



Scaphocapitate fusion for the treatment of Lichtman stage III Kienböck's disease. Results of a single center study with literature review

S. Collon, S.K.Y. Tham, D. McCombe, G. Bacle

► To cite this version:

S. Collon, S.K.Y. Tham, D. McCombe, G. Bacle. Scaphocapitate fusion for the treatment of Lichtman stage III Kienböck's disease. Results of a single center study with literature review. *Hand Surgery and Rehabilitation*, 2020, 39, pp.201 - 206. <10.1016/j.hansur.2020.01.002>. <hal-03491102>

HAL Id: hal-03491102

<https://hal.science/hal-03491102v1>

Submitted on 22 Aug 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons CC BY-NC 4.0 - Attribution - Non-commercial use - International License

Scaphocapitate fusion for the treatment of Lichtman stage III Kienböck's disease.

Results of a single center study with literature review

Arthrodèse scapho-capitale dans le traitement de la maladie de Kienböck de stade III de Lichtman. Résultats d'une série monocentrique et revue de la littérature

Sylvie Collon^{1,2}, Stephen K.Y. Tham^{1,3}, David McCombe^{1,3}, Guillaume Bacle^{1,3,4}

1: Victorian Hand Surgery Associates, St. Vincent's Hand Surgery Unit, Fitzroy St. Vincent's Hospital, Suite C37, Level 3, Building C, 41 Victoria Parade, Fitzroy VIC 3065, Australia

2 : Clinique des Ormeaux, 36, rue Marceau, 76600 Le Havre, France

3: Hand and Wrist Biomechanics Laboratory, O'Brien Institute, 42 Fitzroy St, Fitzroy VIC 3065, Australia

4: Department of Orthopaedic Surgery, Hand Surgery Unit, Hôpital Trousseau – CHU de Tours, Avenue de la République, 37170 Chambray-lès-Tours, France

Corresponding Author and Details:

Guillaume Bacle

Department of Orthopaedic Surgery, Hand Surgery Unit, Hôpital Trousseau – CHU de Tours,
Avenue de la République, 37170 Chambray-lès-Tours, France

Telephone numbers: (+33) 2 34 38 94 44

Fax number: (+33) 2 47 47 91 44

Email address: guillaume.bacle@univ-tours.fr

Other authors

Sylvie Collon, MD: sylvie.collon@gmail.com, no ORCID ID

Stephen K. Tham, MBBS: stham@bigpond.net.au, ORCID ID: [0000-0003-3545-2544](https://orcid.org/0000-0003-3545-2544)

David McCombe, MBBS, MD: david.mccombe@vhsc.com.au,

ORCID ID: 0000-0003-4458-3925

Guillaume Bacle, MD, PhD: guillaume.bacle@univ-tours.fr

ORCID ID: 0000-0001-8899-2638

Investigation Performed at Victorian Hand Surgery Associates and Hand Surgery Unit, St. Vincent's Hospital, Suite C37, Level 3, Building C, 41 Victoria Parade, Fitzroy VIC 3065, Australia.

Running Head:

Scaphocapitate fusion treatment of advanced Kienböck's disease

Ethical Approval:

Obtained from St Vincent's Hospital, Suite C37, Level 3, Building C, 41 Victoria Parade, Fitzroy VIC 3065, AUSTRALIA.

Registration number: HREC-A 078/15, 17 June 2015.

Level of evidence: IV, case series.

Scaphocapitate fusion for the treatment of Lichtman stage III Kienböck's disease.

Results of a single center study with literature review

Arthrodèse scapho-capitale dans le traitement de la maladie de Kienböck de stade III de Lichtman. Résultats d'une série monocentrique et revue de la littérature

Abstract

The purpose of this study was to report the outcomes of scaphocapitate fusion without lunate excision for the treatment of stage III Kienböck's disease and to compare these results with historical results of limited wrist arthrodesis and proximal row carpectomy. Clinical and radiographic evaluations were performed preoperatively and at a mean of 5.8-years' follow-up (range 1.5 to 10.5 years) on 17 patients with advanced Kienböck's disease (Lichtman stages: IIIA n=4 and IIIB n=13) treated by scaphocapitate fusion without lunate excision between January 2000 and July 2015. The average DASH score was 19 points (range 2 to 61) and the PRWE score was 23 points (range 0 to 77). The average preoperative VAS for pain of 8 was significantly reduced to an average of 4 with activity ($p = 0.002$) and 1 at rest ($p = 0.001$). The flexion/extension arc was 91° and grip strength was 76% of the contralateral side. The preoperative mean modified carpal height ratio decreased significantly to an average of 1.14 at the latest follow-up ($p = 0.02$). The average carpal-ulnar distance ratio was not altered ($p = 0.89$). The radioscapoid and scapholunate angles were restored to their normal range. Four scaphocapitate joints failed to fuse. No re-operations were performed. Scaphocapitate fusion for advanced Kienböck's disease maintains wrist motion and significantly relieves pain. Lunate excision is not necessary. Based on a literature review, our results were comparable to those of scaphotrapeziotrapezoid fusion. Proximal row carpectomy is still an option when the radius and capitate articular surfaces are free of significant chondral lesions.

