Journal of Orthopaedic Science and Research

Open Access

Review Report

Non-operative Treatment of Kienbock's Disease, Systematic Literature Review and Report on Three Cases

Bryce N Clinger[1*], Mark S Anderson[1], Moheb S Moneim[1]

[1]Department of Orthopaedics and Rehabilitation, University of New Mexico School of Medicine, Albuquerque, New Mexico

[*]**Corresponding Author:** Bryce N Clinger, Department of Orthopaedics and Rehabilitation, University of New Mexico School of Medicine, Albuquerque, New Mexico; Email: bnclinger@salud.unm.edu

Received Date: 14-08-2020; **Accepted Date:** 09-09-2020; **Published Date:** 18-09-2020

Abstract

Objective: Evaluate patient outcomes after non-operative treatment for Kienbock's disease.

Methods: A systematic review of literature using CINAL, Cochrane and PubMed databases was performed by the authors. Common keywords associated with Kienbock's disease were searched. Articles were limited to those published less than 40 years ago and those in English. The bibliographies of all relevant results were manually searched for any additional references. Duplicates and paediatric articles were removed and abstracts were reviewed for relevance. Each eligible study was independently reviewed in its entirety by two of the investigators. Three cases with stage II Kienbock's disease on MRI treated non-operatively are also presented.

Results: 15 out of 967 articles met inclusion criteria. Various surgical techniques compared to non-operative treatment. Surgery was largely no better than non-operative treatment with symptom relief. Wrist mobility, grip strength, and activity modification showed non-operative treatment having better long term outcomes. The cases of three patients with stage II disease on MRI treated non-operatively are presented. At follow up, patients reported improved pain and function. One patient demonstrated improved vascularity on repeat MRI.

Conclusion: Based on the results of our systematic review along with the successful outcomes of three cases presented by the authors, non-operative treatment of Kienbock's disease may be more beneficial than previously thought or described regardless of the stage of Kienbock's disease.

Clinger BN | Volume 1; Issue 1 (2020) | JOSR-1(1)-002 | Review Report

Citation: Clinger BN, et al. Non-operative Treatment of Kienbock's Disease, Systematic Literature Review and Report on Three Cases. J Ortho Sci Res. 2020;1(1):1-13.

DOI: http://dx.doi.org/10.46889/JOSR.2020.1102

Keywords

Kienbock's Disease; Lunatomalacia; Avascular Necrosis of Lunate; Aseptic Necrosis of Lunate; Osteonecrosis of Lunate; Lunate; Wrist pain

Introduction

Osteonecrosis of the lunate was described in 1910 by Kienböck's when he published a series of 16 patients with X-rays [1]. Surprisingly the etiology and best treatment for Kienböck's disease is not clear.

A classification by Stahl, in 1947, was later modified to the current classification used today [2]. In 1977, Lichtman described his classification when he published work on implant arthroplasty of the lunate for Kienbock's [3]. His classification persisted and the MRI findings were added with its advent [4]. Additionally, it is important to understand that ulnar negative variance can have an impact on treatment decisions and this is not included in the current classification scheme.

Treatment can be grouped into operative and non-operative. Operative strategies are based on Lichtman's classification with the additional consideration for ulnar negative variance [5,6]. In early stages, prior to lunate collapse, the goal of intervention is to prevent such collapse and subsequent degenerative sequela. This is accomplished through unloading the lunate, with radial shortening osteotomy or intercarpal shortening. Revascularization of the lunate is another strategy to prevent lunate collapse to stimulate healing, such as a core decompression or by vascularized pedicle bone graft [7]. If the lunate has collapsed or if degenerative changes are present in the later stages, the strategy shifts to salvage and prevention of further degenerative changes. Proximal row carpectomy, limited mid-carpal arthrodesis, and finally total wrist arthrodesis have been described. Implant arthroplasty has fallen out of favour.

