Treatment of intra-articular fractures of the distal radius

FLUOROSCOPIC OR ARTHROSCOPIC REDUCTION?

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In a randomised prospective study, 20 patients with intra-articular fractures of the distal radius underwent arthroscopically- and fluoroscopically-assisted reduction and external fixation plus percutaneous pinning. Another group of 20 patients with the same fracture characteristics underwent fluoroscopically-assisted reduction alone and external fixation plus percutaneous pinning. The patients were evaluated clinically and radiologically at follow-up of 24 months. The Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire and modified Mayo wrist score were used at 3, 9, 12 and 24 months post-operatively. In the arthroscopically- and fluoroscopically-assisted group, triangular fibrocartilage complex tears were found in 12 patients (60%), complete or incomplete scapholunate ligament tears in nine (45%), and lunotriquetral ligament tears in four (20%). They were treated either arthroscopically or by open operation. Patients who underwent arthroscopically- and fluoroscopically-assisted treatment had significantly better supination, extension and flexion at all time points than those who had fluoroscopically-assisted surgery. The mean DASH scores were similar for both groups at 24 months, whereas the difference in the mean modified Mayo wrist scores remained statistically significant.

Although the groups are small, it is clear that the addition of arthroscopy to the fluoroscopically-assisted treatment of intra-articular distal radius fractures improves the outcome. Better treatment of associated intra-articular injuries might also have been a reason for the improved outcome.

Most fractures of the distal radius are reducible with adequate stability and can be treated by closed reduction and casting. However, fractures that are unstable or involve the articular surfaces can jeopardise the congruence and kinematics of the wrist joint.^{1,2} In complex intra-articular fractures of the distal radius, arthroscopically-assisted surgery allows more accurate reduction of the articular surface and treatment of soft-tissue injuries.³ The place of arthroscopy in the management of these fractures, however, remains controversial.³⁻⁵

There are no prospective studies comparing arthroscopically- and fluoroscopically-assisted techniques and only one retrospective study comparing fluoroscopic and arthroscopic reduction of fractures of the distal radius.⁶

We undertook this prospective study of intra-articular fractures of the distal radius to evaluate surgical and radiological findings, functional outcomes and quality of life after reduction either by an arthroscopically- and fluoroscopically-assisted technique or a fluoroscopically-assisted only technique along with stabilisation

with an external fixator and possible augmentation using Kirschner (K)-wires and bone graft.

Patients and Methods

A total of 40 consecutive patients, 23 female, 17 male, treated between July 2000 and October 2003 were included in the study. They were assigned randomly for treatment. Each picked one of 40 sealed envelopes, 20 containing the words arthroscopically- and fluoroscopically-assisted and 20 the words fluoroscopically-assisted group.

All patients had similar fracture characteristics and demographics (age, gender, and degree of comminution of the articular surface). Those admitted to the study had an intra-articular fracture (AO type C1, C2 or C3)⁷ with a step-off or gap greater than 2 mm after closed reduction. Patients with volar lip fractures, open fractures, or associated upper extremity injuries were excluded. Patients with central nervous system disorders such as previous stroke or cerebral palsy were also excluded.

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Fig.1

Fracture intra-articular of the distal radius under fluoroscopy, after placement of the K-wires.

Fig. 2

Free cartilage fragments that were removed arthroscopically (r, radius; ch, chondral fragment).

The arthroscopically- and fluoroscopically-assisted group included 11 women and nine men with a mean age of 44 years (31 to 72). The fluoroscopically-assisted group included 12 women and eight men with a mean age of 47 years (25 to 68). The mechanism of injury was a fall on the outstretched extremity in 30 patients and a motor vehicle accident in ten (six patients in the arthroscopically- and fluoroscopically-assisted group and four in the fluoroscopically-assisted only group had high-energy injuries secondary to motor vehicle accidents). The dominant hand was injured in eight patients in the arthroscopically- and fluoroscopically-assisted group and in nine patients in the fluoroscopically-assisted group. The operation was performed under axillary block in 16 patients in the arthroscopically- and fluoroscopically-assisted group and 14 patients in the fluoroscopically-assisted group. The remaining ten patients (four in the arthroscopically- and fluoroscopically-assisted group and six in the fluoroscopically-assisted group) underwent general anaesthesia. Informed consent was obtained using a specifically-designed form which was approved by our Ethical Committee.

