External Pin Fixation for Unstable Colles' Fractures

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ABSTRACT: During a five-year period, a double-pin Roger Anderson apparatus, with pins perpendicularly placed in the second and third metacarpals and in the distal part of the radius, was applied in 130 patients with an unstable Colles fracture. Sixty of the 130 were followed for two years. Shortening was limited to a median of two millimeters and dorsal angulation, to a median of 3 degrees. Wrist dorsiflexion averaged 58 degrees, and volar flexion averaged 50 degrees. Pronation and supination had an average loss of 5 degrees when compared with the uninjured side. Repeat reduction was required in only three patients.

Patient assessment revealed that 85 per cent of the patients had good results; 12 per cent, fair; and 3 per cent, unsatisfactory. Objective analysis (McBride system) revealed that 90 per cent had good to excellent results; 8 per cent, fair; and 2 per cent, poor. Ninety-two per cent had no pain, 89 per cent had no deformity, and the mean grip strength was twenty kilograms. Sixteen patients had complications; seven of the sixteen had pin loosening, which occurred most frequently late during the course of treatment and without adverse sequelae.

Unstable Colles' fractures have an inherent capacity for loss of reduction or shortening, or both. The instability can be recognized by the presence of much comminution, severe dorsal angulation (20 degrees or more), or extensive intra-articular involvement. It is difficult to align the fracture fragments and to maintain the reduction. In 1929, Böhler advocated that the reduction be maintained by fixed traction and that this was adequate treatment for unstable fractures.

In sixty patients with unstable fractures of the distal end of the radius (Colles' fractures), external pin fixation was used as the preferred method of treatment.

Material

There were 525 patients with Colles' fractures seen at the Mayo Clinic from 1972 to 1976, and 130 (24.8 per cent) had unstable fractures. Of these 130 patients, sixty-five were followed for at least two years. Of the sixty-five patients, two died and three did not return for review. We interviewed and examined the remaining sixty patients personally at least two years after the original injury.

Their mean age was sixty-three years old. There were fifty-three women and seven men. Fifty patients (83 per cent) had injured the dominant hand. The two main mechanisms of injury were a fall on the outstretched hand (fifty patients) and a motor-vehicle accident (six patients). In four injuries no specific mechanism was recorded. Six patients (10 per cent) had associated injuries of the upper extremity: one scaphoid fracture, one radial-head fracture, three humeral fractures, and one multiple fracture of the forearm. In two patients the Colles fracture was open.

Analysis of the original roentgenograms revealed that forty-two patients (70 per cent) had moderate to severe comminution and forty-nine (82 per cent) had marked to severe displacement. According to the Frykman classification (Table I), 48 per cent of the fractures were types VII and VIII, indicating involvement of both the radiocarpal and the radio-ulnar joints; 71 per cent were types V through VIII; and 88 per cent had some intra-articular component. The 12 per cent with no intra-articular component had severe comminution or displacement. Measurements of carpal length from the pre-reduction roentgenograms were compared with those from the post-reduction roentgenograms made while the patient was in

<table>
<thead>
<tr>
<th>Type</th>
<th>No.</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>I (extra-articular, no fracture of ulna)</td>
<td>3</td>
<td>5</td>
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<tr>
<td>II (extra-articular, fracture of ulna)</td>
<td>4</td>
<td>7</td>
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<tr>
<td>III (intra-articular radiocarpal, no fracture of ulna)</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>IV (intra-articular radiocarpal, fracture of ulna)</td>
<td>7</td>
<td>12</td>
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<tr>
<td>V (intra-articular radio-ulnar, no fracture of ulna)</td>
<td>6</td>
<td>10</td>
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<tr>
<td>VI (intra-articular radio-ulnar, fracture of ulna)</td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td>VII (intra-articular radiocarpal and radio-ulnar, no fracture of ulna)</td>
<td>12</td>
<td>20</td>
</tr>
<tr>
<td>VIII (intra-articular radiocarpal and radio-ulnar, fracture of ulna)</td>
<td>17</td>
<td>28</td>
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<tr>
<td>Total</td>
<td>60</td>
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traction. The former showed the following median values: shortening of the radius, ten millimeters (range, two to twenty-nine millimeters); dorsal angulation, 21 degrees (range, -4 to 54 degrees); and radial angulation, 14 degrees (range, -10 to 30 degrees). The normal angulation is volar and measures 10 degrees; the normal radial angulation is 22 degrees.

Traditional methods of closed reduction and cast application were preferred for most of the stable fractures. With the patient under local or sedative anesthesia, manipulative reduction was commonly performed, although general anesthesia or brachial-block anesthesia, followed by reduction in traction, was preferred for patients with unstable fractures and was always used for primary pin fixation.

