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CONSERVATIVE TREATMENT

Conservative treatment of distal radius fractures in adults is recommended and reliable for non-displaced extra-articular and intra-articular fractures, for displaced fractures that remain stable following closed reduction (stable fractures) and certain unstable fractures in the elderly, in which the surgeon accepts the possibility of a tolerable amount of secondary displacement, which will fall in the category of an asymptomatic, well functioning malunion.

First of all selection of the fractures and ruling out unstable patterns is imperative. These are fractures with the following radiographic findings on initial X-rays:

- 1) >than 20° of dorsal (or palmar) angulation
- 2) displacement of more than 2/3 of the width of the shaft in any direction
- 3) metaphyseal comminution
- 4) more than 5 mm of shortening
- 5) intra-articular component
- 6) associated ulnar fracture
- 7) osteoporosis.

If the fracture is non or minimally displaced, a short period of immobilization of 3-4 weeks followed by a removable wrist splint until the patient feels comfortable usually by 5-6 weeks following injury, is our current treatment protocol.

Closed Reduction is indicated for *displaced fractures*, in which there is radiographic evidence that a

stable re-alignment of the fracture fragments can be achieved and that the minimal residual inter-fragmentary motion can be controlled with meticulous casting technique. Adequate anesthesia, depending on the local soft tissue conditions, is imperative. Fracture hematoma block, intravenous regional, brachial plexus block or general anesthesia have specific indications. The first two are usually selected for low energy displaced fractures without significant swelling.

Manipulative Reduction is obtained by applying the opposite force to the one responsible for the fragment displacement (mechanism of injury). However, the first step is to disimpact the fracture by increasing the initial deformity. Following this, Colles fractures are reduced with a combined application of traction, palmar flexion, and pronation of the distal fragment. Conversely, Smith fractures will require extension and supination of the distal fragment.

Longitudinal Traction with finger traps and a counterweight applied to the arm is an alternative method that uses the principle of ligamentotaxis for disimpaction and fragment realignment. Although length and ulnar inclination is invariably achieved, restoration of palmar tilt requires and additional palmarly directed force, by translating the hand palmarly. This displaces the capitate palmarly, which in turn palmarly rotates the scaphoid and lunate effectively and forces the distal fragment into flexion (1).

IMMOBILIZATION

I prefer the three-point contact casting technique of Charnley (2). This implies the application of two points of contact proximally and distally to the fracture on the side of the concavity of the initial angulation, and a counter-point of contact at the fracture level on the convexity of the initial angulation. A slight bend to the splint or cast (10-15°) will place the soft-tissue hinge (periosteum and overlying tendons) under tension, provided that the opposite cortex has good contact (tension-band principle), and will maintain a stable reduction.

Colles' fractures are immobilized initially in 15° of palmar flexion and slight pronation (25°) the first two weeks in a sugar tong splint. Conversely Smith fractures will require 30° of dorsal flexion and 40° of supination.

For the first two weeks the sugar tong splint is maintained, and follow-up X-rays are performed 3, 7, and 12 days following reduction; this enables to detect early loss of reduction, and whether or not settling and residual deformity is acceptable or not. During the first two weeks the initial splint should be adapted and re-molded as soon as soft tissue swelling decreases. This is obtained with tighter wrapping of the splint with elastic bandages at the time of the X-ray controls. In this way a continuous and sufficient pressure is maintained throughout the early post-reduction period, reducing the possibility of secondary displacement. At two weeks the splint is changed to a short forearm cast for another 3-4 weeks, taking care to maintain the 3-point contact principle avoiding bulky padding of the cast.

When does closed reduction and casting work?

The ideal scenario is a bending type fracture with moderate amount of angulation (25-30°), moderate metaphyseal comminution on the concave side of the angulation and a simple transverse fracture of the opposite cortex as well as adequate bone quality. If the simple cortical non-comminuted fracture is well reduced without over-lapping of the fracture edges (palmar cortex in a Colles fracture),

and the soft tissue hinge is maintained under tension, the chances of secondary displacement are minimal. However, with increasing osteoporosis a greater amount of settling and shortening is to be expected.

OPERATIVE TREATMENT

Operative treatment is indicated in *extra-articular unstable fractures and displaced intra-articular fractures*. In both scenarios the goal of treatment is to achieve anatomic reduction of the fracture since anatomical reconstruction of both the radiocarpal and radioulnar joint architecture and ligamentous restraints are pre-requisites for the restoration of normal wrist kinematics. Practically, this is readily feasible with the current methods of treatment for both extra-articular unstable fractures and for simple intra-articular fractures patterns with a maximum of four to five sizeable fragments (3). However, achievement of this aim is very difficult, and sometimes impossible, if the joint is massively disrupted as in multifragmentary fractures. Additional chondral damage, ligamentous disruption, and distal radioulnar joint derangement associated with high energy insults will negatively influence the final outcome. For these "non-salvageable" intra-articular fractures the best possible joint alignment without carpal subluxation should be achieved with *legamentotaxis (bridging external fixation)*. Since the chances of salvaging the radiocarpal joint are minimal, every effort should be concentrated on the restoration of the radial length, so as to guarantee normal alignment of the distal radioulnar joint that will allow free and early forearm rotation. Metaphyseal defects should be grafted to accelerate fracture healing and permit early removal of the frame. This approach offers the best possible scenario for reconstructive surgery if the wrist becomes painful.

