Acta Orthopaedica

ISSN: 1745-3674 (Print) 1745-3682 (Online) Journal homepage: informahealthcare.com/journals/iort20

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To cite this article: Isam Atroshi, Elisabeth Brogren, Gert-Uno Larsson, Jan Kloow, Manfred Hofer & Anne-Marie Berggren (2006) Wrist-bridging versus non-bridging external fixation for displaced distal radius fractures: A randomized assessor-blind clinical trial of 38 patients followed for 1 year, Acta Orthopaedica, 77:3, 445-453, DOI: 10.1080/17453670610046389

To link to this article: https://doi.org/10.1080/17453670610046389

Published online: 08 Jul 2009.

Wrist-bridging versus non-bridging external fixation for displaced distal radius fractures

A randomized assessor-blind clinical trial of 38 patients followed for 1 year

Isam Atroshi[1], Elisabeth Brogren[1], Gert-Uno Larsson[1], Jan Kloow[1], Manfred Hofer[2] and Anne-Marie Berggren[3]

Departments of [1]Orthopedics Hässleholm-Kristianstad, Hässleholm Hospital, Hässleholm, [2]Physical and Occupational Therapy, Kristianstad Hospital, Kristianstad, [3]Radiology, Kristianstad Hospital, Kristianstad, Sweden
Correspondence IA: Isam.Atroshi@skane.se
Submitted 05-03-30. Accepted 05-10-20

Background **Non-bridging external fixation has been introduced to achieve better fracture fixation and functional outcomes in distal radius fractures, but has not been specifically evaluated in a randomized study in the elderly. The purpose of this trial was to compare wrist-bridging and non-bridging external fixation for displaced distal radius fractures.**

Method **The inclusion criteria were women ≥ 50 or men ≥ 60 years, acute extraarticular or intraarticular fracture, and dorsal angulation of ≥ 20° or ulnar variance ≥ 5 mm. The patients completed the disabilities of the arm, shoulder and hand (DASH) questionnaire before and at 10, 26 and 52 weeks after surgery. Pain (visual analog scale), range of motion and grip strength were measured by a blinded assessor.**

Results **38 patients (mean age 71 years, 31 women) were randomized at surgery (19 to each group). Mean operating time was shorter for wrist-bridging fixation by 10 (95% CI 3–17) min. There was no significant difference in DASH scores between the groups. No statistically significant differences in pain score, range of motion, grip strength, or patient satisfaction were found. The non-bridging group had a significantly better radial length at 52 weeks; mean difference in change in ulnar variance from baseline was 1.4 (95% CI 0.1–2.7) mm (p = 0.04). Volar tilt and radial inclination were similar in both groups.**

Interpretation **For moderately or severely displaced distal radius fractures in the elderly, non-bridging external fixation had no clinically relevant advantage over wrist-bridging fixation but was more effective in maintaining radial length.**

Wrist-bridging external fixation has been a common treatment method for displaced distal radius fractures (Cooney et al. 1979, Paksima et al. 2004) and is supported by evidence of efficacy (Handoll and Madhok 2003). Because of concern about possible adverse effects of wrist immobilization and distraction, the use of non-bridging external fixation, previously described in a small number of reports (Forgon and Mammel 1981, Jenkins et al. 1987, Melendez et al. 1989), has increased and new fixators have been introduced (Bishay et al. 1994, Krishnan et al. 1998, McQueen 1998, Fischer et al. 1999, Flinkkila et al. 2003). Non-bridging fixation may facilitate better fracture reduction and secure fixation, and may accelerate functional recovery and improve wrist motion. No randomized study has been performed previously to evaluate non-bridging external fixation for distal radius fracture in the elderly.

In this randomized clinical trial, we compared wrist-bridging and non-bridging external fixation for moderately or severely displaced distal radius fractures using patient-reported outcomes as primary outcome measure, and clinical and radiographic variables as secondary outcome measures.

