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Research Article

Evaluate the Core Decompression by Drilling Method Outcome with and Without Bone Marrow for Treatment of Kienbock Disease

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Abstract

Introduction: Kienbock disease is defined by avascular necrosis of the lunate bone. If left untreated, the condition often progresses, leading to bone collapse, wrist shortening, and the need for ankle fusion. In this study, we performed a novel surgical method for treating Kienbock disease. We evaluated and compared the outcomes of lunate decompression with and without bone marrow injection in patients affected by Kienbock disease.

Method: In this study, 20 patients with Kienbock disease stages I to IIIa were assessed in two groups: one group received core lunate decompression. In contrast, the other group underwent core lunate decompression followed by an injection of bone marrow. This study took place from April 2015 to April 2016. The researchers assessed the patient's pain levels, range of motion, functional disability, and radiographic indices before and one year after the procedure.

Result: The average age of patients in the Bone Marrow (BM) group was 35.66 years (standard deviation: 13.02), compared to 30.33 years (standard deviation: 0.66) in the control group (P = 0.126). The mean postoperative Mayo score for the BM group was 88.12 (standard deviation: 6.51), while the control group had a mean score of 76.66 (standard deviation: 2.88) (P = 0.126). Additionally, the mean postoperative performance score in the BM group was 24.37 (standard deviation: 1.76), compared to 18.33 (standard deviation: 2.88) in the control group (P = 0.09). Bone vascularization and mineralization were more significant in the BM group than in the control group.

Conclusion： The results of this study indicate that core lunate decompression is an effective treatment for Kienbock disease. The outcomes in the BM group were significantly better than those in the control group. Additionally, improvements in bone density and radiological changes were observed in the BM group. However, further studies with larger sample sizes and longer follow-up durations are necessary for a more comprehensive evaluation of the BM treatment.

Keywords: Kienbock desease, Lunate bone, Bone Marrow.

Introduction

Kienböck initially described lunatomalacia and its original radiographic findings in 1910 and supposed that some form of trauma leads to a “disturbance of the nutrition” of the lunate, causing sclerosis, fracture, and collapse [1]. The primary etiology of Kienböck disease is unknown, although the condition is assumed to progress through stages, as first reported by Stahl and modified by Lichtman and Degnan [2-4]. Notably, the natural history of the disease recommends that the lunate will sequentially fracture and collapse [5-7]. Ultimately, the wrist converts arthritis as a consequence of the altered biomechanics [7].

Many factors may influence Kienböck disease, but it is likely caused by a mixture of repeated loading, vascular risk, and mechanical options [8]. Treatments to date have been designed to reduce the compressive loading of the lunate to stop the lunate collapse and allow lunate revascularization [9].

Many investigations showed a relationship between negative ulnar variance and the progress of Kienböck disease and suggested a shortening of the radius or lengthening of the ulna [10-12].

The core decompression technique is a technically simple procedure that does not invade the wrist joint or require any form of internal fixation [13].

The lack of postoperative complications such as nonunion, distal radioulnar joint incongruence, or ulnocarpal impingement, or problems such as limited wrist mobility, carpal malalignment, or complications from internal fixation makes this approach worthy of consideration [14-16].

Many surgical methods, including excision arthroplasty, radial shortening osteotomy, limited intercarpal fusion, and blood vessel transplantation, have been used to manage patients with Kienböck disease [17]. These methods are invasive, though, and not necessarily sufficient to induce improvement of the necrotic lunate. They also have some disadvantages, such as large, invasive, and complicated procedures and uncertain lunate bone regeneration [18].

Despite this approach, the treatment for Kienböck disease remains controversial. Recently, developments in regenerative medicine have enabled us to apply various methods of bone regeneration to bone necrosis [15]. Mont et al. reported the feasibility of using growth and differentiation factors for femoral head osteonecrosis. Connolly reported good clinical results were obtained using multiple drilling and bone marrow (BM) autografting for nonunions [19]. BM includes mesenchymal stem cells and many growth and differentiation factors.

As such, we investigated the effectiveness of BM transplantation for regenerating necrotic bone in patients with Kienböck disease [20].

In this study, we performed a new surgical method for the treatment of Kienbock disease. We evaluated and compared the outcomes of lunate decompression with and without bone marrow in Kienbock patients.