Treatment by external pin fixation was limited to patients with: (1) comminuted, displaced fractures that were inherently unstable, as defined subsequently, or (2) comminuted fractures that had sustained a loss of reduction after a closed reduction was performed and a cast was applied. A fracture was defined as unstable if there was an inability to maintain satisfactory fracture alignment at the time of reduction or in the presence of severe comminution, intra-articular components, and severe displacement when difficulties were anticipated in maintaining fracture reduction by cast support alone (that is, more than 20 degrees of dorsal angulation and ten millimeters of radial shortening). If there was a loss of reduction with dorsal angulation of more than 5 degrees or with five millimeters or more of shortening, then the fracture also was considered to be unstable and external pin fixation was performed. Early in the series, several of the patients had repeat reductions and applications of a cast, with a second or third reduction performed before external pin fixation was instituted. Patients who had cast immobilization alone without external pins were excluded from the study, however.

Of the sixty patients, thirty-two had primary external pin fixation and twenty-eight had secondary pin fixation. No patient had bilateral Colles' fracture. Of the twenty-eight patients who had closed reduction and cast treatment (secondary pin fixation), twenty-four had local or sedative anesthesia, fourteen (50 per cent) had one attempt at a manipulative reduction, ten (36 per cent) had two, and three (10 per cent) had three or more. Only three patients (9 per cent) needed repeat reduction of the fracture after pins were inserted. The average period of retention of the external pins was 6.8 weeks, with a range of five to ten weeks.

**Technique**

The pins are inserted percutaneously in a transverse direction through the bases of the second and third metacarpal bones and the radius, and external immobilization is achieved by a Roger Anderson device\(^1\) (Fig. 1). Initially we used two pins and a single bar in nine patients, but stability was increased by adding a second pin distally and a triangle fixateur in thirteen patients. Later, we preferred four pins and a quadrilateral (parallel piped) fixation device that was more rigid; this was used in thirty-eight patients.

After anesthesia is administered, traction is applied to the hand for ten minutes with three to five kilograms of pull to distract the fracture fragments and allow gentle reduction. Hyperextension-flexion maneuvers are not utilized. Exact alignment of the volar cortices (Fig. 2-A) and full restoration of length (ten to fourteen millimeters between the levels of the distal end of the ulna and the radial styloid process) are the required evidence that reduction is complete. Accurate reduction of the distal radio-ulnar joint is important, and the forearm is maintained in slight to full supination as necessary to achieve the reduction in a stable position. Once satisfactory reduction is obtained, Steinmann pins (2.0 to 2.3 millimeters in diameter) or, more recently, Crowe-point pins (2.3 millimeters in diameter) are inserted using a low-torque power drill. Hand-drilling is difficult in the distal part of the radius and is not recommended unless self-tapping and self-drilling pins are to be used. The distal pins are placed transversely and perpendicular to each other through the bases of the second and third metacarpals (Fig. 2-B). Parallel pins are drilled through the distal part of the radius three to five centimeters proximal to the fracture site. Traction is maintained during the insertion of the pins and the application of the Roger Anderson device. Two-plane roentgenograms are made.

An ulnar gutter splint is applied for comminuted fractures of the distal part of the ulna or those with displacement of the distal radio-ulnar joint. The period of immobilization usually is six to eight weeks, but ten weeks may be necessary for the more comminuted fractures.

Early motion of the digits, elbow, and shoulder is enforced and active exercises of the hand are done during the first twelve to twenty-four hours. The wrist is held in neu-
tral flexion-extension and slight ulnar deviation, with the result that motion of the digits is not restricted when immobilization is discontinued. The pins are removed without the use of anesthesia, an Orthoplast volar splint is applied, and wrist motion is started.

Results

Our assessment of results followed the McBride system of evaluation, which included the subjective impressions of the patient, objective grading of function and deformity, and comparison of final and initial roentgenograms.

![Fig. 2-A](image)

Anatomical alignment of the volar cortices (arrow) provides a stable shelf of bone that helps to prevent angulation deformity.

![Fig. 2-B](image)

Distal pins are perpendicular to each other in the bases of the second and third metacarpals. Parallel pins are placed three to four centimeters proximal to the fracture. The extensor tendons and sensory nerves can be avoided by direct palpation of the bone prior to drilling the radius. Plaster-cast support usually is not required.

The subjective response of the sixty patients in whom evaluation was possible indicated that fifty-one (85 per cent) were fully satisfied, two (3 per cent) were unsatisfied, and seven (12 per cent) were only partly satisfied. The nine patients who were not fully satisfied had pain in the wrist, deformity, or weakness of grip. Fifty-six patients (94 per cent) had any important loss of dorsiflexion or palmar flexion (fifty-seven had more than half the range on the normal side). Only three patients had any important loss of dorsiflexion or palmar flexion (fifty-seven had more than half the range on the normal side). Four patients had an important loss of radial deviation, and one patient had a loss of ulnar deviation of more than half the range of the normal side.