DOI 10.1080/17453670610046389


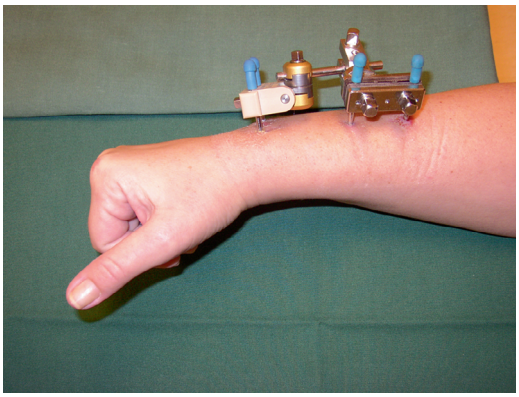

Figure 1. Non-bridging external fixation in a patient attempting maximum wrist extension and wrist flexion 6 weeks post-operatively.

Patients and methods

Eligibility criteria

The inclusion criteria were (1) women 50 years or older or men 60 years or older, (2) acute dorsally displaced distal radius fracture that is extraarticular or intraarticular with at least 2 large articular fragments, and (3) dorsal angulation of ≥ 20 degrees (measured from neutral) and/or radial shortening (ulnar variance) of ≥ 5 mm.

The exclusion criteria were (1) articular step-off > 2 mm, (2) fracture of the ulna proximal to the styloid, (3) additional fractures in the same or contralateral arm, (4) nerve or tendon injuries, (5) multiple injuries, (6) high-energy trauma (such as motor vehicle accident or fall from a height), (7) previous fracture in the injured radius, (8) inflammatory joint disease, cerebrovascular disease or other severe medical illness, (9) inability to give written informed consent or to complete questionnaires because of cognitive disorder or language problems, and (10) abuse of drugs or alcohol.

The regional ethics committee approved the study (LU53-98).

Recruitment and randomization

Patients were recruited among those who attended the emergency department because of distal radius fracture. Before enrollment all patients gave informed consent. In the operating room, the patients were assigned to a treatment group according to sequentially opened sealed envelopes based on a computer-generated randomization list.

Interventions

Regional or general anesthesia and intraoperative fluoroscopy was used.

For wrist-bridging fixation, we used the Hoffmann external fixator (Stryker, Mahwah, NJ). Through small incisions, 2 longitudinally parallel 3-mm pins were inserted in the radius proximal to the fracture and 2 pins were similarly inserted in the second metacarpal. Closed fracture reduction was performed and the instrument was locked. No additional fixation was used.

For the non-bridging external fixation we used the Hoffmann II Compact external fixator (Stryker, Mahwah, NJ) (Figure 1). Through small incisions, 2 longitudinally parallel pins were inserted in the radius proximal to the fracture. For pin insertion in the distal fragment, a transverse incision was used in the first 10 patients and 2 longitudinal incisions (one on each side of Lister's tubercle) were used in the remaining patients. The extensor pollicis longus (EPL) tendon was identified. After drilling, 2 transversely parallel 3-mm pins were inserted in the distal fragment parallel to the joint surface. The aim was to place the pins in the subchondral bone. Manipulation of the distal fragment with the pins was done to reduce the fracture. The periarticular pin clamp was applied and the instrument was locked (Figure 2). No additional fixation was used.

All patients received Flucloxacillin 750 mg twice daily for 10 days. Patients were instructed on early motion exercises of the fingers, wrist (non-bridging group), elbow and shoulder. The duration of external fixation was 6 weeks, after which the

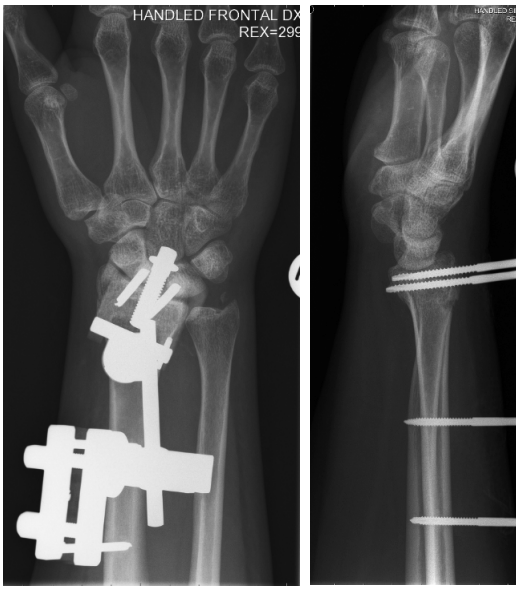

Figure 2. Distal radius fracture 2 weeks after non-bridging external fixation.

