Complications of Hinged External Fixation Compared With Cross-pinning of the Elbow for Acute and Subacute Instability

David Ring MD, PhD, Wendy E. Bruinsma MD,
Jesse B. Jupiter MD

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Abstract

Background Elbows that are unstable after injury or reconstructive surgery often are stabilized using external fixation or cross-pinning of the joint supplemented by cast immobilization. The superiority of one approach or the other remains a matter of debate.

Questions/purposes We compared patients treated with external fixation or cross-pinning in terms of (1) adverse events, (2) Broberg and Morrey scores, and (3) ROM.

Methods Between 1998 and 2010, 19 patients (19 elbows) had hinged external fixation and 10 patients (11

elbows) cross-pinning and casting for subacute or acute posttraumatic elbow instability. Our general indications for both techniques were persistent elbow instability after usual treatment. Initially, we used external fixation for delayed treatment of fracture-dislocations and cross-pinning for simple elbow dislocations in patients who could not tolerate surgery, but more recently we have used cross-pinning for both indications. Adverse events, elbow scores, and ROM were retrospectively evaluated by chart review, with the latter two end points being calculated at a mean of 31 months (range, 5–83 months) and 10 months (range, 5–21 months) after index procedure for the patients treated with external fixation and cross-pinning, respectively.

Results Seven of 19 patients treated with external fixation experienced nine device-related adverse events: three pin tract infections, two nerve problems, one broken pin, one residual subluxation, one suture abscess, and one pin tract fracture of the ulna resulting in a nonunion. Of the 10 patients (11 elbows) treated with cross-pinning, one patient had pin tract inflammation that resolved with pin removal. Mean Broberg and Morrey score was 90 (95% CI, 84–95) after external fixation and 90 (95% CI, 84–96) after cross-pinning ($p = 0.88$). There were no differences between the external fixation and cross-pinning groups in mean flexion (123° versus 128° , $p = 0.49$), extension (29° versus 29° , $p = 0.97$), forearm pronation (68° versus 74° , $p = 0.56$), and forearm supination (47° versus 68° , $p = 0.15$).

Conclusions When the elbow remains unstable after reduction and usual treatment for fractures and dislocations or has been out of place for more than 2 weeks, both cross-pinning and external fixation can help maintain elbow alignment while structures heal. Hinged external fixation is associated with more adverse events related to the device, but Broberg and Morrey score and ROM are similar between techniques.

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This work was performed at the Orthopaedic Hand and Upper Extremity Service, Massachusetts General Hospital, Boston, MA, USA.

D. Ring, J. B. Jupiter
Orthopaedic Hand and Upper Extremity Service, Harvard
Medical School, Massachusetts General Hospital, Boston, MA,
USA

W. E. Bruinsma (✉)
Trauma Unit, Department of Surgery, Academic Medical Center,
Amsterdam, Meibergdreef 9, 1100 DD Amsterdam,
The Netherlands
e-mail: w.e.bruinsma@amc.nl; w.e.bruinsma@amc.uva.nl

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Introduction

Hinged external fixation or cross-pinning of the elbow is used to manage traumatic instability in the following circumstances: (1) in the setting of acute injury, when the elbow is unstable after ligament or bone repair or (2) when the repairs are tenuous and need to be protected with more than a cast (eg, a comminuted coronoid or capitellum/trochlea fracture); (3) when the elbow has been subluxated or dislocated for more than 10 days; or (4) in conjunction with a reconstructive procedure (contracture or heterotopic bone release, interposition arthroplasty) that destabilizes the elbow [4, 7]. It is our impression that improved recognition of fracture patterns, fixation of the coronoid, restoration of radiocapitellar contact, and lateral collateral ligament repair have led to less use of external fixation and cross-pinning [6, 8]. Cross-pinning of the elbow holds less appeal than one might guess based on the fact that it is simpler than external fixation and something the average surgeon is capable of performing.

We therefore reviewed our experience with these treatments of elbow instability by comparing patients treated with hinged elbow fixation or cross-pinning of the elbow in terms of (1) adverse events, (2) Broberg and Morrey scores, and (3) ROM.