We hypothesize based on this systematic review and a review of three cases treated non-operatively, that initial non-operative management is a reasonable option. Additionally, we examine the evidence to determine superiority of surgery over non-operative treatments. Non-operative treatments including watchful waiting, activity modification, bracing, hand therapy, and cast immobilization have been utilized [8].

Materials and Methods

Eligibility Criteria

Inclusion criteria included articles published within the last 40 years, written in English, and level of evidence at least IV or greater. Exclusion criteria consisted of level of evidence V (as

Citation: Clinger BN, et al. Non-operative Treatment of Kienbock's Disease, Systematic Literature Review and Report on Three Cases. J Ortho Sci Res. 2020;1(1):1-13.

DOI: http://dx.doi.org/10.46889/JOSR.2020.1102

determined by expert opinion), animal studies and paediatric studies with patients less than 18 years old.

Search Methods

The authors performed a systematic review of literature using CINAL, Cochrane and PubMed Databases between April 27th-30th, 2020 (Fig. 1). The following words were used in the search engine: "Kienböck's Disease", "Kienböck's Disease", "Lunatomalacia", "Aseptic Necrosis of Lunate" or "Avascular Necrosis of Lunate." No language restriction, publication year restriction or other filters were applied. The bibliographies of all relevant results were manually searched for any additional potential references. The authors also hand searched the Journal of the American Academy of Orthopaedic Surgeons.

Data Extraction

Information relevant to the study type including type of treatment, patient outcomes, and complications were extracted. Each eligible study was independently reviewed by two investigators without disagreements for inclusion.

Study Selection

A total of 967 articles were found with the initial search. 531 duplicates were removed, 428 remained. Eight additional articles were identified through a manual search of the Journal of the American Academy of Orthopaedic Surgeons, giving a total of 436 papers. After review of abstract and title 415 were excluded. Full text reviews were performed on the remaining 21 articles. The bibliographies of relevant articles were reviewed for additional articles to complete a comprehensive search (Fig. 1).

Citation: Clinger BN, et al. Non-operative Treatment of Kienbock's Disease, Systematic Literature Review and Report on Three Cases. J Ortho Sci Res. 2020;1(1):1-13.

DOI: http://dx.doi.org/10.46889/JOSR.2020.1102

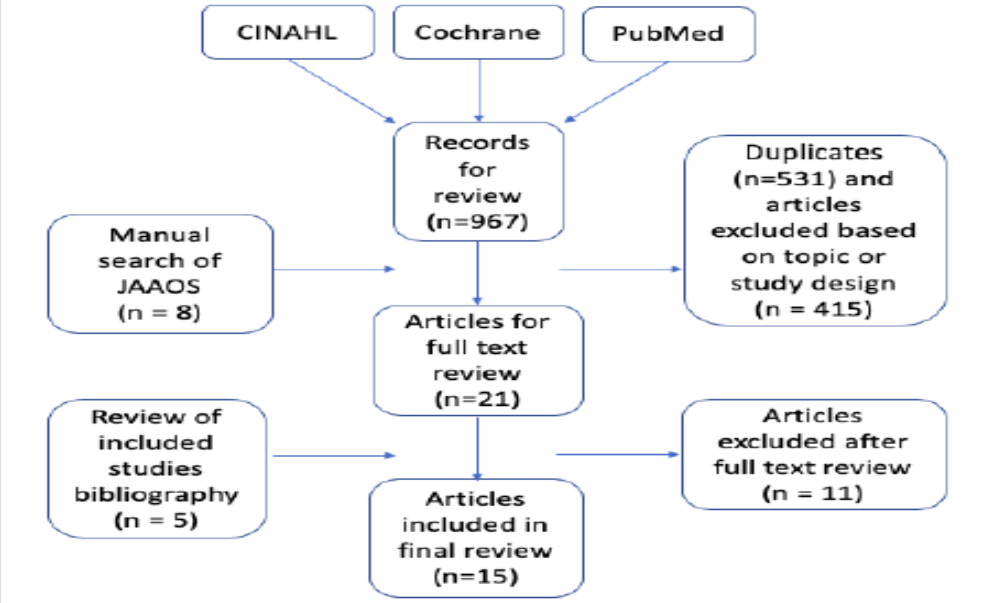

Figure 1: 967 articles were found for review from searching multiple data bases. Articles were further reduced if they were duplicates or if didn't correlate with study topic. After thorough review of 21 articles including bibliography review and full text review 15 articles were left to be included in final systematic review.