patients were referred to physiotherapists for range of motion and strengthening exercises aimed at restoring normal hand and wrist function. Therapy continued until the aim had been achieved or no further improvement was expected.

Outcome measures

In the emergency room, the patients completed the disabilities of the arm, shoulder and hand (DASH) questionnaire (inquired about arm disability and symptoms during the week before injury), the SF-12 health status and quality of life questionnaire, and a comorbidity questionnaire (American Academy of Orthopedic Surgeons 1998), which is a 14-item questionnaire inquiring about limitation of activity caused by specific disorders (such as heart or lung disease, diabetes, and rheumatoid arthritis) and which gives a comorbidity score ranging from 0 (no comorbidity) to 100 (most severe comorbidity). Follow-up evaluations at 10, 26 and 52 weeks after surgery consisted of the DASH and SF-12 questionnaires, pain rating, and range of motion and grip strength measurements performed by the same physiotherapist. Radiographic examination was done at 2, 6 and 52 weeks postoperatively and once for the non-injured wrist.

Primary outcome

The primary outcome was the DASH 30-item disability/symptom scale (Hudak et al. 1996, Atroshi et al. 2000), scored from 0 (no disability) to 100 (most severe disability).

Secondary outcomes

The secondary outcomes were the SF-12 physical health score, patient satisfaction, pain, motion, grip strength, radiographic variables and complications.

SF-12. The physical health score is compared to norms that have a mean of 50 and standard deviation of 10 (Gandek et al. 1998).

Patient satisfaction. The follow-up questionnaires included an item inquiring about patient satisfaction with the outcome (American Academy of Orthopedic Surgeons 1998).

Pain. The patients rated the severity of wrist pain on a visual analog scale (VAS) ranging from 0 (no pain) to 100 (most severe pain). The VAS scores were recorded for pain at rest, motion-related pain and activity-related pain.

Wrist motion and grip strength. Range of motion of both wrists and forearms were measured with a goniometer. Any flexion deficit in the fingers was measured. Grip strength was measured with a Jamar dynamometer (with 3 trials recorded for each hand).

Radiography. A radiologist experienced in skeletal radiology, an orthopedic surgeon and a resident independently classified the type of fracture according to the AO classification. The type recorded by at least 2 of the observers was used in the analysis. The radiologist measured volar tilt of the articular surface of the radius (from neutral), radial inclination, ulnar variance, articular step-off, and fracture union. The measurements were double-checked by an resident in orthopedics.

Blinding

The therapist who performed the follow-up physical examinations was blinded to the surgical method, as the injured hand and forearm were covered with a thin stretchable tubular bandage.

Sample size

At the start of the trial we found no published distal radius fracture studies that had used the DASH. As

an indicator of the adequacy of the sample size in detecting clinically important differences, we present the 95% confidence intervals for the DASH disability/symptom score differences between the 2 groups (Guyatt et al. 1995). The minimal clinically important difference for the DASH score has been estimated to be 10 points (Gummesson et al. 2003).

