Pins and Plaster Treatment of Comminuted Fractures of the Distal End of the Radius

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ABSTRACT: The technique used in the treatment of seventy-five patients with severely comminuted, often intra-articular fractures near the wrist was as follows: Pins were inserted through the metacarpals and proximal part of the ulna, reduction was done, and the pins were incorporated in a cast from elbow to knuckles. This allowed movement of the fingers and the elbow. The main complications — loss of radial length and pintract infection — are avoided by attention to technical details. Of the patients with adequate follow-up, 86 per cent had good or excellent results.

The optimum treatment of Colles’ fractures remains controversial. Some authors 13,40,42,47,53 reported functionally good results in a high percentage of patients, but the majority noted that the results are not uniformly good.1,3,10,14,23,24,28,30,38,42,43. In particular, many fractures of the distal end of the radius in middle-aged and elderly individuals are severely comminuted and intra-articular. It is in these difficult fractures that the results frequently are poor. There appears to be general agreement that reduction is easy to achieve in these fractures, but is difficult to maintain.

Several maneuvers have been advocated to avoid loss of reduction or to regain it: wedging the plaster cast; changing the cast seven to ten days after the initial reduction; resecting the distal end of the ulna; pinning the distal fragment percutaneously; immobilizing the forearm and wrist in supination; external fixation with a Roger Anderson device; and fixing the fracture fragments with pins which are incorporated in a plaster cast, as advocated in this report. Many varieties of the method have been described (Fig. 1). In each of these techniques, however, the basic underlying principle was the same: to provide a fixed traction which prevents shortening of the radius at the fracture site. Cole and Obletz 14 concluded that prolonged immobilization of eight weeks is required for the comminuted fracture to prevent this shortening. Because of the relatively long period of immobilization needed, it is imperative that the method employed permit free, active motion of the fingers, particularly full use of the hand, elbow, and shoulder. Our technique is not original, but the modifications we advocate are designed for early maximum use of the hand and maintenance of a full range of motion of all the joints.

Material

In 1970, a study was begun in which all those patients with comminuted, intra-articular fractures of the distal end of the radius were selected for treatment with pins and plaster. We estimate that these patients represent approximately 15 per cent of all the adults treated who had fractures of the distal end of the radius. Patients with simple, non-comminuted fractures which did not involve the articular surface of the radius were treated with the more conventional techniques of closed reduction and plaster immobilization.

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Fig. 1
Since Böhler’s original description of the pins and plaster method in 1929, many variations and modifications of the technique have been used.

Seventy-eight fractures in seventy-five patients were treated by the pins and plaster method. The age range was from nineteen to seventy-nine years, with an average age of 50.6. The mechanism of injury in thirty-two patients was a fall on the outstretched hand, the typical cause of a Colles’ fracture. Many patients were injured by more violent trauma, including falls from heights (sixteen patients) and traffic accidents (eleven patients). Seventeen patients sustained multiple injuries. One patient had a concomitant fresh fracture of the scaphoid.

Sixty-four of the fractures were of the Colles type; that is, with dorsal displacement (volar angulation) of the distal fragment. Three of the injuries were Smith’s fractures, with volar displacement (dorsal angulation). There were nine Barton’s or reverse-Barton’s fracture-dislocations; that is, proximal displacement of the carpus accompanied by a fragment of radius including part of the articular surface.

Of the forty-five patients whose end evaluations are reported here, forty-two had comminuted intra-articular fractures; six of these had severe loss of length, ten had moderate loss of length, and twenty-six had minimum loss of length. The other three patients had severely comminuted fractures with moderate or severe loss of length, but these fractures were not intra-articular. Two patients with gunshot wounds are included in the series because they presented the essential problem of prevention of loss of length. In sixty-five patients pins and plaster was the initial treatment. In the other ten this method was used two to thirteen days after unsuccessful attempts at reduction by closed manipulation and application of plaster casts.

Technique

Although no special equipment is needed, all the necessary instruments must be on hand before the procedure is begun. For applying traction either the wire finger traps or the Weinberger apparatus is satisfactory. Counter-traction can be provided by a padded sling and 2.3 to 4.5 kilograms of weight from the traction cart.

A pin-fixation tray should provide all the necessary instruments: a hand drill, a scalpel with No. 11 or No. 15 blade, two pairs of needle-nosed pliers, a pin cutter, several 2.3-millimeter smooth (unthreaded) stainless-steel Steinmann pins, and several towel clips.

