Radial osteotomy for Kienböck's disease evaluated by magnetic resonance imaging

24 cases followed for 1–3 years

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24 patients with Kienböck's disease were followed with magnetic resonance imaging (MRI) for 1–3 years. 9 patients were treated with radial shortening, 10 with radial wedge osteotomy and 5 patients were treated non-operatively. Signal intensity of the lunate on T_1-weighted or T_2-weighted images increased postoperatively in all operated on patients, and normal or near-normal signal intensity was observed in 9 patients on T_1-weighted images and in 15 patients on T_2-weighted images postoperatively. Signal intensity did not increase in any patient treated non-operatively. The postoperative increase in signal intensity on MRI following radial shortening and radial wedge osteotomy presumably is due to revascularization of the lunate.

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Little is known about the effect of radial osteotomy on the avascular changes in the lunate in Kienböck's disease. Recent advances in magnetic resonance imaging (MRI) have made it possible to evaluate osteonecrosis of the lunate noninvasively. Although a few articles (Sowa et al. 1989, Viegas and Anparo 1989, Greenan and Zlatkin 1990) have described the appearance of the wrist following radial shortening, sequential changes in a series of patients with Kienböck's disease followed by MRI have not been reported. We describe the effect of radial shortening and radial wedge osteotomy in patients with Kienböck's disease by comparing pre- and postoperative MRI findings.

Material and methods

Between 1988 and 1990, 24 patients (21 men, mean age 34, and 3 women, mean age 38) were followed with serial MRI for more than 1 year and were included in this study. 1 patient had a Stage-I lesion, 9 patients Stage-II, 8 patients Stage-III and 6 patients Stage-IV according to Lichtman's criteria (Lichtman et al. 1982). 9 patients with zero or negative ulnar variance underwent radial shortening, and 10 patients with zero or positive ulnar variance underwent radial wedge osteotomy (Figure 1). The remaining 5 patients were treated with leather wrist splint or elastic bandage for 2–3 months. Clinical results were evaluated and scored in terms of wrist pain, range of motion, grip strength,

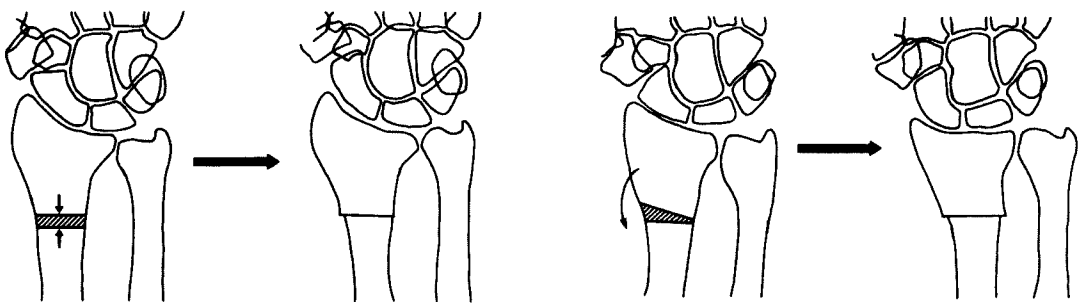

Figure 1. Radial shortening (left) and radial wedge osteotomy (right) for Kienböck's disease.

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Table 1. Classification of the appearance of the lunate by MRI in patients with Kienböck's disease

Grade	
I	Normal (iso-intensity)
II	Localized regions of slightly decreased signal intensity
III	Generalized slight decrease in signal intensity
IV	Low signal intensity with regions of high or iso-intensity signal
V	Generalized low signal intensity

and radiographic findings by a system we developed (Nakamura et al. 1990). Pre- and postoperative lunate architecture were compared, based on the radiographic extent of sclerosis, cyst formation and fragmentation.

Preoperative and postoperative MRI studies were performed in all patients. All patients were evaluated 1–3 years (average 1 year and 11 months) following treatment and 12 of 25 patients also were evaluated within 1 year of surgery. High-resolution images were obtained using a 1.5-T superconducting MRI scanner (Signa, General Electric Medical Systems, Milwaukee, U.S.A.) and a 7.5-cm surface coil. A repetition time (TR) of 500 ms and a spin-echo (SE) of 20 ms were used for the T_1-weighted sequence. The format for the T_2-weighted images was a TR of 2000 ms and a TE of 80 ms. The wrist was imaged in 3 planes (transverse, coronal, and sagittal) with a section thickness of 3 mm, a 256 × 256 matrix, and 8- or 10-cm field of view. Preoperative and postoperative MRI findings were evaluated using coronal and sagittal views together, and the signal intensity of the lunate was graded on a scale from I to V (Table 1). The appearance following radial osteotomy was compared to a wrist treated non-operatively. The correlation between clinical outcome, radiographic appearance of the lunate and MRI findings also were studied.

Results

The clinical outcome following radial osteotomy for Kienböck's disease was scored as excellent in 4 patients, good in 10 patients, fair in 5 patients, and poor in none. Excellent or good results were obtained in 8 of 9 patients by radial shortening, and the results in 6 of 10 patients were rated excellent or good after radial wedge osteotomy. The outcome in the 5 patients managed non-operatively was good in 1, fair in 3 and poor in 1 (Table 2).