Statistics

The VAS scores for motion-related pain and activity-related pain were averaged because few patients had pain at rest. The independent t-test was used to compare the 2 groups regarding operating time, DASH, SF-12 and pain VAS scores, range of motion, grip strength and radiographic variables. Mixed-model analysis was performed on repeated measures of the outcome variables to compare the 2 groups regarding the change over time for each variable. For the variables that were measured before surgery (DASH, SF-12, and radiographic variables) the mixed-model analysis provided the between-group difference and 95% confidence intervals in change from baseline to 10 weeks, 26 weeks and 52 weeks after surgery. For the variables that were first measured at 10 weeks postoperatively, the changes from 10 weeks to 26 weeks and 52 weeks were compared. Age, sex, comorbidity score, and fracture AO type were included in the model. The mixed-model analysis has the important advantage of including subjects with incomplete data. Responses to the patient satisfaction item were dichotomized into (very/rather satisfied vs. neutral or rather/very dissatisfied) and the 2 groups were compared with Fisher's exact test. All analyses were done on an intention-to-treat basis. A p-value of less than 0.05 was used as an indicator of statistical significance.

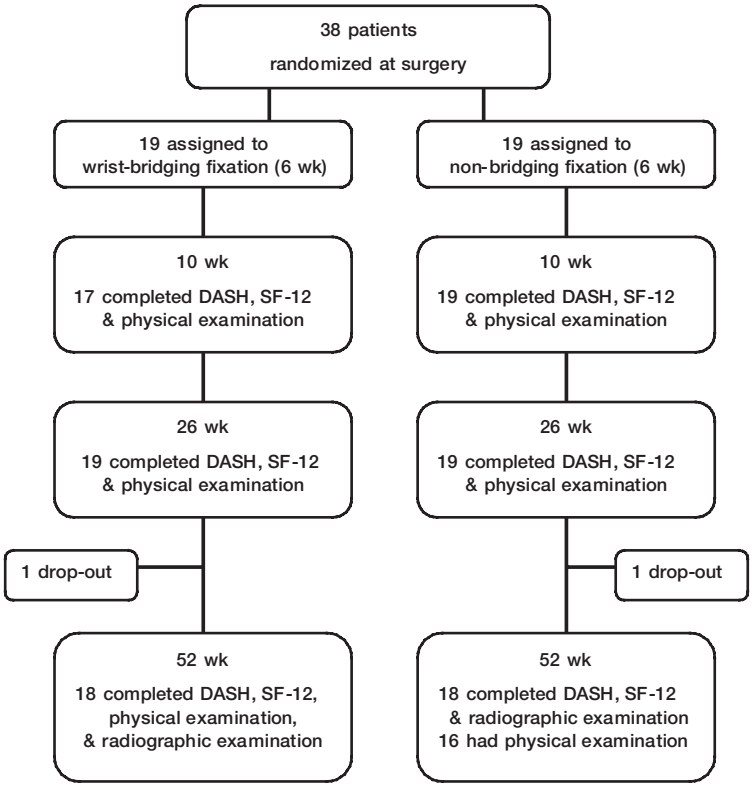

Figure 3. Flow chart of patients in the trial.

Results

Study population

From March 1998 through March 2002, 38 patients were enrolled and randomized, with 19 patients assigned to each group (Figure 3). No patients were excluded after enrollment. 2 patients (woman of 73 years, non-bridging group; woman of 81 years, bridging group) declined follow-up at 52 weeks because of illness. At enrollment, the 2 groups were similar in terms of patient characteristics and preoperative scores but there were fewer type C fractures in the non-bridging group (Table 1).

Surgery and operating time

All operations were done within 4 days of injury. The mean (SD) operating time for wrist-bridging fixation was 27 (11) min, and for non-bridging fixation it was 37 (11) min. The mean difference (95% CI) was 10 (3–17) min ($p < 0.01$).

