J Orthop Spine Trauma. 2023 December; 9(4): 160-3. DOI: 10.18502/jost.v9i4.13929

Review Article

Definition and Classifications of Kienbock Disease in the Past 100 Years: A Review of the Evidence

Mazaher Ebrahimian[1], Mir Mansour Moazen Jamshidi[2], Behzad Enayati[3], Amir Reza Mafi[4], Amir Hosein Mafi[1], Alireza Moharrami[1,*]

[1] Resident, Department of Orthopedics, Imam Khomeini Hospital, School of Medicine, Tehran University of Medical Sciences, Tehran, Iran
[2] Hip and Pelvic Surgery Fellowship, Associate Professor, School of Medicine, Zanjan University of Medical Sciences, Zanjan, Iran
[3] Hand Surgery Fellowship, Associate Professor, School of Medicine, Arak University of Medical Sciences, Arak, Iran
[4] General Practitioner, Tehran University of Medical Sciences, Tehran, Iran

[*]Corresponding author: Alireza Moharrami; Department of Orthopedics, Imam Khomeini Hospital, School of Medicine, Tehran University of Medical Sciences, Tehran, Iran. Tel: +98-21 61192767, Email: a.moharramy@gmail.com

Received: 09 April 2023; **Revised:** 18 June 2023; **Accepted:** 14 August 2023

Abstract

Kienbock disease (KD) was described by Robert Kienbock in 1910 as osteomalacia of the lunate. A century has passed since the first description of KD, and numerous theories, classifications, and treatments have been published for achieving the best outcomes for this disease, but the treatments remain controversial among surgeons. Various classifications have been proposed for KD based on radiography, magnetic resonance imaging (MRI), arthroscopy, and morphology from 1947 to 2017. Recently, the pioneers of KD (Lichtman and Bain) proposed a new classification based on all the previous classifications (radiography, MRI, and arthroscopy). This classification seems to be the best evaluation and treatment method for KD. We recommend using this new classification for the assessment of KD.

Keywords: Kienbock Disease; Classification; Lunate Bone; History

Citation: Ebrahimian M, Moazen Jamshidi MM, Enayati B, Mafi AR, Mafi AH, Moharrami A. **Definition and Classifications of Kienbock Disease in the Past 100 Years: A Review of the Evidence.** *J Orthop Spine Trauma* 2023; 9(4): 160-3.

Background

Kienbock disease (KD) was described by Robert Kienbock in 1910 as osteomalacia of the lunate (1). Additionally, Müller supported the discovery of the Kienbock in 1920 (2). Nevertheless, the etiology of KD remains unclear, but several studies have identified the risk factors for KD or the "at-risk" patients (3, 4). A century has passed since the first description of KD, and numerous theories, classifications, and treatments have been published for achieving the best outcomes for this disease, but the treatments remain controversial among surgeons. Various classifications have been proposed for KD based on radiography, magnetic resonance imaging (MRI), arthroscopy, and morphology from 1947 to 2017. In the present study, we reviewed and compared the classifications of KD that were proposed in the past 100 years from 1920 to 2020.

Classifications

A modified classification of KD was proposed in 1947 by Stahl (5). A 4-type classification was described in 1977 by Lichtman et al. based on radiological imaging (6). Throughout the 40 years, Lichtman's classification remained the main diagnostic and treatment tool for KD ranging from stage 0 to stage IIIC (6). Bain and Begg proposed a new classification of KD based on cartilage involvement (number of nonfunctional articular surfaces) in arthroscopic evaluation from stage 0 to stage IV (7). Despite this, in 2011, they altered their classification by adding more details to the consideration of the treatments (8). In 1997, Schmitt et al. introduced their classification based on the vascular perfusion of the lunate with MRI using gadolinium intravenous (IV) contrast (9). Based on the necrotic pattern of the lunate in the MRI, four stages of KD were identified: N, A, B, and C (9). The previous classifications, which were based on the osseous (Lichtman) (6), vascular (Schmitt) (9) and cartilage (Bain) (7) were merged into the Lichtman et al. classifications (10). Their study classified patients with KD from A1 to C4 and recommended appropriate treatment methods for each stage (10).

The KD can be treated with a variety of techniques (11), such as splinting, core decompression (12), vascularized bone graft (VBG) (13), radial shortening osteotomy (RSO) (13-15), proximal row carpectomy (PRC) (16), radioscapholunate arthrodesis (RSL fusion), and scaphocapitate arthrodesis (SC fusion) (17-19). Bain theories in the articular-based approach demand that nonfunctioning articular surfaces are excised or fused, in order to restore functionality to the remaining joint surfaces (7, 8, 20).

