Acta Orthop. Belg., 2005, **71**, 163-168

ORIGINAL STUDY

Vascularised bone graft and osteotomy of the radius in Kienböck's disease

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Treatment of stage III A and III B avascular necrosis of the lunate bone remains controversial. We present a series of 5 cases in young patients treated with a vascularised bone graft from the second metacarpal, combined with a lateral shortening and closing wedge osteotomy of the radius. Good clinical and radiographic results were obtained and disease progression was halted with the combination of these two surgical procedures.

INTRODUCTION

In 1910, Kienböck (*15*) described the radiological and clinical characteristics of a disease which he described as lunatomalacia. The treatment of avascular necrosis of the lunate bone progressed substantially thanks to the work of Hultén (*10*), who reported in 1928 an association between the condition and the presence of a cubitus minus, and proposed shortening radial osteotomy as a treatment (*11*). Persson (*23*) subsequently introduced the concept of ulnar lengthening. Since then, a large number of treatments have been proposed. Some are aimed at reducing pressure on the lunate bone, either by levelling ulna and radius at the wrist by a shortening radial osteotomy (*1, 8, 28*) or a lengthening ulnar osteotomy (*26*), or by other techniques such as closing wedge lateral osteotomy (*16*), opening wedge lateral osteotomy (*29*) or closing wedge medial osteotomy (*29*) ; all these techniques are based on biomechanical studies that support the rationale of osteotomy (*2, 7, 13, 14, 20, 27*). Other treatments aim at addressing the actual necrosis of the lunate through autologous bone graft or vascularised bone graft (*4, 9, 18, 24*). This study presents a continuous series of 5 patients in stages III A and III B in whom we combined a vascularised bone graft from the index metacarpal and a lateral closing and shortening wedge osteotomy of the radius, in order to provide lunate vascularisation and to reduce pressure on the bone.

MATERIAL AND METHODS

Since January 1994, 5 patients (4 males and 1 female) with necrosis of the lunate in radiological stages III A (two cases) and III B (three cases) on the Lichtman scale (*17*) were treated with lateral closing and shortening wedge osteotomy of the radius and vascularised bone graft from the index metacarpal (fig 1). The average age of the patients was 20 years (range : 16 to 23). The average follow-up period was 21.2 months (range : 16 to 25).

The patients received regional anaesthesia. Vein emptying was performed using an elastic bandage with little pressure in order to visualise the pedicle vessels at all

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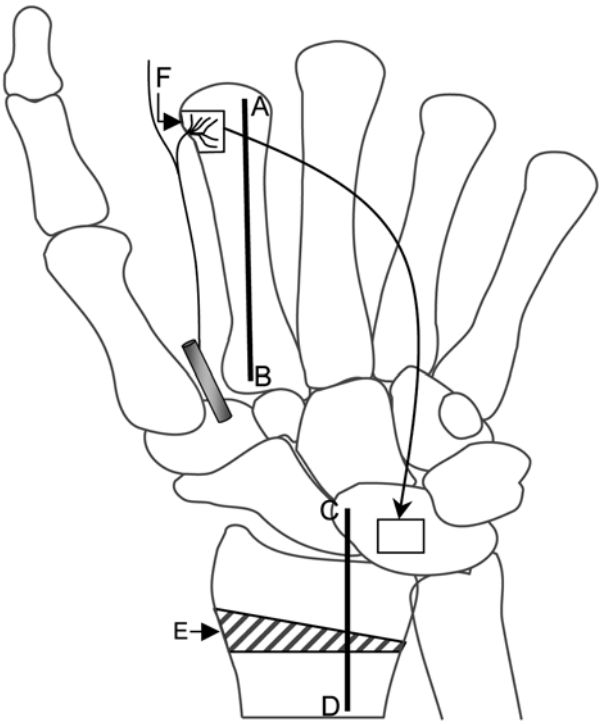

Fig. 1. — Drawing of graft procurement. AB and CD = cutaneous incisions. Diagram of the type of radial osteotomy = E, and procurement of the vascularised bone graft from the second metacarpal bone = F.

