Intra-articular Fractures of the Distal Radius: Bridging External Fixation in Slight Flexion and Ulnar Deviation Along Articular Surface Instead of Radial Shaft

Ali Moradi, MD, Mohammad H. Ebrahimzadeh, MD,* and Jess B. Jupiter, MD†*

Abstract: Forty-one patients with intra-articular fracture of the distal radius (AO Type C) were treated with a double joint-bridging external fixator placed radial side of the fracture site and the wrist placed in slight flexion and ulnar deviation equal to the palmar tilt and radial inclination of the uninjured wrist. The patients were evaluated according to the system of Gartland and Werley an average of 43 months (range, 34 to 53 mo) after surgery. There were 14 excellent, 18 good, 7 fair, and 2 poor results. The average flexion was 94% of the normal side, extension 91%, pronation 95%, and supination 84%. The average radial inclination was 22 ± 10 degrees, palmar tilt 8 ± 14 degrees, and maximum articular step or gap was 2 mm. Bridging external fixation with slight wrist flexion and ulnar deviation equal to preinjured palmar tilt and radial inclination provides acceptable clinical and radiologic results.

Key Words: distal radius fracture, external fixator, fracture, hand surgery, wrist fracture

(*Tech Hand Surg* 2014;18: 41–50)

Bridging external fixation of the wrist for fracture of the distal radius was traditionally applied to maintain reduction, but it might lead to loss of palmar tilt.[1–4] One way to prevent is substantial wrist flexion; however, wrist flexion can contribute to finger stiffness and median nerve compression in the carpal tunnel.[5–8] Consequently, external fixation is currently accompanied by adjunctive fixation with Kirschner wires to assist in maintaining reduction of intra-articular fractures,[9,10] external fixation pins in the distal fracture fragments (nonbridging external fixators),[8,11] or bone graft or graft substitutes placed in the metaphyseal defect.[12,13]

Although the tendency of orthopedic surgeons have been changing from external fixation methods to internal fixation,[14] we have tried to introduce a new modification to improve the results with external fixation. To improve the efficiency of bridging external fixation, while maintaining effectiveness, we applied a double joint fixator so that it positions the wrist in flexion and ulnar deviation equals the palmar tilt and radial inclination measured on radiographs of the uninjured wrist. As the fixator is placed perpendicular to articular surface instead of along the radius shaft, the distraction force would be applied directly in the way of fragment reduction.

The study presents our clinical results of bridging external fixating with the wrist in slight flexion and ulnar deviation equal to prefracture palmar tilt and radial inclination, respectively, that causes the slight distraction force of the external fixator to work directly perpendicular to distal radius articular surface for AO type C distal radius fractures.

From the *Department of Orthopedic Surgery, Orthopedic Research Center, Ghaem Hospital, Mashhad University of Medical Sciences, Mashhad, Iran; and †Department of Orthopaedic Surgery, Yawkey Center for Outpatient Care, Massachusetts General Hospital, Boston, MA.
Conflicts of Interest and Source of Funding: The authors report no conflicts of interest and source of funding.
Address correspondence and reprint requests to Mohammad H. Ebrahimzadeh, MD, Department of Orthopedic Surgery, Orthopedic Research Center, Ghaem Hospital, Mashhad University of Medical Sciences, Ahmad-Abad Street, Mashhad 91766-99199, Iran. E-mail: ebrahimzadehmh@mums.ac.ir.

MATERIALS AND METHODS

Between 2006 and 2012, 48 consecutive adult patients with an isolated AO type C intra-articular fracture of distal radius were treated with double joint, force control bridging external fixator (Osveh 3D Distal Radius External Fixator, Osveh Asia Medical Co., Mashhad, Iran) with the wrist in slight flexion and ulnar deviation. The amount of wrist flexion was equal to prefracture palmar tilt, which was defined according to intact contralateral side wrist. Ulnar deviation was equal to other side radial inclination as well. Six patients moved and 1 died, leaving 41 patients for analysis. This study was approved by our Institutional Research Committee.

Preoperative Management

In our study, instead of applying longitudinal distraction force along distal radius axis, which is exerted by an external fixator frame, a decision was made to put the distraction force perpendicular to distal radius articular surface (Fig. 1). We believed that if the distraction force applies along the radius shaft, a shearing force is created parallel to articular surface which displaces the fragments, radial side and lead to articular stepping (Fig. 1). In contrast, if the distraction force is exerted perpendicular to articular surface, it will lead to reduction of the fragments like the preinjury time (Fig. 1).