Methods

This study involved 20 patients (12 men and eight women, with an average age of 33.33 and a standard deviation of 11.89) diagnosed with Kienbock disease in stages I to IIIa.

From April 2015 to April 2016, patients were assigned to one of two treatment groups. One group received core lunate decompression, while the other group received core lunate decompression in combination with bone marrow treatment. Among the patients, 17 had a minus ulnar condition, and 17 had an ulnar plus condition. In the intervention group, one patient had an ulnar plus condition, while two patients in the control group were also classified as an ulnar plus.

Ethics committee approval and informed consent were obtained from each patient before the study. Ten patients underwent core lunate decompression alone, while the other ten received core lunate decompression in addition to bone marrow treatment. Each patient signed an informed consent form before the procedure began.

We included patients with stage I to IIIa Kienböck disease who were willing to provide informed consent. The exclusion criteria included patients with a history of diabetes mellitus, previous wrist surgery, stage IV disease, or existing osteoarthritis. Additionally, we excluded individuals with a history of significant wrist trauma. All participants were elective cases; emergent cases were not considered for the study.

Before the intervention, we discussed the different treatment options with the patients. All participants received the standard anesthesia technique. Preoperatively and postoperatively, we interviewed and examined all patients for pain, range of motion, functional disability, and radiographic indices.

A different radiologist and hand surgery specialist evaluated the results pre- and post-operation.

In this study, we used the Mayo Wrist Score. One hundred scores are equally distributed between the pain, active flexion/extension arc as a percent of the opposite side, grip strength as a present of the opposite side, and the ability to return to regular employment or activities.

The evaluator rates pain as none (25 scores), mild (20 scores), moderate (10 scores), or severe (0 scores) based on the patient's subjective description. The total score ranges from 0 to 100 points, with higher scores indicating a better result. An excellent outcome is specified as 90–100, sound, 80–89, fair, 65–79 scores, and poor, less than 65 scores.

The ulnar variance was determined by measuring the distance between lines painted perpendicular to the long axis of the radius and tangential to the lunate facet of the radial articular surface and the distal extent of the ulnar head. We obtained magnetic resonance imaging for all patients preoperatively to clearly define the extent of necrosis and rule out other conditions. We examined all patients for wrist range of motion and lunate tenderness. We repeated all measurements six months postoperatively.

We identified the lunate with a guide wire under fluoroscopic control. We used a dental burr (2.5 mm) to decompress the lunate thoroughly from a dorsal entry under fluoroscopic control. We did not remove the cancellous bone. Bone marrow (1.5 to 2 ml) obtained from the iliac crest of the same patients was injected slowly into one hole. After filling the inside, the rest of the bone marrow was used to surround the bone in the pouch.

After one week, we placed a light cast on the affected area for six weeks to protect the decompressed bone. Following this, we began range-of-motion exercises. Six months after the procedure, we assessed the patients again using the same questionnaires, re-evaluated their radiographic indices, and examined their wrist movements.

Descriptive statistics were calculated for the data presented. We used the chi-square test and Fisher's exact test to determine the association between qualitative variables. Comparisons between the groups were conducted using the non-parametric Mann-Whitney test. The Kolmogorov-Smirnov test was employed to assess the normality of the data. The analysis was performed using SPSS version 20 (SPSS Inc., USA). A significance level of 0.05 was established for all tests.

Results

Twenty patients were evaluated for participation in the study. The average age of patients in the BM group was 35.66 (13.02) years, while in the control group, it was 30.33 (0.66) years (P=0.126).

There was no significant difference between the two groups regarding gender, age, and staging distribution.

The average preoperative Mayo score in the BM group was 48.33 (SD 12.74), while in the control group, it was 43.33 (SD 7.63) (P=0.126) (P=0.60). There was no statistically significant difference in the Mayo score between the two groups before the operation.

The mean postoperative Mayo score in the BM group was 88.12 (6.51), while in the control group, it was 76.66 (2.88) (P=0.07) (Fig 3). The average postoperative performance score in the BM group was 24.37 (with a standard deviation of 1.76), while the control group had an average score of 18.33 (with a standard deviation of 2.88) (P=0.09). Both groups experienced a significant reduction in pain after surgery; however, there was no significant difference in pain levels between the two groups (Table 1).

Bone vascularization and mineralization were more significant in the BM group than in the control group.
The two groups had no statistically significant difference regarding radio scaphoid angle and Carpel Height pre- and postoperative (Table 2).