Regional anesthesia must be obtained at the outset. Regional anesthesia by intravenous lidocaine was used in the majority of our patients, although brachial block or general anesthesia occasionally was used.

Once anesthesia is established, the finger traps and the counter-traction sling are applied. At least ten minutes of uninterrupted traction should be used; that alone will usually achieve the required length of radius, but some gentle manipulation in addition may be needed.

Roentgenograms are then made in at least two planes, preferably three — anteroposterior, lateral, and oblique. Distraction of the bones of the carpus should not be of concern but it is important that the anatomical length of the radius be restored. While the roentgenograms are being developed, the entire hand and the forearm are scrubbed and the forearm is draped with sterile towels. It is difficult to isolate the finger traps from the operative field, and the surgeon should take great care not to contaminate his hands or the instruments.

Careful placement of the distal pin is important. It should enter the second metacarpal immediately distal to the flare, of the base, an anatomical landmark easily palpated. The thumb should be adducted and the hand cupped by an assistant during placement of the pin, so that the pin engages only the second and third metacarpals. Incorporating the fourth and fifth metacarpals should be avoided, to prevent flattening the normal arch of the palm.

If the pin is left straight in its position of insertion, however, limitation of extension and abduction of the thumb will often result. It was pointed out by one of our former residents (Dr. J. W. Tippett) that this problem can be avoided by bending the pin directly at its exit from the base of the second metacarpal so as to allow full range of motion of the thumb (Fig. 2). We now do this routinely. This is easily accomplished with the pliers. Although 2.3-millimeter pins seem rather large for transfixing the metacarpals, we have found that smaller pins will sag in the plaster cast, resulting in loss of length of the radius. The

* A sixteen-millimeter sound movie depicting this technique is available in the film library of The American Academy of Orthopaedic Surgeons (Green, D. P., and Williamson, R. W., Jr.: Pins and Plaster Treatment of Comminuted Fractures of the Distal Radius. Film No. 028, S4).

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proximal pin is drilled through the ulna at least six centimeters from the tip of the olecranon, passing from medial to lateral to avoid injury to the ulnar nerve. With subsequent active motion in the elbow, pins placed more proximally in the ulna are more likely to loosen and drainage to develop.

Sterile cast padding is wrapped directly over the pins. Gauze dressings should not be placed over the exit wounds, because they hinder the purchase of the plaster on the pins. The cast is applied with the wrist in neutral position, neither flexed nor extended, and the traction must be maintained until the plaster sets. The pins are carefully incorporated into the plaster both proximally and distally. No attempt should be made to contour the cast to its final dimensions. Roentgenograms are made before the cast is trimmed.

Generous trimming of the cast is an important part of the procedure, because it allows maximum active motion by the patient. Dorsally the plaster is cut at the level of the metacarpophalangeal joints. Volarly the entire palm, including the thenar and hypothenar eminences, is uncovered (Fig. 5). At the elbow, the cast is also generously trimmed anteriorly to allow full elbow flexion. Brady  advocated a similar cast in 1963.

The patient should be admitted to the hospital at least overnight for elevation of the hand and for observation. The early post-reduction management is an integral part of the technique, and failure to work closely with the patient in the first two to three weeks will compromise the result. The basic reason for applying the type of cast described is to allow the patient to move the fingers. With this technique, all patients have some pain in the second and third metacarpals. The surgeon must succeed in encouraging the patient, during the first days after the pins are inserted, to achieve a full active range of motion. If the patient fails to achieve this goal, the services of a physical therapist may be helpful, but this was not needed in the majority of our patients.

At least eight weeks of immobilization are required for the treatment of a severely comminuted fracture. We have seen loss of length of the radius following removal of the pins at six weeks. Ten weeks of fixation may be required for extremely comminuted fractures. During this rather prolonged period of immobilization, the patient must be encouraged to use the hand as nearly normally as possible. All joints, including those of the fingers, thumb, elbow, and shoulder, must be put through a full range of motion daily.

Results

Of the seventy-five patients we treated by this method, eighteen were lost to follow-up after removal of the pins and plaster. Another twelve patients were treated too recently for follow-up data to be meaningful. These thirty patients were in essentially the same age distribution as the patients reported here. The remaining forty-five patients were carefully reviewed clinically and roentgenographically in a final follow-up examination at from six to thirty months after injury, with an average of 13.1 months.