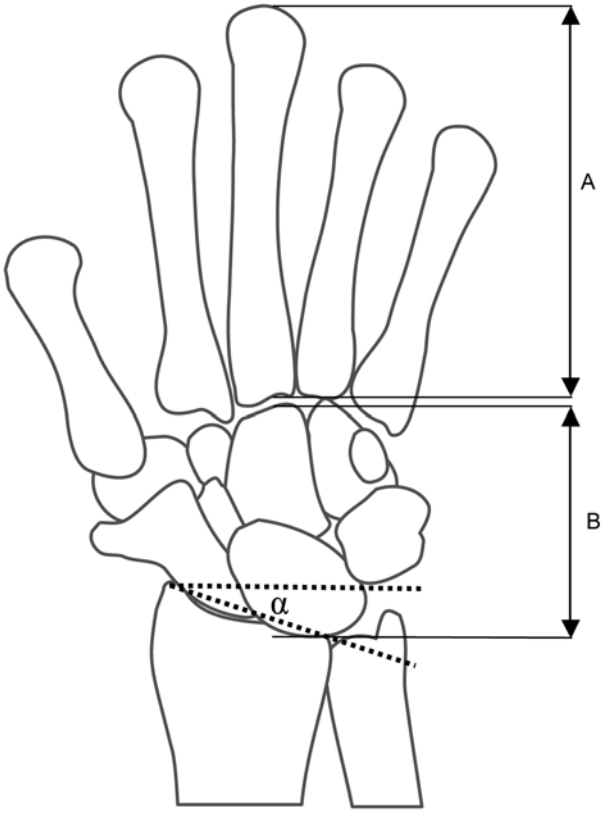

Fig. 2. — Measurement of radiographic parameters. Carpal height = A/B : α = radius inclination angle.

times. Dissection and procurement of the vascularised bone graft were performed with a 4 × magnifying glass.

The radius was approached through a dorsal incision and 2-3 mm bone was resected to bring the articular surfaces of radius and cubitus at the same level. A T-plate and 3.5 mm screws were used for fixation (Synthes, Switzerland). The lunate was approached through the distal part of the incision and a central dorsal bed measuring approximately 1.2 cm × 0.6 cm. was prepared. An additional dorsal skin incision was used to prepare a vascularised bone graft at the neck-head transition of the second metacarpal, conserving a large pedicle based on the dorsal artery of the first metacarpal, which sometimes presents a surface branch and another deep branch extending to the aponeurosis ; the fascia of the first interosseus muscle must be included in the dissection in order to preserve the pedicle. The graft was tunnelled subcutaneously and brought to the prepared bed in the lunate bone. The graft was easily pressed *in situ* and if necessary transfixed with a 1-mm Kirschner wire. The tourniquet was released and revascularisation of the flap was observed. A drain was installed and after wound closure a posterior plaster splint was applied for 6 weeks.

Pain, wrist strength, wrist mobility and ability to return to work were determined before and after surgery. Nakamura's clinical evaluation system (*22*) was used to determine the final clinical result. Ulnar variance, carpal height, radial joint surface inclination angle, Stahl index, density, fragmentation, bone cysts or lunate bone collapse were also noted preoperatively and at the final follow-up evaluation (fig 2).

Statistical analysis was performed using Microsoft© Excel© 97 (Microsoft Corporation, Redmond, Wash). The comparison of paired samples (t test) for quantitative variables, comparison between the pre and post-surgery evaluation, was used for analysis purposes. A value of $p < 0.05$ was considered to be significant.