Résumé

Le but de l'étude était de rapporter les résultats de l'arthrodèse scapho-capitale sans excision du lunatum dans le traitement de la maladie de Kienböck au stades III de Lichtman et de les confronter aux résultats de la littérature des arthrodèses partielles et des résections de la rangée proximale du carpe. Nous avons évalué cliniquement et radiologiquement en préopératoire et avec un suivi moyen de 5,8 ans (de 1,5 – 10,5 ans) 17 patients avec une maladie de Kienböck avancée (4 stades IIIA et 13 stades IIIB de Lichtman) traités par arthrodèse scapho-capitale sans excision du lunatum entre janvier 2000 et juillet 2015. Le score DASH moyen était de 19 points (extrêmes : 0 – 77). La douleur moyenne était améliorée en activité ($p=0,002$) et au repos ($p=0,001$). Le secteur de flexion/extension était de 91° et la force de préhension représentait 76% de celle du côté opposé. Le Ratio Moyen de Hauteur du Carpe préopératoire avait diminué de façon significative pour atteindre une moyenne de 1,14 au recul final ($p=0,02$). Les angles radio-scaphoïdien et scapho-lunaire étaient restaurés à des valeurs normales. Quatre arthrodèses n'étaient pas consolidées. Aucune réintervention n'avait été effectuée. L'arthrodèse scapho-capitale dans le traitement des stades avancés de la maladie de Kienböck permet de préserver les mobilités et améliore la douleur. La littérature montre des résultats comparables pour l'arthrodèse scapho-trapézo-trapézoïdienne. La résection de la rangée proximale du carpe reste possible si les surfaces articulaires du radius et du capitatum sont exemptes de lésion chondrale.

Keywords: Scaphocapitate fusion; Kienböck disease; Limited wrist arthrodesis; Lunate necrosis

Mots-clés : Arthrodèse scapho-capitale ; Maladie de Kienböck ; Arthrodèse partielle du carpe ; Nécrose du lunatum

1. Introduction

Kienböck's disease is an avascular osteonecrosis of the lunate and is one of the most challenging wrist conditions to treat. Its pathophysiology is poorly understood and is likely to be an interplay of several unfavorable vascular and anatomical factors [1,2]. High loads and/or repetitive mechanical stresses applied to an "at-risk" lunate can lead to fractures with subsequent progression to osteonecrosis, fragmentation and collapse [1,3]. Despite a lack of consensus, therapeutic strategies depend on clinical symptoms and radiologic staging of the disease. Treatment options in the advanced stages aim at addressing the lunate and carpal collapse to delay the onset of osteoarthritis (OA). In those late stages without wrist OA (i.e., Lichtman stages IIIA and IIIB), limited wrist arthrodesis (LWA) and proximal row carpectomy (PRC) are two motion-preserving treatment options [3].

Both scaphotrapeziotrapezoid (STT) [4-7] and scaphocapitate arthrodesis (SCA) [8-11] have been reported as valuable LWA treatment options for advanced Kienböck's disease. More recently, PRC has also been reported as a valuable therapeutic option with favorable long-term functional results [12-14].

The outcomes of SCA for the treatment of advanced Kienböck's disease have been reported in the literature [8-11]; however, recent reports are impaired by limited follow-up, variable treatments and heterogeneous study populations.

The purpose of our study was to report the clinical and radiologic outcomes of a SCA case series with homogenous surgical management leaving the lunate untouched for the treatment of stage III Kienböck's disease and to compare our findings with results of LWA treatment with and without lunate excision and PRC in the published literature.

2. Patients and methods

2.1. Ethics approval and inclusion procedure

Institutional ethics approval was obtained (HREC-A 078/15) before the start of the study. All consecutive patients in a single center who underwent SCA between January 2000 and July 2015 for symptomatic Lichtman stage IIIA and IIIB Kienböck's disease with at least 12

months of follow-up were included in this study. In all cases, surgical management was performed due to persistent pain and impaired wrist function after at least 3 months of conservative treatment. All lunates were fragmented but without joint space narrowing at the lunocapitate, radiolunate or midcarpal joints on plain radiographs and CT arthrography.