For this purpose, one has to know preinjured palmar tilt and radial inclination. Radiographs of the uninjured side were obtained to estimate preinjury palmar tilt and radial inclination of the distal radius. For example, if palmar tilt and radial inclination of the intact side were 14 and 27, respectively, the preinjured palmar tilt and radial inclination of the injured side were considered equal to these values. Taking into account these values, the estimated external fixator bending in vertical and horizontal axis would be 14 and 27, respectively. In this way, the distal part of connective bar would be perpendicular to preinjured articular surface of the distal radius.

Operative Technique

The patient is placed in the supine position on the operating table, with the arm supported on a hand table. After elementary

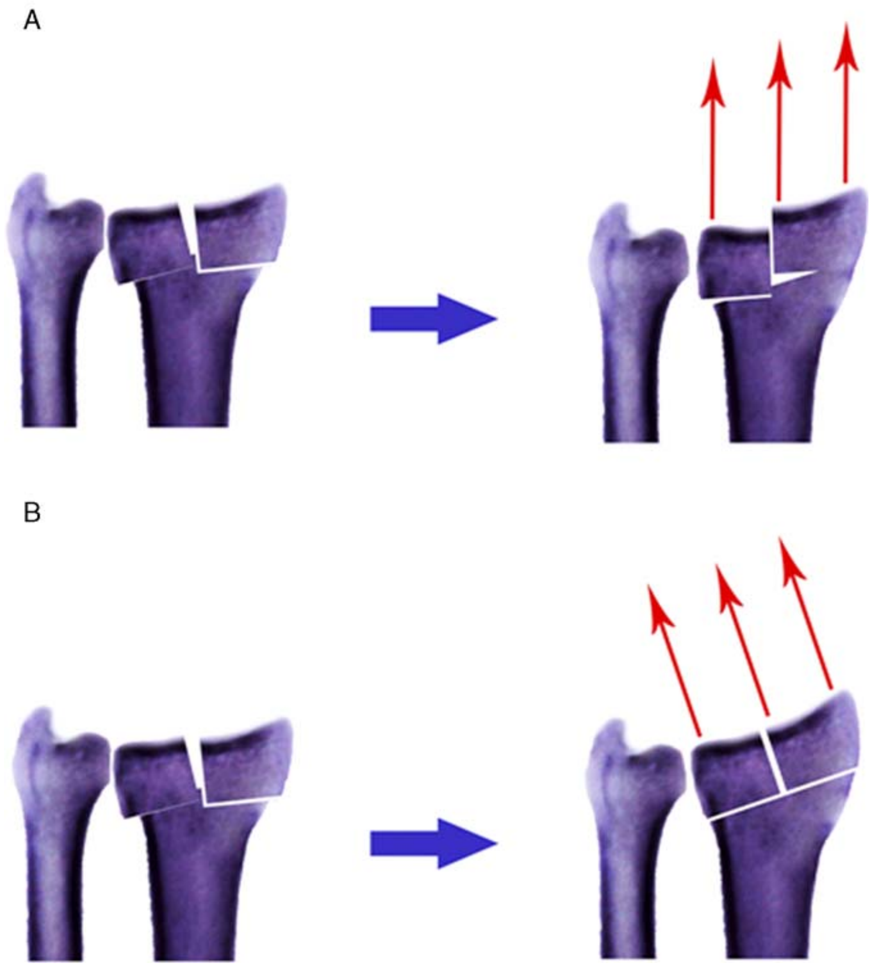

FIGURE 1. This illustration demonstrates the hypothesis that we used in adjusting our bridging external fixator. If the distractions force is applied along the radius shaft (A), a shearing force is created parallel to articular surface which displaces the fragments radial side and lead to articular stepping. In contrast, if the distraction force is exerted perpendicular to articular surface (B), it will lead to reduction of the fragments like the preinjury time.

traction for fracture fragment disengagement (Fig. 2A), a longitudinal skin incision, about 1 cm in length, is made for insertion of each of 4 external fixator pins (2.4 mm). The first pin is inserted perpendicular to third metacarpal transversely through the bases of the second and third metacarpals. We push the first dorsal interosseous muscle to the volar side to avoid its being caught as the pin is inserted into the base of the second metacarpal (Fig. 2B). The second pin is inserted same as the previous one and parallel to it about 50 mm distal to the third pin through the metaphyseal region. The third pin is inserted perpendicular to shaft of radius, parallel to coronal plane of radius, about 30 mm proximal to the fracture site. The last one is inserted into the radius about 30 mm proximal and parallel to the first one (Fig. 3C). Accurate placement across the intramedullary canal and slight protrusion through the far cortex are desired. Care should be taken to protect the branches of the radial sensory nerve by blunt dissection (Fig. 2B). Usage of protective sleeve and low-speed drilling is necessary to prevent mechanical and thermal injury, respectively.