Table 1: Distribution of Mayo Wrist Score at six months postoperative

Items	**control**	**BM**	**P-value**
Pain	23.33 (2.88)	25.00 (0.00)	0.48
Return to regular employment or activities	18.33 (2.88)	24.37 (1.76)	0.09
Active flexion/extension arc as a percentage of the opposite side	15.00 (0.00)	16.87 (5.30)	0.77
Grip strength	20.00 (0.00)	21.87 (2.58)	0.33
Total	76.66 (2.88)	88.12 (6.51)	0.07

Table 2: The Radio-Scaphoid angle and Carpel Height in study participants at six months postoperative

Items	BM	control	Total	P-value
Radio-Scaphoid angle	44.44 (5.10)	41.66 (1.15)	43.75 (4.55)	0.48
Carpel Height	0.50 (0.02)	0.51 (0.01)	0.50 (0.02)	0.60

Figure 1: Dental burr (2.5 mm) to decompress the lunate thoroughly from a dorsal entry under fluoroscopic control.

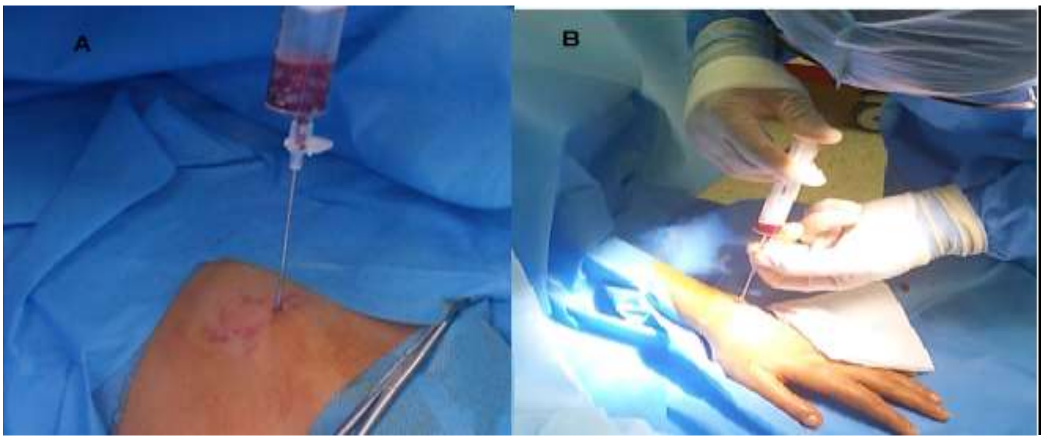

Figure 2: Bone marrow (1.5 to 2 ml) obtained from the iliac crest (A) of the same patients was injected slowly into one hole (B).

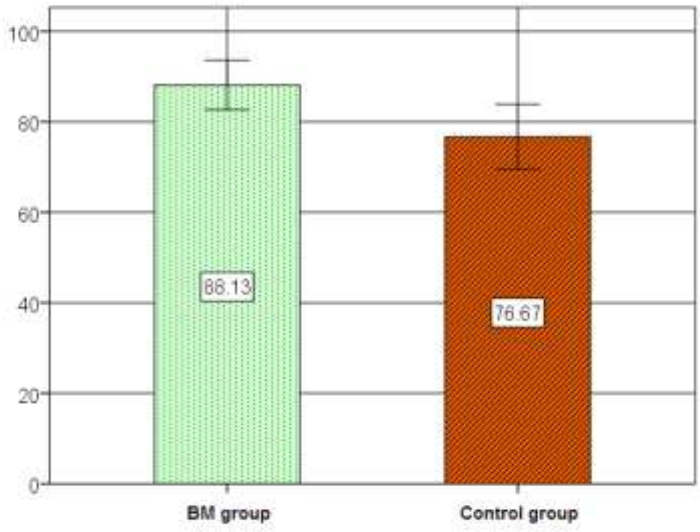

Figure 3: The mean of total Mayo Wrist Score in two groups

Discussion

We confirmed that decompression through drilling and bone marrow transplantation for 20 patients with Kienböck disease in Lichtman stages I or IIIa resulted in good clinical outcomes. These outcomes were comparable to those achieved with conventional treatment methods for Kienböck disease. Additionally, we observed that only the decompression method involving drilling could accommodate vascular invasion.

