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Surgical results in Kienböck's disease

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Abstract

There are different surgical treatment methods due to the stage of Kienböck's disease. In this study, we aimed to report our clinical experience regarding surgical treatment of Kienböck's disease. Thirty-seven patients were operated on in our hospital due to Kienböck's disease. Lichtman classification was used for disease staging. Metaphyseal decompression was applied to early-stage patients and proximal row carpectomy for late-stage. Patients were evaluated in terms of preoperative and postoperative grip strength, flexion-extension range, ulnar-radial deviation range, VAS scoring, DASH scoring, and patient satisfaction. The mean length of follow-up was 44.02 (20-80) months. According to the Lichtman classification, 24 (64.86%) patients were stage 2 before the treatment; one (2.7%) was stage 3A; five (13.51%) were stage 3B; seven (18.91%) were stage 4. Of the 24 patients who underwent metaphyseal decompression, 13 (54.2%) were female and 11 (45.8%) were male. Of the 13 patients who underwent proximal row carpectomy, eight (61.5%) were female and five (38.5%) were male. A statistically significant increase was recorded in all clinical markers in all patients but one underwent metaphyseal decompression. Preoperative and postoperative mean DASH scores were 89.37 and 49.04 (p=0.0001), respectively. There was a decrease in grip strength in patients who underwent proximal row carpectomy, but it was not statistically significant. The increase in ulnar-radial deviation range of motion was not statistically significant. The increase in the extension-flexion range of motion (from preoperative 71.530 to postoperative 850 p=0.008) and VAS (from preoperative 7.84 to postoperative 4.46 p=0.003) and DASH (from preoperative 87.92 to postoperative 55.23 p=0.006) scores were statistically significant. In conclusion, it was determined that the interventions terminate the radiological progression of Kienböck's disease to a large extent. We think that early diagnosis and treatment of Kienböck's disease is important since the clinical results of early-stage interventions are better.

Keywords: Kienböck's disease, metaphyseal decompression, proximal row carpectomy

Introduction

Kienböck's disease is the osteonecrosis of the lunate, one of the proximal row carpal bones of the wrist. It is stated that the collapse of the lunate was first described in anatomical specimens by Peste in 1843 [1,2]. In 1910, Robert Kienböck, a radiologist, proposed the theory that the disease occurs secondary to repetitive traumas, resulting in decreased blood supply to the lunate bone. According to the radiographic evidence provided by Kienböck, isolated changes begin in the proximal part of the lunate and the radiolunate joint is affected [3]. It is stated that avascular necrosis in Kienböck's disease was first described histologically by Baum [1].

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Diagnosis and treatment of the disease are more complex than many orthopedic pathologies. Its diagnosis cannot be made [1]. In general, it is a rare disease and its true incidence is unknown. Data of patients with involvement of both extremities are published as case reports [2]. The disease has an insidious onset and a progressive course. Patients often have a trauma history. In the late stages, wrist instability, carpal collapse, and established wrist arthrosis can be seen [4].

In diagnosis, direct radiography and computed tomography can be applied to investigate the presence of lunate fracture in the early stage and magnetic resonance and scintigraphy can be used to identify avascular changes [5]. Lichtman classification is used in staging [6] (Table 1). Staging plays a very important role in the clinical course of the disease, its treatment, and the preference and prognosis of the surgical procedure if surgery will be performed [7,8] (Table 2).

In this study, we aimed to share our clinical experiences by comparing the pre-and postoperative results of patients hospitalized

in our unit and operated on due to Kienböck's disease.

Materials and Methods

In our study, 37 Kienböck patients registered in Inonu University Faculty of Medicine Orthopedics and Traumatology Clinic, Department of Hand and Upper Extremity Surgery were evaluated retrospectively. The data obtained from 12 of the 23 patients included in the metaphyseal decompression section of our study were originally published in the European Review for Medical and Pharmacological Sciences [37]. However, a specialty thesis was prepared with more patients at different stages, added later. This article is the data analysis of the specialization thesis. The minimum sample size was calculated as 27 with a medium (0.5) effect size, a confidence interval of 95%, and a power of 80%. Institutional review committee approval and ethics committee approval was obtained (Inonu University ethics committee 2014/136, 01.10.2014). All patients gave their informed consent. All procedures in our study complied with the ethical standards of the Declaration of Helsinki. Since the stage of the disease affects the treatment applied, two surgical treatment groups were compared pre-and postoperatively within themselves.