The results of treatment in these forty-five patients were assessed by the following criteria: appearance; range of motion of the elbow, forearm, wrist, and fingers; grip strength; pain; symptoms of median-nerve compression; and status as regards return to work. Each category was assessed on a five-point scale.

The end-result roentgenograms were also graded on a five-point scale according to radial tilt, dorsal tilt, and length of radius. The length of the radius was measured in millimeters, using the distal end of the ulna (not the styloid process) as a reference. Similar measurements were made on all roentgenograms previous to the final one (those made initially, those made in finger-trap traction at the time of reduction, those made immediately after application of the pins and plaster, and check-up roentgenograms made subsequently throughout the course of treatment). The comparison of the serial measurements enabled us to determine when any loss of length or position occurred. In the final examination roentgenograms of the opposite wrist were made for comparison, because in some individuals the radius actually is shorter than the ulna (the so-called ulna-plus variant).

The examiner's estimate of the result was good (twenty-nine cases) or excellent (ten cases) in 86 per cent of our forty-five patients. Two patients had fair results and one had a poor result. The results in three patients were considered absolute failures; each of these patients had to have a Darrach procedure — resection of the distal end of the ulna — because of excessive shortening of the radius. In two of these patients the shortening was due to loss of purchase of the pins in the plaster, necessitating premature removal of
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the cast (see Complications). In one patient, loss of length was due to a technical error. The results in all three patients were rated poor as regards appearance.

The patient's estimate of the result was good (five) or excellent (thirty-five) in 89 per cent. Two patients thought that their results were fair and three thought that they were poor. There was no significant correlation between the severity of the original fracture and the end result. The patient's estimate of the end result was most closely correlated with the appearance of the wrist and the range of pronation and supination of the forearm.

Besides the three patients who had Darrach procedures, deformity was present in thirteen other patients: moderate in one; mild but of some concern to the patient in another; and minimum and of no concern to the patient in the remainder. The range of motion of the elbow was normal in all patients. Twenty-four had full range of forearm motion (pronation-supination); in three it was 50 to 75 per cent and in eighteen it was 75 to 95 per cent of the opposite, normal side. Fifteen patients had normal wrist motion; four had 50 to 75 per cent and three had 25 to 50 per cent of normal motion. All but nine patients had a full range of finger motion at end-result evaluation. One could flex his fingers so that the finger tips reached to within three centimeters of the palmar crease, and in the other eight the interval was less than one centimeter. The grip strength was normal in thirty patients, 50 to 75 per cent in ten, 25 to 50 per cent in four, and less than 25 per cent in one. No patient had pain severe enough to restrict activity significantly. No pain was present in twenty-seven. Fifteen patients had aches in cold weather, and three said their pain was mildly restrictive. One patient had a mild carpal-tunnel syndrome, which became asymptomatic with conservative therapy. All patients returned to their preinjury employment status, only three noting some mild limitations.

Normal volar tilt of the distal part of the radius was not restored in any patient; in the majority (twenty-eight), the radial articular surface ended up in a neutral plane on the lateral roentgenogram. Many of the patients with this roentgenographic finding had excellent results, with virtually normal motion of the wrist and forearm. Eight patients had more than 10 degrees of dorsiflexion tilt, and eight had zero to 10 degrees. One had volar tilt of 5 degrees.

Using a computer analysis, each of the fifteen clinical and roentgenographic parameters was correlated with all the others. Failure to restore normal radial length or normal radial tilt correlated closely with a less than satisfactory result. This loss in length was frequently accompanied by poor appearance and limitation of wrist flexion-extension and forearm rotation, the last presumably related to disruption of the distal radio-ulnar joint. No change in length was recorded in twenty-one patients; eighteen lost zero to two millimeters, three lost three to five millimeters, and one lost more than five millimeters. Two had arthritic changes in the wrist in addition to loss of length. Irregularity of the distal articular surface of the radius was most frequently the result of failure to reduce a dorsomedial intra-articular fracture fragment, the so-called die-punch fracture 40. In some patients with this fragment, the initial traction and manipulation reduced the fracture; in several others it was not reduced anatomically (Fig. 3).