Table 1. Patient characteristics at enrollment

	Wrist-bridging	Non-bridging
Women : men	15 : 4	16 : 3
Age [a]	71 (57–84)	70 (55–86)
Side, dominant : non-dominant	10 : 9	9 : 10
Comorbidity score [a]	4 (0–26)	6 (0–15)
DASH score [b]	7 (0–28)	7 (0–41)
SF-12 physical health score [b]	47 (17–56)	48 (33–58)
Fracture type, A2/A3 : C2/C3	8 : 11	11 : 8
Fracture of the ulnar styloid	15	17
Radiograph of uninjured wrist [c]		
Volar tilt (°) [a]	7 (17 to –23)	14 (24 to –13)
Radial inclination (°) [a]	21 (16 to 26)	22 (10 to 27)
Ulnar variance (mm) [a]	1 (–4 to 7)	0 (–3 to 5)

[a] Values are mean (range).
[b] DASH score available for 15 patients in each group, and SF-12 score for 15 in the wrist-bridging and 17 in the non-bridging group.
[c] Available for 16 patients in the wrist-bridging group and 18 patients in the non-bridging group.

DASH

No statistically significant differences in the mean DASH scores or in mean score changes over time were found between the 2 groups at any follow-up evaluation (Table 2). For both groups, the mean DASH score recorded at 10 weeks had improved at 52 weeks to almost pre-injury level.

SF-12

The wrist-bridging group had a significantly greater worsening of the mean SF-12 physical health score from baseline to 10 weeks (Table 2). No statistically significant differences were found between the 2 groups at any of the other follow-up evaluations, or in changes over time.

Patient satisfaction

No significant difference in patient satisfaction was found at any follow-up time. At 52 weeks, 16 patients in the wrist-bridging group were very/rather satisfied, 2 were neutral, and none were dissatisfied, as compared to 14, 2, and 2 patients, respectively, in the non-bridging group.

Pain

No statistically significant differences in the mean pain VAS scores were found between the 2 groups at any follow-up evaluation (Table 2). At 10 weeks postoperatively, the mean pain score was worse for the wrist-bridging group than for the non-bridging group but the difference was not statistically significant. The wrist-bridging group had a signifi-

Table 2. Results of patient-reported outcome measures and pain

	Wrist-bridging mean (SD)	Non-bridging mean (SD)	Mean difference (95% CI)	Change from baseline [a] mean difference (95% CI)	p-value
DASH [b]					
10 w	22 (11)	21 (18)	1 (–9 to 11)	4 (–5 to 13)	0.4
26 w	10 (10)	19 (20)	–8 (–19 to 2)	–6 (–15 to 3)	0.2
52 w	7 (8)	11 (12)	–4 (–11 to 4)	–4 (–12 to 5)	0.4
SF-12 Physical [c]					
10 w	43 (8)	48 (9)	–5 (–11 to 1)	–6 (–12 to –0.6)	0.03
26 w	46 (10)	45 (10)	2 (–5 to 8)	1 (–5 to 6)	0.8
52 w	48 (10)	49 (7)	–1 (–7 to 5)	1 (–5 to 6)	0.8
Pain [d]					
10 w	17 (15)	12 (16)	5 (–6 to 15)	baseline	
26 w	5 (8)	11 (14)	–6 (–13 to 1)	–11 (–20 to –2)	0.01
52 w	3 (6)	5 (9)	–2 (–8 to 3)	–9 (–18 to 0)	0.05

For number of patients at each follow-up, see Figure 3 (pain was assessed at physical examination).
[a] Mixed-model analysis comparing the 2 groups (adjusting for age, sex, comorbidity, and fracture type).
[b] Score range 0 (no disability) to 100 (most severe disability).
[c] Population norm, mean 50 and standard deviation 10.
[d] Visual analog scale (VAS), range 0 (no pain) to 100 (most severe pain).

Table 3. Results of physical examination, shown as mean (SD)

	10 weeks		26 weeks		52 weeks	
	B	NB	B	NB	B	NB
Range of motion (degrees)						
Flexion	53 (8)	53 (12)	61 (9)	60 (10)	63 (9)	64 (9)
Extension	50 (14)	49 (13)	59 (10)	57 (12)	62 (12)	60 (12)
Radial deviation	13 (4)	13 (4)	16 (4)	14 (3)	16 (3)	16 (3)
Ulnar deviation	21 (7)	22 (6)	23 (5)	23 (5)	24 (6)	24 (5)
Pronation	76 (9)	77 (9)	81 (6)	81 (7)	80 (7)	83 (6)
Supination	67 (16)	69 (19)	74 (14)	75 (11)	78 (11)	77 (13)
Grip strength (kg)	13 (6)	16 (10)	19 (6)	23 (10)	22 (8)	27 (13)