Before external fixator application, we angulate the joint that moves in vertical surface (proximal joint) of fixator equal to intact side palmar tilt (Fig. 2D) and the joint that moves along horizontal surface (distal joint) equal to radial inclination and tighten them (Fig. 2E). The external fixator is adjusted so that its joints are at the fracture site and all of the clamps are 10 to 15 mm away from the skin. All of the distal and proximal clamps are tightened. The surgeon, using the distraction screw, pushes the distal part of the external fixator until external fixator dynamometer demonstrates approximately 2.5 to 3.5 kg of distraction force creation. At the end, pins are trimmed and capped (Fig. 2F). We did not open the fracture site and no bone grafting was used for metaphysical defects.

Postoperative Management

The patients were taught finger and forearm motion exercises and discharged the day after the operation (Fig. 3). The pins were cleaned every day and the crusts around the pins were removed. Passive and active range of motion for fingers and elbow were encouraged. The patients were seen 1 and 2 weeks after surgery, then approximately every 2 weeks until union, then at 6 months, and then yearly. The external fixator was

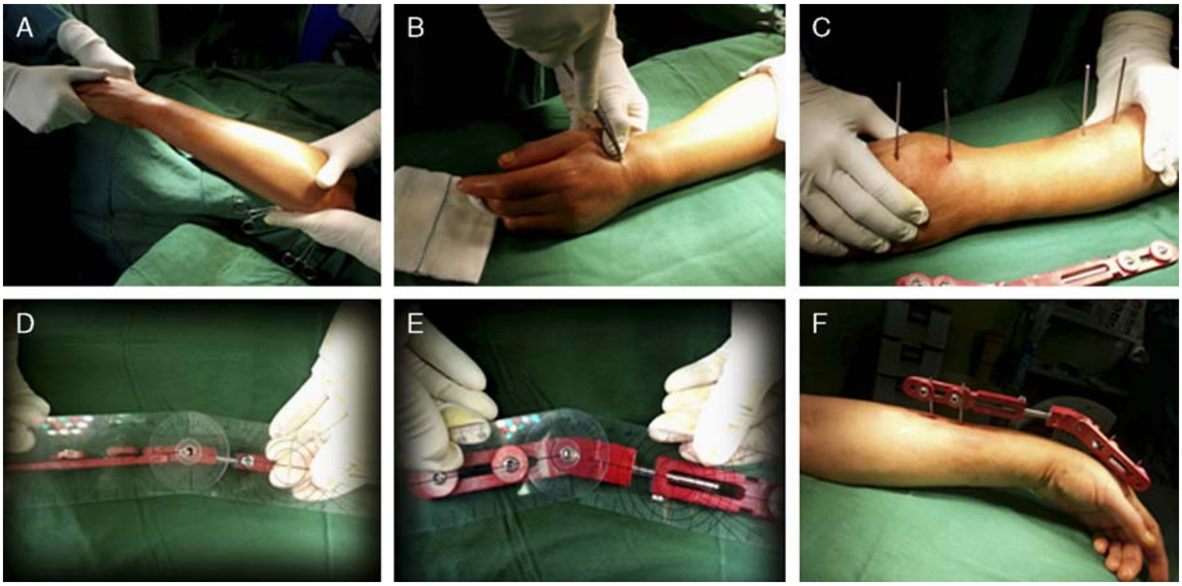

FIGURE 2. Operative technique. A, Continuous traction of distal radius for fragments disengagement. B and C, Soft-tissue dissection and pin insertion. D, Adjustment of proximal joint of external fixator equal to predicted radial inclination in radial-ulnar deviation plane. E, Adjustment of distal joint of external fixator equal to predicted palmar tilt in flexion-extension plane F, The pins were cut.

removed averagely 6 weeks after operation (5 to 8 wk) and physiotherapy of upper extremity was begun with emphasis on wrist and forearm range of motion.