Table I. — Patient summary

Patient, #, Age, & Gender	Radiographic Grade	Follow-up Months	Pain		Grip Strength (kg)		Extension/Flexion (degrees)				Clinical Result (Nakamura)
			Pre.	Post.	Pre.	Post.	Pre.	Post.	Pre.	Post.	
1, 21, M	IIIB	25	++	-	14	20	35	45	40	50	Good
2, 20, M	IIIA	16	++	-	11	23	45	65	50	60	Excellent
3, 16, M	IIIB	25	++	+/-	8	16	30	40	35	70	Good
4, 20, M	IIIA	20	++	-	16	25	5	40	45	50	Good
5, 23, F	IIIB	20	++	+/-	10	18	30	40	22	60	Good

Pain : ++ : Pain in daily activity ; + : pain in light work ; +/- : pain in hard work ; - : no pain.

RESULTS

Clinical results are summarised in table I. All patients complained of pain before surgery. All patients were clinically improved, with four (80%) reporting the absence of any discomfort and only one (20%) reporting slight discomfort after effort. Wrist muscle strength improved significantly ($p < 0.001$) in all patients, with a preoperative average of 11.8 +/- 3 Kgf (61% of the contralateral healthy wrist) and a postoperative average of 20.4 +/- 3 Kgf (88% of the contralateral healthy wrist). Average preoperative wrist extension was 29° +/- 14° and 46° +/- 10° postoperatively, the difference being statistically significant ($p < 0.05$). Average preoperative flexion was 38° +/- 10° and 58° +/- 8° postoperatively, the difference being statistically significant ($p < 0.05$). All patients returned to normal work. None of the patients complained of ulnar wrist pain or presented clinical signs of ulnar impaction due to ulnar deviation of the joint. The clinical results were excellent in one case and good in four, according to Nakamura's evaluation. None of the patients presented postoperative complications.

Radiographic results

Average preoperative ulnar variance was -3.4 mm +/- 1.1 mm and postoperatively 0.2 mm +/- 0.8 mm, the difference being statistically significant ($p < 0.001$). Preoperative carpal height was 0.41 mm +/- 0.05 mm and postoperatively 0.46 mm +/- 0.05 mm (not statistically significant). The mean preoperative Stahl index was 29.8% +/- 8.4% and postoperatively 28.8% +/- 5.7% (not statistically significant). Mean preoperative radial inclination was 23° +/- 2° and 16° +/- 3° postoperatively, the difference being statistically significant ($p < 0.05$).

The preoperative radiographic appearance showed increase in bone density and bone fragmentation in 5 cases, and bone cysts in 4. Postoperatively the appearance of the lunate bone improved with partial resolution of density in 4 cases, obliteration of bone cyst in one case. Fragmentation remained unchanged (fig 3). In one patient presenting total lunate collapse, radiographical improvement was initially observed in the immediate postoperative stage but at final follow-up, collapse had recurred (fig 4), and this was his final result.

DISCUSSION

In stages III A and III B of Kienböck's disease, shortening radial osteotomy normalising radial and ulnar length at the level of the wrist has become an accepted treatment. Radial osteotomy may be performed in two ways : transverse with segmental resection or wedging. High percentages of satisfactory results have been published with shortening radial osteotomy (*1, 8, 24, 28*), radial shortening and lateral closing (*24*) or lateral closing (*20, 22*) in stages II, III and even IV (*25*). Lengthening osteotomy of the ulna yields equivalent results but warrants a graft from the iliac crest and non-union of the osteotomy has been described (*26*).