Lichtman Classification (1977) (Stahl Classification Modified by Lichtman): In 1977, Lichtman et al. modified Stahl (5) classification of KD, which was proposed in 1947 to a new classification (6). KD has been diagnosed and followed using plain radiographs using the Lichtman classification for almost 40 years (6). In the last few decades, it has evolved to include stages 0 and IV (21-23) (Table 1).

Table 1. The Lichtman classification of Kienbock disease (KD)

Stage	Description	Treatment
I	No visible changes on X-ray, changes seen on MRI	Immobilization and NSAIDs
II	Sclerosis of lunate	Joint leveling procedure (ulnar negative patients) Radial wedge osteotomy or STT fusion (ulnar neutral patients) Distal radius core decompression Revascularization procedures
IIIA	Lunate collapse, no scaphoid rotation	Same as stage II above
IIIB	Lunate collapse, fixed scaphoid rotation	PRC, STT fusion, or SC fusion
IV	Degenerated adjacent intercarpal joints	Wrist fusion, PRC, or limited intercarpal fusion

MRI: Magnetic resonance imaging; NSAIDs: Non-steroidal anti-inflammatory drugs; STT: Scaphotrapeziotrapezoid; PRC: Proximal row carpectomy; SC: Scaphocapitate

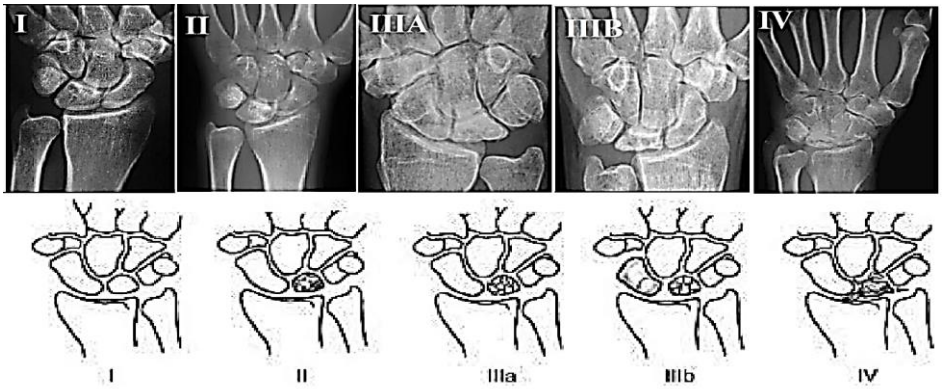

Figure 1. The Lichtman classification based on radiography, which was first described in 1977 by Lichtman et al. (6)

They developed their classification in 2010 based on the staging and treatment of KD (22) (Figure 1).

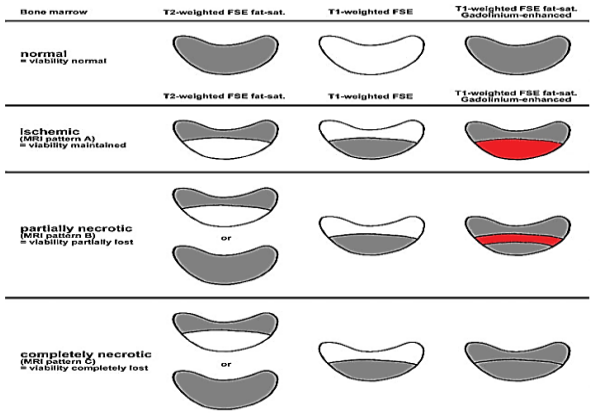

Figure 2. Schmitt schematic diagram of bone-marrow viability in gadolinium-enhanced magnetic resonance imaging (MRI) normal marrow (viability unaffected) described by Schmitt et al. (9) [photo from a study by Lichtman et al. (10)]

Schmitt Classification (1997): After administration of IV gadolinium contrast, Schmitt et al (9) classified lunate signal changes (Figure 2):

1. MRI stage N-normal: A normal lunate signal without enhancement

2. MRI stage A-ischemic (viability maintained): The proximal lunate appears edematous, but is well perfused (enhancement with gadolinium)

3. MRI stage B-partially necrotic (viability partially lost): Necrotic lunate at the proximal end (no enhancement), adjacent reparative zone enhanced, and viable distal lunate