The end results of radial tilt were normal in fifteen patients, while twenty-one had between 15 and 20 degrees and nine had between 10 and 15 degrees.

Advanced age is not a contraindication to the use of this technique. Excellent anatomical and functional results were obtained in many elderly patients, including a seventy-nine-year-old female piano teacher who resumed her usual occupation following treatment. In contrast, the patients who did most poorly as a group in this series were the young men with severely comminuted fractures secondary to violent trauma. Originally we thought that these patients would be ideal candidates for pins and plaster treatment, but this proved not to be the case. Two of the three absolute failures in this series, the patients requiring Darrach procedures, were men, aged twenty and thirty. Pins and plaster were much more poorly tolerated by these young men than by the elderly women in our series. The explanation for this is not readily apparent to us. Perhaps these fractures in young men were not true Colles' fractures, but in fact were much more serious injuries with considerably more extensive damage to adjacent soft tissues as well as more severe comminution of the bone itself.

A comparison of the results achieved in the different reported series of patients with fractures of the distal end of
the radius is difficult, because there is a wide spectrum of fracture patterns classified in the broad category of Colles' fracture. However, the study of Gartland and Werley's end results with Colles' fractures showed that 31.7 per cent of their patients with injuries similar to those in the present study which were treated by conventional closed reduction and cast immobilization had unsatisfactory results. The pins and plaster method in our group of patients with comminuted fractures showed a significant increase in satisfactory (good or excellent) results (86 per cent). Similar results were obtained by other authors using the pins and plaster method: 95 per cent good or excellent results by Brady 9, 94 per cent by Cole and Obletz 14, 81 per cent by Hammond 30, and 75 per cent by Scheck 20. Other methods of treating these difficult comminuted fractures yielded similarly good results: DePalma 20 reported 82.1 per cent good or excellent results using ulnar pinning, and Cozen 17 had good or excellent results in twenty-one of twenty-three patients treated by wedging the plaster to prevent loss of reduction.

Complications

A significant number of the patients in this series (twenty of forty-five) had minor or major complications at some point during the period of treatment. Most of these complications were preventable. Many occurred in patients treated early in the series and we were able to eliminate or minimize them as we gained more experience.

Failure to maintain the restoration of radial length and inclination achieved by the initial reduction was the most common complication in this series. It was attributable either to use of pins of inadequate diameter or to immobilization for less than eight weeks. In the first patients in this series, Kirschner wires 1.6 millimeters in diameter were used, but it soon became apparent that they would bend, with resulting loss of up to five millimeters of radial length. Finally it was demonstrated that 2.3-millimeter Steinmann pins were the smallest that would not bend. Although these pins seem rather large for insertion in the second and third metacarpals, our experience showed that pins of smaller diameter will almost invariably bend.

Eight weeks of immobilization are usually required to ensure adequate consolidation of bone in these severely comminuted fractures. Patients in whom the pins and plaster immobilization was discontinued at the end of six weeks or earlier frequently lost two to three millimeters of radial length over the next several weeks, even if plaster immobilization without pins was instituted when the pins were removed. In no patient was radial length lost after removal of the pins and plaster if they had been maintained for eight weeks.

Drainage from pin tracts was relatively frequent (one-third of the patients), but rarely serious. In only one patient did the drainage not resolve promptly after removal of the pins. This patient required curettage of the pin tract (osteomyelitis of the ulna), and the lesion then healed promptly. Pin-tract drainage was more common early in our series. It seems to be directly related to motion of the pins, which in turn is dependent to a large extent on the purchase of the pins in the bone and in the plaster cast. It is important to be certain that the proximal pin has solid bicortical purchase in the ulna; in two patients, the pin came loose because it had been inserted in the dorsal crest of the ulna. Another common cause for loss of purchase by the plaster on the pins was cutting the pins off too short. At least 2.5 centimeters of pin should protrude from the bone to ensure adequate incorporation in the plaster cast.