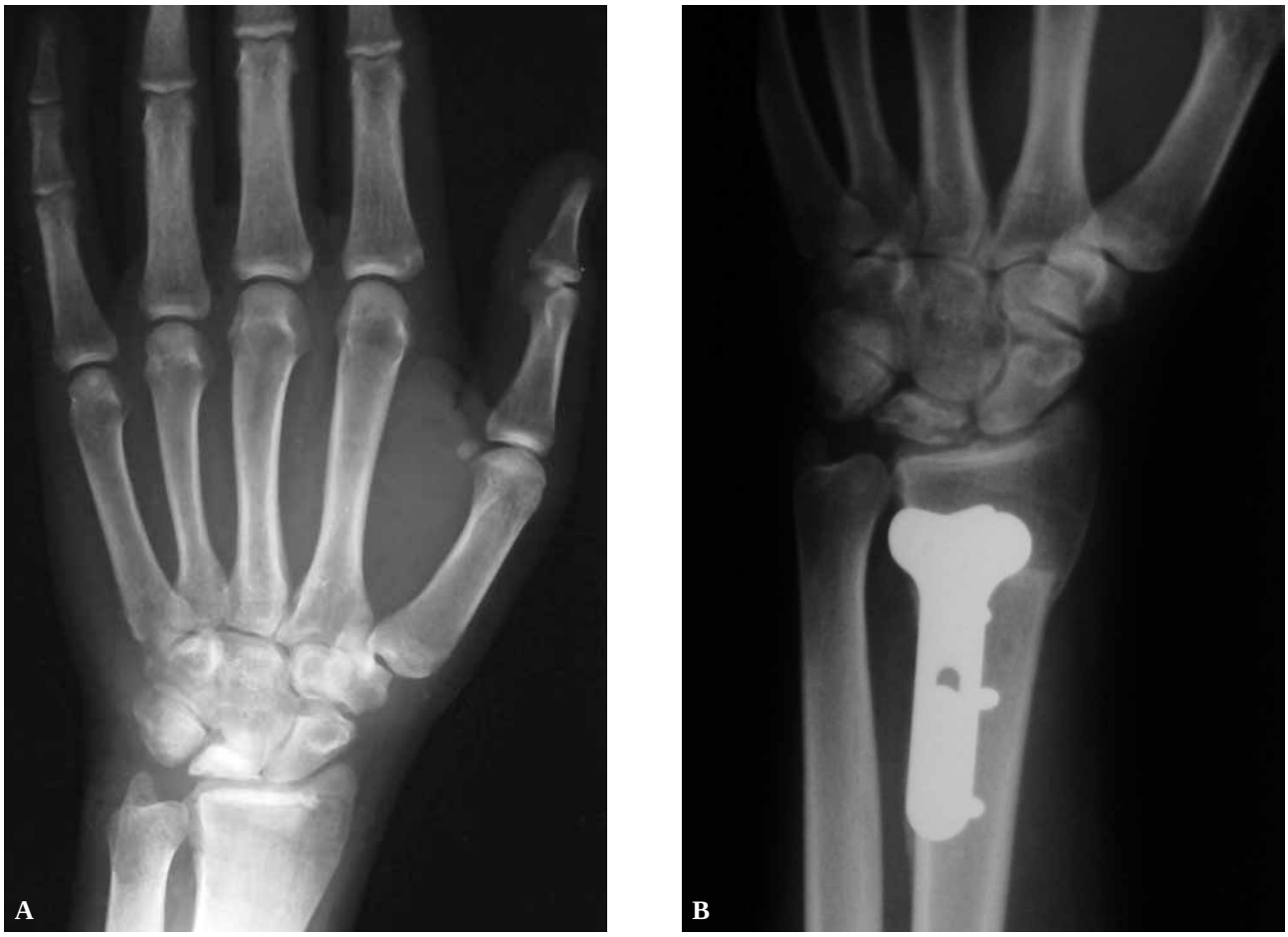

Fig. 3. — Preoperative (A) and postoperative (B) wrist radiographs showing improvement in bone density

Shortening and external closing of the radius were performed in this series. The final objective was to decompress the lunate by two mechanisms : 1) by levelling the distal radio-ulnar joint by means of a radial bone resection of maximum 4 mm to avoid inferior radioulnar incongruence (*21*) ; 2) and by reducing the radial inclination angle, thus diverting the carpus radially and consequently displacing the vector load towards a radial direction of the wrist (*27, 29*). It is worth mentioning that in this study, of all the radiographic parameters evaluated before and after surgery, only normalisation of ulnar variance and reduction of radial inclination of the radial joint face were statistically significant.

