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The Use of the External Fixator in the Treatment of Intra-Articular Fractures of the Distal Radius

B K Chan, L C S Leong, C O Low, H F See

ABSTRACT

Background: A study to assess the use of the external fixator in the treatment of intra-articular fractures of the distal radius was initiated in late 1994.

Method: Thirty patients with these fractures have been treated at our hospital between 1991 and 1994 with the use of either the AO or the Pennig external fixator. The patients were assessed at least one year post-operatively (mean 90.2 weeks) after a course of physiotherapy.

Results: The majority of patients (65%) had either good or excellent results, based on objective and subjective criteria. The common complications included early finger stiffness, pin-tract infections and loss of reduction.

Keywords: distal radius fractures, external fixator

INTRODUCTION

Unstable intra-articular fractures of the distal radius are associated with a high incidence of morbidity and complications as a result of the disruption of the articular surface of the distal radius and periarticular soft-tissue. These are typically high-energy injuries occurring in the young or middle-aged population who are economically active. Effective treatment with minimal complications and early return to work are the main goals in the management of these patients. Non-operative treatment with reduction and casting has a high incidence of loss of reduction during the phase of fracture healing. There have been other methods of reducing and maintaining the reduction of the fracture published in the literature. Methods such as the pin and cast[1], percutaneous pinning[2] and open reduction with internal fixation[3] have been proposed. We present our department's experience in the use of the external fixator in the treatment of these complex injuries.

Department of Orthopaedic Surgery
Changi General Hospital
2 Simei St 3
Singapore 529889

B K Chan, MMed, FRCS (Glas), FRCS (Edin)
Registrar

L C S Leong, MBBS
Medical Officer

C O Low, MBBS, FRCS (Glas), FAMS
Consultant

H F See, MBBS, FRCS (Glas), FAMS
Senior Consultant and Chief

Correspondence to:
Dr B K Chan

PATIENTS AND METHODS

The study was conducted over a period of three years from 1991 to 1994 at the (former) Toa Payoh Hospital. The cohort consisted of 30 patients (26 males) with 32 fractured radii; 2 patients had bilateral fractured distal radii. The patients selected for this study had fractures involving the articular surface of the distal radius and the fragments were displaced more than 2 mm on the initial radiographs. The patients were operated and managed by one of the four consultant orthopaedic surgeons at our hospital. The patients' age ranged from 20 to 57 years (median 42).

Twelve of the fractures occurred as a result of road traffic accidents, 12 from industrial accidents and the remainder were due to home accidents. The fractures were classified according to the AO system[4] and the distribution is shown in Table I.

These patients were treated using the external fixator alone (24 patients) or supplemented with some other method of fixation (8 patients), for example, plates, Kirschner wires or bone grafting. In 5 of our patients, there was a medial "die-punch" fragment which required percutaneous pinning with Kirschner wires (3 patients) and screw fixation (2 patients) for accurate reduction. Three patients required bone grafting, a check radiograph was done in all cases before the reversal of anaesthesia. The types of external fixator used were the AO (27 radii) or the Pennig external fixator (5 radii). In our study, the Pennig external fixator was used as a static form of fixation.

The patients were then followed up with X-rays of the fracture site fortnightly. A referral to the occupational therapist was made for all patients in order to minimise stiffness of the fingers. They were also sent for daily pin-site dressings at the outpatient clinic. At follow-up, they were assessed for fracture healing as well as any complication which may have occurred.

The external fixators were removed after an average of 6.9 weeks (range: 4 to 8 weeks). These patients were then sent for wrist mobilisation exercises and followed up until discharged from the specialist clinic.

Table I – Distribution of fracture configuration

B1	=	3
B2	=	0
B3	=	1
C1	=	16
C2	=	7
C3	=	5

All of our study subjects had at least one year between the time of trauma and the final assessment. They were interviewed with regards to their wrist function, residual pain and mobility. This subjective evaluation was complemented with an objective evaluation whereby the range of wrist movements was documented and the wrist radiographs assessed for the anatomical measurements of the distal radius, joint congruity and the presence of degenerative changes (Tables II and III)[5]. The grip strength was assessed using the My-Gripper dynamometer. The contralateral limb was similarly assessed, both clinically and radiologically and the differences between the normal and affected limbs were compared. The combined evaluation according to the Gartland and Werley demerit scoring system, as modified by Sarmiento et al (Table IV)[6] was used for the functional assessment of the wrist injuries.