2.2. Clinical and radiographic assessments

All patients underwent a clinical and radiological assessment preoperatively and at follow-up. Two independent examiners performed the chart reviews, clinical assessments, and radiographic analyses. Clinical examination of the affected and contralateral wrists included pain assessment by visual analog scale (VAS), range of motion (ROM) in flexion/extension and in radial/ulnar deviation, and grip strength measured with a Jamar™ hydraulic hand dynamometer (Lafayette Instrument Company, IN, USA).

Radiographic evaluation consisted of standard posteroanterior and lateral views of the affected wrist. Radiological staging of the disease was done using Lichtman's classification as modified by Alexander et al. [15]. The other radiographic parameters evaluated were (1) signs of OA in either the radiocarpal or midcarpal joint, (2) scapholunate and radioscapoid angles, (3) Stahl index [16] and (4) ulnar variance. Lichtman stages IIIA and IIIB were sorted depending on whether the radioscapoid angle was more or less than 60°, respectively. The modified carpal height ratio (MCHR) [17] and carpal-ulnar distance ratio (CUDR) [18] were determined to monitor carpal collapse and ulnar translation of the carpus, respectively. At review, any additional procedures performed, complications and scaphocapitate joint fusion were noted. Patient satisfaction was rated as poor, fair, good or very good. The functional outcomes were determined using the Patient-Related Wrist Evaluation (PRWE) and Disabilities of the Arm, Shoulder and Hand (DASH) self-reported questionnaires.

2.3. Surgical technique

All procedures were performed by one of two fellowship trained hand surgeons (S.C and G.B.). The procedure was similar in all patients. A longitudinal skin incision was made and the extensor retinaculum incised through the 3-4 extensor compartment. The posterior interosseous nerve was excised. The scaphocapitate joint was identified by fluoroscopy and the wrist capsule incised along its length without exposing the lunate. Articular cartilage from the scaphocapitate joint was removed and the cancellous bone surfaces exposed after confirming the location of the scapholunate joint by fluoroscopy. Cancellous bone graft harvested from the distal radial metaphysis at the 4th extensor compartment was inserted into the scaphocapitate joint. The wrist was then ulnar deviated to extend the scaphoid, increasing the carpal height. The scaphocapitate joint was temporarily fixed with two Kirschner wires and definitively fixed with staples (5 cases) or cannulated headless compression screws (13 cases). In all cases, the lunate was not removed. In case with negative ulnar variance, patients simultaneously underwent radial shortening.

2.4. Statistical analysis

Statistical analysis was performed using the GraphPad Prism™ software. Since the data were not normally distributed, the comparisons of paired data between the preoperative and postoperative assessments were made using the non-parametric Wilcoxon rank sum test with continuity correction. The statistical threshold of significance was set at $p < 0.05$.

3. Results

While 18 patients (18 wrists) were treated, only 17 patients (17 wrists) were available for review. There were 7 men and 10 women, and their dominant side was affected in 11 cases. The median age of the patients at the time of surgery was 29 years (range 18–43 years). The mean follow-up period was 5.8 years (1.5–10.5 years). The preoperative wrist radiographic changes were classified as Lichtman stage IIIA in 4 wrists and stage IIIB in 13 wrists. Thirteen patients were ulnar negative with an average of $-3 \text{ mm} \pm 2 \text{ mm}$ and thus underwent radial shortening. The four remaining patients had neutral ulnar variance. Fourteen of the 15

patients who were employed preoperatively remained so. Two patients changed to less physically demanding occupations. The average DASH score was 19 points (range 2 to 61) and the PRWE score was 23 points (range 0 to 77). Eight patients rated their results as very good, seven as good and two as fair.

The average preoperative VAS for pain of 8 was reduced to an average 4 ($p = 0.002$) with activity and 1 at rest ($p = 0.001$) at the follow-up assessment (Table 1). All patients described having constant pain preoperatively and intermittent pain at follow-up. Of the 17 wrists, 11 were pain-free or mildly painful, 4 were moderately painful and 4 were severely painful. Wrist ROM in flexion/extension and grip strength increased significantly at follow-up compared to the preoperative evaluation while radial and ulnar deviation decreased significantly. In contrast, compared to the contralateral wrist, ROM of the operated wrist was lower in all sectors as well as grip strength (Table 1).

The average preoperative MCHR of 1.45 was less than the normal range (between 1.52 and 1.62) and further decreased significantly to an average of 1.14 at the latest follow-up ($p = 0.02$) (Table 2). The average preoperative and follow-up CUDR did not change ($p = 0.89$). The radioscapoid and scapholunate angles were restored to a normal range. The mean Stahl index was decreased preoperatively but was not reduced further at final follow-up.

At follow-up, four scaphocapitate joints had failed to fuse. Staple fixation was used in three of these wrists. No re-operations were performed. The average ulnar variance was $-2 \text{ mm} \pm 1 \text{ mm}$. The lunate in three stage IIIB wrists had an increase in lunate height (Fig. 1). There were four radiographs with mild dorsal radial rim and radial styloid impingement at the radioscapoid joint. None were symptomatic (Fig. 2).