Reducible extra-articular unstable fractures of the young adult can be adequately managed with closed reduction and *extra- or intrafocal pinning*. Due to the good bone quality in this age group, there is good pin purchase and the chances of secondary

displacement, settling, and shortening are minimal. *The non-bridging fixator is an excellent alternative* (4, 5), especially if there is significant metaphyseal comminution and danger of shortening. This is because it provides cast free after-treatment, controls radial length, offers direct control of the distal fragment (thus allowing restoration of the palmar tilt), and can be safely maintained in place for longer than bridging fixators. Autologous bone grafting should be readily used to fill significant bone defects or devascularised comminuted areas associated with high energy trauma.

Plating is a valid alternative and formally indicated for those extra-articular fractures that are *irreducible*, and also for demanding patients who require early recovery of use of the hand. The prerequisites of plate fixation are solid bony purchase of the screws (adequate fragment size and absence of osteoporosis) and exact reduction of the bony cortex opposite the plate: otherwise additional bone grafting should be used. Especially on the dorsal side of the wrist, the implant should be covered by a substantial retinacular flap to prevent attrition tendinitis. For this reason I prefer, whenever possible, *palmar plate fixation for dorsally displaced radial fractures* (6). The Henry palmar approach is straight forward, and in most cases the palmar cortex has a simple fracture line without comminution. This allows easy anatomic reduction, which automatically restores radial length as well as the palmar and ulnar tilts of the joint surface. Most of the palmar plates available are manufactured with a contour to match the concavity of the palmar radial surface of the radius and the newer plate designs have fixed angle buttress pins. If these pins are placed in a subchondral position, secondary displacement of the fracture is practically impossible, even in osteoporotic bone, since the plate is now acting as an internal fixator. Indirect reduction of the comminuted dorsal cortex maintains vascularity of the fragments and accounts for the rapid healing of the fracture, rendering bone grafting unnecessary. The advantages of palmar plate fixation include avoidance of damage to the extensor tendons (provided that the screws do not protrude dorsally!), the absence of dorsal scarring which produces bet-

ter wrist flexion, and the ability to address pronator quadratus interposition between the fracture fragments which frequently renders the fracture irreducible.

The primary aim in the treatment of *"salvageable" intra articular displaced fractures* is anatomic reduction of the joint surface.

The management of *shearing or partial articular fractures* has stood the test of time and have been treated since the early work of Ellis (7, 8) with open reduction and internal fixation (lag screws, buttress plating). For 3- and 4-part intra-articular fractures if reduction is obtained with longitudinal traction and minimally invasive fixation techniques using fluoroscopic and/or arthroscopic control and followed by a relatively short period of immobilisation with bridging fixation, there is a good chance of obtaining satisfactory long term results (9-12). On the contrary the current management trend for *irreducible compression fractures of the joint surface (C3 fractures, or pilon fractures of the distal radius)*, has drastically shifted from bridging external fixation, pins, and bone grafting to open reduction and stable internal fixation and functional after-treatment.

In 1991 we published the results of *limited open reduction and fragment specific fixation* of patients treated between 1979 and 1986 (13). This technique was recommended for irreducible intra-articular fractures, in other words, for those that reduction was judged unacceptable following closed reduction or after a trial of ligamentotaxis with external fixation. Special emphasis was given to the *volar-ulnar fragment* most of the times fixes with a small L- or T-plate through a proximally extended carpal tunnel (ulnovolar) approach, and then the dorsal die punch was reduced closed with radial deviation and volar flexion, or open through a small dorsal incision, if impacted. The radial styloid fragment was reduced closed and pinned percutaneously obliquely to the shaft. Postoperative immobilization in a sugar-tong splint for two weeks followed by a short forearm-cast was utilized. A short period of bridging external fixation (five weeks) was used only for cases with metaphyseal comminution (risk of shortening) or osteopo-

roris. However, all these patients were grafted with autologous iliac bone, both to accelerate fracture healing, fixator removal, and to provide mechanical subchondral buttressing of small articular fragments. Medoff (14, 15) refined fragment specific fixation with a system of low profile implants to minimize extensor tendon irritation, especially designed for each articular component. The bending stiffness of conventional K-wire fixation was increased by passing through the free end of a plate secured to the cortex of the shaft fragment, creating a "pin-plate" with a rigid three-point fixation construct for stable fixation of the radial column. With additional subchondral buttress pins and a volar L-plate, the combination of cortical screw fixation proximally and subchondral buttressing distally, early cast free after-treatment was possible. Jupiter and Ring have recently adopted fragment specific fixation through a dorsal and a volar-ulnar approach using AO locking plates for the distal radius (16).