Control patients were given DASH and VAS score questionnaires, their routine clinical examinations were performed, and standard wrist radiographs were taken. Jamar hydraulic hand dynamometer was used for the measurement of grip strength and a goniometer was used for the measurement of range of motion. The digital images were recorded and radiologically evaluated in a computerized PACS system at certain periods before and after the treatment.

The limitations of this study are that although it was a single-centered treatment, more than one surgeon was involved in the implementation of treatment methods, the patient population was small, the study was conducted retrospectively, and the follow-up period was relatively short.

Measurements were statistically evaluated in the SPSS for Windows version 16.0. The paired sample t-test and Wilcoxon test were used for the comparison of patient wrists before and after treatment. The Mann-Whitney U test was used according to the suitability of distribution and the number of groups to examine the relationship between treatment methods.

Surgical Procedure

Among the treatment methods applied in our clinic, proximal row carpectomy and metaphyseal decompression were evaluated separately.

Proximal Row Carpectomy

Proximal row bones were removed from the dorsal face and fixed with a temporary K wire after capsule interposition. The K-wire was removed in the postoperative third week. In our clinic, 13 patients underwent proximal row carpectomy (Figure 1).

Metaphyseal Decompression

In metaphyseal decompression, an incision of 2x0.5 cm was made on the bone cortex 2cm above the radius styloid and the distal radius metaphysis was curetted with a curette without removing the cancellous bone (Figure 2). Afterward, the removed cortex was cut into small pieces and placed in the metaphyseal part that was curetted. After the periosteum was repaired, the skin and subcutaneous tissue were repaired, and the patients were asked to come to the outpatient clinic for scintigraphy in the third month. Blood flow increased in all patients after scintigraphy. Metaphyseal decompression was implemented in 24 patients (Figure 3).

Postoperative rehabilitation: In both treatment methods, patients wore a short arm neutral wrist splint for three weeks. In the second-week follow-up, the sutures of the patients were removed. The splint was removed at the third-week follow-up and the patients started physical therapy and a rehabilitation program.

Figure 1. An example of proximal row carpectomy from our clinic

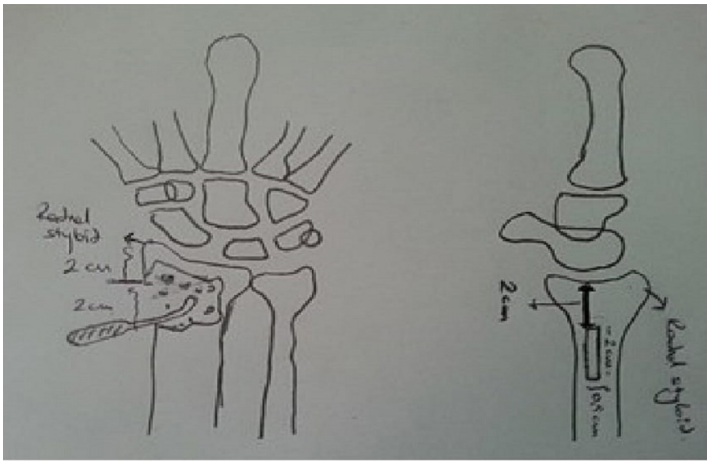

Figure 2. Schematic illustration of metaphyseal decompression applied in our clinic

Figure 3. An example of metaphyseal decompression from our clinic

Results

Sociodemographic Findings of the Patients

Of the patients, 16 were male (43.2%) and 21 were female (56.8%). The mean age of the patients was 38.21 (19-73), 37.06 (23-73) in men, and 40.61 (19-57) in women. Of the patients, 42.85% (n=15)

were aged between 30 and 39; 21.62% (n=8) were aged between 20 and 29; 16.21% (n=6) were aged between 40 and 49; 16.21% (n=6) were aged between 50 and 59. In total, 94.59% (n=35) of the patients were aged between 20 and 59. Only one patient (2.7%) was diagnosed at the age of 20 or younger.