With our method, which allows unrestricted active elbow motion, there is considerable stress and motion of soft tissues around the proximal (ulnar) pin if it is placed too close to the elbow. The ulnar pin should be inserted at least six centimeters distal to the olecranon and should be left protruding sufficiently to ensure solid incorporation in the plaster cast. Then drainage from the proximal pins is minimized. In several of our patients, removal of the proximal pin was necessary prior to eight weeks after injury (range, twelve days to seven weeks). Additional loss of length was minimized (but not totally prevented) by then incorporating the distal pin into a long cast. This was done by hanging the hand up in finger traps with a counter-weight across the upper arm (as for the initial reduction), removing the original cast and proximal pin, and then applying a new cast above the elbow, incorporating the distal pin but again leaving the fingers and palm completely free for full range of motion of the fingers. This procedure was necessary in nine patients, and all of these had at least one to two millimeters loss of radial length.

Drainage around the distal pin was less frequent, but did occur. It was caused most commonly by loss of purchase because of inadequate length of the pin (less than 2.5 centimeters) protruding from the skin for incorporation into plaster.

Many patients in the series maintained nearly a full range of motion of the fingers throughout the entire eight weeks of immobilization, but other, less well-motivated patients did not. However, permanent stiffness of the finger joints of significant degree was encountered in only one patient. She lost flexion, so that the finger tips lacked three centimeters from reaching the palmar crease in full flexion. One patient with multiple injuries, including a severe closed head injury, remained unconscious for nearly the entire eight weeks that her wrist was being treated with pins and plaster. Daily passive range of motion was performed by the nurses, physical therapists, and physicians, and when the cast was removed all the small joints of the hand were completely supple.

One patient, a female inmate of the county jail, sustained a fracture of the second metacarpal at the site of the distal pin when she struck a fellow prisoner.

One patient had 45 degrees of active extensor lag in the long and ring fingers for the duration of his period of immobilization. It was feared that the extensor tendons had been lacerated by the distal pin, but within a few days after pin removal full active extension was regained. Presumably there had been some interference with normal tendon glid-
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The entire palmar aspect of the cast is trimmed away to allow completely unrestricted range of motion of all the small joints of the fingers and thumb. The cast should also be generously trimmed over the antecubital fossa to allow full flexion of the elbow.

The end result one year later. Although there was a fairly good joint surface and length of radius, the distal radio-ulnar joint was clinically and roentgenographically dislocated, resulting in significant loss of rotation of the forearm and, therefore, a poor result.

No patient in this series had symptoms of median-nerve compression during the period of treatment. One patient was found to have mild symptoms of carpal-tunnel syndrome on the follow-up examination, but she responded readily to conservative treatment. The pins and plaster method was employed in one patient after carpal-tunnel syndrome developed following closed reduction and cast immobilization with the wrist in flexion. Following surgical decompression (at which time a hematoma was found in the substance of the median nerve), maintenance of the reduction was achieved with pins and plaster. A forced position of wrist flexion was therefore avoided. This patient is not included in the present series because her fracture did not fulfill the criteria laid out in the prospective study. It indicates an uncommon but useful application of the pins and plaster technique.

FIG. 4-A

Figs. 4-A, 4-B, and 4-C: Disruption of the distal radio-ulnar joint is a frequent concomitant injury seen with fractures of the distal end of the radius. In many cases the irregularity of the joint surfaces is reduced with restoration of the normal length of the radius; in this patient it was not.

Fig. 4-A: A fifty-six-year-old woman sustained this severely comminuted intra-articular fracture of the distal end of the radius, with obvious disruption of the distal radio-ulnar joint.

FIG. 4-B

Reasonably good restoration of the radius was achieved, but the irregularity of the radio-ulnar joint was not reduced.

FIG. 4-C

The entire palmar aspect of the cast is trimmed away to allow completely unrestricted range of motion of all the small joints of the fingers and thumb. The cast should also be generously trimmed over the antecubital fossa to allow full flexion of the elbow.

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Discussion

The results of this study support the concept that good functional and anatomical results can be achieved in many patients with these difficult fractures. The method is not indicated in patients with simple, non-commminuted fractures of the distal end of the radius which do not involve the ar-
The technique is not difficult and requires little in the way of special equipment. However, it does demand of the surgeon a willingness to work very closely with the patient in the early days following reduction so that the discomfort caused by the distal pin, which all of our patients had to a greater or lesser degree, will not prevent active motion. If the patient is encouraged to move the fingers and use the hand fully during the period of fracture healing, one need not fear that the prolonged period of immobilization required in this method of treatment will result in stiffness of the small joints of the hand.

This method carries with it many potential pitfalls and complications, but with careful attention to detail most of these can be avoided.

References