4. MRI stage C-completely necrotic: No enhancement corresponding to complete lunate osteonecrosis.

Bain and Begg Classification (2006): An arthroscopic assessment and classification of KD was reported in 2006 by Bain and Begg (7) based on the number of nonfunctional articular surfaces of the lunate (Figure 3) (7, 8). Articular surfaces that are functional are smooth arthroscopically and feel firm to the touch without significant softening. In order to qualify as nonfunctional, an articular surface must have extensive fibrillation, fissuring, localized or extensive loss, fractures, or a floating surface. Due to the fact that synovitis was diagnosed in all of their cases, they did not grade them based on it. The findings of arthroscopic examination often change the recommended treatment as a result of plain radiographs underestimating the severity of articular changes. In addition, 82% of cases had a nonfunctional articulation, and 61% had a nonfunctional articulation and a functional articulation (8). The functional articular surfaces of the joints were used to develop an articular-based approach to treatment. Identification of nonfunctional (compromised) articulations is followed by excising, fusing, or bypassing them. The remaining functional articulations of the wrist are then mobilized.

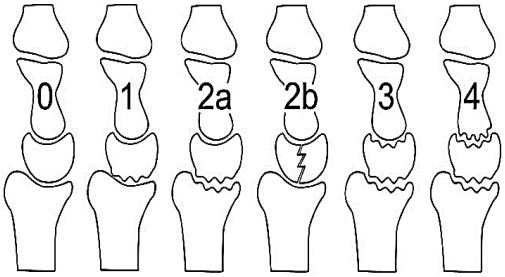

Figure 3. Bain and Begg classification based on arthroscopic evaluation of lunate fossa, which was described by Bain and Begg (7) [photo from Lichtman et al. study (10)]

Lichtman et al. Classification (2017): In 2017, Lichtman et al. proposed a new classification for KD (10). The classification was the strongest definition and treatment for KD and therefore, they named the classification as "A New Algorithm for the 21st Century" (Table 2).

Table 2. The new algorithm for the 21st century for Kienbock disease (KD) (the key questions for KD)

A. Patient's age?
A1. < 15 years – non-operative
A2. 16-20 years – non-operative first. Consider unloading procedure.
A3. > 70 years – non-operative first. Consider synovectomy and/or follow the algorithm below.
B. Stage of the lunate?
B1. Lunate intact (cortex and cartilage intact – Lichtman 0, I, II, Schmitt A, Bain 0)
Protect/unload the lunate:
Orthosis or cast first (trial for 2-3 months)
RSO, capitate shortening for ulnar +ve (radial epiphysiodesis*)
(Alternatives – lunate decompression, VBG*, radius forage*)
B2. Lunate compromised (localized lunate disease – Lichtman IIIA, Schmitt B, Bain 1)
Lunate reconstruction: MFT*, lunate replacement*, PRC [RSL fusion, SC (or STT) fusion]
B3. Lunate not reconstructable (advanced lunate disease – Lichtman IIIC, Schmitt C, Bain 2b)
Lunate salvage (excision): Lunate replacement*, capitate lengthening, PRC (SC fusion)
C. State of the wrist?
C1. Central column articulations compromised (Lichtman IIIA or C, Schmitt B, Bain 2a, 3, or 4)
C1a. Radiolunate articulation compromised (Lichtman IIIA, Schmitt B, Bain 2a)
Fuse or bypass radiolunate joint: RSL fusion, SC fusion, lunate prosthesis, MFT graft
C1b. Radiolunate and midcarpal articulations compromised (Lichtman IIIA or C, Schmitt B, Bain 3 or 4) Bypass central column: SC fusion
C2. Carpal collapse with intact radioscaphoid articulation (Lichtman IIIB or C, Schmitt B, Bain 2-4)
Stabilize radial column: SC fusion
C3. Wrist not reconstructable (advanced wrist disease – Lichtman IV, Schmitt C, Bain 4)
Wrist salvage: Total wrist arthrodesis, total wrist arthroplasty

RSO: Radial shortening osteotomy; VBG: Vascularized bone graft; MFT: Medial femoral trochlea; PRC: Proximal row carpectomy; RSL: Radioscapholunate; SC: Scaphocapitate

Table 3. A new classification and treatment method proposed by Lichtman et al. in 2017 (10)

