Management of Arthroplasty in Elbow Fracture

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Anatomy of Elbow Joint
Anatomy of Elbow Joint

- 3-joint complex
  - Ulno-humeral joint
  - Radio-capitellar joint
  - Proximal radio-ulnar joint

- Need to withstand long moment arm and substantial joint reaction force

- Joint stability: equally contributed by soft tissues & bones
Anatomy of Elbow Joint

- Osseous
- Ligamentous
- Muscular
Anatomy of Elbow Joint

- A modified hinge joint
  - Centre of rotation moves during flexion-extension, suggesting a complex hinge motion
- One of the most congruent and complex joints
Anatomy of Elbow Joint

- Three articulations
  - Radiocapitellar
  - Ulnohumeral
  - Radioulnar
Anatomy of Elbow Joint

- Radiocapitellar joint
  - Pronation and supination
Anatomy of Elbow Joint

- Ulnohumeral articulation
  - Elbow stability
  - Trochlear notch of ulna
    - 55% stability to varus stress in extended elbow
    - 75% resistance to varus stress in 90° elbow flexion
Anatomy of Elbow Joint

- Joint capsule
- Collateral ligaments
  - Medial collateral ligament (MCL)
    - Maintain contact of ulnohumeral articulation
    - Primary stabilizer to valgus stress (30% restraint in extension and 55% in $90^\circ$ flexion)
    - Anterior band – major role
  - Lateral collateral ligament (LCL)
    - Maintain contact of radiocapitellar articulation
    - Restraint against posterolateral rotatory instability (PLRI)
Muscles

- Triceps (TR)
- Brachialis (BR)
- Biceps (BC)

- Exert posteriorly directed forces across ulnohumeral joint
- Coronoid process along with radial head acts as a buttress to such forces
- Anterior articular deficiency → posterior subluxation

Fig. 1. With the elbow flexing and extending, the major motors that flex and extend the joint (triceps [TR], brachialis [BR], and biceps [BC]) all have a component of the resultant vector of the active contraction directed posteriorly. This helps explain why the elbow is subluxed posteriorly when there is articular deficiency anteriorly, usually of the coronoid. (From Morrey BF, An K.)

Fig. 2. The coronoid process and radial head act as a buttress against posteriorly directed muscle forces.
Imaging

- X-ray
  - AP
  - Lateral
  - Capitellum view

- CT scan
Imaging

- Radiograph showing subtle abnormality of the coronoid
- CT scan allows appreciation of the fragment and facilitates preoperative planning
CT Scan
Radial Head Fractures
Mason Classification for Radial Head Fractures

From Calfee. R. Radial Head Arthroplasty.
Mechanism of injury

- Fall on an outstretched hand
- Pronated and semi-flexed position
- Valgus + axial loading onto the radial head from the capitellum
Associated injuries

- MCL
- PIN
- Wrist
- Fracture capitellum
- Fracture distal radius
- DRUJ dislocation & tear of interoseous membrane (Essex Lopresti fracture-dislocation)
- Triceps tendon rupture
- Elbow dislocation
Management

• Mason
  – I : Conservative
  – II : Conservative vs surgery
  – III : Attempt to preserve the head

• Indications for ORIF
  – Fail to achieve articular step off less than 2 mm by closed reduction
  – Fail to achieve functional ROM after administration of local anesthetic block, esp in younger pts
Management

• Radial head resection?
• Immediate, complete radial-head resection is to be avoided in Type-II fracture
  – Results of acute resection of frx frag are unpredictable
• Delayed radial-head excision +/- radial head replacement?
Management

- Aim: restore stability of PRUJ
- Options:
  - Fixation +/- bone graft
  - Partial excision
  - Total excision +/- radial head prosthesis
- AO Mini set - 1.5/2.0mm screws; countersunk
- Herbert/Accutrac screws as alternative
Management

- Posterolateral approach
  - Kocher incision
  - Plane: between anconeus & ECU
  - Capsular incision anterior to the lateral ligament complex

- PIN avoided by
  - Maintain pronation
  - Limit dissection to < 2.5cm distal to the joint
Complications

• Implant impingement
• Heterotopic ossification
• Joint stiffness
• Non-union and implant failure
• AVN of radial head

