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Proceedings

Symposia Handouts
Abstracts of Posters
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American Academy of Orthopaedic Surgeons®
FRAGMENT SPECIFIC FIXATION AND EARLY RANGE OF MOTION

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I. Treatment of distal radius fractures has evolved
A. Better understanding of propensity of unstable fractures to displace in plaster
B. Recognition of importance of augmentation using K-wires
C. Use of bone graft to support crushed metaphyseal component
D. Attention to individual unstable components of complex fractures
   1. “Fragment-specific” fixation
   2. Bi-columnar fixation

II. External fixation relies on “Ligamentotaxis”
A. Distraction force through articular capsule-ligamentous tissues (from Gr. “arrangement”)
   1. Innovative use of technique previously reserved for long bone fractures
   2. Described in hip, ankle, spine, knee, wrist
   3. Recommended for severe articular fractures not amenable to internal fixation
   4. “…a technique for reducing complex comminuted fractures, reconstructing articular surfaces and preserving joint space…”
B. Widespread use for wrist fractures over last three decades
   1. Least effective for volar lip fragments
   2. Ineffective for impacted articular fragments
   ★ Traction alone is insufficient to restore articular congruency
   3. Viscoelasticity of collagenous tissues precludes maintenance of effective traction
      a. Stress relaxation
      b. Are there detrimental effects of excessive tension on ligaments
   4. Original Roger Anderson tenets frequently overlooked (1944)
      a. Fracture reduction easy to attain, difficult to maintain
      b. Inevitable subsidence is due to metaphyseal crushing
      c. Distraction is necessary for 8-12 weeks
      d. Limited open reduction is required for articular fragments
      e. Bone graft all unstable fractures
   5. Complications of ligamentotaxis directly related to degree and duration of distraction
   ★ Without direct fixation, unstable fragments will tend to settle into injury position

III. Internal fixation
A. Makes intuitive sense
   1. Improved outcomes of ORIF for articular fractures in upper and lower extremities
   2. Open reduction allows accurate assessment and reconstruction of joint surface
   3. Enables support of articular surface with bone graft
   4. Rigid internal fixation facilitates early joint motion, benefits articular cartilage
   5. Removal of cast simplifies management of ipsilateral bony or ligament injuries
   6. Open reduction allows repair of associated intercarpal pathology
B. Traditionally fixation implants lack modular design
   1. Fail to capture smaller articular fragments
   2. Unable to secure radial styloid
   3. Use of dual plates (volar/dorsal) unable to compensate
C. Complications of ORIF attributable in large part to soft-tissue disruption
   1. Complication rate reported between 15-35%
      a. Early (infection, wound dehiscence, loss of reduction)
      b. Late; including plate removal and tendon ruptures
      c. Nonunion
   2. Do “low profile” internal fixation systems reduce soft tissue complications?
      a. B plate: 13/22 satisfactory results, 23% tendinopathy, plate removal
      b. Forte plate: 59/73 excellent results
         i. 28% – unable to achieve rigid internal fixation intra-operatively
         ii. 12% loss of reduction during healing
         iii. 19% incidence of plate removal, tendinopathy
D. Steady improvements in ORIF outcomes over past decade

<table>
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<tr>
<th>Author</th>
<th># Pts</th>
<th>Type</th>
<th>% Bone</th>
<th>% ROM</th>
<th>% Grip</th>
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<td>97% G-E</td>
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E. Critical developments in past decade
1. Appreciation of complex fracture patterns
2. Biomechanical understanding of forces across fracture site
3. Enhancement in hardware design
4. Liberal use of bone graft
   ★ Bone graft all unstable distal radius fractures with impacted articular fragments
IV. Mechanical forces at fracture site can be substantial
A. Unanticipated externally applied loads (shopping bags, driving, raking leaves etc.)
B. Internal muscle forces
   1. Primary deforming forces on radial styloid fragment
      a. Pronator quadratus (rotates styloid into pronation)
      b. Abductor pollicis longus, EPB (shear force across fracture)
      c. Brachioradialis (inserts directly on styloid, causes subsidence)
   2. Estimated muscle loads vary considerably
      a. Physiologic muscle tone 40N\(^{22}\)
      b. Active resisted wrist motion 88-135N\(^{22}\)
      c. “Upper limit” of wrist forces estimated at 50N\(^{16}\)
   3. Grip forces generate extreme loads across wrist
      a. 26-52N generated across wrist for each 10N of hand grip\(^{22}\)
      b. Average male generates upwards of 450N grip
      c. Upper limit of grip force = 2410N

Requirements: low profile implants, limited incision techniques, improved mechanics

V. Bicolumnar concept of internal fixation
A. Ultra-low profile implants placed strategically along wrist “columns”\(^{22,27}\)
   1. Radial, intermediate and ulnar columns
   2. 2.0mm implants placed in two planes 50 - 70 degrees apart
      a. Dorso radial (2nd comp.) supports styloid
      b. Dorsoulnar (4th comp.) resists dorsal angulation
   3. 74 fractures reported; majority complex AO C-type fractures
   4. Excellent or good results reported in 97%\(^{22}\)
   5. 23% implant removal, 7% tendon rupture
B. Bicolumnar fixation compared to standard internal fixation\(^{22}\)
   1. Orthogonal 2.0mm plates compared to Pi plate, dorsal T-plate
   2. 4-point bending over 100-400N applied force in three planes
   3. Bicolumnar fixation = incr. stiffness over Pi and dorsal T-plate (p < 0.0001)
   4. Decreased angle of deformation and gap formation
C. Tramed (Valencia, CA) implants; incorporates bicolumnar concept of fixation
   1. Minimizes disruption of soft tissue envelope
   2. Modular system permits “Fragment-specific fixation”
   3. Pin-plates augment stability of percutaneous Kirschner wires
   4. Support articular fragments with wire forms (small fragment clamp, buttress pins)
   5. Biplane fixation: plates placed in orthogonal relationship for maximal stability

VI. Principles of Fragment-specific fixation (TriMed system)\(^{22}\)
A. Reduce fracture through closed or limited open incisions
B. Bone graft metaphyseal defect
C. Preliminary fixation of radial styloid with 0.045 Kirschner wire
D. Support articular fragments with wire forms (small fragment clamp, buttress pins)
E. Apply pin-plates to augment stability of Kirschner wires
F. Tailor modular system to meet requirements of individual fracture pattern

VII. Specific columnar applications
A. Radial column
   1. Key supporting structure of fixation construct
   2. Restores length, facilitates articular surface realignment
B. Intermediate column
   1. Modular implants to accommodate individual fracture configuration
   2. Precise restoration of sigmoid notch to restore DRUJ alignment

Incision: radial and palmar implants
C. Ulnar column
1. Unstable ulna shaft or neck fractures require internal fixation
2. Assess DRUJ stability at conclusion of fixation
3. Grossly unstable joint usually implies bony and soft tissue components
   a. Anatomically reconstructed and aligned sigmoid notch is crucial
   b. Dorsal and palmar DRUJ ligaments & IOM

4. Surgical options
   a. Casting in position of maximum stability
   b. Fixation of ulnar styloid to restore DRUJ ligaments
      i. Single 0.045in K-wire placed through mini-open incision into ulnar styloid
      ii. Engage metaphysis of ulna
      iii. Three hole Ulnar pin plate applied; fixed with two screws
   c. Open TFCC repair to flexor
d. Cross pinning of radius to ulna in neutral position
   i. Two 0.062" K-wires
   ii. Penetrate all four cortices, leave prominent on radial cortex
   iii. 4 weeks generally sufficient to restore soft tissue stability

References