Arthroscopically- and fluoroscopically-assisted reduction and internal fixation. The external fixator is provisionally applied after closed manipulation and reduction of the fracture under fluoroscopy, which is also used to select the site of entry of the K-wire. In all patients two wires were used for better stabilisation (Fig. 1). The wire is introduced into the fragment and its position checked fluoroscopically. When the reduction of the fracture and the articular surface is considered optimal, arthroscopy is performed. With the wrist horizontal on the hand table, a 2.7 mm, 30° small-joint arthroscope is inserted in the 3-4 radiocarpal portal. Inflow is established through the arthroscopic cannula and

outflow is through the 6-U portal. A primary working portal is established at the 4-5 interval with additional portals at the 1-2 and 6-R positions if needed.

Haematoma and debris are removed (Fig. 2) using lavage, suction, mini grasping forceps and a 2.9 mm small-joint shaver until optimum exposure of the fracture is achieved. The position of the wires is checked, and if there is malposition (Fig. 3) the wire is re-directed and checked both arthroscopically and fluoroscopically. The articular surface can be evaluated reliably through the arthroscope (Fig. 4). Fragments can be elevated and small step-offs corrected with small probes. Injuries to the triangular fibrocartilage complex (Fig. 5), scapholunate ligament (Fig. 6), the lunotriquetral ligament and cartilage defects are detected and repaired.

If an acceptable reduction cannot be achieved, open reduction is performed through a limited incision over the dorsum of the distal radius. When an acceptable reduction is achieved, it can be further secured with additional K-wires. When a bone defect is detected during reduction and fixation, autologous cancellous autograft or allograft is inserted through the incision. We believe that in cases of metaphyseal bone defects, cancellous bone graft increases structural support and ensures fracture healing. Antibiotic prophylaxis with a second-generation cephalosporin starts 30 minutes before the induction of anaesthesia and continues for 24 hours. The external fixator and wires are removed six to eight weeks post-operatively.

Fluoroscopically-assisted reduction and external fixation. Reduction of the fracture is attempted by closed manipulation and stabilisation is maintained by an external fixator (Hoffmann II Compact, Stryker Howmedica, Mahwah, New Jersey) and percutaneous pinning. Two 3.5 mm pins are placed in the radius at the junction between the middle and distal thirds and two 2.8

Fig. 3

Following fluoroscopic reduction and K-wire placement, arthroscopy reveals penetration of the articular surface. The position of the K-wire was changed after arthroscopic evaluation (r, radius).

Fig. 4

Articular step-off tear after fluoroscopic reduction (r, radius; sc, scaphoid).

Fig. 5

A radial triangular fibrocartilage complex tear in a patient with an intra-articular fracture of the distal radius. It was repaired with arthroscopic debridement (r, radius; l, lunate; TFCC, triangular fibrocartilage complex).

Fig. 6

A scapholunate ligament injury which was revealed at arthroscopy. It was repaired with arthroscopic debridement and K-wire stabilisation (sc, scaphoid; l, lunate).

mm pins in the proximal third of the second metacarpal. They are inserted under direct vision, with protection of the sensory branch of the radial nerve and the extensor tendons of the index finger. Fluoroscopic images are obtained with the wrist in varying degrees of pronation and supination to locate the fracture fragments. When an acceptable reduction is achieved the external fixator is secured and the intra-articular fragments are stabilised with K-wires under fluoroscopic control. When an acceptable reduction cannot be obtained by closed means, a 1 cm to 2 cm

skin incision is made over the dorsum of the distal radius and a periosteal elevator used to elevate and reduce the fragments under fluoroscopic guidance, followed by fixation with K-wires. If a metaphyseal bone defect is noted after reduction, through the same dorsal incision at the level of the fourth extensor compartment, it is filled with autologous iliac bone graft if the patient is under general anaesthesia or with bone allograft Allogard (Osteocentre Europe, Clermont-Ferrand, France) if the procedure is performed under axillary block. Iliac cancellous bone graft is har-

Table I. Demographic data of patients in the two groups

	AFA* group (20 patients)	FA† group (20 patients)	p-value
Gender			
F:M	11:9	12:8	0.75
Age in yrs (range)	44 (31 to 72)	47 (25 to 68)	0.47
Dominant hand	8	9	0.75
Fall	14	16	0.47
Motor vehicle accident	6	4	0.47
Mean delay to surgery in days (range)	4 (1 to 11)	2 (1 to 10)	0.01
Mean tourniquet time in mins (range)	65 (45 to 86)	35 (25 to 55)	< 0.01
Mean hospitalisation in days	1	1	0.99

* AFA, arthroscopically- and fluoroscopically-assisted

† FA, fluoroscopically-assisted

vested through a minimal incision, morcellised and inserted into the defect under fluoroscopy. The allograft is placed in the defect in the form of impacted small fragments.