• Proximal migration of radius
• Valgus deformity in wrist/elbow
• Painful DRUJ & MCL
What is your choice of implant for fracture radial head and neck?
Radial Head Templating System + ORIF
Radial Head Templating System + ORIF
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Radial Head Templating System + ORIF
Radial Head Templating System + ORIF
Post-op Management

- POP slab
- Hinged elbow brace
- Elevation
  - Pillow
  - 90/90 elevation
- Chart drain
- X-ray elbow
  - AP
  - Lat
  - Capitellum view
- Check for any PIN palsy
- Physiotherapy
- Occupational therapy
Radial Head Templating System
+ ORIF
Removal of Implants
Radial Head Replacement
Indications

- Radial head too comminuted to repair
  - More than 3 fragments
- Presence of ligament injuries → instability
Problems of excision of radial head even in the absence of ligament instability

- Minor losses of elbow motion
- Loss of strength (15%)
- Radiographic evidence of OA of ulnohumeral joint
- Some degree of proximal radial migration (2-3mm)

Sanchez-Sotelo et al. Results of acute excision of the radial head in elbow radial head fracture-dislocation.
J Ortho Trauma 2000, 14: 354-358

Leppilahti J. Early excision of the radial head for fracture
Intl orthop 2000, 24: 160-162

Ikeda M. Function after early radial head resection for fracture, a retrospective evaluation of 15 patients followed for 3-18 years.
Implant type

- Ferrule capsules
  - By speed in 1941
- Silicone model
- Mono-block
- Modular
- Bipolar
• Titanium/ cobalt-chromium
• Loose-fitting stems/ press-fit/cemented stems
  – Spacer/true anatomical prosthesis
Silicone

- Obsolete
  - Induce aggressive synovitis
Monoblock

- Difficult to place with intact LCL “The very nature of most radial head implant designs impart an inverse relationship between the ability to place the implant and the stability afforded by the implant once in place” (Calfee J Hand 2006)
  - Swanson (titanium, Wright Medical)
  - Solar Radial Head (cobalt chrome, cemented only, Stryker)
  - Liverpool Radial Head Replacement (Biomet)
Modular

- Allows improved fit
  - Ascension (cobalt chrome, Ascension Orthopaedics)
  - Evolve (cobalt chrome, Wright Medical)
  - rHead (cobalt chrome, Small Bone Innovations)
Bipolar

- Allows head to self center in ROM avoiding edge binding
  - Katalyst (cobalt chrome, telescoping shaft, KMI)
  - Seitz radial head implant system (Kapp Surgical)
  - Judet (cobalt chrome, Tournier)
- Potential P.E wear
Monoblock vs Bipolar

- No preferences for monoblock over bipolar

Stanislaw P. Contribution of monoblock and bipolar radial head prosthesis to valgus stability of the elbow

JBJS 2001, 83: 12
• No large studies comparing implants
Surgical Approach

1. Lateral approach (Kocher)
2. Posterior approach over the olecranon
   - Additional fractures
   - MCL repair
Avoid disruption of lateral ulnar collateral ligament
Preserve annual ligament
Results

• 1993, Knight
  – 31 patients with Mason III and IV
  – Metal monoblock implant
  – Mean follow up 4.5 years
  – 24 out of 31 with negligible elbow pain
  – Mild loss of flexion and extension (20/10)
  – 2 required removal due to loosening
Results

- **1996, Judet**
  - Modular prosthesis in 12 patients
  - 5 acute reconstruction, 7 late reconstruction
  - 49 months follow up
  - 3 excellent and 2 good functional results in acute reconstruction
  - 1 excellent, 4 good, 3 fair in late group
  - No complications
Results

- 2001, Harrington
  - 20 patients with Mason III, IV
  - 12.1 years follow up
  - Metallic monoblock radial heads
  - 4 patients with implants removed due to pain
Results

- 2001, Moro
  - 25 cases with Mason III and IV
  - titanium monoblock radial head replacement
  - 39 months follow up
  - 17 – good/excellent results, 5 – fair result, 3 – poor outcomes
  - 5 complications: CRPS, ulnar neuropathy, PIN palsy, postop stiffness, wound infection
Results

• Ashwood et al JBJS 2004
• 16 patients with Mason III
• High percentage of ligament injury (injury repaired in contrast to Harrington.)
• Wright Medical monoblock
• 8 excellent, 5 good, 3 fair at 2.8 year follow up
Elbow Stability: Biomechanical Comparison Excision and Arthroplasty