Of the patients, 27 (73%) had right wrist involvement and 10 (27%) had left wrist involvement whereas no patient had bilateral involvement. Of the females, 15 (40.54%) had right and 6 (16.21%) had left wrist involvement. Of the male patients, 12 (32.43%) had right and 10.81% had left wrist involvement. When evaluated according to the dominant wrist involvement, 35 (94.59%) patients had involvement in the right dominant wrist and 2 (5.51%) patients had involvement in the left dominant wrist.

When the occupational distribution of our patients at the time of diagnosis was examined, 45.9% (n=17) of the patients were housewives; 27% (n=10) were workers; 10.8% (n=4) were students; 8.1% (n=3) were government employees; 5.4% (n=2) were farmers; 2.7% (n=1) were retired. Women, who were also dominant in terms of gender distribution, were generally from rural areas. Most of them were engaged in manual labor inside and outside the home, such as gardening. Among the workers, those who worked in jobs that required manual labor, such as construction and industrial work, constituted the majority.

Of the patients, 20 (54.1%) had a trauma history regardless of being minor or major, whereas 17 (45.9%) did not have a specific history. The number of traumatic patients with radiological findings was two. Before being diagnosed with Kienböck's disease, one of these patients had a fracture in the distal radius and the other a fracture in the first metacarpal, and they were diagnosed during their follow-up after treatment.

In 7 stage-4 patients, no additional diagnostic method other than direct radiographs was required for diagnostic purposes, whereas other auxiliary methods such as MRI, CT, and scintigraphy were used in the other 30 patients.

The mean duration of symptoms of the patients before treatment was 42.81 (1-240) months. 29 (78.37%) of 37 treated patients had applied to another health center before applying to the university clinic during this period of symptoms. Only 8.1% (n=3) of the patients were diagnosed in the first 24 months of the complaints; most of the patients (70.27%, n=26) were diagnosed within 24-48 months.

Before the treatment, when the patients' wrists were grouped according to the Lichtman classification, 24(64.86%) patients were stage 2;1(2.7%) was stage 3A;5(13.51%) were stage 3B; 7 (18.91%) were stage 4. According to the Lichtman classification, 18(48.64%) patients were stage 2;5(13.51%) were stage 3A;1(2.7%) was stage 3B;13(35.13%) were stage 4 at the last examination after the treatment (Figure 4).

In terms of treatment methods, 24 (64.8%) of 37 patients underwent metaphyseal decompression and 13 (35.2%) underwent proximal row carpectomy. Among those who underwent metaphyseal decompression, 23 patients were 2 and one was stage 3A. Six of the patients who underwent proximal row carpectomy were stage 3B and seven were stage 4 (Table 3).

The mean length of follow-up of our patients was 44.02+/-15.84 months. Follow-up periods ranged from 20 to 80 months. The follow-up period in patients who underwent proximal row carpectomy was 40 months (20-68) and the follow-up period in patients who underwent metaphyseal decompression was 42.5 months (26-80).

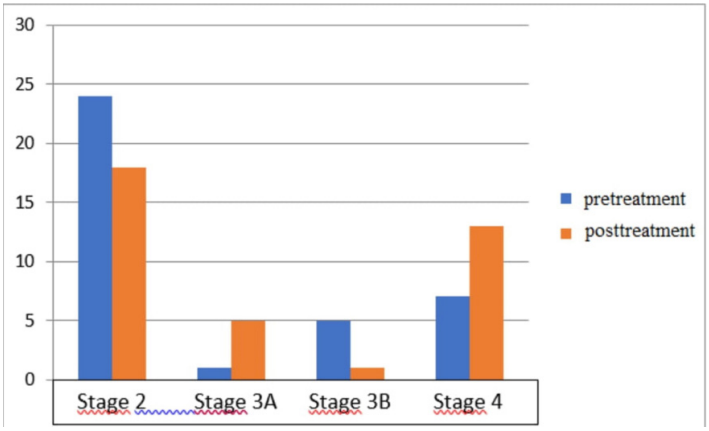

Figure 4. Comparison of pretreatment and posttreatment staging

Table 1. Lichtman classification of Kienböck's disease

Stage 1	Normal radiography or linear fracture, abnormal but nonspecific bone scan, diagnostic magnetic resonance appearance (the lunate shows a low signal on T1-weighted images; the lunate may show high or low signal on T2-weighted images depending on prolongation of the disease course)
Stage 2	Lunate sclerosis, possible premature collapse at the radial edge of the lunate with one or more fracture lines
Stage 3A 3B	Lunate collapse Normal carpal alignment and height Fixed scaphoid rotation (cortical ring sign), reduction in carpal height, proximal migration of capitate
Stage 4	In addition to all findings in stage 3, severe lunate collapse with intra-articular degenerative changes at the midcarpal joint, radiocarpal joint, or both

