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Nonbridging external fixation for fractures of the distal radius

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Objective: To assess the feasibility of using standard components from the small AO external fixator set to support fractures of the distal radius with a construct incorporating distal fixation in the periarticular radius fragment that would allow for primary mobilization of the wrist joint during fracture healing. **Methods:** In a prospective pilot study of a nonbridging external fixator in early 2001, 6 consecutive cases of fracture in the distal radius presenting at a tertiary care centre, the Hamilton General Division of Hamilton Health Sciences, were compared with 6 historical controls treated with a standard bridging construct immobilizing the wrist. Both groups were or had been treated with closed reduction and external fixation of the distal radius under fluoroscopic control. Fracture alignment was measured on radiographs after healing and removal of the fixation devices; additional (secondary) outcome measures were pin-tract sepsis and implant loosening (treatment failure). **Results:** Compared radiographically with controls, alignments after fracture healing were improved (and virtually anatomic) with use of the nonbridging external fixator. The incidence of pin-tract sepsis was similar in the 2 groups, neither of which included any treatment failures. **Conclusions:** Nonbridging external fixation of comminuted distal radius fractures can be accomplished safely and effectively. The results of this pilot study suggest that improved radiographic alignment may be achieved with this technique.

Objectif : Évaluer la faisabilité d'utiliser les composantes standard des petites fixations externes AO pour soutenir les fractures du radius distal dans une structure incorporant la fixation distale dans le fragment du radius périarticulaire qui permettrait une mobilisation précoce de l'articulation du poignet pendant la guérison de la fracture. **Méthodes :** Dans une étude pilote prospective d'un fixateur externe non transversal au début de 2001, on a comparé six cas consécutifs de fracture du radius distal chez des patients qui s'étaient présentés à un centre de soins tertiaires, le Hamilton General Division of Hamilton Health Sciences, à six témoins historiques traités à l'aide d'un pont standard immobilisant le poignet. Les deux groupes ont été traités par réduction à peau fermée et ostéosynthèse externe du radius distal avec contrôle radioscopique. On a mesuré l'alignement de la fracture sur des radiographies après guérison et enlèvement des fixations; les autres mesures de résultats étaient la septicémie dans le trajet des broches et le relâchement de l'implant (échec du traitement). **Résultats :** Par comparaison radiographique avec les témoins, l'alignement après guérison de la fracture s'est amélioré (jusqu'à atteindre presque la position anatomique) après utilisation du fixateur externe non transversal. L'incidence d'une septicémie attribuable aux broches a été la même dans les deux groupes, qui n'ont subi aucun échec de traitement. **Conclusions :** On peut accomplir avec efficacité et en toute sécurité une ostéosynthèse externe non transversale de fracture comminutive du radius distal. Les résultats de cette étude pilote laissent entendre la possibilité d'obtenir un meilleur alignement radiographique à l'aide de cette technique.

Displaced fractures of the distal radius are common, and fracture-site comminution and the complex play of muscle–tendon units across the wrist are destabilizing factors such that many of these injuries are recognized to be inadequately treated in plaster and require surgical stabilization for optimal reconstitution and maintenance of bony alignment.[1] External fixation may improve the maintenance of reduction.[2,3] Late dysfunction of the wrist correlates with residual malalignment of the distal radius.[4–6]

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Although the first description of an external fixator in the treatment of forearm fractures by Ombrédanne[7] in 1929 was of a nonbridging device, standard technique involves and current texts[2,3] describe bridging constructs that cross and necessarily immobilize the wrist during the bony healing process.

Nonbridging constructs offer a potential benefit in accelerating rehabilitation by allowing primary wrist mobilization with the fixator in situ; yet, they are infrequently used and in fact go unmentioned in the most recent instructional course lecture from the American Academy of Orthopedic Surgeons.[1] There may be a clinical concern that compromised bone stock in the distal radius fragment (as is commonly encountered, either from osteoporosis in the geriatric patient or by virtue of fracture comminution in the higher-energy injuries seen in younger patients) may preclude definitive fixation with this technique.