Patients and Methods

Our institutional review board approved this study. We retrospectively reviewed the use of hinged elbow fixation and cross-pinning by two surgeons (JBJ, DR) for acute and subacute elbow instability between 1998 and 2010.

The two surgeons treated a total of 30 elbows in 29 adult (18 years or older) patients using either hinged external fixation (19 elbows in 19 patients) (Fig. 1) or cross-pinning (11 elbows in 10 patients) (Fig. 2). Of the 19 patients treated with hinged external fixation, there were 12 men and seven women, with a mean age of 47 years (range, 18–59 years) (Table 1). Fifteen were injured in a fall from a standing height and four in a higher-energy fall. Of the 10 patients treated with cross-pinning, there were nine women and one man, with a mean age of 64 years (range, 49–86 years) (Table 1). Nine were injured in a fall from a standing height and one in a higher-energy fall. Among the eight patients treated for acute injuries (within 2 weeks of injury), one had external fixation and seven had

cross-pinning. Among the 22 patients treated for subacute instability (persistent subluxation between 2 and 8 weeks after injury), 18 had external fixation and four had cross-pinning. Static external fixation was not used, although several fixators were kept in static mode for the first 2 weeks.

The Compass[®] Hinge (Smith & Nephew, Inc, Memphis, TN, USA) was used in 14 elbows, the OptiROM[®] fixator (EBI, Parsippany, NJ, USA) in three patients, and the DJD[™] (Stryker Orthopaedics, Mahwah, NJ, USA) in two patients. The pinning was performed with two crossed 5/64th-inch (2-mm) K-wires drilled with a slightly distal starting point on the ulna in order to cross the trochlea with the pin tract matching the angle of the trochlea with the shaft of the humerus. An oscillating drill was used to limit the risk of nerve injury. The pins were placed about 1 cm outside the distal humerus posteriorly to allow for easier removal in case of pin breakage. An above-elbow cast was applied for 3 to 4 weeks.

Fourteen patients had the fixator removed under anesthesia in the operating room and five had it removed in the office. The pins were buried and removed in the operating room in two elbows and removed in the office in nine elbows.

Evaluation was performed by chart review at a mean of 31 months (range, 5–83 months) after surgery for the group treated with external fixation. Three of the 10 patients in the cross-pinning group had no final evaluation, two who underwent pin removal and one who died. Evaluation in the eight elbows (seven patients) with followup in this group was likewise by chart review, at a mean of 10 months (range, 5–21 months) after surgery. The difference in followup duration reflects a shift in practice pattern away from the use of the external fixator in recent years.

Independent variables were injury mechanism, mode of treatment (hinged external fixation or cross-pinning), age at surgery, hand dominance, sex, followup, and the existence of a coronoid fracture, a radial head fracture, and an olecranon fracture. Dependent variables were adverse events, ROM, Broberg and Morrey score, and Broberg and Morrey rating. In the categorical Broberg and Morrey rating, a Broberg and Morrey score of 95 to 100 points indicates an excellent outcome; 80 to 94 points, a good outcome; 60 to 79 points, a fair outcome; 60 points or less, a poor outcome. ROM (pronation/supination/flexion/extension) was also an independent variable measured at the outpatient clinic by either of the two treating surgeons as part of clinical care using a universal goniometer. Patient demographics were retrieved from case files. Because of the nature of this study (retrospective), followup time was subject to the treatment at that time and not according to specific frequencies/intervals.

Fig. 1 An elbow treated with external fixation is shown.

The Shapiro-Wilk test indicated that only a few parameters were not normally distributed, so we decided to use parametric tests for all data. A Fisher's exact test was used to compare the number of adverse events occurring in each group. We used SPSS® for Windows® (Version 21.0.0; IBM Corp, Armonk, NY, USA) for statistical analyses. A post hoc power analysis determined that we had 73% power to detect a 10-point difference in Broberg and Morrey scores with a significance level of 0.05.