Table 2. Treatment methods and staging in Kienböck's disease

GENERAL TREATMENT METHOD	STAGE
Conservative Treatment	1
Re-blood-Supply	2, 3A
Radial Shortening - Ulnar Extension	2, 3A
Silicone Arthroplasty	3A
Excision + Autogenous Tendon Graft	3A
Capitatum-hamatum Arthrodesis + Silicone Arthroplasty	3A, 3B
Triple Arthrodesis + Silicone Arthroplasty	3B
Limited Intercarpal Arthrodesis	3B, 4
Salvage Surgery (Proximal Row Carpectomy, Arthrodesis, Denerva-tion, etc.)	4

Table 3. Treatment methods applied according to the disease stage

Operation/Stage	2	3A	3B	4	Total
Metaphyseal Decompression	23	1	0	0	24
Proximal Row Carpectomy	1	0	5	7	13
Total	24	1	5	7	37

Table 4. Comparison of pretreatment and posttreatment mean values of clinical measurements on patient wrists according to the treatment methods applied (* significant values)

Patient Wrists	Flexion-Extension Range of Motion		Ulnar-Radial Deviation Range of Motion		DASH Score		VAS Score		Grip Strength	
Treatment Method	**Pre-treatment**	**Post-treatment**	**Pre-treatment**	**Post-treatment**	**Pre-treatment**	**Post-treatment**	**Pre-treatment**	**Post-treatment**	**Pre-treatment**	**Post-treatment**
Metaphyseal Decompression	95.08	123.95* P=0.0001	40.75	50.08* P=0.0001	89.37	49.04* P=0.0001	7.08	2.66* P=0.0001	7.33	25.66* P=0.0001
Proximal Row Carpectomy	71.53	85* P=0.008	30.76	33.46 P=0.584	87.92	55.23* P=0.006	7.84	4.46* P=0.003	0.76	9.53 P=0.605

Table 5. Comparison of the mean clinical measurement values of patient wrists in the pre- and posttreatment periods and statistical evaluation (*significant values in clinical parameters)

CLINICAL FIND-INGS	PRE-TREATMENT	POST-TREATMENT	STATISTICAL EVAL-UATION
MEAN VALUES	**INVOLVED WRIST**	**INVOLVED WRIST**	**INVOLVED WRIST**
Grip Strength	15.02	20	0.002*
Flexion-Extension	86.81	110.27	0.0001*
Radial-Ulnar Devia-tion	37.24	44.24	0.003*
DASH Score	88.86	51.21	0.0001*
VAS Score	7.35	3.29	0.0001*

Comparison and Statistical Evaluation of Mean Clinical Measurement Values

Among the patients who underwent metaphyseal decompression, 13 (54.2%) of 24 patients were female and 11 (45.8%) were male. The mean length of follow-up of the patients was 46.75 (26-80) months and the mean age was 35.54 (19- 53) years. 14 (58.3%) patients had a trauma history. In the study, preoperative and postoperative grip strength, extension-flexion range of motion, ulnar-radial deviation range of motion, DASH score, and VAS score were evaluated. There was a statistically significant increase in all postoperative clinical markers. 23 of 24 patients (95.8%) were able to return to work after the surgery. One patient with continuing symptoms underwent proximal row carpectomy as an additional surgical procedure since the patient had radiological progression. This patient was also able to return to work after the intervention (Table 4).

Of the 13 patients who underwent proximal row carpectomy, 8 (61.5%) were female and 5 (38.5%) were male. The mean length of follow-up of the patients was 39 (20-68) months and the mean age was 43.15 (28-73) years. Six patients (46.2%) had a trauma history. In the study, preoperative and postoperative grip strength, extension-flexion range of motion, ulnar-radial deviation range of motion, DASH score, and VAS score were evaluated. There was a decrease in grip strength, but it was not statistically significant. The increase in ulnar-radial deviation range of motion was not statistically significant. The increase in the extension-flexion range of motion, VAS score, and DASH score was considered statistically significant. 11 of 13 patients were able to return to their work after the surgery. Wrist denervation was performed in the other two patients as an additional surgical intervention. One of the patients could not return to work after the additional surgical procedure. No significant complications were encountered in the treatment of the patients (Table 4).