Patients were invited to return for a research-specific evaluation at an average of 43 months (range, 34 to 53 mo) after surgery using the system of Gartland and Werley[15] as modified by Sarmiento et al[16] (Table 1). Grip strength was measured as the best of 3 attempts for both sides using a dynamometer (Jaymar Engineering, Los Angeles, CA). Dominant side grip was multiplied by a factor of 0.85 to compensate for the usually weaker nondominant side.[17]

Light-touch sensibility was evaluated using Semmes-Weinstein monofilament testing. Pin-track problems were classified according to pin site classification of Dahl et al.[18]

Subjective evaluation consists of a detailed checklist according to subjective part of Demerit point system to evaluate end results of the healed intra-articular distal radius fracture, completed for each patient, and factors such as pain (no pain, occasionally with work, occasionally with weather changing, constant pain), activity restrictions (no disability or limitation of motion, slight limitation of motion and no disability, no particular disability if careful and activities slightly

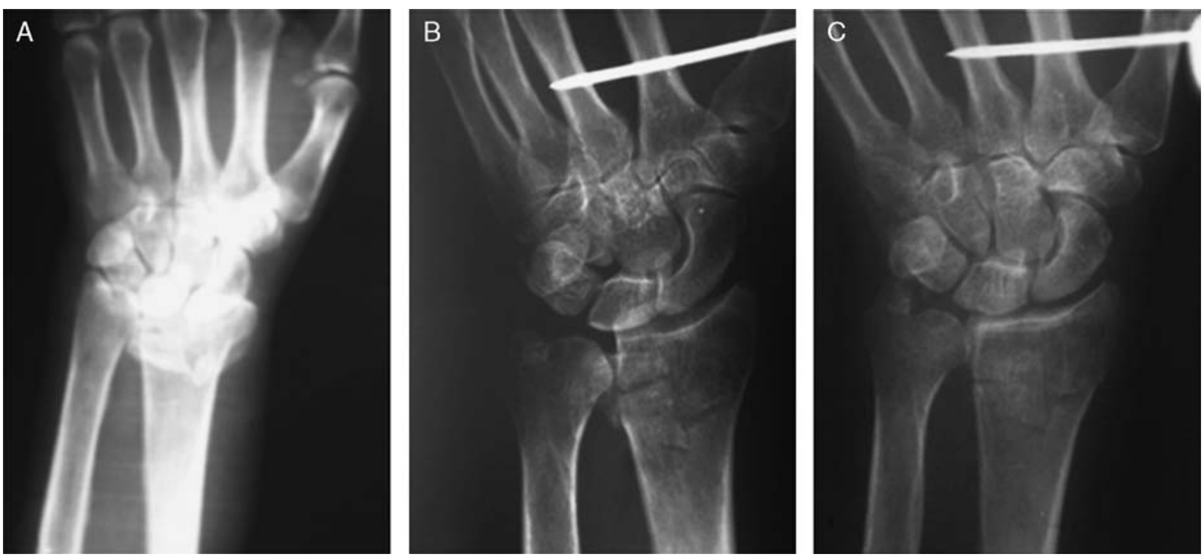

FIGURE 3. A 71-year-old man with intra-articular fracture on the left side. A, Before operation. B, After operation. C, Three weeks after operation the displaced fragment was reduced spontaneously because of active range of motion.

TABLE 1. Demerit Point System Used to Evaluate End Results of the Healed Intra-articular Distal Radius Fracture

	Point
Residual deformity (range, 0-3 points)	
Prominent ulnar styloid	1
Residual dorsal tilt	2
Radial deviation of hand	2 or 3
Subjective evaluation (range, 0-6 points)	
Excellent: no pain, disability, or limitation of motion	0
Good: occasional pain, slight limitation of motion, and no disability	2
Fair: occasional pain, some limitation of motion, feeling of weakness in the wrist, no particular disability if careful, and activities slightly restricted	4
Poor: pain, limitation of motion, disability, and activities more or less markedly restricted	6
Objective evaluation* (range, 0-5 points)	
Loss of dorsiflexion	5
Loss of ulnar deviation	3
Loss of supination	2
Loss of palmar flexion	1
Loss of radial deviation	1
Loss of circumduction	1
Pain in distal radioulnar joint	1
Grip strength: ≤60% than on opposite side	1
Loss of pronation	2
Complications (range, 0-5 points)	
Arthritic 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 due to cast	1-2
Final result (ranges of points)	
Excellent	0-2
Good	3-8
Fair	9-20
Poor	>20

*The objective evaluation is based on the following ranges of motion as being the minimum for normal function: dorsiflexion, 45 degrees; palmar flexion, 30 degrees; radial deviation, 15 degrees; ulnar deviation, 15 degrees; pronation, 50 degrees; and supination, 50 degrees.

restricted, limitation of motion, disability, and activities more or less markedly restricted), appearance satisfaction (prominent ulnar styloid, residual dorsal tilt, radial deviation of hand), and occupational considerations (return to previous work with no difficulties, return to previous work with some limitations, could not continue the previous occupation).