Results

There were proportionally more complications associated with hinged fixator application, although the difference was not significant (one of 11 versus nine of 19, $p = 0.11$) (Table 2). In the hinged external fixation group, there were nine adverse events related to the device experienced by seven patients. Three had pin tract infections treated with oral antibiotics and removal of the fixator earlier than planned. One patient had breakage of an external fixation pin; the pin fragment was left in the humerus and the remainder of the hinge was removed in the office. Two patients had nerve problems related to the hinge: one had a radial nerve palsy related to retraction during insertion of the most proximal radial pin and the other had ulnar nerve irritation from the distal medial humeral Compass® hinge pin that resolved after fixator removal. One patient had a fracture through the proximal ulna pin tract 2 weeks after removal treated with open reduction and internal plate fixation. Other adverse events included a suture abscess in one patient treated with local débridement and oral

Fig. 2 An elbow treated with cross-pinning is shown.

antibiotics and residual subluxation in one patient related to insufficient coronoid process (in the one patient with a posterior olecranon fracture-dislocation). In the cross-pinning group, one patient had a superficial pin tract infection treated with pin removal and oral antibiotics.

After all repeat surgeries, there was no difference in mean Broberg and Morrey score between groups (90 points [95% CI, 84–95 points] after hinged external fixation versus 90 points [95% CI, 84–96 points] after cross-pinning; $p = 0.88$) (Table 2). The categorical ratings of the results according to Broberg and Morrey were six excellent, 11 good, one fair, and one poor in the hinged external fixation group and three excellent and five good in the cross-pinning group.

The mean flexion was 123° (95% CI, 117°–130°) in the hinged external fixation group compared to 128° (95% CI, 117°–138°) in the cross-pinning group ($p = 0.49$) (Table 2). There was also no difference ($p = 0.97$) in mean extension between the hinged external fixation group (29°; 95% CI, 23°–35°) and the cross-pinning group (29°; 95% CI, 13°–44°). The mean forearm pronation was 68° (95% CI, 56°–80°) in the hinged external fixation group compared to 74° (95% CI, 64°–84°) in the cross-pinning group ($p = 0.56$). The mean forearm supination was 47° (95% CI, 31°–64°) in the hinged external fixation group compared with 68° (95% CI, 44°–91°) in the cross-pinning group ($p = 0.15$).

Discussion

Cross-pinning and static or dynamic (hinged) external fixation are used to hold the elbow reduced while the

Table 1. Patient demographic and clinical data

Variable	Cross-pinning group	Hinged external fixation group	p value
Number of patients/elbows	10/11	19/19	
Age (years)*	64 (49–86)	47 (18–59)	0.001 [†]
Number of men	1	12	0.007 [‡]
Followup (months)*	10 (5–21)	31 (5–83)	0.007 [†]
Dominant side (number of elbows)	2	2	0.14 [‡]
Radial head fracture (number of elbows)			0.12 [§]
None	7	5	
Mason Type I	0	0	
Mason Type II	2	9	
Mason Type III	2	5	
Coronoid fracture (number of elbows)	7	16	0.37 [‡]
Olecranon fracture (number of elbows)	2	2	0.61 [‡]
Fall from standing height (number of elbows)	9	15	
Higher-energy fall (number of elbows)	1	4	

* Values are expressed as means, with ranges in parentheses;

[†]Student's t-test; [‡]Fisher's exact test; [§]chi-square test.

ligaments and complex or tenuous fracture repairs heal. It is our impression that improved recognition of fracture patterns, fixation of the coronoid, restoration of radiocapitellar contact, and lateral collateral ligament repair have led to less use of external fixation and cross-pinning [6, 8]. Cross-pinning seems useful but underappreciated and perhaps underutilized. We therefore compared adverse events, elbow function scores, and ROM after hinged external fixation or cross-pinning.