- Beingessner et al. JBJS 2004
- Biomechanical comparison with and without ligamentous injury on 8 cadaveric specimens
- Ligament intact model
  - Excision caused increased varus/valgus laxity
  - Arthroplasty restored laxity to baseline
- MCL, LCL deficient model
  - Required both radial head replacement and ligament repair to restore varus/valgus stability
- Problems with study
  - MCL healing often occurs in vivo without need for fixation
Problems

1. Difficult to determine the correct implant size/diameter
   - Over-stuffing/under-stuffing
   - Radiocapitellar joint, sigmoid notch
   - Margin of error is very narrow
Problems

2. Stems controversy
   - Loose stems → loosening, intact annual ligament
   - Fixed stems → requires close approximation to native anatomy to achieve joint congruity

3. Edge binding problem in monoblock and modular type
Problems

4. Polyethylene wear is of concern in bipolar type

5. Lack of good anatomical implant
   - Ovoid head shape, 15 degree neck-shaft angle
   - Diversity of proximal radial anatomy
   - Poor correlation between head size and medullary canal diameter
   - Complicated biomechanical of radiocapitellar joint and proximal radioulnar joint
Complications

1. Loss of elbow flexion
   - Overstuffing of radiocapitellar joints in flexion
2. Aseptic loosening
3. Radiolucent lines around the stems
   - Very common
   - Unknown significant
4. Longevity
5. OA of capitellum
6. PIN injury, infection, heterotopic ossification, weakness, synostosis
Fig. 1
Lateral radiograph showing loosening of a cemented implant.

Fig. 2
Lateral radiograph showing loosening of a malpositioned uncemented implant.

Fig. 3
Lateral radiograph showing radiolucent lines around the stem of an implant revised for pain. This particular implant is designed to fit loosely in the canal.

Fig. 4
Lateral radiograph showing maltracking of the implant and capitellar erosion. Note ulnar subluxation.
Lateral radiograph a) showing the radial head component dissociated from the stem and b) Post-operative lateral radiograph of the same elbow. The radial head component was removed. At the time of surgery both the elbow and the forearm were stable, and it was decided to simply remove the head.
Case Example

- F/26
- Clerk
- Right handed
- Fell from height with right elbow injury when playing water game in Bali
- Admitted to local hospital in Bali
X-ray right elbow
Excision of radial head and TBW of olecranon fracture performed in Bali with posterior approach
Returned to HK 1/52 after injury
Progress

- 5 years after radial head replacement
- Occasional crepitation without pain
- AROM flexion 10 – 140
- S/P = 80/90
- No PIN palsy
Coronoid fracture

Fracture of the radial head and neck + dislocation = ‘the terrible triad’
**Management of Complex Fracture Dislocation**

<table>
<thead>
<tr>
<th>Table 3</th>
<th>Management of complex fracture dislocation</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Reduce elbow joint closed, or if not possible, open.</td>
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<tr>
<td></td>
<td>Reduce and solidly fix associated fractures ± replace radial head</td>
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<tr>
<td></td>
<td>Repair/reconstruct ligaments</td>
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<tr>
<td></td>
<td>Support with external fixator if;</td>
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<tr>
<td></td>
<td>Still unstable</td>
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<tr>
<td></td>
<td>Fracture fixation, or ligament repair tenuous</td>
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Fig. 1. Surgical treatment algorithm.
Distal Humeral Fractures
Classification of Distal Humeral Fractures

Figure 1  OA/OTA classification system for fractures of distal humerus.
Open Reduction and Internal Fixation

Figure 2  Postoperative anteroposterior (A) and lateral (B) radiographs of ORIF distal humeral fracture treated with perpendicular plates and triceps-splitting approach (15-year follow-up).

