her institution approved the human protocol for this investigation that all investigations were conducted in conformity with ethical principles of research and that informed consent for participation in the study was obtained. The work was done in Katip Celebi University.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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