For radiographic evaluations, anteroposterior and lateral radiographs of both wrists were taken. Radiographic assessment included radial inclination, palmar tilt, radial shortening, articular incongruity, carpal instability, and joint posttraumatic arthritis. Carpal malalignment was defined on a lateral view as the dorsal or volar displacement of the longitudinal axis of the capitate in relation to the long axis of the radius.[19] The degree of articular incongruity and arthritis was evaluated according to the criteria of Knirk and Jupiter[20] (Table 2).

TABLE 2. Articular Incongruity and Arthritis According to Knirk and Jupiter Criteria

Grades	Radial Articular Incongruency Step-Off (mm)	Arthritis Grading Findings
0	0-1	None
1	1-2	Slight joint-space narrowing
2	2-3	Marked joint-space narrowing, osteophyte formation
3	>3	Bone-on-bone, osteophyte formation, cyst formation

For side-to-side comparisons of continuous variables, we used a paired t test. A P-value of <0.05 was deemed to be significant.

RESULTS

There were 9 women and 32 men with an average age of 37±25 years (range, 19 to 71 y). According to AO typing, there were 16, 15, and 10 AO type C1, C2, and C3, respectively. The mechanism of injury was a motor vehicle collision in 18 patients, a fall from a standing height in 15 patients, and a fall from a greater height in 8 patients. The average duration from injury to operation was 3±1.8 days (range, 1 to 7 d). The fixator was removed in the office an average of 6 weeks after surgery (range, 5 to 8 wk).

Nine patients had occasional pain without disability (5 with changes in the weather and 4 in strenuous activity). Three patients had slight restriction of daily activities. Although 13 patients (32%) were manual labors, all patients returned to their prior jobs.

Wrist range of motion was evaluated in injured and normal sides (Tables 3 and 4).

The grip strength on the injured and normal sides averaged 28.9±18.0 kg (range, 8 to 48 kg) and 32.6±16.7 kg (range, 14 to 46 kg), respectively (89% of normal side) (Fig. 4). Mild tightness intrinsic muscles were present in 4 cases.

Radiographic evaluation (Table 5) demonstrated that the average of the radial length difference was −0.63±1.8 (range, −3 to 1). The radial inclination at the time of union achievement was 21.6±11.0 in the injured (range, 14 to 30) wrist and 22.7±5.1 in the normal side (range, 18 to 27) ($P=0.16$).

TABLE 3. Wrist Range of Motion in Injured and Normal Sides

	Injured Side	Normal Side	%
Dorsiflexion	64.0±17.6	70.7±13.2	90.5
Plantar flexion	70.0±15.8	74.4±13.2	94
Radial deviation	20.9±10.3	24.2±11.3	86.4
Ulnar deviation	27.8±13.8	31.9±11.8	87.1
Pronation	76.3±16.1	80.6±12.7	94.7
Supination	69.9±19.8	79.6±12.7	84

TABLE 4. Characteristics of Forty Patients With Distal Radius Fractures Were Fixed With Bridging External Fixator Along Radial Articular Surface (Part 1)