We have applied this technique in a small group of patients, confirming the feasibility of this treatment.

Methods

All 6 consecutive cases, without exception, of comminuted displaced fracture in the distal radius without volar displacement of the distal fragment (as would require buttress plating) presenting to the senior author (D.A.B.) in the first 6 months of 2001 were treated with nonbridging external fixation (Fig. 1). The previous 6 consecutive comminuted distal radius fractures treated by the senior author in late 2000 were analyzed as historical controls (Fig. 2).

All preoperative radiographs were analyzed for fracture classification according to the AO system and to define relevant radiographic parameters of alignment: the height of the radial styloid (radial height in Fig. 3), radial inclination (Fig. 3) and the volar tilt (Fig. 4).[8] Immediate postoperative films were similarly analyzed to quantify improvement in radial inclination and height and volar tilt. Late postoperative films were analyzed for maintenance or potential deterioration of these parameters. Preoperative, immediately postoperative and late images of the 6 immediately preceding cases treated by the senior author with bridging fixator constructs were similarly analyzed for comparison.

Chart records of all cases were reviewed to determine the incidences of pin tract sepsis and potential treatment failure. Image analysis, chart review and statistical analysis were performed independently by the junior author (H.A.) using SPSS 11.0 software. Functional outcome data were not obtained.

All surgeries were performed by the senior author in the operating room under general anesthesia, with standard surgical preparation and free draping of the limb.

All fixations were performed under fluoroscopic guidance with components from the standard AO small external fixator set. The pins used generally were of 4.0 mm diameter with a 20-mm thread length; 2.5-mm pins with 15 mm of thread were used in the metacarpals of smaller patients. They were inserted through small incisions (5–10 mm) just large enough to reveal the bone without use of retractors. The radius was then predrilled with a 2.0-mm drill working through a protective drill-guide. All pins used were short-threaded so as to optimize purchase of the screw shank through the proximal cortex, and inserted with bicortical purchase.

Preliminary and usually incomplete fracture reduction was performed under fluoroscopy. Next, a proximal pin was inserted into the intact radial shaft 2–4 cm proximal to the fracture.

In the study group, 2 pins were then inserted to the distal fragment, 1 on each side of Lister's tubercle so as to preserve the extensor pollicis longus pulley there. These pins were inserted under lateral fluoroscopic control into immediately subchondral bone. The pins were cross-linked with a short connecting rod. Any residual volar tilt was then corrected, likewise under lateral fluoroscopy. A longitudinal rod was used to connect the distal construct to the proximal pin. A fourth pin was then inserted to the radius 2–3 cm proximal to the first pin and connected to the longi-

FIG. 1. Lateral radiograph of a study patient, with a nonbridging fixator.

FIG. 2. Lateral radiograph of a control case. Note the derotational pin in the periarticular fragment.

tudinal rod. Finally, a second longitudinal rod was connected to complete the assembly (Fig. 1).

After surgery, radiographs of both the operated and unoperated wrist were taken to allow the determination of the normal radiographic parameters for each patient.

In the control group, distal pins were inserted to the second metacarpal shaft and incremental longitudinal traction applied to optimize reduction before connection of the 2 longitudinal rods. A fifth pin was then inserted to the periarticular radius fragment and used as a joystick to reduce residual volar tilt before being connected to one of the longitudinal rods to hold that reduction (Fig. 2). Biplane fluoroscopic assessment was then used to confirm the adequacy of fracture reduction.

In all 12 patients, any skin tethering around the pins was incised for release and any gaping of skin around the pins was loosely approximated with 3-0 nylon suture. Two-inch (~ 5 cm square) Kling gauze was then loosely wrapped around the bases of the pins to protect the pin–skin interface.

Afterward, patients used a simple sling for comfort for 1–2 weeks, without wrist splints. Pin-site care included maintaining the gauze dressings in place until any bleeding or fluid discharge had stopped, at which point dressings were removed; pins were left exposed to the air and not purposefully disturbed. Active range-of-motion exercises of the fingers (and the wrist, in the study group) were encouraged, but physiotherapy was not immediately prescribed.