Results

11 primary scientific articles and two review articles were included for final review (Table 1). Average follow up of primary studies was ten years and ranged from three months to over 20 years with longest follow up over 30 years. The average number of patients in each study was 38 and ranged from 8 to 104 patients. Five level III studies and six level IV studies were identified. These studies spanned all stages of the disease.

Six studies found that the disease can progress with operative or non-operative treatment [9-13]. Six studies also found that patients symptoms can improve with non-operative treatment [8,13-17]. Symptoms were not correlated with stage of disease or its progression in five studies [15,17-20]. The radiographic osseous architecture of the lunate was found to improve in some patients with non-operative treatment in three studies [16,17,21]. Additionally, radial shortening osteotomy was found to improve symptoms sooner and more reliably than non-operative treatment in one study [21].

Two prior systematic reviews reviewed were level IV studies. A recent 2018 study comparing radial shortening osteotomy to non-operative treatment found osteotomy is not superior to non-operative treatment in terms of disease progression. It may provide greater pain relief and motion [22]. An earlier 2010 review of surgical treatment versus non-operative therapy found

Citation: Clinger BN, et al. Non-operative Treatment of Kienbock's Disease, Systematic Literature Review and Report on Three Cases. J Ortho Sci Res. 2020;1(1):1-13.

DOI: http://dx.doi.org/10.46889/JOSR.2020.1102

no active treatment is superior and there is insufficient data to determine if intervention is superior to no treatment or the natural history of the disease [23].

Three cases of non-operative treatment of Kienbock's are presented with one year or longer follow up and improvement in symptoms. It is to be noted that the three patients were women with the left wrist being involved.

Study	Level of Evidence	Number of Subjects	Length of Follow Up
Keith et al., J Hand Surg 2004	IV	33	8.1 years
Dungen et al., Chirugie de la main 2006	III	104	13 years
Wollstein et al., J hand therapy 2013	IV	11	12 weeks
Martin et al., Hand 2013	III	66	5-10 years
Viljakka et al., Scand J Surg 2016	IV	8	18 years
Fujisawa et al., J ortho Sci 1996	IV	17	15.6 years
Evans et al., J Hand Surg Euro 1986	III	14	20 years
Kristensen et al., J Hand Surg Euro 1986	IV	46	20.5 years
Delaere et al., J Hand Surg Euro 1998	IV	43	3 years
Salmon et al., JBJS 2000	III	33	3.6 years
Beckenbaugh et al., CORR 1980	III	46	9 months - 27 years

Table 1: Studies included in this systematic review were from 1980-2016 and were III or IV level of evidence with all stages of Kienbock's Disease included with follow up time ranging between 9 months to 27 years.

Case 1

A 46-year-old right hand dominant female presented to the hand surgery clinic with progressively worsening atraumatic left wrist pain for the past one-two years which began insidiously. Past medical history included fibromyalgia and laboratory positive anti-nuclear antibody. Per rheumatology evaluation she was not considered to have lupus and never required treatment or used prolonged oral steroids for ANA positivity.

Initial radiographs and MRI scan (Fig. 2) were consistent with Lichtman stage II Kienbock's with ulnar negative variance and a sagittal plane fracture through the lunate. Clinical exam was significant for central dorsal wrist tenderness, 20 degree wrist extension deficit, and a weak grip compared to the contralateral hand. She had no swelling or synovitis. Wrist brace wear

Citation: Clinger BN, et al. Non-operative Treatment of Kienbock's Disease, Systematic Literature Review and Report on Three Cases. J Ortho Sci Res. 2020;1(1):1-13.