4. Discussion

Current therapeutic options for advanced Kienböck's disease with lunate collapse without OA (i.e. Lichtman stage III) are controversial [1, 3]. The available motion-preserving options are PRC [12-14,19] and LWA, mainly STT arthrodesis [4-7] and SCA [8-11]. STT arthrodesis is

the most widely used LWA procedure for treating Kienböck's disease [11]. In contrast, apart from the study reported by Sennwald et al. in 1995 [8], to the best of our knowledge, there is no other published study reporting the results of SCA without lunate excision in a homogeneous population of Lichtman stage III Kienböck wrists.

We found at follow-up a significant reduction in wrist pain at rest ($p < 0.001$) and during activity ($p < 0.002$), and an improvement in grip strength (+10 Kg, $p = 0.001$). These data are consistent with those from the literature [4-11,19]. On the other hand, unlike the previous data reported, our study found a significant postoperative improvement in wrist flexion ($p = 0.034$) and extension ($p = 0.007$) [9-11]. The total active motion (TAM) of 91° at 69 months' follow-up in our study compares favorably. Unfortunately, Sennwald et al. [8] did not report the change in ROM of the operated wrists between preoperative and final follow-up. We believe this progression could be explained by the radiocarpal joint and lunate being left untouched, underestimation of the preoperative ROM due to pain and articular synovitis, and finally, by not including Lichtman stage IV wrists. Indeed, with more than 40% OA stage wrists included in the studies of Luegmair et al. [9] and Rhee et al. [10], the postoperative mobility might be altered by progression of the wrist OA at the final exam, which was 41% and 50% in their respective studies. In comparison, OA occurred in 23% of wrists in our study but remained asymptomatic. In addition, Luegmair et al. [9] and Rhee et al. [10] reported the results of patients with multiple concomitant and/or subsequent procedures and many patients were lost to follow-up. These two studies mix different stages of Kienböck's disease (stages III and IV) making difficult to interpret the results.

We agree with Watson et al. [4] and Nakamura et al. [19] who described advanced Lichtman stages as a good indication for LWA with pre-existing carpal OA (i.e. Stage IV) as a relative contraindication. Fifteen patients (88%) in our study rated their outcome as good or very good. Unfortunately, preoperative functional scores were not available, but the follow-up mean DASH score at 19 points and PRWE score at 23 points describe satisfactory levels of function and symptoms compared to the values from the general population [20]. These

results are accompanied by pain relief and return to work in most of our patients. The two patients who were restricted to alternate duties rated their result as fair.

In contrast, there were significant functional alterations of the operated wrists. We noted a decrease of about 20° in TAM radial/ulnar deviation between the preoperative state and the final assessment. Similarly, extension was the most restricted motion at the final follow-up compared to the contralateral side. These data are consistent with those reported by others for LWA [4-11,19] and supported by experimental studies [21]. However, these limitations in wrist ROM were not sufficient to hinder daily living activities [22] and none of the patients in this study complained of limited wrist motion.

It remains questionable whether lunate excision is mandatory and improves wrist function.

The results reported by Sennwald et al. [8] did not support lunate excision. Besides, Rhee et al. reported that lunate excision may contribute to progressive ulnar translocation of the carpus [10]. The mean CUDR did not change in our series. More recently, Charre et al. [11] reported a case series with no obvious consequences on ROM or pain relief attributable to lunate excision. So far, no evidence supports excising the lunate during LWA in Kienböck's disease and we think it makes the procedure more difficult with no evidence of improved outcomes. The fractured lunate did not heal at follow-up. However, the purpose of SC fusion was not an attempt to heal the fractured avascular lunate, but to unload the lunate, reduce wrist pain and maintain wrist mobility.

However, like Rhee et al. [9], our radiographic evaluation found progression of the carpal collapse with a significant decrease in the MCHR from 1.47 preoperatively to 1.12 at follow-up, despite restoring the radioscapoid and scapholunate angles to normal values, suggesting loss in height of the proximal carpal row. We have no obvious explanation for this decrease except that Kienböck's disease is progressive and that stabilization of the lateral carpal column through SCA is not sufficient to maintain carpal height, thus the continued collapse. The increased loading of the radioscapoid joint after SCA [23], demonstrated by the increased sclerosis of the scaphoid fossa (Fig. 1), is likely to account for the development of radioscapoid osteoarthritis with a reported 9% to 50% incidence of radiographic changes

[8,9,24]. Four of our patients developed non-symptomatic radiological impingement without narrowing at the radioscapoid joint. Luegmair et al. [9] reported a 50% incidence of radioscapoid osteoarthritis with one patient requiring re-operation.