The addition of a supplementary source of vascularisation to lunate bone necrosis is a highly physiological alternative. For this purpose, we considered combining this surgical method with a radial osteotomy. Various vascularised bone grafts have been described for lunate bone necrosis : pronator teres (*4*), second metacarpal artery (*18*), etc. Vascularised bone grafts from the second metacarpal head have been used mainly in scaphoid non-union (*6, 19*) and described recently in one case of lunate bone necrosis in stage IIIA (*4*).

The first metacarpal dorsal artery that feeds the second metacarpal head, according to Hurlbut's anatomical studies (*3, 12*), offers a good size (approximately 1 mm) and relatively long pedicle (40-42 mm) and the second metacarpal head–neck is a fairly good source of corticocancellous bone grafts. We therefore decided to take this vascularised bone graft.

Fig. 4. — Radiographs with (A) lunate collapse prior to surgery, (B) postoperative reconstruction of the lunate and (C) further collapse 25 months after surgery.

Various studies report favourable results with radial osteotomy combined with vascularised grafts. Quenzer *et al* (*24*) report favourable clinical results in 97% and radiographical results in 55%. Other authors such as Bochud and Buchler (*5*) achieved a 37% success rate in the reconstruction of the lunate by associating osteotomy, and vascularised bone graft. In this study the authors obtained good clinical results in all patients, good radiographical results in 80%, improvement in bone density in 80% and obliteration of cysts in 20%. In one case the total initial collapse of the lunate was nicely reconstructed operatively, but bone collapse recurred months later. These results were better than with any of the two procedures performed separately (*25*).

In conclusion, the performance of a shortening and lateral closing osteotomy of the radius in combination with a vascularised autologous graft from the second metacarpal bone may be an efficient treatment in particularly young patients with grade III A and III B necrosis of the lunate and cubitus minus.

Acknowledgement

To Dr. Esteban Tarradas for the potographic work and to Mr Paul Edson for the translation.