All operations were performed by two of the authors (SEV, ZHD). Another (GKB) did all the post-operative evaluations.

Post-operatively, the physical examination assessed scapholunate instability using the Watson, Ashmead and Makhlong⁸ or scaphoid shift test, lunotriquetral instability using the Linscheid et al⁹ or ulnar snuffbox compression test, and instability of the distal radioulnar joint by evaluating movement of the ulnar head in relation to the distal radius during pronation and supination. Grip strength, using a Jamar dynamometer (Preston Inc, Clifton, New Jersey) and range of movement were also documented by an independent therapist. At 3, 9, 12 and 24 months, all patients were examined using the modified Mayo wrist score¹⁰ and completed the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire.¹¹ This may reflect other pathology in the upper extremity, such as at the elbow or the shoulder, but is more reliable than measuring only isolated parameters and recording satisfaction.

Anteroposterior, lateral, and oblique radiographs of the distal radius and wrist, standardised for rotation were used to measure radial tilt, radial inclination, scapholunate angle, capitulate angle, articular step-off, articular gap, and ulnar variance. Measurements were performed by the same surgeon (GKB) using the e-film-medical software (InstallShield Software Corporation, Toronto, Canada).

Statistical analysis. The two groups were compared using the *t*-test for independent samples when the variables were continuous. For categorical 2 × 2 variables, Fisher's exact test was used. The two groups were compared in terms of DASH score or modified Mayo wrist score using a general linear model for repeated measurements with Bonferroni's correction. The model included the DASH or the modified Mayo wrist score as explanatory variables, the group effect (arthroscopically- and fluoroscopically-assisted and fluoroscopically-assisted), the patients within-group effect, the follow-up period effect (0, 12 and 24 months) and the interaction between group and follow-up effect, i.e., to test

whether differences between groups are consistent during follow-up. A *p*-value < 0.05 was considered statistically significant. The analysis was performed using SPSS r.11 (SPSS Inc., Chicago, Illinois) and Statistica v.6 (Stat Soft Inc., Tulsa, Oklahoma). Sample size was not calculated before the study as there was no currently-published study comparing these two techniques in terms of DASH and modified Mayo wrist score at 24 months' follow-up, which were considered as the primary outcomes, and therefore the expected group difference (arthroscopically- and fluoroscopically-assisted *vs* fluoroscopically-assisted) and data variability cannot be estimated as these two quantities are necessary for calculating sample size. Therefore, no statistical decision on sample size was made and all available patients in our clinic were selected on inclusion criteria. Nevertheless, a power analysis for the DASH score based on the observed data (group effect was 3.3 and pooled SD was 6.58) produced a power of 34%, whereas for the modified Mayo wrist score (group effect was 4.5 and pooled SD was 2.63) the power was 99%.

Results

Significant differences between the groups were found for the delay to surgery (*p* = 0.01) and tourniquet time (*p* < 0.01). In comparing axillary block with general anaesthesia there was a significant difference only in the proportion of motor vehicle accidents (*p* = 0.01). The time from injury to surgery was a mean of four days (4 to 11) for the arthroscopically- and fluoroscopically-assisted group and two days (1 to 10) for the fluoroscopically-assisted group (Table I). The mean tourniquet time was 65 minutes (45 to 85) for the arthroscopically- and fluoroscopically-assisted group and 35 minutes (25 to 55) for the fluoroscopically-assisted group. This difference was significant (*p* < 0.01). Iliac crest bone graft or allograft was used for subchondral support in 14 patients (six arthroscopically- and fluoroscopically assisted and eight fluoroscopically-assisted). In the former group, two patients received autologous bone and four received allograft. In the latter group, four patients received autologous graft and four allograft. As all

Table II. Findings during arthroscopy (20 wrists)

Additional diagnosis from arthroscopy	Number of patients
Scapholunate ligament tears (total)	9
Lunotriquetral tears (total)	4
Cartilage injuries	9
Free cartilage bodies	8
Triangular fibrocartilage complex	
Ulnar peripheral detachment	6
Radial avulsion fracture	3
Radial tear	3

fractures healed there was no evident superiority of the autologous bone graft. No donor site complications were noted.