Table 2. Clinical outcome and MRI findings in patients treated for Kienböck's disease

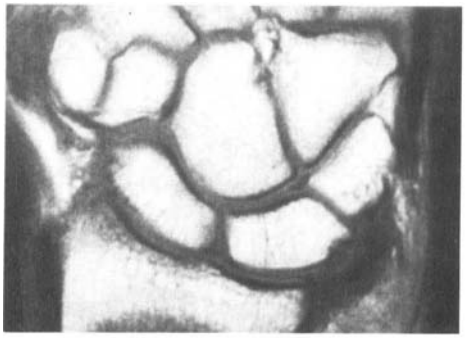
Case	Age	Sex	Lichtman Stage	Ulnar variance (mm)	Treatment[a]	Clinical ouctome[b]	Radio-graphy[c]	T_1[d]		T_2[d]		Follow-up (mo)
								Pre	Post	Pre	Post	
1	25	M	II	0	S	G	I	V	I	III	I	35
2	28	M	IV	–2	S	G	I	V	III	III	II	12
3	25	M	III	0	S	G	I	IV	II	IV	II	17
4	54	M	II	0	S	G	A	V	IV	III	II	13
5	45	F	III	–1	S	F	U	IV	III	IV	I	20
6	28	M	II	–1	S	G	I	IV	II	IV	II	23
7	24	M	II	–2	S	G	A	V	IV	IV	III	26
8	18	M	II	–1	S	G	I	V	IV	V	II	12
9	19	M	IV	–1	S	E	U	V	III	IV	III	19
10	29	M	I	0	W	G	I	IV	I	II	I	20
11	40	M	II	1	W	G	A	V	V	IV	II	44
12	39	M	III	5	W	E	I	IV	I	IV	I	29
13	38	M	II	2	W	F	I	V	IV	III	II	34
14	26	M	II	0	W	F	I	IV	II	II	II	24
15	34	M	III	0	W	E	A	V	V	III	II	29
16	46	M	III	0	W	G	I	V	II	V	III	32
17	46	F	IV	0	W	F	U	II	II	II	I	14
18	24	F	IV	1	W	F	A	IV	III	IV	III	30
19	39	M	II	1	W	E	I	IV	I	IV	I	24
20	26	M	III	0	C	F	U	V	V	V	V	31
21	39	M	III	0	C	F	U	IV	IV	III	III	25
22	58	M	IV	2	C	G	U	IV	IV	III	III	12
23	49	M	IV	2	C	P	A	IV	V	II	II	13
24	51	M	III	0	C	F	U	IV	IV	II	II	13

[a] S radial shortening, W radial wedge osteotomy, C closed treatment.
[b] E excellent, G good, F fair, P poor.
[c] Postoperative radiographic appearance of the lunate compared with the preoperative: I improved, U unchanged, A aggravated.
[d] MRI Grading, signal intensity increases from V to I.

Figure 2. Case 19. Pre- and postoperative MRI in a patient with Kienböck's disease treated by radial wedge osteotomy.

Preoperative T_1-weighted image shows low signal intensity of the lunate with focal areas of only slightly decreased signal intensity.

Preoperative T_2-weighted image shows low signal intensity of the lunate with focal areas of only slightly decreased signal intensity.



T_1-weighted image 24 months after radial wedge osteotomy shows increased signal intensity of the lunate.

T_2-weighted image 24 months postoperatively also shows increased signal intensity with an area of high signal intensity.

The lunate architecture improved radiographically in 5 of 9 patients following radial shortening and in 6 of 10 patients following radial wedge osteotomy. Lunate architecture did not improve in any patient treated non-operatively. The T_1-weighted images prior to treatment were scored as Grade IV or V in all but 1 patient, irrespective of the roentgenographic stage of illness. Early postoperative T_1-weighted images, obtained within 1 year of surgery, showed improved signal intensity in 5 of 12 patients who underwent the examination. The appearance on T_1-weighted images more than 1 year after surgery showed improvement in 17 of 19 patients and 9 patients showed normal or near-normal (Grade I or II) signal intensity. No patient treated non-operatively showed increased signal intensity, and no patient had Grade I or II signal intensity at follow-up (Figures 2 and 3).

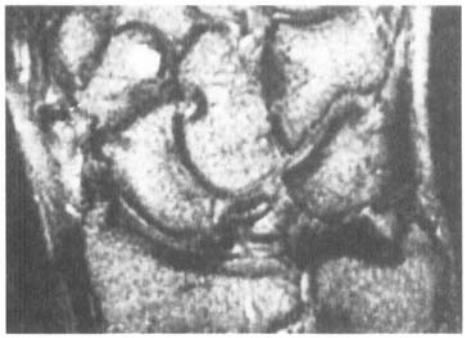
The appearance on T_2-weighted images prior to treatment ranged from Grade II to V: Grade II, 5; Grade III, 7; Grade IV, 9; and Grade V, 3. T_2-weighted signal intensity improved in all 12 patients who were studied within 1 year of surgery. Improvement was seen in 18 of 19 patients studied more than 1 year after surgery and 15 patients showed normal or near-normal signal intensity. No patient treated non-operatively showed increased signal intensity and none showed Grade I or II signal intensity at follow-up.