DOI: http://dx.doi.org/10.46889/JOSR.2020.1102

and activity modifications were initiated. She was followed every 3 months with serial radiographs.

The patient's symptoms improved with reduced wrist tenderness and increased grip strength equivalent to the contralateral side. She remained with a wrist extension deficit but no swelling or synovitis. No radiographic progression to carpal collapse was observed. Repeat MRI at one year follow up was obtained which demonstrated improved vascularity within the lunate and decreased bone marrow edema (Fig. 3). Last seen at 18 months with no swelling or pain with grip of 24 kilos compared to 30 kilos on the contralateral side. She continued with bracing as needed and was discharged.

Figure 2: Imaging obtained at the time of the initial diagnosis of the left wrist. Wrist radiographs show sclerosis (S) of the lunate as well as a fracture (F). MRI imaging shows edema (E) and decreased marrow (M) of the lunate.

Citation: Clinger BN, et al. Non-operative Treatment of Kienbock's Disease, Systematic Literature Review and Report on Three Cases. J Ortho Sci Res. 2020;1(1):1-13.

DOI: http://dx.doi.org/10.46889/JOSR.2020.1102

Figure 3: Imaging of the left wrist one year after diagnosis while being treated conservatively. Follow up radiographs shows fracture healing and unchanged sclerosis of the lunate. MRI shows diminished edema (E) and increased marrow (M) of the lunate.

Case 2

A 57-year-old right hand dominant female presented to the hand surgery clinic with three months of progressive atraumatic left wrist pain. Past medical history included coronary artery disease and hypertension. Clinical exam revealed mild central dorsal wrist tenderness without swelling or motion loss. Grip strength was weak compared to the right side. Initial radiographs and MRI obtained were consistent with stage II Kienböck's (Fig. 4).

Treatment with as needed brace wear and NSAID therapy was initiated. She was followed serially with x-rays and exam every three months for 12 months. At her most recent follow up radiographs were stable (Fig. 5), exam was normal. When contacted at 18 months she had no pain, swelling or limitations of motion and declined to return for examination as she lived 200 miles away.

Citation: Clinger BN, et al. Non-operative Treatment of Kienbock's Disease, Systematic Literature Review and Report on Three Cases. J Ortho Sci Res. 2020;1(1):1-13.

DOI: http://dx.doi.org/10.46889/JOSR.2020.1102

Figure 4: Imaging of the Left wrist at time of diagnosis. Wrist radiographs show sclerosis (S) and MRI shows decreased marrow (M) and increased edema (E) of the lunate.

Figure 5: Imaging of the left wrist at one year follow up while being treated non-operatively. Radiograph shows stable appearance of the lunate without worsening sclerosis compared to initial radiographs.

Clinger BN | Volume 1; Issue 1 (2020) | JOSR-1(1)-002 | Review Report

Citation: Clinger BN, et al. Non-operative Treatment of Kienbock's Disease, Systematic Literature Review and Report on Three Cases. J Ortho Sci Res. 2020;1(1):1-13.

DOI: http://dx.doi.org/10.46889/JOSR.2020.1102

Case 3

A 54-year-old right hand dominant female who works as a waitress presented to the hand surgery clinic with four month history of atraumatic left wrist pain. No past medical history. Clinical exam showed no swelling of the left wrist and moderate pain to palpation of the dorsum of the wrist. Range of motion and grip strength was reduced compared to the other side. Initial radiographs and MRI were obtained showing signs consistent with stage II Kienböck's (Fig. 6).

The patient began treatment with brace wear and NSAID therapy. Most recent radiographs at nearly one year of treatment continue to show stable appearance of lunate (Fig. 7). The patient was able to work during treatment and at one year she reported improvement in pain and swelling. On exam, range of motion (60° extension and 30° flexion) and grip strength (Left 22kg vs Right 24kg) had improved.

Figure 6: Imaging of the Left wrist at time of initial presentation. Wrist radiographs show sclerosis (S) of the lunate and MRI shows decreased marrow (M) on T1 with cystic changes (C) on T2.