Similar to Pisano et al. [24] who reported a 12% incidence of non-union, we also report a high number of scaphocapitate non-union (4 cases, 23%). Three of these non-union cases had the arthrodesis site stabilized by staples. Insufficient fixation with staples is likely to be responsible for the single non-union case in the Luegmair et al. and Charre et al. studies [9,11]. We no longer recommend this type of fixation.

Finally, the clinical, functional, and radiographic results of SCA and STT arthrodesis are quite similar (Table 3). Like Moy and Peimer [22], we believe SCA is an equally valid option for treating Lichtman stage III Kienböck's disease. We agree with Luegmair et al. [9] and Pisano et al. [24] that SCA is technically easier to perform and to adjust than STT arthrodesis as the arthrodesis is limited to one joint space.

Several reports of PRC with long-term follow-up have shown satisfactory results [13,14]. Despite these findings, Nakamura et al. [19] cautioned about the risk of earlier and more frequent radiographic degenerative changes after PRC compared to LWA. Due to the early involvement of the radiolunate joint in the disease progression [24], PRC in the advanced stages of Kienböck's disease was historically not recommended. Croog et al. [13] and Lumsden et al. [14] reported the presence of radiocapitate joint degenerative signs in 76% and 100% of cases respectively. Croog et al. advised caution in patients with stage IV disease [13]. Similarly, DiDonna et al. [26] considered PRC only for patients over 35 years because of a higher risk of failure in active younger people. If PRC is a considered option, then several authors recommend that the integrity of radial and capital articular surfaces be assessed by arthroscopy [25].

5. Conclusion

SCA for advanced Kienböck's disease with preservation of the lunate and radiocarpal joint maintains wrist motion and significantly relieves pain. Our results were comparable to published results for STT fusion. Staple fixation of LWA in Kienböck's disease seems to be inadequate. Finally, PRC remains possible if the articular surfaces that will be constrained are evaluated first, preferably by arthroscopy.

Conflict of interest:

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

Acknowledgment and funding: A scholarship from the French Orthopedic Society (Société Française de Chirurgie Orthopédique et Traumatologique, S.O.F.C.O.T.) was awarded to Dr Sylvie Collon and to Dr Guillaume Bacle.

References

1. Beredjiklian PK. Kienböck's disease. J Hand Surg Am 2009;34:167-75.
2. Fontaine C. Kienböck's disease. Chir Main 2015;34:4-17.
3. Amadio PC, Moran SL. Fractures of carpal bones. In: Green DP, Pederson WC, Hotchkiss RN, Wolfe SW (eds) Green's operative hand surgery, 5th ed. Philadelphia, Elsevier Churchill Livingstone, 2005, pp 711-68.
4. Watson HK, Monacelli DM, Milford RS, Ashmead D IV. Treatment of Kienböck's disease with scaphotrapezio-trapezoid arthrodesis. J Hand Surg Am 1996;21:9-15.
5. Sauerbier M, Tränkle M, Erdmann D, Menke H, Germann G. Functional outcome with scaphotrapeziotrapezoid arthrodesis in the treatment of Kienböck's disease stage III. Ann Plast Surg 2000;44:618-25.
6. Meier R, Van Griensven M, Krimmer H. Scaphotrapeziotrapezoid (STT) arthrodesis in Kienböck's disease. J Hand Surg Br 2004;29:580-4.
7. Lee JS, Park MJ, Kang HJ. Scaphotrapeziotrapezoid arthrodesis and lunate excision for advanced Kienböck's disease. J Hand Surg Am 2012;37:2226-32.
8. Sennwald GR, Ufenast H. Scaphocapitate arthrodesis for the treatment of Kienböck's disease. J Hand Surg Am 1995;20:506-10.
9. Luegmair M, Saffar P. Scaphocapitate arthrodesis for treatment of late stage Kienböck disease. J Hand Surg Eur 2014;39:416-22.
10. Rhee PC, Lin IC, Moran SL, Bishop AT, Shin AY. Scaphocapitate arthrodesis for Kienböck disease. J Hand Surg Am 2015;40:745-51.
11. Charre A, Delcaux S, Apredoai C, Ayel J, Rongieres M, Mansat P. Results of scaphocapitate arthrodesis with lunate excision in advanced Kienböck disease at 10.7-year mean follow-up. J Hand Surg Eur 2017;43:362-8.
12. De Smet L, Robijns P, Degreef I. Proximal row carpectomy in advanced Kienböck's disease. J Hand Surg Br 2005;30:585-7.