B: bridging; NB: non-bridging

Table 4. Results of radiographic assessment, shown as mean (SD)

	Preoperative		2 weeks		6 weeks		52 weeks	
	B (n = 19)	NB (n = 19)	B (n = 17)	NB (n = 19)	B (n = 15)	NB (n = 16)	B (n = 19) [a]	NB (n = 19) [a]
Volar tilt (°)	–29 (7)	–30 (11)	5 (8)	6 (10)	5 (8)	6 (10)	4 (11)	5 (11)
Radial inclination (°)	13 (5)	13 (5)	20 (4)	19 (4)	20 (4)	20 (5)	19 (5)	17 (5)
Ulnar variance (mm)	3.3 (2.3)	3.2 (2.4)	0.8 (1.5)	0.3 (1.9)	0.9 (1.6)	0.3 (2)	2.7 (2.6)	1.0 (2.3) [b]

B: bridging; NB: non-bridging.
[a] For the 2 drop-outs, the last radiographs (6 months postoperatively) were used.
[b] p = 0.04.

cantly greater decrease in mean pain score from 10 weeks to 26 and 52 weeks. No pain at 52 weeks was reported by 11 patients in each group.

Range of motion

No statistically significant differences between the 2 groups were found in any range of motion variable on any of the follow-up occasions, or in changes over time (Table 3). Wrist flexion and extension and forearm pronation and supination improved significantly over time, mainly between the 10-week and the 26-week evaluations.

Grip strength

The differences in mean grip strength between the 2 groups (Table 3) and the differences in mean change in grip strength over time were not statistically significant ($p > 0.1$). For both groups, grip strength improved from 10 weeks to 26 weeks postoperatively by an average of 7 kg, and to 52 weeks postoperatively by an average of 10 kg ($p < 0.001$).

Radiography

Possible previous distal radius fracture of the injured wrist (not remembered by the patient) was reported by the radiologist in 3 patients in the wrist-bridging group. These patients were analyzed in their assigned group (intention-to-treat principle), but analysis excluding them gave similar results. None of the radiographic variables differed between the 2 groups before surgery (Table 4). At 52 weeks, the non-bridging group had significantly better radial length. In the mixed-model analysis, the mean difference between the groups in change in ulnar variance from baseline to 52 weeks was 1.4 (95% CI 0.1–2.7) mm ($p = 0.04$). No significant differences in volar tilt or radial inclination were found between the groups. All fractures healed, none of them with articular step-off exceeding 1 mm.

Complications

One patient (wrist-bridging) fell during the fixation period and sustained a hip fracture; no immediate radiographic examination of the arm was done but follow-up radiographic evaluation showed a

healed fracture of the radius at a proximal pin site. Another patient (wrist-bridging) had a fracture of the second metacarpal after fixator removal; the fracture healed after splinting. A patient (wrist-bridging) whose radiographic examination 8 days postoperatively was judged by a surgeon (not involved in the trial) as fracture displacement, underwent a second closed reduction and addition of a percutaneous pin.

Pin site infection (skin redness and discharge) was recorded in 6 patients in the wrist-bridging group and 9 patients in the non-bridging group ($p = 0.3$); all were diagnosed within 2 weeks of surgery and treated with antibiotics. No deep infections occurred.

Numbness in the median nerve distribution was reported similarly in both groups, but no patient had surgery for carpal tunnel syndrome. 1 patient (wrist-bridging) had transient numbness in the radial sensory nerve distribution. No tendon rupture or complex regional pain syndrome was diagnosed.