Citation: Clinger BN, et al. Non-operative Treatment of Kienbock's Disease, Systematic Literature Review and Report on Three Cases. J Ortho Sci Res. 2020;1(1):1-13.

DOI: http://dx.doi.org/10.46889/JOSR.2020.1102

Figure 7: Radiographs after one year of nonoperative treatment shows unchanged sclerosis of the lunate compared to initial radiographs.

Discussion

Kienböck's disease can progress, it often stabilizes into a chronic arthritic condition which may not be particularly symptomatic for some patients. It is unclear if surgery is superior to non-operative treatment in management of symptoms or hinder progression and the natural history of the disease. It is also unclear whether active immobilization or non-operative measures are superior to the natural history of the disease. This review summarizes available evidence in support of initial non-operative treatment that may be a reasonable option for patients. In two recent surveys of hand surgeons, non-operative treatment was initiated by surgeons primarily in the earliest stage and surgical treatment was often chosen for later stages (II-IV) [24,25].

Two studies in the non-English literature were identified but not included for review [26,27]. Martini et al. found in review of the natural history of 114 patients that remission is possible in the early stages. However, they also found that collapse can occur with time and progression of arthritis. In a review of 120 patients, Saffar et al., found in 80 patients without surgery that arthritis progressed over ten years but no patient required change in occupation [26]. In 40 patients treated with surgery, half of patients required change in occupation.

Three case reports were identified of patients treated non-operatively. All patients did not require surgery and symptoms of pain improved [27,28]. One notably reported follow up of 60 years in a patient who did progress from IIIB at diagnosis to stage IV [29].

Citation: Clinger BN, et al. Non-operative Treatment of Kienbock's Disease, Systematic Literature Review and Report on Three Cases. J Ortho Sci Res. 2020;1(1):1-13.

DOI: http://dx.doi.org/10.46889/JOSR.2020.1102

The radiographic osseous architecture of the lunate was found to improve in some patients with non-operative treatment in three studies. These included two of nine patients with stage III disease followed over ten years [17]. In a cohort compared to radial shortening osteotomy, Salmon et al., found that one patient out of four with stage II disease demonstrated less sclerosis over time and the other three had stable findings over three years [21]. They did however find the disease progressed rapidly in six patients over 6-18 months. Fujisawa et al., found 4 out of 17 patients followed over ten years had improved restoration of bone height, fracture healing, decrease in radio density, and reconstitution of bony trabeculae [16]. Five wrists were stable and eight progressed to worse stages.

If revascularization and healing do not occur, Kienböck's can progress with either operative or non-operative treatment [15-19]. Many studies found that though this progression does occur, patients' symptoms can improve or stabilize with non-operative treatment [17-21]. Furthermore, symptoms are not necessarily correlated with the stage of disease or its progression [16-21].

Three studies deemed that non-operative treatment was not adequate. Kristensen compared immobilization to no treatment at all and found immobilization was not superior to no treatment [8]. They found that poor outcomes were often secondary to osteoarthritis as a sequela. Keith et al., similarly found that Kienbocks does progress with time to stage IV and findings of degenerative arthritis associated with carpal collapse [12]. Viljakka et al., followed eight patients with stage III disease over a period of 10-38 years. They found that arthritis progressed in eight of nine wrists. Most patients in this study had stable or slightly improved symptoms with only three reporting worsening pain over time [17]. However, as none of these studies compared non-operative treatment to surgery, they were not able demonstrate a benefit of surgery over non-operative treatment.

Radial shortening osteotomy was found to improve symptoms sooner and more reliably than non-operative treatment in one study [21]. Van Leeuwen et al., compared radial shortening osteotomy to non-operative treatment in 48 patients with radiographic follow up of one year [18]. They found no benefit to radial shortening osteotomy. In a systematic review of 17 studies comparing radial shortening osteotomy to non-operative treatment, Shin et al. reported that 5.7% of patients had more than moderate pain with surgery and 23.2% of patients had more than moderate pain without surgery. Wrist motion was 107.4˚in the surgical subset and 88.8 degrees without surgery [2]. No other surgical intervention demonstrated superiority to non-operative treatment in any other included study.