Case	Age/ Sex	Injured Limb	AO Type	Fernandez Type	Follow-Up (mo)	Dorsiflexion		Palmar Flexion		Radial Deviation		Ulnar Deviation		Pronation		Supination	
						Normal	Injured	Normal	Injured	Normal	Injured	Normal	Injured	Normal	Injured	Normal	Injured
1	29/M	Right	C3	Type 5	46	75	70	75	80	20	20	30	20	85	85	90	85
2	45/F	Right	C3	Type 5	50	65	60	65	65	13	10	32	23	80	75	85	75
3	71/M	Left	C2	Type 3	44	55	50	55	60	15	15	25	25	80	80	75	65
4	31/M	Right	C3	Type 5	51	65	60	65	65	23	20	40	35	75	75	70	60
5	53/F	Left	C1	Type 3	53	65	45	65	70	35	30	34	34	70	55	70	50
6	34/F	Left	C1	Type 3	42	70	65	70	75	20	10	20	20	85	80	90	75
7	43/M	Right	C2	Type 3	49	70	55	70	70	23	18	28	19	90	85	85	70
8	21/M	Left	C3	Type 5	49	75	60	75	65	23	20	30	25	85	80	75	70
9	38/M	Right	C3	Type 3	50	75	70	75	70	27	23	35	35	70	70	70	60
10	35/M	Left	C1	Type 3	49	65	65	65	65	20	20	30	30	75	75	80	70
11	47/M	Right	C2	Type 3	44	65	60	65	60	10	13	25	23	80	80	70	60
12	23/F	Left	C2	Type 3	46	80	65	80	70	27	23	42	35	80	70	80	55
13	20/M	Right	C1	Type 3	42	80	65	80	75	35	25	35	23	75	70	75	70
14	27/M	Left	C1	Type 3	45	65	55	65	65	20	13	25	21	80	80	85	75
15	30/M	Right	C3	Type 5	44	70	60	70	70	20	20	25	17	85	85	80	70
16	26/M	Right	C1	Type 3	50	75	75	75	70	25	23	40	40	85	80	80	65
17	53/M	Right	C2	Type 3	43	60	55	60	55	20	20	25	25	75	75	80	70
18	64/F	Left	C2	Type 3	46	60	55	60	65	20	17	30	25	65	60	75	70
19	34/M	Left	C3	Type 5	41	75	70	75	65	25	25	35	28	90	85	90	80
20	49/M	Left	C2	Type 3	40	65	50	65	55	20	15	35	35	85	65	85	70
21	47/M	Right	C1	Type 3	42	70	60	70	75	25	23	40	37	80	80	80	70
22	29/M	Left	C3	Type 5	36	75	60	75	70	20	20	35	35	85	80	80	65
23	43/F	Left	C2	Type 3	43	60	60	60	65	25	25	35	30	75	70	75	70
24	32/M	Right	C1	Type 3	46	80	80	80	70	30	30	35	30	80	80	80	75
25	28/M	Left	C1	Type 5	41	75	60	75	60	30	25	40	30	85	75	85	70
26	27/M	Right	C1	Type 3	49	75	75	75	85	25	25	30	30	85	85	85	85
27	55/M	Left	C2	Type 3	40	60	55	60	60	20	15	20	20	70	70	65	50
28	23/F	Left	C2	Type 3	37	80	75	80	80	25	23	30	25	85	80	80	75
29	47/M	Right	C2	Type 3	47	65	65	65	70	25	15	25	20	75	70	75	70
30	35/M	Left	C1	Type 3	43	75	65	75	70	25	20	30	20	75	65	75	60
31	44/M	Left	C1	Type 3	36	65	55	65	65	25	20	30	17	70	60	70	55
32	29/F	Left	C1	Type 3	38	75	75	75	85	33	30	40	40	85	85	85	85
33	33/M	Right	C3	Type 5	35	70	65	70	70	25	23	33	30	85	80	85	75
34	37/M	Right	C2	Type 3	40	75	75	75	85	35	30	40	40	90	90	85	85
35	58/M	Left	C1	Type 3	41	70	65	70	70	25	23	27	27	80	75	85	70
36	43/F	Right	C2	Type 3	37	75	75	75	75	30	25	40	37	90	85	85	85
37	36/M	Left	C3	Type 5	38	80	75	80	80	23	20	35	25	75	65	75	50

TABLE 4. *(continued)*

Case	Age/Sex	Injured Limb	AO Type	Fernandez Type	Follow-Up (mo)	Dorsiflexion		Palmar Flexion		Radial Deviation		Ulnar Deviation		Pronation		Supination	
						Normal	Injured	Normal	Injured	Normal	Injured	Normal	Injured	Normal	Injured	Normal	Injured
38	19/M	Right	C1	Type 3	39	80	80	80	85	35	27	35	33	85	85	90	90
39	29/M	Left	C2	Type 3	34	70	60	70	70	20	20	25	17	85	80	80	75
40	24/M	Left	C2	Type 3	37	75	65	75	65	23	15	25	25	85	80	75	70
41	38/M	Right	C1	Type 3	36	75	70	75	80	25	23	35	35	85	80	80	70

Palmar tilt was 8.2 ± 14.6 in the injured wrist (range, −6 to 20) and 10.6 ± 7.5 in the normal side (range, 0 to 16) ($P = 0.041$). Numbers of considerable fragments were 2, 3, and >3 in 10, 16, and 15 patients, respectively. There was no carpal instability.

According to the criteria of Knirk and Jupiter scoring,[20] 31 patients had grade 0 articular incongruity and 10 cases had grade 1 incongruity. No patient had >2 mm articular incongruity.

In our institution, the average costs of treatment with the new technique for AO-C type distal radius fracture was significantly lower as compared with the patients treated with routine internal fixator devices such as distal radius LCPs ($284 vs. $553).

At the final evaluation, 27 patients had no arthritic changes (grade 0), 12 had slight joint narrowing (grade 1), and in 2 cases had marked joint space narrowing (grade 2). No patient had grade 3 arthritis.