In the arthroscopically- and fluoroscopically-assisted group a subchondral K-wire, placed initially under fluoroscopy had to be repositioned in nine patients (45%) after arthroscopic evaluation. It was malpositioned in the radial side of the wrist joint, penetrating the articular surface in seven patients and pushing the fracture fragments apart in two.

The arthroscopic findings are summarised in Table II. A total of 15 patients (75%) had intercarpal ligament injuries. These included 12 (60%) with triangular fibrocartilage complex injuries, nine (45%) with scapholunate ligament injuries and four (20%) with lunotriquetral ligament injuries. Five patients (25%) had concomitant injuries of the triangular fibrocartilage complex and scapholunate ligament, two had injuries of the triangular fibrocartilage complex and lunotriquetral ligament, one had injuries of the scapholunate and lunotriquetral ligament, and one had injuries of the triangular fibrocartilage complex, the scapholunate and lunotriquetral ligaments. Scapholunate ligament injuries included seven grade II tears and two grade III tears.¹² The latter were suspected on the pre-operative radiographs. These injuries were characterised by large avulsion fragments of the proximal pole of the scaphoid, and were reduced and pinned arthroscopically with transcutaneous intra-articular pins. Four patients (20%) had lunotriquetral ligament tears. The tears were all stable, and arthroscopic debridement was only needed to debride the lips of the tear. Six of the 12 triangular fibrocartilage complex tears were ulnar-sided. Three patients had a radial avulsion fracture of the triangular fibrocartilage complex, and three a radial tear. Arthroscopic debridement was performed in all these patients. In two, additional repair was carried out with sutures and in one patient an open triangular fibrocartilage complex repair was needed. Cartilage injuries were found in nine patients (45%), all treated by cartilage shaving. Free cartilage fragments were also found in eight patients and all were removed arthroscopically.

Final follow-up data were obtained at 24 months for both groups. The patients were also examined after removal of the external fixator and wires at 3, 9 and 12 months post-operatively. All fractures united. No patient had articular incongruity of > 1 mm, and there was no evidence of radiocarpal

degenerative changes. The mean step-off at 12 months was statistically significant for the fluoroscopically-assisted group (fluoroscopy-assisted -0.78 mm and arthroscopically- and fluoroscopically-assisted 0.30 mm; $p < 0.05$). The mean volar tilt restoration at 12 months was 8.0° (SD 1.78) for the arthroscopically- and fluoroscopically-assisted group and 7 (SD 2.98) for the fluoroscopically-assisted group. The p -value was not significant at 0.5. No patient had distal radioulnar joint instability or ulnar abutment. The other radiological parameters at 12 and 24 months showed no statistical significance between the groups (Table III).

The arthroscopically- and fluoroscopically-assisted group had less pain and an earlier return to daily activities. The DASH and modified Mayo wrist scores were significantly better ($p < 0.01$) at three-month follow-up (Table IV). All were free of pain and had returned to their previous occupation.

Wrist movement in both groups is summarised in Table IV. Supination, extension, and flexion showed statistically significant differences in favour of arthroscopically- and fluoroscopically-assisted at three months ($p < 0.01$).

At 12 months' follow-up the DASH and modified Mayo wrist scores were better than at three months in both groups. However, these scores at both times were better for the arthroscopically- and fluoroscopically-assisted than for the fluoroscopically-assisted group (Table V). The mean DASH score at 12 months for the arthroscopically- and fluoroscopically-assisted group was 4.7 (SD 4.4) and for the fluoroscopically-assisted group was 7.9 (SD 8.4) (Table V). Differences in pronation were not statistically significant ($p = 0.24$), but supination, extension-flexion, radial deviation and ulnar deviation showed statistically significant differences between the groups at 12 months in favour of arthroscopically- and fluoroscopically-assisted ($p < 0.01$). Grip strength was 95% of the uninjured side in the arthroscopically- and fluoroscopically-assisted group and 90% of the uninjured side in the fluoroscopically-assisted group.