RESULTS

The results were evaluated according to the system of Gartland and Werley, which is based on residual deformity, subjective and objective evaluations, and complications.

Residual deformity

Fifteen (47%) of our patients had some form of residual deformity. Seven had a prominent ulnar styloid, 5 had a residual dorsal tilt of the distal radius and 3 had some degree of radial deviation.

Subjective evaluation

On a scale of 0 to 6 (0 being an excellent result as perceived by the patient with a painless and fully functional wrist), the average score was 2.5.

Objective evaluation

The range of motion was assessed using a goniometer. A loss in the range of movement was recorded as being present if it was less than the proposed minimum range required for normal function (according to Gartland and Werley's criteria). Eleven (34%) had, by definition, loss of dorsiflexion whilst four (12.5%) had loss of palmarflexion. Four patients (12.5%) had a loss of supination while none had loss of pronation. Twelve (37.5%) had significant loss of grip strength and 6 (16.3%) had residual pain in the distal radio-ulnar joint. However, we also noted the difference in the absolute values of the various clinical measurements as compared to the contralateral side (two patients with bilateral fractures were excluded) and the results are shown in Table V.

Using the modified Gartland and Werley demerit scoring system, the average score in the study cohort was 7.22 (range 1 – 18). There were 21 (65%) patients who had either excellent or good results and 11 (35%) had fair results. We did not have any patient with a poor outcome.

The radiological parameters of the injured and uninjured radii are shown in Table VI.

With regards to articular congruity, 27 (84.3%) had none or mild articular incongruity. The assessment of the radiographs at follow-up showed that the majority (69%) had mild degenerative changes in the wrist joint. The remaining (31%) did not have any radiological signs of degenerative change in the wrist joint.

Complications

We had 5 cases of pin-tract infection, in which 1 required an early removal of the external fixation at 4 weeks with continued treatment in a plaster back-slab and daily dressing. The other 4 patients recovered with application of topical antibiotics and pin-site dressings. One patient had loss of reduction in the early post-operative period and required admission for fracture manipulation and adjustment of the external fixator. There were 11 (34.3%) patients who had early finger stiffness despite being on the rehabilitation programme but all of these patients recovered full finger movements at the time of final assessment. We did not have any median nerve injuries, although 1 patient had injury to the superficial radial nerve with no recovery at 1 year. There was no incidence of tendon injury.

Recovery period

The median recovery period (as indicated by the amount of medical leave given from the time of injury) was 26.3 weeks (range 8 – 62). Of our cohort of patients, 23 (72%) were able to return to their previous jobs while the rest required modification of their work (10%) or a completely new job (18%).

Table II – Joint congruity

Grade 0	Step-off < 1 mm
Grade 1	Step-off 1 – 2 mm
Grade 2	Step-off 2 – 3 mm
Grade 3	Step-off > 3 mm

Table III – Severity of degenerative changes

Nil	None
Mild	Slight joint space narrowing
Moderate	Marked joint-space narrowing, osteophyte formation
Severe	Bone-on-bone, osteophyte formation, cyst formation

DISCUSSION

Although high complication rates have been reported by Weber and Szabo[1], many other studies have quoted good results with the use of external fixators[7,8,9]. To ensure consistently good results, the surgeon needs to know and avoid the common pitfalls in the surgical technique. One should also

Table IV – Gartland-Werley demerit point scoring system (modified by Sarmiento)