Two patients had median nerve dysfunction before surgery that resolved spontaneously. One patient had an ulnar nerve palsy that was identified and released 19 days after injury. Two patients had injury to the superficial radial nerve, 1 transient and 1 permanent (treated with neuroma resection 3 mo after injury). One patient who began military activity immediately after fixator removal had a stress fracture at a pin site at the base of second metacarpal.

There were 19 minor, transient (grade 1, 2, and 3 according to Dahl classification[18]) pin-track infections among 164 pins.

Finally, according to the grading system of Gartland and Werley, modified by Sarmiento et al,[16] the final outcome were excellent in 14 patients, good in 18, fair in 7, and poor in 2 patients. Patients with low-energy accidents (fall from a standing height) had better results compared with high-energy ones (motor vehicle collision and fall from a greater height) ($P = 0.048$). There was no statistical difference between outcomes in AO subgroups.

DISCUSSION

External fixation is one of the methods used in the management of the unstable distal radius fractures.[1–6,9,17,21] Despite some excellent results, such as Edwards'[1] study, there are some concerns about the efficacy of the external fixator alone in the maintenance of the reduction and wrist stiffness.[5–8] According to a meta-analysis carried out by Esposito et al,[22] they concluded plate fixation in comparison with external fixator provides lower DASH score and infection rate and better restored radial length. Other studies support their results.[23,24] However, some recent randomized clinical trials reported open reduction and volar plating did not yield better subjective results than EF, especially in long time.[25,26] Handoll et al[27] could not find sufficient evidence to determine superiority between different methods of external fixation such as pin and plaster, bridging external fixator, and nonbridging ones.

Volar tilt, carpal alignment, grip strength, and range of motion are better maintained with nonbridging fixator, compared with the bridging fixator.[11] However, the usage of nonbridging external fixator is limited to extra-articular and nondisplaced intra-articular fractures.[11]

Morbidity may arise from the donor site of autogenous bone grafting.[28,29] Artificial materials introduce additional costs and risks to the patient.[12,13] Ancillary pins are not

FIGURE 4. A 29-year-old man with intra-articular distal radius fracture on the right side. A, AP and lateral views before operation. B, After external fixator application. C, MRI view 26 months after operation. There was no sign of step-off or arthritis. D and E, AP and lateral views 46 months after operation. F–I, Range of motion.

reusable and may introduce extra risk of pin-track infection and nerve injury.[3]

Our overall results were mostly comparable to the studies of nonbridging external fixation or some combined methods[1,3,6,9,15,16,20,30–35] (Table 6). Achievement of superior clinical results in our study would be because of less traction needed in this method to maintain the reduction. This may be partly owing to applying the distraction force exactly perpendicular to the articular surface of distal radius. In addition, the majority of our patients were young and may have better bone stock and more motivation for rehabilitation.

During the routine application of external fixation for the management of intra-articular distal radius fracture, the procedure mandates continuous and sequential imaging using fluoroscopy to achieve and maintain precise and acceptable reduction. This is a time-consuming process and leads to more radiation exposure. However, in our modified technique, we use fluoroscopy only to adjust the joints of the external fixator at the level of fracture and for final check of the reduction. In our method, we rely on mathematical concepts, and achieve and maintain more anatomic reduction without any concern of extra radiation hazards. In addition, in our experience we think the latter method takes less operating time than the conventional external fixation methods.

Our study also advocates the possibility of cost effectiveness of the new technique. As compared with the routine application of internal fixator devices such as distal radius LCPs, the usage of this new device markedly reduces the costs of treatments for the patients, especially in limited resources and developing countries.

In the current study, we used this technique alone; however, this conception can be used in combination with other methods such as minimal internal fixation, bone grafting, or as a primary reduction technique before open reduction or arthroscopic methods.

Limitations of this study include small amount of cases, short follow-up, and lack of a cohort group with other fixation methods. The lack of a patient self-reported measure such as DASH score, before and after operation, is another limitation in our study.

ACKNOWLEDGMENT

The authors thank Dr David Ring for his kind collaboration in scientific and English editing of the article.