Discussion

This randomized clinical trial compared wrist-bridging and non-bridging external fixation mainly in older patients with displaced distal radius fractures, and we found no significant differences in patient-reported symptom and disability outcomes. Although the sample size was relatively small with potential risk of type-2 error, the results of the DASH score (primary outcome variable) indicate that, except at 10 weeks postoperatively, a larger sample would likely not show a clinically important difference (10 points) in favor of non-bridging fixation. The limit of the 95% confidence interval for the difference in mean DASH score that may favor non-bridging fixation at 26 weeks was only 2 points, and 4 points at 52 weeks. The corresponding limits for the difference in change from baseline were 3 and 5 points, respectively. A larger sample might in fact show a clinically relevant difference in DASH score in favor of wrist-bridging fixation.

The non-bridging group had significantly better SF-12 physical health score (change from baseline) and a somewhat lower pain score at 10 weeks postoperatively, which might suggest a possible advantage in the early postoperative period. The DASH score is a measure of disability, with only 2 pain items. Possibly, the difference in pain at this stage was not large enough to have an effect on arm-related disability. In the wrist-bridging group, 3 patients had early complications (metacarpal fracture, repeat surgery, and radius shaft and hip fracture) that might have affected the 10-week comparison.

The range of motion in wrist and forearm was almost identical in both groups as early as 4 weeks after fixator removal. The motion obtained during non-bridging fixation did not accelerate recovery as compared to 6-week wrist immobilization. Grip strength was better in the non-bridging group, but the difference was not statistically significant and did not translate into less disability.

Radial shortening was significantly less with non-bridging fixation at 52 weeks. Although the difference in radial shortening was not associated with any differences in symptoms or function in this patient population, its long-term clinical significance should be evaluated. Distal radio-ulnar joint disorders after radius fractures may cause residual ulnar wrist pain, and the ability of non-bridging fixation in maintaining radial length may prove to be more important in a younger patient population.

Our study is the first randomized trial to compare bridging and non-bridging external fixation with the Hoffmann fixator in the elderly. The 2 previous randomized studies that compared bridging and non-bridging fixation used different fixators and included many younger patients (McQueen 1998, Krishnan et al. 2003). Also, the first study involved mainly extraarticular fractures that had become displaced within 2 weeks after initial reduction and splinting, while the second involved almost only severe intraarticular fractures. The 2 previous studies did not use validated measures of patient-reported outcomes or blinded assessment. Based on the overall results of the 3 randomized studies, however, non-bridging fixation does not seem to give better results regarding disability and pain, or to result in clinically important differences in wrist motion. Rupture of the EPL tendon, an uncommon complication, occurred only with non-bridging fixation (McQueen 1998, Krishnan et al. 2003).

Other surgeons might choose methods other than external fixation to treat the fractures included in our study. Percutaneous pinning has yielded similar results when compared to non-bridging external fixation in extraarticular fractures (Franck et al. 2000, Harley et al. 2004) and to wrist-bridging fixation in intraarticular fractures (Harley et al. 2004). In patients with displaced intraarticular fractures (mean age 40, 109/179 males), external fixation gave better results than volar or dorsal plating 6 months postoperatively (musculoskeletal functional assessment questionnaire), but similar results at 1 year (Kreder et al. 2005).

External fixation is a relatively simple procedure, and in our study it yielded good results regarding pain and arm function. Wrist-bridging fixation was effective in maintaining the volar tilt achieved after closed reduction, but failed to maintain radial length at 1 year. It is possible that closed reduction and splinting could have given similar results in this age group. Although only half of the fractures were intraarticular, all had a degree of initial displacement shown to be associated with a high probability of instability (Leone et al. 2004)—which is why primary external fixation was considered appropriate.

The lack of a clear clinically relevant advantage does not support non-bridging fixation instead of bridging fixation for older patients with distal radius fracture.

Contributions of authors

IA contributed to study conception and design, analysis and interpretation of data and drafting of the manuscript; GUL and MH participated in design and conduction of the study, acquisition of data and critical revision of the manuscript; EB and AMB participated in acquisition of data; JK participated in study conduction.

This research was supported by grants from Region Skåne, Sweden. The authors thank Jonas Ranstam for statistical advice.

No competing interests declared.

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