The analysis for repeated measures for DASH showed that the overall group and follow-up effects were significant ($p < 0.01$) and there was interaction between group and follow-up effects ($p < 0.01$). Thus, differences between groups varied across the follow-up period. For the modified Mayo wrist score overall group and follow-up effects were significant ($p < 0.01$) whereas the interaction between group and follow-up effect was not ($p = 0.198$). At two years the results were the same as at one-year follow-up. With regard to the radiological follow-up, there were no differences between 12 and 24 months.

There was no correlation between the outcome scores and type of fracture, age, gender, or operative delay. Slight loss of movement and grip strength was the main reason for inferior results. All patients returned to their regular employment or activities, but this occurred earlier in the arthroscopically- and fluoroscopically-assisted group. Differences regarding return to work were not statistically significant. In the arthroscopically- and fluoroscopically-assisted group

Table III. Radiological results at 12 and 24 months' follow-up

	12 months			24 months		
	AFA* (n = 20)	FA† (n = 20)	p-value	AFA (n = 20)	FA (n = 20)	p-value
Radial inclination (°) (SD)	21 (3.2)	25 (3)	< 0.01	21 (1.96)	24 (2)	< 0.01
Scapholunate ligament interval in mm (SD)	1.67 (0.7)	1.75 (0.5)	0.68	1.65 (0.34)	1.77 (0.3)	0.13
Lunotriquetral ligament interval in mm (SD)	1.55 (0.9)	1.76 (0.8)	0.44	1.6 (0.5)	1.78 (0.5)	0.15
Step-off in mm (SD)	0.30 (0.2)	0.78 (0.2)	< 0.01	0.3 (0.28)	0.8 (0.3)	< 0.01
Ulnar negative variance in mm (SD)	1.04 (0.18)	0.64 (0.12)	< 0.01	1.08 (0.22)	0.64 (0.16)	< 0.01
Ulnar styloid nonunion (%)	15	25	0.67	15	25	0.67
Volar tilt (°)	8	7	0.5	7	7	0.5

* AFA, arthroscopically- and fluoroscopically-assisted

† FA, fluoroscopically-assisted

Table IV. Mayo and Disability of the Arm, Shoulder and Hand (DASH) scores and functional results at three months' follow-up

	AFA* (n = 20)	FA† (n = 20)	p-value
DASH score (SD)	12 (4.1)	25 (8.5)	< 0.01
Modified Mayo wrist score (SD)	81.2 (2.2)	75.3 (2.1)	< 0.01
Supination (°) (SD)	72 (7.2)	62 (5.9)	< 0.01
Pronation (°) (SD)	79 (3.7)	80 (3.5)	0.39
Extension (°) (SD)	73 (5.8)	61 (6.1)	< 0.01
Flexion (°) (SD)	64 (7.3)	53 (3.6)	< 0.01
Radial deviation (°) (SD)	9 (1.8)	9 (3.9)	0.98
Ulnar deviation (°) (SD)	23 (3.5)	21 (3.8)	0.09

* AFA, arthroscopically- and fluoroscopically-assisted

† FA, fluoroscopically-assisted

Table V. Mayo and Disability of the Arm, Shoulder and Hand (DASH) scores and functional results at 12 and 24 months' follow-up

	AFA* (n = 20)	FA† (n = 20)	p-value
12 months			
DASH score (SD)	4.7 (4.4)	7.9 (8.4)	0.14
Modified Mayo wrist score (SD)	90.9 (2.5)	85.3 (4.1)	< 0.01
Supination (°) (SD)	80 (5.8)	73 (2.3)	< 0.01
Pronation (°) (SD)	83 (2.6)	82 (2.7)	0.24
Extension (°) (SD)	76 (5.0)	65 (2.6)	< 0.01
Flexion (°) (SD)	76 (5.2)	63 (5.1)	< 0.01
Radial deviation (°) (SD)	15 (0.1)	12 (2.5)	< 0.01
Ulnar deviation (°) (SD)	25 (2.2)	22 (3.0)	< 0.01
24 months			
DASH score (SD)	4.8 (4.2)	8.3 (7.4)	0.12
Modified Mayo wrist score (SD)	91.2 (2.2)	86.7 (3.0)	< 0.01

* AFA, arthroscopically- and fluoroscopically-assisted

† FA, fluoroscopically-assisted

patients returned to work after a mean of 8.8 weeks (8 to 12). In the fluoroscopically-assisted group, patients returned to work after a mean of 9.9 weeks (8 to 14).