There is evidence to suggest that if Kienböck's disease will progress it may do so rapidly with a time span of around nine months [25]. In these patients who demonstrate rapid progression non-operative intervention may not be sufficient and surgical intervention is more warranted. However, without rapid progression surgery may not be superior to non-operative treatment. Additionally, non-operative treatment may not alter the natural course of the disease. It is

Citation: Clinger BN, et al. Non-operative Treatment of Kienbock's Disease, Systematic Literature Review and Report on Three Cases. J Ortho Sci Res. 2020;1(1):1-13.

DOI: http://dx.doi.org/10.46889/JOSR.2020.1102

important to discuss the available treatment options with patients and tailor treatment to individual needs and wishes. Also, it is important to consider today's economic and healthcare climate globally. It is prudent for the physician to treat patients with evidence-based care that is also cost effective. There may be evidence in favour of radial shortening osteotomy over non-operative treatment in terms of improvement of patients' symptoms and perhaps motion. Surgery may not impede progression of disease and prevent carpal collapse and this is important for patients to know.

This review highlights the lack of high quality prospective and randomized studies in Kienböck's disease treatment. Further research and attention should be directed to resolve this scarcity. Future cost utility analysis may help shed light on the most appropriate treatment.

References

1. Peltier LF. The classic. Concerning traumatic malacia of the lunate and its consequences: Degeneration and compression fractures. Privatdozent Dr. Robert Kienbock. Clin Orthop. 1980;149:4-8.
2. Stahl Folke. On lunatomalacia (Kienbock's disease) a clinical and roentgen logical study, especially on its pathogenesis and the late results of immobilization treatment. Lund: Ohlsson.1947.
3. Lichtman DM, Mack GR, MacDonald RI, Gunther SF, Wilson JN. Kienbock's disease: The role of silicone replacement arthroplasty. J Bone Joint Surg Am. 1977;59(7):899-908.
4. Szabo RM, Greenspan A. Diagnosis and clinical findings of Kienbock's disease. Hand Clin. 1993;9(3):399-408.
5. Cross D, Matullo KS. Kienböck Disease. Orthop Clin North Am. 2014;45(1):141-52.
6. Lichtman DM, Pientka WF, Bain GI. Kienböck Disease: Moving Forward. J Hand Surg. 2016;41(5):630-8.
7. Moneim MS, Duncan GJ. Kienbock's disease: treatment of vascular pedicle and bone grafting. Lowa Orthopaedic J. 1998;18:67-73.
8. Wollstein R, Wollstein A, Rodgers J, Ogden TJ. A hand therapy protocol for the treatment of lunate overload or early Kienbock's disease. J Hand Ther. 2013;26(3):255-60.
9. Kristensen SS, Thomassen E, Christensen F. Kienbock's disease. A late results by non-surgical treatment. A follow-up study. J Hand Surg Edinb Scotl. 1986;11(3):422-5.
10. Salmon J, Stanley JK, Trail IA. Kienbock's disease: Conservative management versus radial shortening. J Bone Joint Surg Br. 2000;82(6):820-3.
11. Van den Dungen S, Dury M, Foucher G, Marin Braun F, Lorea P. Conservative treatment versus scaphotrapeziotrapezoid arthrodesis for Kienbock's disease. A retrospective study. Chir Main. 2006;25(4):141-5.
12. Keith PPA, Nuttall D, Trail I. Long-term outcome of nonsurgical managed Kienbock's disease. J Hand Surg. 2004;29(1):63-7.
13. Delaere O, Dury M, Molderez A, Foucher G. Conservative versus operative treatment for Kienbock's disease. A retrospective study. J Hand Surg Edinb Scotl. 1998;23(1):33-6.
14. Evans G, Burke FD, Barton NJ. A comparison of conservative treatment and silicone replacement arthroplasty in Kienbock's disease. J Hand Surg Edinb Scotl. 1986;11(1):98-102.
15. Beckenbaugh RD, Shives TC, Dobyns JH, Linscheid RL. Kienbock's disease: The natural history of Kienbock's disease and consideration of lunate fractures. Clin Orthop. 1980;149:98-106.
16. Fujisawa K, Hirata H, Tomita Y, Higuchi Y, Morita A, Matsumoto M. Long-term follow up of patients with conservatively treated Kienböck's disease. J Orthop Sci. 1996;1(3):182-6.