The average grip strength (Fig. 3) was twenty kilograms (range, two to sixty kilograms) for the injured hand compared with thirty kilograms (range, ten to sixty-five kilograms) for the uninjured side. Forty-eight patients (80 per cent) had a grip strength of 50 per cent or more of the uninjured side. Tip-pinch strength averaged five kilograms for the injured hand compared with six kilograms for the uninjured hand.

In the roentgenographic evaluation, thirty-three patients had a grade-1 fracture — no deformity, no dorsal angulation beyond neutral, and shortening of three millimeters or less. Twenty patients had a grade-2 fracture — no or slight deformity, dorsal angulation of 1 to 11 degrees, and shortening of three to six millimeters. Seven patients had a grade-3 fracture — mild to moderate deformity, dorsal angulation of 11 to 15 degrees, and shortening of six to twelve millimeters. No patients had severe deformity, more than 15 degrees of dorsal angulation, or more than twelve millimeters of shortening.

We measured radial shortening due to loss of reduction as the difference between the initial post-reduction and final roentgenograms made for each patient. There was an average loss of two millimeters. Thirty patients had a grade-1 fracture — no deformity, no dorsal angulation beyond neutral, and shortening of three millimeters or less. Twenty patients had a grade-2 fracture — no or slight deformity, dorsal angulation of 1 to 11 degrees, and shortening of three to six millimeters. Seven patients had a grade-3 fracture — mild to moderate deformity, dorsal angulation of 11 to 15 degrees, and shortening of six to twelve millimeters. No patients had severe deformity, more than 15 degrees of dorsal angulation, or more than twelve millimeters of shortening.

The final dorsal angulation averaged 3 degrees, with a range of -14 to 20 degrees, as compared with the normal 10-degree volar tilt (Fig. 4). Thirty patients had neutral or volar angulation of the distal part of the radius at the end of treatment. Twenty-two patients had from zero to three millimeters, nineteen had two to six millimeters, and eleven had seven to ten millimeters of shortening. Of those eleven, three lost 30 to 45 degrees of supination and four lost 20 to 60 degrees of pronation, while four also had mild to moderate pain on motion and three had localized tenderness.

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Fourteen patients had local tenderness, usually over the distal radio-ulnar joint. Three patients had a symmetric deformity. Measurement of wrist motion revealed median dorsiflexion of 58 degrees as compared with 65 degrees on the uninjured side, palmar flexion of 52 degrees (uninjured side, 62 degrees), radial deviation of 18 degrees (uninjured side, 22 degrees), and ulnar deviation of 30 degrees (uninjured side, 40 degrees). The average pronation was 80 degrees, and supination was 75 degrees (Fig. 3). This represents an average loss of 10 degrees of pronation-supination. Only five patients had losses of more than half the range (45 to 50 degrees). Only three patients had any important loss of dorsiflexion or palmar flexion (fifty-seven had more than half the range on the normal side). Four patients had an important loss of radial deviation, and one patient had a loss of ulnar deviation of more than half the range of the normal side.
EXTERNAL PIN FIXATION FOR UNSTABLE COLLES' FRACTURES

Comparison of extension and flexion (upper left), pronation and supination (upper right), radial and ulnar deviation (lower left), and grip strength (N = normal) (lower right) of the fractured side with the uninjured side.

was 21 degrees. Radial angulation (averaging 14 degrees before reduction) was the deformity most easily corrected by external pin fixation (Fig. 4). There was a final average of 21 degrees of radial angulation with a range of 8 to 25 degrees compared with a normal of 22 degrees. Clinical deformity was thus minimum, with no residual ulnar angulation of the wrist.

We rated the objective results on a scale of zero to ten points, based on the roentgenographic evaluation of the deformity, physical evaluation, and complications. The end result was rated excellent (zero to two points), good (three to six points), fair (seven to nine points), or poor (ten or more points). The objective end result was excellent in twenty-eight patients, good in twenty-six, fair in five, and poor in one. Therefore, fifty-four patients (90 per cent) had good or excellent objective results. When the objective and subjective results were combined, nineteen patients had excellent results, thirty-three had good results, and eight had fair results; there were no poor results. Thus, fifty-two patients (87 per cent) had good or excellent results.

Complications

Sixteen complications were noted (27 per cent of the patients). Seven resulted from errors in external pin fixation. Most of the seven were not serious and were recognized early and treated either by reinsertion of the pins or by the addition of plaster support. Loosening of pins was more frequent when two pins were used (six of the first nine patients) than when three or four pins were used (one of fifty-nine patients). Three of the six patients with two pins had loss of reduction and required additional manipulation. The other four patients (three with two pins and one with more than two pins) had loosening of one pin some time during the treatment period, generally during the sixth to eighth week, and then either a cast or a splint was applied.