Complications were encountered in seven patients. One of the fluoroscopically-assisted group had superficial infection around a K-wire. This resolved after local treatment, oral antibiotics and early removal of the pins. Of the 40 patients, six (15%) suffered from algodystrophy (complex regional pain syndrome),¹³ two in the arthroscopically- and fluoroscopically-assisted group and four in the fluoroscopically-assisted group. All were treated early by intravenous

regional anaesthesia with lidocaine and methylprednisolone with resolution of symptoms after six to eight weeks.

Discussion

Arthroscopically-assisted fixation of fractures of the distal radius allows direct observation of articular reduction under magnification. In particular, rotation of the fracture fragments, which is difficult to judge under fluoroscopy, may be detected and corrected. Irrigation to remove fracture haematoma and debris potentially reduces the inflam-

matory reaction and improves the range of movement.³ Wrist arthroscopy also allows for the management of associated acute soft-tissue injuries, whose treatment has a better prognosis than chronic lesions.³ Our study confirms this observation, as the patients in the arthroscopically- and fluoroscopically-assisted group showed better results after immediate treatment of scapholunate injuries, notwithstanding reports showing a discrepancy between radiological appearance and function.^{14,15}

Treatment of displaced fractures of the distal radius aims to restore normal anatomy.^{16,17} An intra-articular step of more than 2 mm will not be generally accepted when treating these injuries,¹⁸ and recent studies indicate that the critical tolerance may be as low as 1 mm.¹⁹⁻²¹ Edwards et al⁴ recently reported that arthroscopy may help to identify residual gapping of the articular surface not detected with fluoroscopy, and another study⁵ reported that arthroscopy after fluoroscopic reduction resulted in a modification of the treatment in five of seven patients treated for intra-articular fractures. The identification of the nature and severity of associated soft-tissue lesions is probably the major role of arthroscopy for such fractures.²²⁻²⁴ For example, Ruch, Yang and Smith²⁵ reported that urgent arthroscopic treatment of acute triangular fibrocartilage complex injuries associated with intra-articular distal radial fractures have good results.

In our study, triangular fibrocartilage complex tears were found in 12 of 20 patients (60%). In another arthrographic study of 58 distal radial fractures in patients with a mean age of less than 50 years, the triangular fibrocartilage complex was injured in 39 (67%).²⁶ Geissler,²⁷ in a series of 60 intra-articular fractures which were treated by arthroscopy, found associated triangular fibrocartilage complex tears in 26 (43%). They were more likely in patients with concomitant fractures of the ulnar styloid. As disruption of the triangular fibrocartilage complex leads to instability and degenerative changes,²⁶ the immediate treatment of these tears can explain the better functional outcome following arthroscopically- and fluoroscopically-assisted compared with fluoroscopically-assisted treatment. Lindau et al²³ found that ten of 11 patients with complete peripheral triangular fibrocartilage complex tears noted at arthroscopy had instability of the distal radioulnar joint at follow-up, whereas only seven of 32 patients with incomplete lesions reported symptoms. Also, they predicted that 21% (8 of 39) of patients with incomplete lesions of the triangular fibrocartilage complex would continue to have symptoms.²³ Our study, which does not include patients with such symptoms after arthroscopic treatment, does not corroborate this, but our follow-up of two years is relatively short.

The incidence of associated ligament injuries had been variously reported: lesions of the scapholunate ligament in up to 40% (12 of 30) of intra-articular fractures,²⁸ lunotriquetral ligament injuries in 20% (19 of 88), and combined scapholunate and lunotriquetral injuries in 10% (9 of 118) of fractures.²⁹ Finally, articular cartilage lesions have

been noted in both the radiocarpal and midcarpal joints in up to 30% (12 of 39) of distal radial fractures in young adults.²⁴

The operation time was significantly increased by approximately 30 minutes in the arthroscopically- and fluoroscopically-assisted group, but there is no other study for comparison. The two groups showed no differences in hospital stay or time to mobilisation. Although the range of movement was acceptable in both groups, this study shows the arthroscopically- and fluoroscopically-assisted technique to be superior, at least in the early months. There was a statistically significant difference between the outcome in the two groups which decreased with time.