Management of articular fractures through a *dorsal approach* and *dorsal single or double plate fixation* (17-20) allows reduction of the radial styloid, central joint impaction, proximal carpal row, and the dorsal die-punch fragment. Although it may be utilized in four-part fractures with a non-displaced volar-ulnar fragment, the risk of iatrogenic displacement is relatively high. The major disadvantage of the dorsal exposure are that it does not permit direct control and visualization of the volar ulnar fragment, which is the *keystone* of the distal radial joint surface. Failure to restore the anatomy of the volar ulnar corner, the concavity of the lunate fossa, and the corresponding area of the sigmoid notch is *fatal* for both the radiocarpal and distal radioulnar joints! Furthermore, in spite of newer low profile designs, implants placed under the extensor tendons have a non-negligible incidence of irritation, attrition tendinitis, and late tendon rupture.

One of the most important recent development of distal radius internal fixation technology has been the introduction of fixed-angle pegs and screws to conventional plates (6, 20, 21). This avoids screw loosening in the distal fragment ("toggling effect"), reducing the danger of second-

dary displacement. Subchondral placement of smooth pegs are useful to buttress small articular fragments, and successfully controls shortening and angular displacement (especially in the osteoporotic bone), since the plate is now functioning as an "internal fixator".

Management of compression fractures of the articular surface through a *volar approach* is also possible (6, 22). This implies the use of an extended flexor carpi radialis volar approach with release of the radial septum (brachioradialis insertion and palmar sheath of the 1st extensor compartment), that facilitates better visualisation and reduction of the radial styloid fragment.

Furthermore by pronating the shaft fragment the dorsal die-punch and centrally impacted fragments can be visualized through the fracture plane (intrafocal exposure) and manipulated into a reduced position against the proximal carpal row. Thereafter the proximal fragment is supinated back in place and the fracture fixed with a volar T-shaped fixed-angle plate. The volar and dorsal ulnar fragments are stabilized with a screw through the plate. The major advantage of this technique is the absence of extensor tendons related complications. Furthermore, a single implant controls stability of both the radial and ulnar columns and provides subchondral buttressing the articular fragments. Indirect reduction of the dorsal comminuted area with preserved vascularity accounts for the rapid healing of the dorsal cortex, therefore reducing the need of bone grafting significantly.

Several authors (23-28) have favored the use of *arthroscopic assisted reduction* in the management of intra-articular fractures of the distal radius, claiming better visualization of the joint surface, TFCC, and carpal ligaments with minimal soft tissue disruption (devascularization of bony fragments) and avoidance of extensive capsulotomies, that may lead to post-operative stiffness or even radiocarpal instability. There is still, however, a lack of consensus of whether the appraisal of residual congruity following reduction with fluoroscopy alone is sufficient to attain the desired less than 1 mm step of or anatomical result. Arthroscopy may detect fragment tilting in the sagittal plane, not ap-

precited on lateral fluroscopy because of the overlapping images of the scaphoid, distal ulna, and lunate fossae (27). One of the greatest advantages of arthroscopic techniques is the early detection and concomitant treatment of associated carpal ligament and TFCC disruption.

It is important to stress the necessity for the early assessment and management of concomitant carpal ligament injuries and distal radioulnar lesions, since their sequelae are responsible for a large number of painful wrists, even if there was an adequate reduction of the fracture of the radius. Associated intercarpal ligament lesions, especially non-dissociative ones, are often not recognised at the time of the injury. Risk factors that should alert suspicion include: the mechanism of injury, an intra-articular fracture line which enters the scapholunate ridge, and massive displacement of the scaphoid and lunate facets of the radiocarpal joint surface which are readily seen in plain radiographs. Traction views may show an axial scaphoid shift sign with disruption of the Gilula lines (29) and early wrist arthroscopy will provide an accurate diagnosis (30). Dissociative tears require aggressive initial treatment with primary repair, while non-dissociative tears will heal adequately in the time required for fracture healing (27, 31). Similarly, triangular fibrocartilage tears with or without fracture of the ulnar styloid, primary distal radioulnar joint instability, and intra-articular fractures affecting the joint need to be assessed immediately after completion of the distal radius fixation. Distal radioulnar joint disruption with initial clinical instability and radiographic incongruity deserves primary treatment, while stable lesions are managed with early functional forearm rotation exercises.

Finally, for more *complex fractures patterns such as C3-3 or Type V combined injuries (high energy trauma)* no single implant or technique is appropriate to solve all the components of the fracture and associated soft tissue injuries. Usually a combined dorsal and volar exposure with compartment and median nerve release, *autologous cancellous bone grafting* of metaphyseal defect and a combination of external and internal fixation is required.

The final outcome of distal radial fractures is undoubtedly multifactorial. Our role is to clearly identify the fracture type and associated injuries and provide the best possible restoration of anatomy with the simplest and safest method. Due to wide variety of fracture patterns and increasing complexity of these injuries, it is imperative that surgeons retain a flexible approach to treatment choice and master non-operative management, as well as both external and internal skeletal fixation techniques.

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