The general clinical findings of our patients after the treatment were evaluated by comparing the pre-and post-treatment findings of the patients' wrists. Grip strength increased from 15.02 to 20 after the treatment and the increase was statistically significant (p=0.002). The extension-flexion range of motion increased from 86.81 to 110.27 and the increase was statistically significant (p=0.0001). The ulnar-radial deviation range of motion increased from 37.24 to 44.24 after the treatment and the increase was statistically significant (p=0.003). The DASH score decreased from 88.86 to 51.21 and the decrease was statistically significant (p=0.0001). The VAS score decreased from 7.35 to 3.25 after the treatment and the decrease was statistically significant (p=0.0001). Of the patients, 31 were satisfied with the surgical intervention. Three of the seven patients whose pain continued required additional surgical intervention. Except for one patient, all of our patients were able to return to work after surgical interventions (Table 5).

Discussion

Kienböck's disease has been introduced radiologically and clinically for about a century; however, it is still not fully identified in all aspects [1]. The most commonly accepted theory is the irregular burden on the lunate bone with repetitive traumas [9]. In studies conducted to date, consistent or contrary findings have been obtained and discussed.

Kienböck's disease has been frequently reported in young and young adult males aged between 20 and 40. It develops two to three times more often in males than in females and at a later age in women than in men [1,2,10]. Taniguchi and Tamaki reported the mean age of 133 patients, 47 female (35.33%) and 86 male (64.66%) patients, as 42.7 years (14-80) [11,12]. Considering all the findings in the literature, only 13 (1.15%) of 1126 patients were aged 15 or below. Stahl reported in 1947 that three (1.55%) of 193 patients were aged 15 and below. In these patients who had

not completed their skeletal development, Kienböck's disease is more self-limiting, unprogressive, and is generally curable or close to complete recovery [10]. The demographic data in our study were consistent with those in the literature. Similar to those in the literature, women were diagnosed at an average age of 2 years older than men. When the gender distributions were examined in the study, it was determined that our patients were mostly female. This may indicate that we may have a different gender distribution from other populations or may be associated with women's easier access to hospitals. Likewise, Calli et al. reported a higher number of female patients in their study conducted in our country before [13].

No information regarding the incidence of Kienböck's disease was reached in the literature. However, 37 patients diagnosed within 8 years in our study can roughly give information about the incidence of the disease. Accordingly, it can be said that an average of 4 new patients are diagnosed with the disease per year. In recent years, due to the easiness in patients' access to hospitals as a result of social policies in our country, we think that the number of annual diagnoses of Kienböck's disease may increase.

Dominant wrist involvement is evident in Kienböck's disease. It is mostly seen on the right wrist [1,2,10–12]. Bilateral involvement is very rare and has been reported in very few publications. In studies by Beckanbaugh et al., Therkelsen and Andersen, Viljakka et al., bilateral involvement was reported between 3.5% and 7.5% in patients [14–16]. Taniguchi and Tamaki reported an incidence of 4% in 126 patients in Japan [11,12]. In our study, 27 (73%) patients had right wrist involvement and 10 (27%) had left wrist involvement. In addition, no patient had bilateral involvement. When the prevalence of the disease on the dominant side was examined, involvement was in the right wrist in 35 patients (94.59%) and the left wrist in two patients (5.51%). The findings were consistent with those in the literature. We think that the involvement of the dominant wrist may be a reason for early admission to the health center among patients who had been actively using their wrists.

Etiologically, instantaneous, high-energy burdens and traumas, as well as low-energy but very repetitive burdens, have also been considered responsible. Gemme and Saraste (1987) and Letz et al. (1992) reported the association between the use of vibrating tools and Kienböck's disease. Beckenbaugh et al. determined a significant trauma history in 72% of 46 patients and reported fracture lines on direct radiographs in 82% of their patients [14]. However, it is controversial whether fractures are the cause of avascular necrosis [8,17,18]. Nakamura reported a history of significant trauma to the peripheral lunate in only 12% of 122 patients in 1991 [19]. Beckenbaugh et al. (1980) and Green (1993) reported that osteonecrosis is very rare after dislocations in the perilunate, lunate, and scapholunate [14,20]. In our study, trauma history was determined in 20 patients (54.1%) regardless of being minor or major. On the other hand, 17 patients (45.9%) did not have a specific trauma history. The number of traumatic patients with radiological findings was two. Before the diagnosis of Kienböck's disease, one of these patients had a distal radius fracture and the other had a fracture in the first metacarpal; they were diagnosed during their posttreatment follow-ups. According to the findings obtained in our study, trauma history may be associated with the etiology of the disease.