REFERENCES

1. **Almquist EE, Burns JF Jr.** Radial shortening for the treatment of Kienböck's disease : a 5- to 10- year follow-up. *J Hand Surg* 1982 ; 7 : 348-352.
2. **An KN.** The effect of force transmission on the carpus after procedures used to tread Kienböck's disease. *Hand Clin* 1993 ; 9 : 445-454.
3. **Bengoechea-Beeby MP, Cepeda-Uña J, Abascal-Zuloaga A.** Vascularized bone graft from the index metacarpal for Kienböck's disease : A case report. *J Hand Surg* 2001 ; 26-A : 437-443.
4. **Braum RM.** Pronator pedicle bone grafting in the forearm and proximal carpal row. *J Hand Surg* 1983 ; 8 : 612-613.
5. **Bochud RC, Buchler U.** Kienböck's disease, early stage 3 : height reconstruction and core revascularization of the lunate. *J Hand Surg* 1994 ; 19-B : 466-478.
6. **Brunelli F, Mathoulin C, Saffar P.** Description d'un greffon osseux vascularisé prélevé au niveau de la tête du deuxième métacarpien. *Ann Chir Main* 1992 ; 11 : 40-45.
7. **Coe MR, Trumbe TE.** Biomechanical comparison of methods used to treat Kienböck's disease. *Hand Clin* 1993 ; 9 : 417-429.
8. **De Smet L, Verellen K, D'Hoore K *et al.*** Long-term results of radial shortening for Kienböck's disease. *Acta Orthop Belg* 1995 ; 61 : 212-217.
9. **Hori Y, Tamai S, Okuda H *et al.*** Blood vessel transplantation to bone. *J Hand Surg* 1979 ; 4 : 23-33.
10. **Hulten O.** Über anatomische Variationen der Handgelenknochen. Ein Beitrag zur Kenntuis der Genese zwei verschiedener Mondbeinveränderungen. *Acta Radiol* 1928 ; 9 : 155-168.
11. **Hulten O.** Über die Enstehung und Behandlung der Lunatummalazie (Morbus Kienböck). *Acta Chir Scand* 1935 ; 76 : 121-135.
12. **Hurlbut PT, Van Heest AE, Lee K-H.** A cadaveric anatomic study of radial artery pedicle grafts to the scaphoid and lunate. *J Hand Surg* 1997 : 22-A : 408-412.
13. **Iwasaki H, Genda E, Minami A *et al.*** Force transmission through the wrist joint in Kienböck's disease : a two-dimensional theoretical study. *J Hand Surg* 1998 ; 23-A : 415-424.
14. **Kam B, Topper SM, McLoughlin S, Liu Q.** Wedge osteotomies of the radius for Kienböck's disease : a biomechanical analysis. *J Hand Surg* 2002 ; 27-A : 37-42.
15. **Kienböck R.** Concerning traumatic malacia of the lunate and its consequences : degeneration and compression fractures. *Clin Orthop* 1980 ; 149 : 4-8.
16. **Kojima T, Kido M, Tsumura H *et al.*** Wedge osteotomy of radius for Kienböck's disease. *J Jpn Soc Surg Hand* 1984 ; 1 : 431-434.
17. **Lichtman DM, Degnan GG.** Staging and its use in the determination of treatment modalities for Kienböck's disease. *Hand Clin* 1993 ; 9 : 409-416.
18. **Makino M.** Vascularized metacarpal bone graft for scaphoid non-union and Kienböck's disease. *J Reconstr Microsurg* 2000 ; 16 : 261-268.
19. **Mathoulin C, Brunelli F.** Further experience with the index metacarpal vascularized bone graft. *J Hand Surg* 1998 ; 23-B : 311-317.
20. **Miura H, Uchida Y, Sugioka Y.** Radial closing wedge osteotomy for Kienböck's disease. *J Hand Surg* 1996 ; 21-A : 1029-1034.
21. **Nakamura R, Imaeda T, Miura T.** Radial shortening for Kienböck's disease : factors affecting the operative result. *J Hand Surg* 1990 ; 15-B : 40-45.
22. **Nakamura R, Tsuge S, Watanabe, Tsunoda K.** Radial wedge osteotomy for Kienböck's disease. *J Bone Joint Surg* 1991 ; 73-A : 1391-1396.
23. **Persson M.** Causal treatment of lunatomalacia : further experiences of operative ulnar lengthening. *Acta Chir Scand* 1959 ; 100 : 532-544.
24. **Quenzer DE, Dobyns JH, Linscheid RL *et al.*** Radial resection osteotomy for Kienböck's disease. *J Hand Surg* 1997 ; 22-A : 386-395.
25. **Soejima O, Iida H, Komine S *et al.*** Lateral closing wedge osteotomy of the distal radius for advanced stages of Kienböck's disease. *J Hand Surg* 2002 ; 27-A : 31-36.
26. **Sundberg SB, Linscheid RL.** Kienböck's disease : results of treatment with ulnar lengthening. *Clin Orthop* 1984 ; 187 : 43-51.
27. **Watanabe K, Nakamura R, Horii E, Miura T.** Biomechanical analysis of radial wedge osteotomy for the treatment of Kienböck's disease. *J Hand Surg* 1993 ; 18-A : 686-690.
28. **Weiss AP, Weiland AJ, Moore JR, Wilgis EF.** Radial shortening for Kienbök's disease. J *Bone Joint Surg* 1991 ; 73-A : 384-391.
29. **Werner FW, Palmer AK.** Biomechanical evaluation of operative procedures to treat Kienböck's disease. *Hand Clin* 1993 ; 9 : 431-443.