Assessment				Treatment	
Osseous (Lichtman)	Vascular (Schmitt)	Cartilage (Bain)	Description	Principle	Procedure
B1: Lunate intact				Lunate protection	
0, I, II	A	0	Intact lunate	Lunate unloading, venous decompression, revascularization	Immobilizing, unloading procedures, lunate decompression, VBG
B2: Lunate compromised				Lunate reconstruction	
IIIA	B	1	Proximal lunate collapse	Lunate reconstruction	MFTG, PRC (RSL fusion, lunate replacement)
B3: Lunate unreconstructable				Lunate salvage	
IIIC	C	2b	Lunate collapse	Lunate excision	Lunate replacement, capitate lengthening, PRC
C1-3: Wrist compromised				Wrist reconstruction	
IIIA	B	2a	RC joint compromised	Fuse or bypass RL joint	RSL fusion, SC fusion
IIIA or C	B	3, 4	RC and MC joint compromised	Bypass central column	SC fusion, hemiarthroplasty
IIB	B	2-4	Carpal collapse, (RSA > 60 degrees)	Stabilize radial column	SC fusion
C4: Wrist not reconstructable				Wrist salvage	
IV, KDAC	C	4	Pan-OA	Salvage	Wrist fusion, wrist arthroplasty

KDAC: Kienbock disease advanced collapse; MC: Midcarpal; MFTG: Medial femoral trochlear graft; Pan-OA: Pan carpal osteoarthritis; PRC: Proximal row carpectomy; RC: Radiocarpal; RL: Radiolunate; RSA: Radioscaphoid angle; RSL: Radioscapholunate; SC: Scaphocapitate; VBG: Vascularized bone graft

The previous classifications, which were based on the osseous (Lichtman) (6), vascular (Schmitt) (9) and cartilage (Bain) (7) were merged into the Lichtman et al. classification (10). Their study classified patients with KD from A1 to C4 and recommended appropriate treatment methods for each stage (10) (Table 3).

Bain et al. published a review article in 2016 about the "at-risk" patients of the KD and they reviewed some etiologies such as lunate anatomy, avascular necrosis (AVN) (3), stress fracture of the lunate, active male, and compartment syndrome of the bone. AVN may be one of the etiologies of KD as a result of compartment syndrome of the lunate due to arterial supply, emboli, venous drainage, and translunate fracture dislocation (3, 24).

Based on the Lichtman et al. classification in 2017, splinting and VBG were recommended for the patients with intact lunate (B1) and also RSO for the cases with negative ulnar variance. Furthermore, they suggested PRC for the cases with nonfunctional proximal lunate articular surface and salvage procedures such as RSL fusion, SC fusion, wrist fusion, and arthroplasty for stages more severe than B1 (10).

Conclusion

KD was defined based on the previous studies in the past 100 years with various classifications which changed and developed by progressing in diagnostic equipment. The first classification was based on radiographs, then based on MRI, and finally based on the arthroscopic evaluation. Recently, the pioneers of KD (Lichtman and Bain) proposed a new classification based on all the previous classifications (radiographs, MRI, and arthroscopy). This classification seems to be the best evaluation and treatment method for KD. We recommend using this new classification for the assessment of KD.

Conflict of Interest

The authors declare no conflict of interest in this study.

Acknowledgements

None.