Vascular insufficiency and micro-traumatic factors are likely significant contributors to the development and progression of Kienböck disease [21]. Although joint-leveling methods and revascularization procedures have become standard strategies over the past decade, these approaches have not been practical in modifying Kienböck disease [22]. Some studies have reported that 25% of patients experience complications, which may include infection, nonunion, and ulnar impingement [17-22]. In our study, however, we did not observe any complications.

In 2001, Illaramendi described the technique of core decompression of the distal radius and ulna for treating Kienböck disease, reporting positive outcomes. Our study aligns with these findings. We believe that decompression of the lunate can decrease intraosseous pressure, similar to the approach used in femoral head avascular necrosis, which has shown favorable results with core decompression in stages I to IIIa.

A study indicates that decompression methods for the radius and ulna may help reduce pain through a process known as secondary hyperemia [23]. In contrast, the lunate decompression method directly lowers intraosseous pressure, enhancing comfort, improving motion, and promoting revascularization [19]. Our findings support these results. This study proposes a decompression technique involving drilling and bone marrow transplantation for treating Kienböck disease. This approach offers several advantages as a joint-leveling method, including pain reduction, increased functional activity, and improved motion while minimizing complications.

The disease did not progress in two groups. This research's outcomes are consistent with results from several studies on radial shortening.

Recent advancements in regenerative medicine have enabled the use of various techniques for bone regeneration in cases of bone necrosis [15-19]. One study demonstrated the feasibility of utilizing growth factors to treat femoral head osteonecrosis .

The primary benefit of this method is its simplicity and the low risk of complications compared to traditional joint-leveling techniques. Consequently, further randomized clinical trials are needed to evaluate its effectiveness.

In our clinical results, we observed a significant improvement in the rate of return to regular employment and daily activities. Notably, all Mayo Wrist Scores were higher in the bone marrow (BM) group, highlighting a significant difference. One of the key findings of our study was the improvement in bone density and radiological changes in the BM group when comparing the two procedures.

Ogawa et al. [24] investigated the midterm clinical and radiographic outcomes of various treatments, including drilling, bone marrow transfusion, external fixation, and low-intensity pulsed ultrasound, for patients with Kienbock's disease. They concluded that the BM method could serve as a less invasive surgical treatment alternative for Kienbock's disease. With an average follow-up period of six years, this new treatment has proven reliable and durable for patients with Lichtman stage II or stage III Kienbock's disease.

Our study found no statistically significant differences between the two groups regarding the radio scaphoid angle and Carpal Height before and after surgery .

Koh et al. reported that the Carpal Height Ratio (CHR) changed from 0.52 to 0.51 following a radial shortening osteotomy. Similarly, Watanabe et al. also reported a change in the CHR from 0.52 to 0.51.

However, the present study has several limitations:

The sample size was small. We could not determine the proportion of mesenchymal stem cells in the transfused bone marrow. Caution should be exercised in patients with a fragmented lunate due to the risk of lunate collapse and nonunion.

In summary, we applied a new method involving drilling and bone marrow transfusion to 20 patients with Lichtman stage I or stage IIIa Kienbock's disease. At the final follow-up, all patients showed improvements in wrist pain, range of motion, and functional disability. However, these patients did not exhibit significant postoperative improvements compared to the control group. Radiographic evaluations indicated that lunate collapse had progressed in most cases. With an average six-month follow-up period, this method is a less invasive surgical treatment. It is a reliable and durable procedure for patients with Lichtman stage I or stage IIIa Kienbock's disease.

Conclusion

The results of this study indicate that core lunate decompression is an effective treatment for Kienbock disease. The outcomes in the BM group were significantly better than those in the control group. Improvements in bone density and radiological changes were observed in the BM group. However, further studies with larger sample sizes and extended follow-up periods are necessary for more conclusive results.

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Conflict of Interest Disclosures

The authors declare that they have no conflict of interest.

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Authors' Contributions

Concepts, data gathering, data analysis, writing and editing: Emami maybodi, Mohammad Kazem, Hamidreza Dehgha Manshadi, Mohammad Nabi Sajad, Hamid Hesarikia, Soleymani Amiri, Jaber

Ethical Statement

Ethical committee of Baqiyatallah University of Medical Sciences confirmed the protocol of this study.

Declaration of Generative AI and AI-assisted technologies

None.

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