It may be questioned whether there was an overestimation of arthroscopic findings in the arthroscopically- and fluoroscopically-assisted group in relation to the clinical findings. A significant number of tears was found, mainly grade II. These injuries necessitated treatment including open repair or stabilisation with K-wires for scapholunate ligament tears. We do not consider this as overtreatment, as the functional results are significantly better in this group.

One weakness of the study is the differences within and between the groups (some patients had bone grafts) and the various treatments applied for intra-articular and ligamentous injuries. Unfortunately, in order to have adequate subgroups who had similar treatment, the size of the main groups needs to be large, and this could not be achieved in this study.

According to Chen et al,³⁰ despite a steep learning curve, arthroscopically-assisted surgery is a promising technique with few complications in the treatment of complex intra-articular distal radial fractures. We support this view and agree that arthroscopy has a role in their treatment. Although new implants such as the locked palmar plate³¹⁻³⁴ provide satisfactory results after open reduction and internal fixation, they do not address the intra-articular injuries.

In conclusion, we believe the addition of arthroscopy to fluoroscopically-assisted reduction of distal radial fractures improves the outcome.

Supplementary Material

A further opinion by Dr C. Little is available with the electronic version of this article on our website at www.jbjs.org.uk

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References

1. Grewal R, Perey B, Wilkink M, Stothers K. A randomized prospective study on the treatment of intra-articular distal radius fractures: open reduction and internal fixation with dorsal plating versus mini open reduction, percutaneous fixation, and external fixation. *J Hand Surg [Am]* 2005;30-A:764-72.
2. Harley BJ, Scharfenberger A, Beaupre LA, Jomha N, Weber DW. Augmented external fixation versus percutaneous pinning and casting for unstable fractures of the distal radius: a prospective randomized trial. *J Hand Surg [Am]* 2004;29:815-24.
3. Geissler WB. Intra-articular distal radius fractures: the role of arthroscopy? *Hand Clin* 2005;21:407-16.
4. Edwards CC 2nd, Haraszi CJ, McGillivray GR, Gutow AP. Intra-articular distal radius fractures: arthroscopic assessment of radiographically assisted reduction. *J Hand Surg [Am]* 2001;26:1036-41.