When the occupational distribution of the disease in the literature was examined, it was found that the disease is generally seen in the working class who use manual labor dominantly, without gender discrimination. In a study conducted by Therkelsen, 98 patients out of 107 were in the worker's group who used their hands intensively. Stahl, on the other hand, reported that 97% of the patients were such workers. However, in these studies, patient information was mostly collected from health centers where the worker's group received diagnosis and treatment [15,21]. When the occupational distribution of our patients at the time of diagnosis was examined, 45.9% (n=17) of the patients were housewives; 27% (n=10) were workers; 10.8% (n=4) were students; 8.1% (n=3) were government employees; 5.4% (n=2) were farmers; 2.7% (n=1) were retired. Women, who were also dominant in the gender distribution, were generally from rural areas. Most of them were engaged in manual labor inside and outside the home, such as gardening. Among the workers, those who worked in jobs that required manual labor, such as construction and industrial work, constituted the majority. Considering these evaluations, we think that the most important reason that directed our patients to health centers was the limitation of using their hands or wrists in their work.

Although the pathogenesis is not fully known, the volume of fat cells in the bone marrow increases after steroid intake, which results in damage to the circulation in the bone cavities and leads to avascular necrosis. Steroids also increase the frequency of fat embolism in small vessels by increasing serum cholesterol [22]. In addition, excessive alcohol use, hemoglobinopathies, systemic diseases (SLE, Raynaud, Scleroderma, Gaucher's, etc.), and pressure changes also play a role in the development of necrosis [23]. Kienböck's disease has been reported during corticosteroid therapy in SLE and Crohn's enteritis [10]. However, in our study, any of the 37 patients had an accompanying disease or an evident medical treatment history at the time of diagnosis.

We could not find any source information regarding the mean duration of symptoms before the diagnosis, the causes affecting these durations, and the results affected by this period. The mean duration of symptoms of the patients before the treatment was 42.81 (1-240) months. 29 (78.37%) of 37 treated patients had applied to another health center before applying to the university clinic during this period of symptoms. Only 8.1% (n=3) of the patients were diagnosed in the first 24 months of the complaints; most of the patients (70.27%, n=26) were diagnosed within 24-48 months. The patients had waited for a long time to apply to health institutions after their complaints had started. The patients in our study might have been expecting that the disease would start slowly and then show progressive characteristics. We think that the patients had waited until the complaints affected their daily lives as well as their working lives and that this extended the period. As a result, most patients were at an advanced stage when the correct diagnosis was made and thus, the treatment outcomes were affected.

In the literature, the follow-up periods reported by the authors for different treatment methods range from 36 months to 240 months. In general, the duration is 95 months on average. In these studies, it was especially emphasized that the clinical and radiological

findings of these patients were significant in the long term [13,16,19,24–29]. The mean length of follow-up of our patients was 44.02 months (approximately 3 years and 8 months). Our follow-up periods ranged from 20 months to 80 months. These findings are not consistent with relevant literature findings.

Clinical findings generally manifest with pain in the mid-dorsal part of the wrist. When compared to the other wrist, the range of motion and grip strength in all planes is significantly reduced [2]. In the studies conducted by Brumfield, Champoux, and Palmer, functional wrist range of motion was reported to be within the range of 5-10 degrees of flexion, 30-35 degrees of extension, 10 degrees of radial deviation, and 15 degrees of ulnar deviation for activities of daily living and personal hygiene [30,31]. Although all of our patients had the functional wrist range of motion described by the authors at the time of diagnosis, the pain felt by our patients was the most important factor in their preferences for surgical treatment.