Our results should be viewed in light of several limitations. The sample size is small but reasonable given that this is an uncommon problem, perhaps even less common in recent years as the treatment of traumatic elbow instability has improved. It is difficult to study uncommon problems prospectively; and retrospective data collection and small series may miss some details or fail to resolve some differences between treatments that might be more apparent in larger studies. Followup was considerably longer in the external fixator group (31 months [range, 5–83 months] versus 10 months [range, 5–21 months], $p = 0.007$), reflecting a shift in practice pattern at our site away from this approach in recent years. While this difference would tend to accentuate the negative findings in that group, the reason for the shift was the perception, borne out in general by this study, that the complications were more frequent and more severe in that group. The cross-pinning cohort had more acute injuries, more women (nine of 10

Table 2. Results

Variable	Cross-pinning group (n = 11 elbows)	Hinged external fixation (n = 19 elbows)	p value
Adverse events (number of elbows)	1	9	0.11 [†]
Extension (°)*	29 (13–44)	29 (23–35)	0.97 [‡]
Flexion (°)*	128 (117–138)	123 (117–130)	0.49 [‡]
Pronation (°)*	74 (64–84)	68 (56–80)	0.56 [‡]
Supination (°)*	68 (44–91)	47 (31–64)	0.15 [‡]
Broberg and Morrey score (points)*	90 (84–96)	90 (84–95)	0.88 [‡]

* Values are expressed as means, with 95% CIs in parentheses;

[†]Fisher's exact test; [‡]Student's t-test.

versus seven of 19, $p = 0.007$), had fewer terrible triad injuries, and was older (64 years [range, 49–86 years] versus 47 years [range, 18–59 years], $p = 0.001$), reflecting a clear selection bias in the initial use of this procedure for older, more infirm patients. Only eight of 11 elbows had a final evaluation in the cross-pinning cohort. Also, the only patient with an adverse event in the cross-pinning group was lost to followup. Many of the evaluations were very short term—good enough for device-related complications but not long enough to know the final motion, pain, and arthrosis. While long-term results are desirable, the key outcome is concentric elbow reduction without external support. It can be argued that, in an aligned elbow, the long-term outcomes relate more to other aspects of the injury and adverse events than they do to the device used to keep the elbow in joint while the ligaments heal.

Hinged external fixation was associated with a higher complication rate than cross-pinning (nine versus one, $p = 0.11$). Cheung et al. [1] reviewed the complications associated with hinged external fixation of the elbow in their experience with 100 patients. They documented pin site irritation in 15 patients, superficial pin site infection in one, deep pin infection in four, fixator malalignment in one, and pin loosening in four. Duckworth et al. [3] reported 17 patients with a posterior dislocation of the elbow and either no fracture or a minimal capsuloligamentous avulsion fracture treated operatively for persistent redislocation after manipulative reduction. Two patients could not tolerate (prolonged) anesthesia and had closed reduction and cross-pinning of the elbow. There were no reported complications with either patient. Cramer et al. [2] described 17 patients followed a mean of 17 months after temporary articular screw or Steinmann pin fixation for persistent elbow instability after an elbow or fracture dislocation. Complications included two superficial pin tract infections, heterotopic ossification treated with a second surgery, and one broken screw.

In our study, hinged external fixation was able to maintain elbow alignment in all but one patient who may have had inadequate coronoid reconstruction with a bone graft from a radial head remnant and had slight subluxation. Recurrent dislocation is a known complication in patients with acute and subacute trauma [5], although it was not encountered in our small series, perhaps because we had learned from prior adverse events both in terms of indications and leaving the hinge in a static (nonmoving) mode early on when there is less confidence in elbow stability.

The method of keeping the elbow in the joint while bone and ligaments healed did not affect the ultimate Broberg and Morrey score. There was an important difference in followup duration that might have favored the cross-pinning group since these scores may deteriorate over time, but we believe it more likely would favor the external fixation group because motion and pain can improve for more than 1 year after elbow surgery.

With the numbers available, there were no differences in ROM between the two treatment approaches considered here. Although there was an important difference in followup duration, this is unlikely to influence this finding, because the small increases in motion among those with short followup and the slight decreases in motion that might occur with arthrosis over the years or decades are unlikely to change the results observed between 6 months and 5 years after surgery.

In conclusion, immobilization of the elbow allowed healing of ligaments and fractures, thereby restoring stability in difficult and complex cases of traumatic elbow

instability, many of them subacute. The key to a reasonable result is adequate coronoid reconstruction and limited articular surface degeneration. Both cross-pinning of the elbow and external fixation can help maintain elbow alignment while structures heal. Hinged external fixation is associated with more adverse events related to the device, but we found no differences in Broberg and Morrey scores or ROM between techniques.

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