TABLE 5. Characteristics of Forty Patients With Distal Radius Fractures Were Fixed With Bridging External Fixator Along Radial Articular Surface (Part 2)

Case	Radial Shortening	Radial Inclination		Palmar Tilt		Incongruity	Arthritis	Grip Strength		Styloid Fracture	Overall Grading
		Normal	Injured	Normal	Injured			Normal	Injured		
1	1	23	21	12	8	0	0	23	17	Yes	Good
2	1	26	24	4	5	0	1	15	13	Yes	Good
3	0	25	22	2	0	0	0	30	25	Yes	Good
4	0	20	18	16	14	0	1	36	40	No	Good
5	2	22	21	14	3	1	2	18	11	No	Fair
6	0	22	21	16	15	0	0	22	23	No	Excellent
7	1	24	26	7	11	1	1	43	40	Yes	Good
8	−1	20	22	0	7	0	0	33	30	Yes	Good
9	0	19	20	13	15	0	0	46	48	No	Excellent
10	1	27	25	7	6	1	1	35	30	No	Good
11	0	23	24	15	15	0	0	31	33	No	Excellent
12	0	20	18	7	10	1	2	27	11	No	Fair
13	0	24	27	6	4	0	0	45	42	Yes	Good
14	1	27	28	13	15	1	1	45	34	Yes	Good
15	0	21	22	11	18	0	0	32	30	No	Excellent
16	2	24	26	9	4	0	0	23	25	No	Excellent
17	1	21	17	13	10	0	0	31	28	No	Excellent
18	3	24	22	13	−2	1	1	14	8	No	Fair
19	1	21	18	10	13	0	0	43	37	Yes	Good
20	0	24	27	11	7	0	1	25	19	No	Fair
21	0	22	19	7	12	0	0	25	27	No	Excellent
22	1	27	23	12	7	1	0	46	33	No	Good
23	1	20	17	12	9	0	0	27	25	No	Excellent
24	0	24	27	13	14	0	0	38	41	No	Excellent
25	2	21	19	8	2	0	1	36	27	Yes	Fair
26	0	19	19	9	12	0	0	42	35	No	Excellent
27	0	22	23	12	15	0	0	34	32	No	Good
28	0	21	23	9	7	0	0	20	21	No	Good
29	1	22	19	14	12	0	1	39	36	Yes	Good
30	2	22	18	10	8	1	1	35	24	Yes	Good
31	2	24	26	12	3	1	1	37	21	Yes	Good
32	0	22	25	11	16	0	0	34	31	No	Excellent
33	1	26	24	13	14	0	0	43	35	No	Good
34	0	25	28	15	17	0	0	37	38	No	Excellent
35	0	21	23	8	2	0	0	32	32	Yes	Good
36	1	25	22	11	13	0	0	30	27	No	Excellent
37	2	18	21	12	5	1	2	34	25	Yes	Fair
38	0	23	22	6	7	0	0	37	39	No	Excellent
39	0	25	22	13	16	0	0	33	29	No	Excellent
40	−1	20	21	16	12	0	0	33	34	Yes	Good
41	1	24	26	14	7	0	0	27	29	No	Good

TABLE 6. Comparision of Different Results in Current Studies

												Functional Results (Gartland and Werley)			
References	Method	Average of Age	No. Fractures	Type of Fracture	Plantar Flexion	Dorsiflexion	Radial Deviation	Ulnar Deviation	Pronation	Supination	Grip (%)	Excellent	Good	Fair	Poor
Gartland and Werley[15]	Plaster cast	53	60	88% IA	—	—	—	—	—	—	—	22	47	28	3
Sarmiento et al[16]	Functional brace	40	44	100% IA	—	—	—	—	—	—	—	42	39	18	0
Cooney et al[5]	EF	63	60	88% IA	58	52	18	30	80	75	—	26	35	33	6
Knirk and Jupiter[20]	Various	28	43	AO C3	65	53	21	30	75	69	—	26	35	33	6
Bradway et al[30]	IF	40	16	AO c3-2	55	55	21	23	—	—	75	56	25	19	0
Fernandez et al[2]	Various	37	40	AO B, C	63	60	10	25	77	73	85	—	—	—	—
Sanders et al[33]	EF	51	35	97% AO B, C	53	54	18	30	72	78	—	34	34	29	3
Edwards[1]	EF	56	30	AO C3	70	64	19	27	83	89	92	90	7	0	3
Steffen et al[34]	EF	54	32	AO C, B	53	55	22	33	78	68	92	35	62	22	3
Zanotti et al[35]	EF	34	20	AO C3	66	58	19	29	90	77	88	5	75	20	0
Bass et al[3]	EF + IF	31	13	AO C3	60	45	21	35	75	64	83	11	45	33	11
Hegeman et al[31]	EF	67	16	AO C	—	—	—	—	—	—	—	44	19	12	25
Huang et al[32]	EF	59	70	AO C	56	58	22	9	72	67	87	32	51	13	4
This study	EF	37	41	AO C	70	64	20	27	76	69	89	34	44	17	5

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