In our most recent patients, this complication seems to have been averted by using Crowe-point pins — these hold better in bone that often is osteoporotic. No patients had a serious pin-tract infection, and no patient had a radial sensory neuritis. Two patients had a secondary, undisplaced fracture of the radius through a radial pin site.

Of the other seven patients with complications, one had a carpal-tunnel syndrome with acute sympathetic reflex dystrophy. Carpal-tunnel release was done in that patient. Three additional patients had a mild neuropathy of the median nerve which subsided without surgical treatment. One patient had a rupture of the extensor pollicis longus tendon. At surgical exploration the rupture appeared to be secondary to the fracture and not to a pin. No patient had any serious loss of finger flexion.

When one considers only the serious complications in the series, the rate was 13 per cent (eight patients). This
incidence represents an improvement over more conservative therapy. Our recent review of all Colles’ fractures showed a rate of serious complications of 35 per cent.

Discussion

External pins through the second and third metacarpal bones rigidly fixed by the Roger Anderson (or Hoffmann) apparatus to the distal part of the radius probably provide the best stabilization for Colles’ fracture. With this method there is fixed traction to minimize the shortening that may result from resorption of bone at the fracture site. The tensile distraction allows healing of comminuted dorsal fragments of the radius to occur without displacement. The mechanical stability is firm because there is fixation of the bone elements between the bases of the second and third metacarpals and the distal part of the radius, firmer than can be achieved by any other method (including employing a proximal pin through the ulna or distal pins through the thumb or fourth and fifth metacarpal bones, or both). The technique that we used also provides for retention of an anatomical reduction of the volar cortex obtained by traction with gentle manipulation. The distal fragments therefore are stabilized volarly; dorsal displacement is prevented and so is angulation. Union of the volar elements of the fracture is provided when bone contact and alignment are maintained. Reduction of the displaced distal radio-ulnar joint or of the fracture of the distal part of the ulna can be performed more readily after pin fixation is achieved. The reduction is well maintained by an ulnar gutter support splint holding the forearm in supination.

Several authors have recommended pin fixation for Colles’ fractures since Böhler’s description of his method. Our use of the Roger Anderson apparatus is not new. There have been reports by many others of modifications of external pin fixation. In general, they have stressed the benefits of the principle and reiterated the theme that the unstable Colles fracture requires firm fixation. We agree with Green that a good functional result usually accompanies a good anatomical result, and with Cole and Obletz that the goal of treatment of the intra-articular fracture is anatomical reduction and maintenance of reduction until the fracture heals. Treatment by standard techniques is often unsatisfactory for the unstable fracture.

Failure to identify the unstable fracture by the degree of displacement, the severity of comminution, the involvement of the radiocarpal or radio-ulnar joints, and especially the loss of reduction after a cast is applied will lead, in our opinion, to a poor long-term result.

Study of our patients who had less satisfactory results revealed that when we used fixation with two pins, we did not control the fracture well enough. Therefore we now insert four pins for fixation, and we make sure that they pass through both cortices. The forces across the fracture occur in more than one plane and therefore cannot be adequately neutralized by two pins. The technique of using plaster of Paris to fix the pins is not satisfactory because rotation can occur around the pins. With two pins the complication of pin loosening is more frequent even if a cast is applied. Finger motion may also be restricted when a cast is used.

The loss of radial length and the complication of dorsal angulation were of lesser degrees and occurred less often in our series than in the series reported by Green, who used two pins and plaster casts.

We recommend that the pins be 2.0 to 2.3 millimeters in diameter, and they must be carefully inserted. Distally, one must place the thumb in abduction, palpate the second and third metacarpal bones directly, and avoid the extensor tendons of the fingers and thumb and the radial sensory
nerve. The placement of the proximal pins involves retraction of the soft tissue by the finger and placement of the pin point firmly on the bone prior to drilling. Both cortices of bone must be traversed by each pin.

We used the McBride evaluation\(^6,8,10\) to compare our results with those of others, and we concluded that our results are better with this form of treatment. The advantages of our method are that we maintain the anatomical reduction achieved by traction and manipulation and prevent settling, while the freedom of elbow and hand motion is retained so that all activities of daily living can be performed unencumbered. The swelling and constriction that so often accompany cast treatment are avoided, as are its associated complications. A strong, painless wrist with excellent motion and good strength therefore is assured in all but a small percentage of patients.

External pin fixation may not be warranted in some elderly patients for whom only the simplest of treatments is indicated, or in patients for whom cooperation and follow-up may not be optimum.

References