13. Croog AS, Stern PJ. Proximal row carpectomy for advanced Kienböck's disease: average 10-year follow-up. *J Hand Surg Am* 2008;33:1122-30.
14. Lumsden BC, Stone A, Engber WD. Treatment of advanced-stage Kienböck's disease with proximal row carpectomy: an average 15-year follow-up. *J Hand Surg Am* 2008;33:493-502.
15. Alexander AH, Turner MA, Alexander CE, Lichtman DM. Lunate silicone replacement arthroplasty in Kienböck's disease: a long-term follow-up. *J Hand Surg Am* 1990;15:401-7.
16. Stahl F. On lunatomalacia (Kienböck's disease): a clinical and roentgenological study, especially on its pathogenesis and late results of immobilization treatment. *Acta Chir Scand* 1947;126:1-133.
17. Nattrass GR, King GJ, McMurtry RY, Brant RF. A, alternative method for determination of carpal height ratio. *J Bone Joint Surg Am* 1994;76:88-94.
18. Youm Y, McMurtry RY, Flatt AE, Gillespie TE. Kinematics of the wrist. I. An experimental study of radial-ulnar deviation and flexion-extension. *J Bone Joint Surg Am* 1978;60:423-31.
19. Nakamura R, Horii E, Watanabe K, Nakao E, Kato H, Tsunoda K. Proximal row carpectomy versus limited wrist arthrodesis for advanced Kienböck's disease. *J Hand Surg Br* 1998;23:741-5.
20. Hunsaker FG, Gioffi DA, Amadio PC, Wright JG, Caughlin B. The American academy of orthopaedic surgeons outcomes instruments: normative values from the general population. *J Bone Joint Surg Am* 2002;84:208-15.
21. Douglas DP, Peimer CA, Koniuch MP. Motion of the wrist after simulated limited intercarpal arthrodeses. An experimental study. *J Bone Joint Surg Am* 1987;69:1413-8
22. Moy OJ, Peimer CA. Scaphocapitate fusion in the treatment of Kienböck's disease. *Hand Clin* 1993;9:501-4.
23. Iwasaki N, Genda E, Barrance PJ, Minami A, Kaneda K, Chao EY. Biomechanical analysis of limited intercarpal fusion for the treatment of Kienböck's disease: a three-dimensional theoretical study. *J Orthop Res* 1998;16:256-63.

24. Pisano SM, Peimer CA, Wheeler DR, Sherwin FS. Scaphocapitate intercarpal arthrodesis. J Hand Surg Am 1991;16:328-33.
25. Bain G, Begg M. Arthroscopic assessment and classification of Kienböck's disease. Tech Hand Up Extrem Surg 2006;10:8-13.
26. DiDonna ML, Kiefhaber TR, Stern PJ. Proximal row carpectomy: study with a minimum of ten years of follow-up. J Bone Joint Surg Am 2004;86:2359-65.

Figure legends

Fig. 1. Increased modified carpal height ratio following SC fusion with increased lunate height between preoperative (A) and postoperative (B) status. Note increased sclerosis of the scaphoid fossa (*yellow solid arrow*) and osteoporosis of the lunate fossa (*orange dotted empty arrow*) reflecting changes in load bearing.

Fig. 2. PA (A) and lateral (B) wrist views made at 5 years' follow-up showing SC fusion and screw positioning.

Table titles

Table 1. Preoperative and postoperative follow-up clinical outcomes

Table 2. Preoperative and postoperative radiographic outcomes

Table 3. Aggregate results of limited wrist arthrodesis and proximal row carpectomy for advanced Kienböck's disease treatment in the recent literature

Fig. 1. Increased modified carpal height ratio following SC fusion with increased lunate height between preoperative (A) and postoperative (B) status. Note increased sclerosis of scaphoid fossa (*yellow full arrow*) and osteoporosis of lunate fossa (*orange dotted empty arrow*) reflecting change in load bearing.