References

1. Kienböck R. Concerning traumatic malacia of the lunate and its consequences: joint degeneration and compression. *Fortsch Geb Roentgen*. 1910;16:77-103. [In German].
2. Müller W. About the softening and compaction of the lunate bone, a typical disease of the wrist. *Bruns' Beitr Klin Chir*. 1920;119:664-82. [In German].
3. Bain GI, MacLean SB, Yeo CJ, Perilli E, Lichtman DM. The etiology and pathogenesis of Kienbock disease. *J Wrist Surg*. 2016;5(4):248-54. doi: 10.1055/s-0036-1583755. [PubMed: 27777813]. [PubMed Central: PMC5074830].
4. Ringsted AX, Mb D. Kienböck with 2 brothers. *Acta Chir Scand*. 1932;69:185-96. [In German].
5. Stahl F. On lunomalacia (Kienbock's Disease): A clinical and roentgenological study, especially on its pathogenesis and the late results of immobilization treatment. *Acta Chir Scand [Suppl]*. 1947;126:3-133.
6. 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. [PubMed: 908720].
7. Bain GI, Begg M. Arthroscopic assessment and classification of Kienbock's disease. *Tech Hand Up Extrem Surg*. 2006;10(1):8-13. doi: 10.1097/00130911-200603000-00003. [PubMed: 16628114].
8. Bain GI, Lichtman D. Algorithmic treatment of Kienbock disease; beyond staging. *Tech Hand Up Extrem Surg*. 2011;15(1):32. doi: 10.1097/BTH.0b013e318209fef6. [PubMed: 21358522].
9. Schmitt R, Heinze A, Fellner F, Obletter N, Struhn R, Bautz W. Imaging and staging of avascular osteonecroses at the wrist and hand. *Eur J Radiol*. 1997;25(2):92-103. doi: 10.1016/s0720-048x(97)00065-x. [PubMed: 9283837].
10. Lichtman DM, Pientka WF, Bain GI. Kienbock Disease: A New Algorithm for the 21st Century. *J Wrist Surg*. 2017;6(1):2-10. doi: 10.1055/s-0036-1593734. [PubMed: 28119790]. [PubMed Central: PMC5258126].
11. Danoff JR, Cuellar DO, O J, Strauch RJ. The Management of Kienbock Disease: A Survey of the ASSH Membership. *J Wrist Surg*. 2015;4(1):43-8. doi: 10.1055/s-0035-1544225. [PubMed: 25709878]. [PubMed Central: PMC4327716].
12. Bain GI, Smith ML, Watts AC. Arthroscopic core decompression of the lunate in early stage Kienbock disease of the lunate. *Tech Hand Up Extrem Surg*. 2011;15(1):66-9. doi: 10.1097/BTH.0b013e3181e1d2b4. [PubMed: 21358528].
13. Afshar A, Eivaziatashbeik K. Long-term clinical and radiological outcomes of radial shortening osteotomy and vascularized bone graft in Kienbock disease. *J Hand Surg Am*. 2013;38(2):289-96. doi: 10.1016/j.jhsa.2012.11.016. [PubMed: 23313249].
14. Watanabe T, Takahara M, Tsuchida H, Yamahara S, Kikuchi N, Ogino T. Long-term follow-up of radial shortening osteotomy for Kienbock disease. *J Bone Joint Surg Am*. 2008;90(8):1705-11. doi: 10.2106/JBJS.G.00421. [PubMed: 18676901].
15. Matsui Y, Funakoshi T, Motomiya M, Urita A, Minami M, Iwasaki N. Radial shortening osteotomy for Kienbock disease: Minimum 10-year follow-up. *J Hand Surg Am*. 2014;39(4):679-85. doi: 10.1016/j.jhsa.2014.01.020. [PubMed: 24612833].
16. Ilyas AM. Proximal row carpectomy with a dorsal capsule interposition flap. *Tech Hand Up Extrem Surg*. 2010;14(3):136-40. doi: 10.1097/BTH.0b013e3181d44526. [PubMed: 20818213].
17. Pisano SM, Peimer CA, Wheeler DR, Sherwin F. Scaphocapitate intercarpal arthrodesis. *J Hand Surg Am*. 1991;16(2):328-33. doi: 10.1016/s0363-5023(10)80121-2. [PubMed: 2022848].
18. Luegmair M, Saffar P. Scaphocapitate arthrodesis for treatment of late stage Kienbock disease. *J Hand Surg Eur Vol*. 2014;39(4):416-22. doi: 10.1177/1753193413496177. [PubMed:

23824220].
19. Rhee PC, Lin IC, Moran SL, Bishop AT, Shin AY. Scaphocapitate arthrodesis for Kienbock disease. *J Hand Surg Am*. 2015;40(4):745-51. doi: 10.1016/j.jhsa.2014.12.013. [PubMed: 25701486].
20. MacLean SBM, Bain GI. Long-term outcome of surgical treatment for Kienbock disease using an articular-based classification. *J Hand Surg Am*. 2021;46(5):386-95. doi: 10.1016/j.jhsa.2020.11.004. [PubMed: 33423849].
21. Lichtman DM, Degnan GG. Staging and its use in the determination of treatment modalities for Kienbock's disease. *Hand Clin*. 1993;9(3):409-16. Retrieved from. [PubMed: 8408251].
22. Lichtman DM, Lesley NE, Simmons SP. The classification and treatment of Kienbock's disease: The state of the art and a look at the future. *J Hand Surg Eur Vol*. 2010;35(7):549-54. doi: 10.1177/1753193410374690. [PubMed: 20621943].
23. Schmitt R, Kalb K. Imaging in Kienbock's disease. *Handchir Mikrochir Plast Chir*. 2010;42(3):162-70. [In German]. doi: 10.1055/s-0030-1253433. [PubMed: 20552545].
24. Bain GI, MacLean SB, Tse WL, Ho PC, Lichtman DM. Kienbock disease and arthroscopy: assessment, classification, and treatment. *J Wrist Surg*. 2016;5(4):255-60. doi: 10.1055/s-0036-1584546. [PubMed: 27777814]. [PubMed Central: PMC5074828].