5. Augé W, Velázquez P. The application of indirect reduction techniques in the distal radius: the role of adjuvant arthroscopy. *Arthroscopy* 2000;16:830-5.
6. Ruch DS, Vallee J, Poehling GG, Smith BP, Kuzma GR. Arthroscopic reduction versus fluoroscopic reduction in the management of intra-articular distal radius fractures. *Arthroscopy* 2004;20:225-30.
7. Müller ME, Nazarian S, Koch P. *Classification AO des fractures: les os longs*. Berlin: Springer-Verlag 1987.
8. Watson HK, Ashmead D 4th, Makhlong MV. Examination of the scaphoid. *J Hand Surg [Am]* 1988;13:657-60.
9. Linscheid RL, Dobyns JH, Beckenbaugh RD, Cooney WP 3rd, Wood MB. Instability patterns of the wrist. *J Hand Surg [Am]* 1983;8:657-60.
10. Herzberg G, Comtet JJ, Linscheid RL, et al. Perilunate dislocations and fracture-dislocations: a multicenter study. *J Hand Surg [Am]* 1993;18:768-79.
11. Hudak PL, Amadio PC, Bombardier C. Development of an upper extremity outcome measure: the Dash (disabilities of the arm, shoulder and hand). *Am J Ind Med* 1996;29:602-8.
12. Geissler WB, Freeland AE, Savoie FH, McIntyre LW, Whipple TL. Intracarpal soft-tissue lesions associated with an intra-articular fracture of the distal end of the radius. *J Bone Joint Surg [Am]* 1996;78-A:357-65.
13. Doury PCC. Algodystrophy: a spectrum of disease, historical perspectives, criteria of diagnosis and principles of treatment. *Hand Clin* 1997;13:327-37.
14. Catalano LE 3rd, Cole RJ, Gelberman RH, et al. Displaced intra-articular fractures of the distal aspect of the radius: long term results in young adults after open reduction and internal fixation. *J Bone Joint Surg [Am]* 1997;79-A:1290-302.
15. Caladruccio JH, Gelberman RH, Duncan SF, et al. Capitulum arthrodesis with scaphoid and triquetrum excision. *J Hand Surg [Am]* 2000;25:824-32.
16. Anderson DD, Bell AL, Gaffney MB, Imbriglia JE. Contact stress distributions in malreduced intraarticular distal radius fractures. *J Orthop Trauma* 1996;10:331-7.
17. Baratz ME, Jardins JD, Anderson DD, Imbriglia JE. Displaced intra-articular fractures of the distal radius: the effect of fracture displacement on contact stresses in a cadaver model. *J Hand Surg [Am]* 1996;21:183-8.
18. Viegas SF. Midcarpal arthroscopy: anatomy and portals. *Hand Clin* 1994;10:577-87.
19. Levy HJ, Glickel SZ. Arthroscopic assisted internal fixation of volar intraarticular wrist fractures. *Arthroscopy* 1993;47:122-4.
20. Llinas A, McKellop HA, Marshall GJ, et al. Healing and remodelling of articular incongruities in a rabbit fracture model. *J Bone Joint Surg [Am]* 1993;75-A:1508-23.
21. Trumble TE, Culp R, Hanel DP, Geissler WB, Berger RA. Intra-articular fractures of the distal aspect of the radius. *J Bone Joint Surg [Am]* 1998;80-A:582-600.
22. Adolfsson L, Jörgsholm P. Arthroscopically assisted reduction of intra-articular fractures of the distal radius. *J Hand Surg [Br]* 1998;23:391-5.
23. Lindau T, Aldercreutz C, Aspenberg P. Peripheral tears of the triangular fibrocartilage complex cause distal radioulnar joint instability after distal radius fractures. *J Hand Surg [Am]* 2000;25:464-8.
24. Lindau T, Arner M, Hagberg L. Intraarticular lesions in distal fractures of the radius in young adults: a descriptive arthroscopic study in 50 patients. *J Hand Surg [Br]* 1997;22:638-43.
25. Ruch DS, Yang CC, Smith BP. Results of acute arthroscopically repaired triangular fibrocartilage complex injuries associated with intra-articular distal radius fractures. *Arthroscopy* 2003;19:511-16.
26. Fontes D, Lenoble E, de Somer B, Benoit J. Lesions of the ligaments associated with distal fractures of the radius: 58 intraoperative arthrographies. *Ann Chir Main Memb Supr* 1992;11:119-25 (in French).
27. Geissler WB. Arthroscopically assisted reduction of intra-articular fractures of the distal radius. *Hand Clin* 1995;11:19-29.
28. Peicha G, Seibert F, Fellinger M, Grechenig W. Midterm results of arthroscopic treatment of scapholunate ligament lesions associated with intra-articular distal radius fractures. *Knee Surg Sports Traumatol Arthrosc* 1999;7:327-33.
29. Richards RS, Bennett JD, Roth JH, Milne K. Arthroscopic diagnosis of intra-articular soft tissue injuries associated with distal radial fractures. *J Hand Surg [Am]* 1997;22:772-6.
30. Chen AC, Chan YS, Yuan LK, et al. Arthroscopically assisted osteosynthesis of complex intra-articular fractures of the distal radius. *J Trauma* 2002;53:354-9.
31. Freeland AE, Lubert KL. Biomechanics and biology of plate fixation of distal radius fractures. *Hand Clin* 2005;21:329-39.
32. Wiesler ER, Chloros GD, Lucas RM, Kuzma GR. Arthroscopic management of volar lunate facet fractures of the distal radius. *Techniques in Hand & Upper Extremity Surgery* 2006;10:139-44.
33. Guofen C, Doi K, Hattori, Kitajima I. Arthroscopically assisted reduction and immobilization of intraarticular fracture of the distal end of the radius: several options of reduction and immobilization. *Techniques in Hand & Upper Extremity Surgery* 2005;9:84-90.
34. Arora R, Lutz M, Hennerbichler A, et al. Complications following internal fixation of unstable distal radius fracture with a palmar locking-plate. *J Orthop Trauma* 2007;21:316-22.