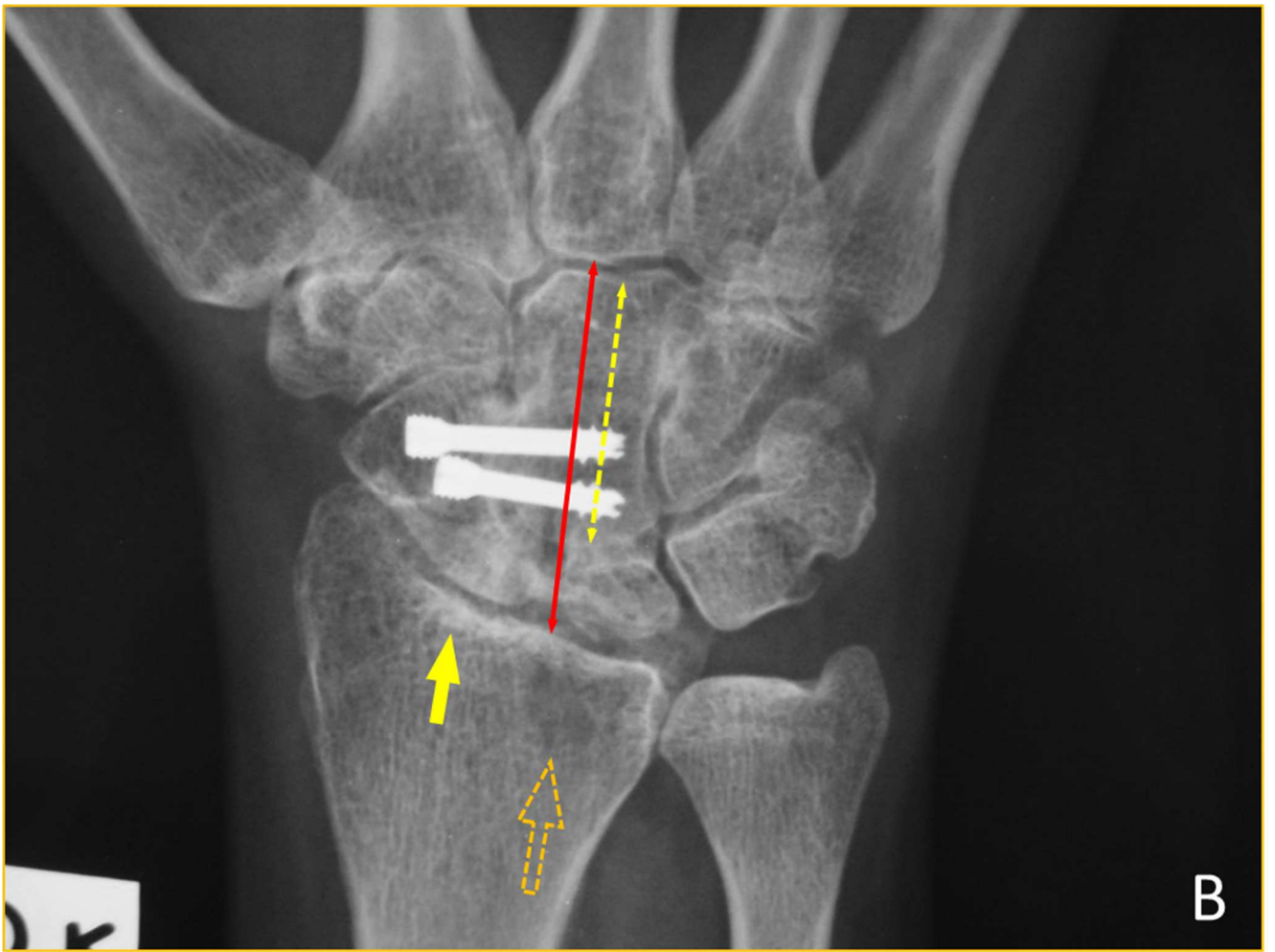


Fig. 2. 5 years' follow-up PA (A) and lateral (B) wrist views showing SC fusion healing and screws positioning.





Table 1. Preoperative and postoperative follow-up clinical outcomes

	Preoperative Mean (SD)	Postoperative Mean (SD)	Difference between preoperative and postoperative values	<i>p</i> -value ^a	Percentage of postoperative relative to contralateral
Pain during activity (VAS)	8 pts (1 pts)	4 pts (2 pts)	3 pts (1 pts)	0.002	<i>N/A</i>
Flexion	35° (13°)	45° (18°)	+ 10° (15°)	0.034	54
Extension	36° (17°)	46° (15°)	+ 10° (15°)	0.007	74
Radial deviation	20° (10°)	10° (8°)	- 10° (11°)	0.003	40
Ulnar deviation	32° (11°)	20° (9°)	- 12° (9°)	0.002	71
Grip strength	20 Kg (7Kg)	30 Kg (7Kg)	+ 10 Kg (6Kg)	0.001	76

SD: standard deviation; *VAS*: visual analog scale; *pts*: points; °: degree; *Kg*: kilogram; *N/A*: not assessed

^a *p*-value from Wilcoxon rank sum test with continuity correction

Table 2. Preoperative and postoperative radiographic outcomes

	Preoperative	Postoperative at the latest follow-up	<i>p</i> -value ^a
Modified CHR	1.45 ± 0.12	1.14 ± 0.35	0.02
Modified CUDR	0.66 ± 0.16	0.68 ± 0.16	0.89
Radioscaphoid angle	62° ± 15°	48° ± 11°	0.01
Scapholunate angle	33° ± 7°	48° ± 13°	0.003
Stahl index	0.37 ± 0.1	0.40 ± 0.1	0.69
Ulnar variance	−3 ± 2	−2 ± 1	0.27