5 of 6 patients studied 2–5 months following surgery showed increased signal intensity on T_2-weighted image only. This was followed in all cases by an increase in T_1-signal intensity. Therefore, signal intensity on T_2-weighted images is believed to be more sensitive than T_1-weighted images in detecting healing.

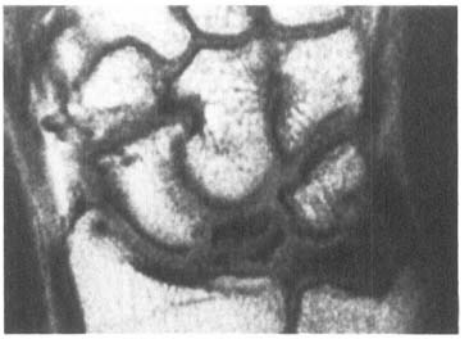
No significant correlation between lunate signal intensity and clinical outcome or between the radiographic appearance of the lunate and clinical outcome was detected. However, 8 of 9 patients with normal or near-normal T_1-weighted signal intensity postoperatively showed improved lunate architecture radiographically, and a significant correlation was observed between the postoperative signal intensity on the T_1-weighted image and the postoperative radiographic appearance of the lunate (χ^2 test with correction of continuity, $0.025 < P < 0.05$).

Figure 3. Case 20. MRI in a patient with Kienböck's disease before and after non-operative treatment.

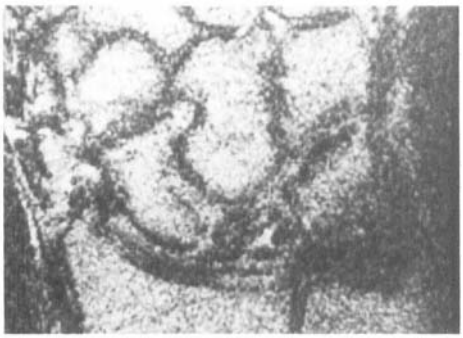
T_1-weighted image before treatment shows generalized low signal intensity of the lunate.



T_2-weighted image before treatment also shows low signal intensity of the lunate with an area of high signal intensity.



T_1-weighted image 31 months after conservative treatment shows essentially unchanged low signal intensity of the lunate.



T_2-weighted image also shows essentially unchanged low signal intensity of the lunate.

Discussion

The etiology and treatment of lunatomalacia have been discussed extensively since Kienböck's description in 1910, but no consensus on either has been reached. In 1935, Hultén proposed radial shortening as a treatment for Kienböck's disease after concluding that negative ulnar variance is the predominant predisposing factor (Hultén 1928, 1935). Since then, numerous investigators consistently have reported good clinical results by radial shortening (Calandriello and Palandri 1966, Viernstein and Weigert 1967, Axelsson 1973, Rosenmyer et al. 1976, Grassi et al. 1978, Eiken and Niechajev 1980, Ovesen 1981, Almquist and Burns 1982, Schattenkerk et al. 1987, Nakamura et al. 1990, Rock et al. 1991, Weiss et al. 1991). A radial wedge osteotomy, which reduces radial inclination, was devised by Tsumura, et al. in 1984. Our clinical experience with this procedure has been satisfactory and results are comparable to radial shortening (Nakamura et al. 1991). Decompression of the axial load through the lunate has been confirmed in vitro by biomechanical studies following both types of radial osteotomy, (Trumble et al. 1986, Tsumura et al. 1987, Horii et al. 1990).

MRI appears useful in detecting Kienböck's disease, although it is not completely specific (Reinus, et al. 1986), Nägele, et al. 1990, Cristiani, et al. 1990). Trumble and Irving (1990) have confirmed that low signal intensity on T_1- and T_2-weighted images in Kienböck's disease correlates with histologic osteonecrosis.

Although there has been no direct evidence that the increased signal intensity of the lunate is indicative of revascularization, Sowa et al. (1989), Viegas and Amparo (1989) and Greenan and Zlatkin (1990) have reported that signal intensity of the lunate in Kienböck's disease increases with healing. Furthermore, in our study, postoperative signal intensity on T_1-weighted images increased with radiographically-confirmed healing of the lunate. These results suggest that increased signal intensity of the lunate indicates revascularization and healing of osteonecrosis. In our series, signal intensity of the lunate increased in most patients following radial osteotomy. We believe that the increase in signal intensity observed following both

radial shortening and radial wedge osteotomy reflect revascularization of the lunate.

Our results also show that signal intensity on T_2-weighted images increases earlier than on T_1-images. Thus, we believe that T_2-weighted imaging is a more sensitive indicator of healing than T_1-weighted imaging.

Both radial shortening and radial wedge osteotomy resulted in increased signal intensity of the lunate on MRI in most patients with Kienböck's disease, presumably due to healing of osteonecrosis.

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