	Points
Residual Deformity (0 – 3 points)	
Prominent ulnar styloid	1
Residual dorsal tilt	2
Radial deviation on the hand	2 – 3
Subjective Evaluation (0 – 6 points)	
Excellent : no pain, limitation of motion or disability	0
Good : Occasional pain, slight limitation of motion, no disability	2
Fair : Occasional pain, some limitation of motion. Feeling of weakness in wrist, no particular disability if careful activities, slightly restricted	4
Poor : Pain, limitation of motion, disability, activities more or less markedly restricted	6
Objective Evaluation (0 – 5 points)	
Loss of dorsiflexion (< 45°)	5
Loss of ulnar deviation (< 15°)	3
Loss of supination (< 50°)	2
Loss of pronation (< 50°)	2
Loss of palmar flexion (< 30°)	1
Loss of radial deviation (< 15°)	1
Loss of circumduction	1
Pain in distal radio-ulnar joint	1
Grip strength (60% of opposite side or less)	1
Complications (0 – 5 points)	
Osteoarthritic change	
Minimum	1
Minimum with pain	3
Moderate	2
Moderate with pain	4
Severe	3
Severe with pain	5
Nerve complications (median)	1 – 3
Poor finger function	1 – 2
End Result (point ranges)	
Excellent	0 – 2
Good	3 – 8
Fair	9 – 20
Poor	> 20

Table V – Loss in range of movement (as compared to normal side)

	Average	Range
Wrist dorsiflexion	12.0°	0 – 45°
Wrist palmarflexion	11.3°	0 – 60°
Supination	9.8°	0 – 90°
Pronation	1.4°	0 – 20°
Radial deviation	7.2°	0 – 30°
Ulnar deviation	8.3°	0 – 25°

Table VI – Radiological parameters of the injured radii

	Mean value (injured radii)	Mean value (normal radii)	Mean loss (compared to normal side)
Palmar tilt	9.8° (– 15 – 25)	16.5°	6.7°
Radial angle	19.8° (10 – 30)	23.5°	3.7°
Radial height	10.8 mm (7 – 14)	11.3 mm	1.5 mm

realise that good anatomical reduction has been shown to be the most important factor in obtaining good functional outcome[5,10].

The concept of continuous distraction (commonly known as ligamentotaxis) is the basis for the use of the external fixator in unstable distal radius fractures. With the distraction, the soft tissues surrounding the fracture help mould the bony fragments and facilitate reduction. The external fixator has an advantage over conventional open reduction and plating when the fracture is comminuted. It restores skeletal length and maintains the reduction during the healing process.

The technique of applying the external fixator has been well described[11]. Adequate exposure allows precise placement of the pins under direct vision and this must be complemented with careful dissection and protection of the soft tissues during drilling, namely the extensor tendons and the superficial radial nerve. The skin at the pin-sites should be inspected and undue pressure on the skin edges should be relieved by extending the incision. By doing so, skin necrosis and subsequent infection can be prevented. We follow the AO recommendation in pre-stressing the pins and this has led to increased stability of the frame construct with no incidence of pin loosening in our study cohort. We did not have elderly patients with osteoporotic bone in our cohort but Vaughan[9] reported a case in his study of pin loosening in an 82-year-old woman. However, the other 25 elderly patients in his cohort who were treated with the external fixator did not have any pin loosening. Although Grana and Kopta[12] suggested in their article that the external fixator be used only in young patients with good bone stock, Vaughan's study seems to suggest that it is safe to use this form of treatment in the elderly patient. Fig 1 shows an example of a patient with a distal radius fracture treated with Pennig external fixator.

Despite the use of the external fixator and the supplementary methods of fixation, the radiological parameters of the injured radii continues to be under-corrected (Table VI). Although the average loss for each parameter is small, it is an indication that in some cases, supplementary methods of fixation may have been warranted either to improve reduction or to stabilise the fracture fragments.

With respect to articular congruity, almost 85% had a step-off of 2 mm or less. With this result, we would have expected a low incidence of degenerative changes. However, at a mean of 90 weeks, 69% of our patients already had mild degenerative changes whilst the remainder did not have any degenerative change. This may be explained by the disruption of the hyaline cartilage at the distal radius with subsequent healing with thinned-out hyaline or fibro-cartilage. At the time of evaluation, these mild degenerative changes on radiographs did not appear to affect the score significantly as most were not associated with pain.