Staging is a guide in choosing the treatment method and predicting the prognosis. The staging system used to determine the best treatment method should be reliable and reproducible. Lichtman's revision of the Stahl classification has increased the superiority of this classification system in the planning of treatment of Kienböck's disease and has become the most commonly used system [32]. Despite this, some studies reported the inadequacy of even this last version [33]. It is based on the radiological image of the lunate on standard radiographs. This feature of the staging system has led to discussions about its reliability and sensitivity by many authors [32,33]. With the introduction of computed tomography, discussions on the correct staging system have increased [34]. When the patients in our study were grouped according to the Lichtman classification at the diagnosis stage before the treatment, 24 (64.86%) patients were stage 2 before the treatment; one (2.7%) was stage 3A; five (13.51%) were stage 3B; seven (18.91%) were stage 4. Although the Lichtman classification was employed in the preference of treatment methods, some patients' disease stages progressed after the treatment.

In our study, metaphyseal decompression and proximal row carpectoy, which were the treatment methods implemented in our clinic, were evaluated separately. In the literature, the most common aspects of the publications on the treatment of this disease are the use of more than one treatment method for different stages and the insufficient number of patients and follow-up durations to compare the treatment methods in these studies [4]. Aldo A. Illarramendi applied metaphyseal treatment to 22 patients between 1976-and 1988. Six of these patients were female and 16 were male, with a mean age of 36 (18-64) and a mean length of follow-up of 10 years. They did not report any complications during this follow-up period. In the study, although the patients' pain was relieved and most of the patients returned to work, the radiological progress of the patients could not be terminated. However, it was claimed it was a successful treatment as other surgical methods [35]. Sherman GM et al., as a result of the biomechanical study they conducted in 2008, determined that although the clinical results of metaphyseal decompression were good, it did not have an evident effect on the lunate [36]. Reşit et al. reported the results of metaphyseal decompression surgery in 12 patients with early-stage Kienböck patients. They reported that the treatment was effective, safe, and had no complications [37]. In our study, 24 patients underwent metaphyseal decompression in our clinic. 13 (54.2%) patients were female and 11 (45.8%) were male. The dominant wrist was involved in 23 patients and the involved wrist was the right wrist in 17 patients. At the diagnosis stage, 23 patients were determined to be in stage 2 and one patient in stage 3A. The mean length of follow-up of the patients was 46.75 months. The mean age of the patients was 35.54 (19-53). 14 (56.3%) of the patients had a trauma history. After the treatment, 18 of our patients were identified as stage 2; five as stage 3A; one as stage 3B. Pre- and posttreatment flexion, extension, radial deviation and ulnar deviation ranges, grip strength, DASH score, and VAS score were evaluated as clinical findings. The mean grip strength increased from 17.33 to 25.66 postoperatively and the increase was statistically significant (p=0.0001). The mean extension-flexion range of motion was 95.08 preoperatively and increased to 123.95 after the treatment and the increase was statistically significant (p=0.0001). The mean ulnar-radial deviation range of motion was 40.75 preoperatively; it increased to 50.08 after the treatment and the increase was statistically significant (p=0.0001). The mean DASH score was 89.37 preoperatively; it decreased to 49.04 after the treatment and the decrease was statistically significant (p=0.0001). The mean VAS score was 7.08 preoperatively; it decreased to 2.66 after the treatment and the decrease was statistically significant (p=0.0001). 23 of our patients were able to continue their work and daily activities without the need for additional intervention, one patient underwent a proximal row carpectomy due to the continued pain and radiological progression from stage 2 to stage 3B. This patient was able to return to work and daily activities after the additional intervention. Our patients improved clinically whereas radiological progression continued in six patients.

Proximal row carpectomy is performed in the treatment of advanced degenerative diseases of the wrist as a method that preserves joint movement [38]. However, the long-term clinical and radiological results are not identified [39]. DiDonna et al. published the results of proximal row carpectomy performed on a degenerative plane in 22 wrists with at least 10 years of follow-up. Despite the progressive degeneration findings seen on the radiographs, the patients were satisfied with the clinical results [40]. Jebson et al. reported that radiographic changes seen in patients during 10-year follow-up were not correlated with patient satisfaction and degree of pain [28]. Inoue and Miura reported the method they implemented in Kienböck's disease as successful in their study [27].