When the fractures were judged radiographically to be healed (mean 8 wk; range 6–10 wk), the fixators were removed in the clinic and physiotherapist-supervised exercises initiated. Follow-up lasted until patients were comfortable and the injured hand and wrist fully functional, at which time they were discharged for active care (mean follow-up 21 wk; range 16–28 wk). No patient was recalled to the clinic specifically for study purposes.

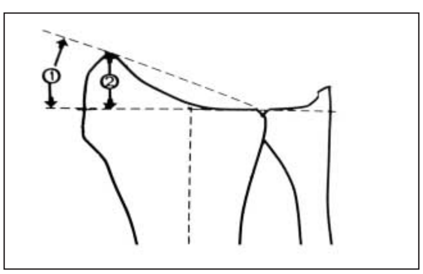

FIG. 3. Line drawing of the distal radius and ulna in the anteroposterior plane. Radial height is dimension 2 (in millimetres); radial inclination is angle 1.

Results

All distal-radius fractures presenting to the senior author in the study period were treated with this technique, including those with comminution and/or articular disruption.

The study group consisted of 3 men and 3 women with a mean age of 55 years (range 42–72 yr). Five were injured in simple falls; 1 had a high-energy fracture resulting from a fall from a height. The control group also consisted of 3 men and 3 women, of mean age 58 years (range 31–88 yr). Five were injured in simple falls, and 1 had a high-energy injury caused by a motor vehicle crash. Demographics and mechanism of injury are accordingly similar between groups.

AO classification of injuries was also very similar (Table 1), although the study group showed a trend toward more severe injuries. Preoperative fracture malalignment in the groups did not differ significantly (Table 2).

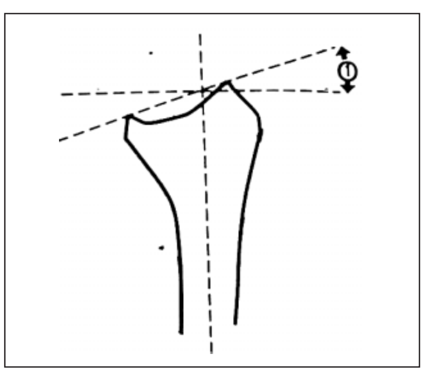

FIG. 4. Line drawing of the distal radius in the lateral plane. Volar tilt is angle 1.

Both immediately after surgery and at late follow-up, mean radial height and inclination in the groups did not differ significantly, but the study group had better volar tilt than controls ($p < 0.03$; Table 2). At late follow-up, all fracture reductions were well maintained.

Comparison within the study group of the 3 radiographic alignment parameters at final follow-up with these same parameters at the contralateral uninjured wrist found no statistically significant differences (Table 3). Distal radius alignment was essentially restored to normal in the study group.

Complications

Two cases of pin-site infection developed, 1 in each group. Both occurred at proximal pins inserted into the intact radial shaft within the first 3 weeks of treatment, and both resolved rapidly with oral antibiotic therapy (cloxacillin). There were no infections involving the more distal pins inserted into distal/periarticular fragments.

No case could be considered as a failure of therapy, as no patients displayed premature implant loosening or infection that might have required early removal of the fixators.

One control patient had mild carpal-tunnel symptoms perioperatively, which resolved within days. One patient in the study group had fracture through the proximal pin site on the radial shaft after a fall

Table 1

AO classifications of the fracture injuries treated in this series, *n*

AO subtype	Study group	Controls
A3	2	3
C1	0	1
C2	2	2
C3	2	0

some 2 weeks after surgery. This was treated with ORIF (open reduction with internal fixation) using a small-fragment dynamic compression plate. The nonbridging external fixator was left in place. Both fractures subsequently did well.

Discussion

The aim of treatment of fracture of the distal radius is the restoration and maintenance of normal anatomical alignment at the wrist. Radiological and clinical results correlate well.[9]

Taleisnik and Watson[10] described symptomatic midcarpal instability caused by malunited fracture of the distal radius, and showed that loss of volar tilt can put the carpus in a position causing dorsal collapse.