A total of 12 patients had loss of motion by definition. Most of these patients had loss of

Fig 1a – Distal radius fracture in a 40-year-old man after a fall. The X-rays show a type C1 fracture with a dorsal tilt of the distal fragment.

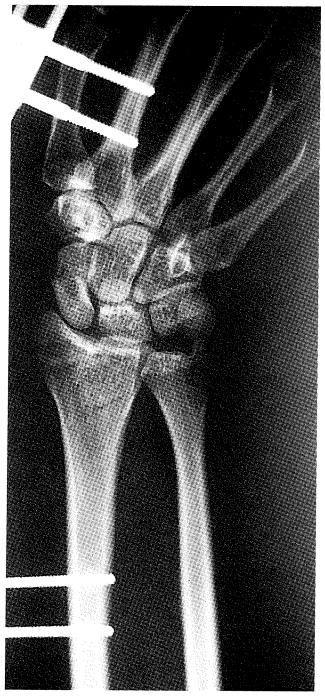

Fig 1b – The fracture was reduced and treated with Pennig external fixator for 6 weeks.

Fig 1c – The X-rays of the injured radius at the end of 8 months. This patient had an excellent result according to the study criteria.

dorsiflexion (11 out of 12). No patient had loss of pronation. When we analysed the mean loss in range of movement (Table V), we found that dorsiflexion was the motion most greatly affected when compared to the normal side and pronation which were the least. This preservation of pronation can be explained by the fact that distraction, fracture reduction and locking of the fixator are carried out with the forearm in a prone or semi-prone position. The loss of dorsiflexion in about a third of our patients may be due to excessive palmar flexion during immobilisation but this was diffficult to assess on the post-operative lateral radiographs with the external fixator present.

We have tried to improve the overall anatomical result with supplementary methods in some cases. There were 5 patients who had a medial "die punch" fragment which did not reduce after distraction. There is much clinical data which has shown that incomplete reduction of severely impacted medial fragments will lead to residual radiocarpal incongruity and disruption of the distal radioulnar joint[5,13]. In 3 of these patients, we reduced and stabilised the fragments using percutaneous Kirschner wires under radiological control and in the remaining 2 patients, the fragments were reduced and fixed through a dorsal approach using screws. All these patient had step-offs of less than 2 mm and all had good outcome.

Three patients had severe comminution of the metaphyseal region of the distal radius and support for the articular surface was restored using autogenous bone graft from the iliac crest. Leung et al cited various advantages of primary bone grafting in these types of fractures which included faster healing rates and maintenance of articular congruity[13]. Out of our 3 patients who had primary bone grafting, 2 patients had their joint incongruity restored to less than 2 mm and both had good results. In the third patient, the joint incongruity was not corrected despite delayed grafting and plating of the fracture.There was a persistent step off of more than 2 mm. This patient ended with a fair result (Fig 2).

Finger stiffness is the most common complication in our study. Although all the patients were referred to the occupational therapist for mobilisation, 11 still suffered finger stiffness to various degrees. To minimise finger stiffness, a pitfall to avoid is to ensure that one does not impale the tendons. The distal pins should be inserted after flexing the second metacarpophalangeal joint to 90°. This brings the intrinsic muscles to maximal length and prevents tethering[9].

CONCLUSION

In our study, we have found that the use of the external fixator in treating patients with complex distal radius fractures have yielded good results. Although there were complications associated with this form of fracture fixation, we believe that the benefits outweigh the various potential problems and complications. With careful assessment, good surgical technique and early augmentation using supplementary fixation methods in some cases, unstable distal radius fractures can be effectively managed with a predictably good outcome using the external fixator.

Fig 2a – This 26-year-old man was injured in a road-traffic accident. He suffered a type C3 distal radius fracture as well as a Bennett's fracture-dislocation on the same side.

Fig 2b – He was treated initially with an AO external fixator with percutaneous pinning of the Bennett's fracture-dislocation. Note the residual metaphyseal defect after fracture reduction.

Fig 2c – The patient subsequently had a delayed bone grafting and plating of the fractured radius at three weeks post-injury. This X-ray shows the fracture with the volar plate in-situ at 18 months post-injury. Note the early degenerative changes and the articular step-off of 3mm.

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