CHR: carpal height ratio; *CUDR*: carpal-ulnar distance ratio; °: degree

^a *p*-value from Wilcoxon rank sum test with continuity correction

Table 3. Aggregate results of limited wrist arthrodesis and proximal row carpectomy for advanced Kienböck's disease treatment in the recent literature

Table 3

Authors	Treatment	Number of cases	Lichtman stage	FU in months (range)	Range of Motion				Grip strength % of CL side	Pain	% Non-union	% OA	Additional procedures	Return to work (%)		DASH score at FU	PRWE score at FU
					Postoperative at FU and % of unaffected wrist									Same Job	Retraining		
					Flexion	Ext.	Radial dev.	Ulnar dev.									
De Smet et al. [11]	PRC	21	IIIA: 2 IIIB:17 IV: 2	67 (12-138)	35° (N/A)	41° (N/A)	16° (N/A)	25° (N/A)	63	None or mild: 13 Moderate: 3 Severe: 5	–	N/A	None	67	33	22 (0-78)	30 (0-83)
Croog et al. [12]	PRC	18	IIIA: 5 IIIB: 12 IV: 1	123 (44-201)	49° (TAM78 %)	56° (TAM78 %)	9° (N/A)	33° (N/A)	87	None or mild: 16 Moderate: 2	–	87	3	83	17	Quick-DASH: 12 (0- 50)	17 (0-81)
Lumsden et al. [13]	PRC	13	Mixed stages III	180 (132-240)	38° (67%)	47° (75%)	20° (71%)	35° (95%)	92	None or mild: 11 Moderate: 2	–	86	None	100	0	N/A	N/A
Watson et al. [3]	STT	28	II: 9 III: 19	20 (16–114)	52° (65%)	48° (73%)	11° (50%)	27° (75%)	83	None or mild: 12 Moderate: 9 Severe: 6	0	N/A	3	N/A	N/A	N/A	N/A
Sauerbier et al. [4]	STT	26	Mixed stages III	35 (10–72)	N/A (TAM63%)		N/A (TAM51%)		71	None or mild: 20 Moderate: 4 Severe: 2	0	0	None	N/A	N/A	24	N/A
Meier et al. [5]	STT	59	II: 1 IIIA: 14 IIIB: 35 IV: 4	48 (24–96)	TAM 67° (TAM 60%)		TAM 31° (TAM 52%)		16% gain	Significantly reduced	15	22	None	N/A	N/A	28 (2-73)	N/A
Lee et al. [6]	STT	16	All stage IIIB	67 (49–108)	29° (N/A)	39° (N/A)	3° (N/A)	17° (N/A)	83	N/A	0	25	None	N/A	N/A	N/A	N/A

Sennwald et al. [7]	SC	11	II:1 IIIA: 4 IIIB: 6	36 (13-57)	TAM 64° (TAM 48%)		TAM 28° (TAM 47%)		83	None or mild: 10 Severe: 1	0	9	None	82	N/A	N/A	N/A
Luegmair et al. [8]	SC	10	IIIB: 4 IV: 6	94 (15–223)	39° (N/A)	45°(N/A)	16° (N/A)	25°(N/A)	64	None or mild: 7 Moderate: 3	10	50	3	50	20	27 (9–56)	N/A
Rhee et al. [9]	SC	27	IIIA: 10 IIIB: 6 IV: 11	60 (12-192)	30° (43%)	36° (54%)	11° (55%)	23° (55%)	150	Improved: 20 Unchanged: 6 Worse: 1	0	41	5	74	26	N/A	N/A
Charre et al. [10]	SC	18	IIIA: 5 IIIB: 12 IV: 1	128 (27-264)	40° (N/A)	45° (N/A)	12° (N/A)	30° (N/A)	74	None or mild: 4 Moderate: 5	6	11	2	61	22	Quick-DASH: 38 (18-63)	36 (9-87)

Current study	SC	17	IIIA: 4 IIIB: 13	69 (18-126)	45° (54%)	46° (74%)	10° (40%)	20° (71%)	76	None or mild: 11 Moderate: 4 Severe: 2	23	23	None	93	7	19 (2-61)	23 (0-77)
---------------	----	----	---------------------	----------------	-----------	-----------	-----------	-----------	----	--	----	----	------	----	---	--------------	--------------

PRC: proximal row carpectomy; *STT*: scaphotrapeziotrapezoid fusion; *SC*: scaphocapitate fusion; *CL*: contralateral; °: degree; %: percentage; *TAM*: total active motion; *N/A*: not assessed; *FU*:

follow-up; *OA*: osteoarthritis; *DASH*: Disabilities of the Arm; Shoulder and Hand; *PRWE*: Patient-Related Wrist Evaluation; *Mod*: moderate.