Bridging external fixators produce fracture reduction primarily by ligamentotaxis across the radiocarpal joint. Less-than-perfect reconstitution of volar tilt can result because volar radiocarpal ligaments are much stronger than the dorsal complex. For this reason, the senior author has routinely inserted a fifth pin into the periarticular distal radius fragment and used it as a derotational joystick to improve volar tilt in his standard bridging construct.

Fracture stabilization techniques involving direct manipulative control of and stable fixation to the distal radius fragment offer potentially optimal results.[11–13] In our control patients as well as our study subjects, volar tilt was increased with fifth-pin manipulation of the fragment (as illustrated in Fig. 2) to optimize distal radius alignment. Although unproven, this technique may have biased the control group toward improved reduction and thereby create concern that our controls may not be equivalent to the classical bridging fixator method, in which the periarticular distal-radius fragment is not directly instrumented.

There has historically been concern that deficient bone stock in the distal radius fragment, either by virtue of osteoporosis in the elderly or fracture comminution in higher-energy injuries as commonly seen in younger patients, would not allow for sufficiently secure and stable fixation without "bridging" the fixator and securing to the metacarpals distally.

Oddly, despite the current standard of practice involving bridging devices,[2] the first report of distal radius external fixation by Ombredanne[7] in 1929 described the use of a nonbridging device. Several authors have more recently presented small series of cases treated with this technique: Meléndez and colleagues[14] reported good results in 13 cases; Krishnan and associates[15] obtained good functional results in 22 patients with intra-articular fractures; and Fischer and coauthors[16] had good results in 17 patients.

Our pilot study is admittedly limited in size but represents the only controlled series in the literature to date. We cannot pretend to present well-objectified functional status information in these cases, but can confirm the feasibility of the nonbridging technique. The "fifth pin" technique used in the control series might tend to improve the quality of reduction in our controls, which would increase the apparent importance of our observation that this small pilot study generated improved quality of reduction in the nonbridging group with statistical significance.

Hopefully this report may inspire others to pursue the nonbridging technique. Only a prospective and controlled multicentre trial will be able to define any potential benefit to functional outcomes. Recognizing the statistical limitations imposed by our small numbers ($n = 6$), we incidentally present what may be improved fracture realignment obtained this way.

One concern with this technique is the possibility of pin-tract sepsis contaminating the wrist joint. To date, this has not occurred, with both of our pin-tract infections involving proximal pins.

Our data not only confirm that nonbridging external fixation of distal radius fractures can be accomplished effectively, but also strongly suggest that significantly improved volar tilt can be restored with this technique as compared with a bridging fixator, even where volar tilt in the bridging construct is optimized through use of a derotation pin in the periarticular fragment.

Conclusion

Nonbridging external fixation of comminuted distal radius fractures can be accomplished safely and effectively. The results of this pilot study suggest that improved radiographic alignment may be achieved with this technique.

Table 2

Mean fracture alignments (and standard deviations) before and after surgery

	Preoperative		Immed postop		Late after surgery	
Alignment measure	Study pts	Controls	Study pts	Controls	Study pts	Controls
Radial height, mm	4 (5)	3 (4)	15 (2)	13 (5)	14 (2)	13 (5)
Radial inclination, °	—	—	28 (6)	27 (4)	25 (7)	27 (6)
Volar tilt, °	–22 (12)	–29 (16)	15 (5)*	5 (11)*	17 (6)†	6 (13)†

*† Postoperative between-group differences were both statistically significant at $p < 0.03$.
Immed postop = measurements taken immediately after surgery; pts = patients

Table 3

Nonbridging group: comparison of mean final radiographic alignment (and SD) with the uninjured wrist

Alignment measure	Injured wrist	Normal side
Radial height, mm	28 (6)	26 (4)
Radial inclination, °	15 (2)	14 (1)
Volar tilt, °	15 (5)	15 (3)

No comparison was significant (all $p > 0.05$).
SD = standard deviation

Competing interests: None declared.

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