Citation: Clinger BN, et al. Non-operative Treatment of Kienbock's Disease, Systematic Literature Review and Report on Three Cases. J Ortho Sci Res. 2020;1(1):1-13.

DOI: http://dx.doi.org/10.46889/JOSR.2020.1102

17. Viljakka T, Tallroth K, Vastamaki M. Long-term natural outcome (7-26 years) of Lichtman stage iii Kienbock's lunatomalacia. Scand J Surg SJS Off Organ Finn Surg Soc Scand Surg Soc. 2016;105(2):125-32.
18. Van Leeuwen WF, Tarabochia MA, Schuurman AH, Chen N, Ring D. Risk factors of lunate collapse in Kienböck disease. J Hand Surg. 2017;42(11):883-8.
19. Martin GR, Squire D. Long-term outcomes for Kienbock's disease. Hand N Y N. 2013;8(1):23-6.
20. Taniguchi Y, Nakao S, Tamaki T. Incidentally diagnosed Kienbock's disease. Clin Orthop. 2002;(395):121-7.
21. Salmon J, Stanley JK, Trail IA. Kienbock's disease: Conservative management versus radial shortening. J Bone Joint Surg Br. 2000;82(6):820-3.
22. Shin YH, Kim JK, Han M, Lee TK, Yoon JO. Comparison of long-term outcomes of radial osteotomy and nonoperative treatment for Kienbock disease: a systematic review. J Bone Joint Surg Am. 2018;100(14):1231-40.
23. Innes L, Strauch RJ. Systematic review of the treatment of Kienböck's disease in its early and late stages. J Hand Surg. 2010;35(5):713-7.
24. Danoff JR, Cuellar DO, Jane O, Strauch RJ. The management of Kienböck disease: a survey of the ASSH membership. Journal of wrist surgery. 2015;4(1):43-8.
25. Stahl S, Stahl AS, Rahmanian-Schwarz A, Meisner C, Leclercq C, Schaller HE, et al. An international opinion research survey of the etiology, diagnosis, therapy and outcome of Kienböck's Disease (KD). Chirurgie de la main. 2012;31(3):128-37.
26. Saffar P, Gentaz R. Comparison between medical and surgical treatment of Kienboeck's disease. Ann Chir Main Organe Off Soc Chir Main. 1982;1(3):250-2.
27. Martini AK. The spontaneous course of lunate malacia. handchirurgie, mikrochirurgie, plastische chirurgie: organ der deutschsprachigen arbeitsgemeinschaft fur handchirurgie: organ der deutschsprachigen arbeitsgemeinschaft fur mikrochirurgie der peripheren nerven und gefasse. Organ Der V. 1990;22(1):14-9.
28. Salt O, Sayhan MB. Avascular necrosis of lunate bone: Kienbock disease. Am J Emerg Med. 2016;34(6):1185-6.
29. Geutjens GG. Kienbock's disease in an elderly patient. J Hand Surg. 1995;20(1):42-3.
30. Meek MF, Lunn PG. Sixty-year follow-up in an untreated patient with Kienböck disease. J Plast Surg Hand Surg. 2011;45(6):307-10.

Citation: Clinger BN, et al. Non-operative Treatment of Kienbock's Disease, Systematic Literature Review and Report on Three Cases. J Ortho Sci Res. 2020;1(1):1-13.

DOI: http://dx.doi.org/10.46889/JOSR.2020.1102