In our clinic, a proximal row carpectomy was performed on 13 patients. Of the patients, eight (61.5%) were female and five (38.5%) were male. At the diagnosis stage, six patients were in stage 3B and seven patients were in stage 4. The mean length of follow-up of the patients was 39 months. The mean age of the patients was 43.15 (28-73). While six (46.2%) patients had a trauma history, no trauma history was determined for seven (53.8%) patients. The dominant wrist was the right wrist in 12 patients and the involved wrist in 10 patients. No radiologically significant degeneration was detected, which can be attributed to the short mean duration of follow-up. Pre- and post-treatment flexion, extension, radial deviation, ulnar deviation ranges, grip strength, DASH score, and VAS score were evaluated as clinical findings. The mean grip strength decreased from 10.76 to 9.53

postoperatively. The mean extension-flexion range of motion was 71.53 preoperatively and increased to 85 after the treatment and the increase was statistically significant (p=0.008). The mean ulnar-radial deviation range of motion was 30.76 preoperatively; it increased to 33.46 after the treatment but the increase was not statistically significant (p=0.584). The mean DASH score was 87.92 preoperatively; it decreased to 55.23 after the treatment and the decrease was statistically significant (p=0.006). The mean VAS score was 7.84 preoperatively; it decreased to 4.46 after the surgery and the decrease was statistically significant (p=0.003).

We evaluated the general clinical findings of our patients after the treatment by comparing the pre-and post-treatment findings of the patients' wrists. Grip strength increased from 15.02 to 20 after the treatment and the increase was statistically significant (p=0.002). The extension-flexion range of motion increased from 86.81 to 110.27 and the increase was statistically significant (p=0.0001). The ulnar-radial deviation range of motion increased from 37.24 to 44.24 after the treatment and the increase was statistically significant (p=0.003). The DASH score decreased from 88.86 to 51.21 and the decrease was statistically significant (p=0.0001). The VAS score decreased from 7.35 to 3.25 after the treatment and the decrease was statistically significant (p=0.0001). Of the patients, 31 were satisfied with the surgical intervention. Three of the seven patients whose pain continued required additional surgical intervention. Except for one patient, all of our patients were able to return to work after surgical interventions. The posttreatment range of motion of our patients complied with the definition of "functional wrist range of motion" in the study conducted by Brumfield, Champoux, and Palmer (30). It was important that the wrist motions were within these limits and painless in terms of patient satisfaction.

One of the findings discussed in many articles published by the authors in the literature is that radiological findings do not correlate with clinical findings in the posttreatment period. In our study, radiological progress continued in 12 of our patients who underwent surgery, but these patients, except for one patient, we're satisfied with the surgical procedure and recovered clinically. The general conclusion in the literature is that the radiological findings always worsen as the follow-up duration increases, but this result is not reflected in the clinical findings at equal ratios [16,19,24–29,39].

The Lichtman classification system has been discussed earlier in the diagnostic evaluations section. Although it is the most common staging system used by the authors in the diagnosis and evaluation of posttreatment findings, controversial opinions continue regarding its inadequacy. It is based on the radiological image of the lunate on standard radiographs. This feature of the staging system has led to discussions about its reliability and sensitivity by many authors [32,33]. It was reported in many studies that radiological findings progress in long follow-up periods. When our patients were grouped according to the Lichtman staging system after the treatment, 18 of our patients were identified as stage 2; five as stage 3A; one as stage 3B; 13 patients as stage 4. Five patients in stage 2 progressed to stage 3A; one patient in stage 3A progressed to stage 3B; six patients in stage 3B progressed to stage 4. As a result, it was determined that radiological progression continued in 32.4% (n=12) of our patients after their treatment. Our radiological findings were not consistent with those in the literature, which may be attributed to the short lengths of follow-up. No significant complications were encountered during the follow-up periods.

Conclusion

It was determined that the radiological progression was terminated in 67.6% (n=25) of the patients after the treatment. Although radiological progression continued in 32.4% (n=12) of our patients, it was determined that radiological findings did not correlate with clinical findings. Treatments administered in our clinic have achieved their purpose. The most important indicator of it is that the patients could return to work with a pain-free wrist with an increased range of motion compared to the pretreatment period. We think that early diagnosis and treatment of Kienböck's disease is better because treatments applied in the early stages yield better clinical outcomes.

Conflict of interests
The authors declare that there is no conflict of interest in the study.

Financial Disclosure
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Ethical approval
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