Figure 3  Postoperative anteroposterior (A) and lateral (B) radiographs of ORIF distal humerus treated with parallel plates and olecranon osteotomy.
Synthes LCP Elbow Set
Synthes LCP Elbow Set

**LCP Olecranon Plate**
Variety of plates:
- Left and right version
- Choice of six lengths with 2, 4, 6, 8, 10 or 12 LCP combi-holes in the shaft
Proximal portion of the plate with 8 locking holes allows to set a maximum number of locking screws.
Guide block for easy and correct insertion

**LCP Distal Humerus Plates**
Variety of plates:
- Dorsolateral plates with and without support
- Medial plates
- All plates in a left and right version
- All plates in five lengths: 3, 5, 7, 9 and 14 holes
Anatomically precontoured: no or only minimal bending necessary
Extensive options for fixation

**LCP Metaphyseal Distal Medial Humerus Plate**
Available in five lengths: 7, 9, 11, 13 and 15 holes
Anatomically precontoured: no or only minimal bending necessary
Improved vascularisation of the bone due to plate undercuts that reduce the plate-to-bone contact
Guide block for easy and correct insertion
Open Reduction and Internal Fixation vs Arthroplasty

• Is ORIF a better option than TEA for distal humerus fractures in patients older than 65 years of age?
Current Opinion

- Linked TEA increasingly popular in
  - Older patients
  - With fragmented fractures of distal humerus
  - And poor bone quality
- ORIF less predictable
  - In older patients owing to failure of fixation related to osteoporosis
  - Risks of nonunion, stiffness
- TEA associated with rapid recovery of elbow motion and comfort
  - More severe complications e.g. prosthetic infection and failure of triceps mechanisms
  - Requires strict activity limitations
  - Eventually loosen and fail
Indications for TEA

Acute distal humeral fractures
1. Nonrheumatoid patients over the age of 75 years;
2. Patients with rheumatoid elbow disease any age;
3. Patients with reduced life expectancy any age;
4. Patients with pathological bone any age;
5. Patients with degenerative elbow disease over the age of 60 years.

Complications of distal humeral fractures
1. Post-traumatic arthritis over the age of 60 years.
2. Non-union of the distal humerus over the age of 70 years.
## Complication Rates after TEA

<table>
<thead>
<tr>
<th>Complication at 90 d</th>
<th>Overall Rate (n = 1,625)</th>
<th>Rheumatoid Arthritis (n = 364)</th>
<th>Osteoarthritis (n = 189)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infection/wound complication</td>
<td>5.42% (88)</td>
<td>4.67% (17)</td>
<td>7.41% (14)</td>
</tr>
<tr>
<td>Revision</td>
<td>0.92% (15)</td>
<td>1.10% (4)</td>
<td>2.12% (4)</td>
</tr>
<tr>
<td>Repeat surgery</td>
<td>8.12% (132)</td>
<td>3.85% (14)</td>
<td>4.76% (9)</td>
</tr>
<tr>
<td>Pulmonary embolism</td>
<td>0.25% (4)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mortality</td>
<td>0.62% (10)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Failure at 1 y</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Revision</td>
<td>2.95% (48)</td>
<td>3.02% (11)</td>
<td>6.35% (12)</td>
</tr>
<tr>
<td>Long-term</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Revision/amputation/arthrodesis</td>
<td>7.75% (126)</td>
<td>10.16% (37)</td>
<td>12.17% (23)</td>
</tr>
</tbody>
</table>
### Complication Rates after TEA

#### Table II  Complications of total elbow replacement

<table>
<thead>
<tr>
<th>Complication</th>
<th>Incidence (%)</th>
<th>Incidence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aseptic loosening (clinical)</td>
<td>6.4</td>
<td>5.1 ± 3.4**</td>
</tr>
<tr>
<td>Aseptic loosening (clinical and radiographic)</td>
<td></td>
<td>13.7 ± 6.8***</td>
</tr>
<tr>
<td>Link designs</td>
<td></td>
<td>10.1 ± 4.8†</td>
</tr>
<tr>
<td>Unlinked designs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dislocation/subluxation</td>
<td>6.5</td>
<td>4.7 ± 3.0**</td>
</tr>
<tr>
<td>Infections, deep</td>
<td>4.6</td>
<td>3.3 ± 2.9**</td>
</tr>
<tr>
<td>Intraoperative fractures</td>
<td>3.2</td>
<td>3.0 ± 2.7**</td>
</tr>
<tr>
<td>Fractures of prosthesis</td>
<td>0.6</td>
<td>2.9 ± 3.6**</td>
</tr>
<tr>
<td>Ulnar nerve complications</td>
<td>10.4</td>
<td>2.9 ± 2.4**</td>
</tr>
<tr>
<td>Delayed healing</td>
<td></td>
<td>2.5 ± 2.6**</td>
</tr>
<tr>
<td>Postoperative fracture</td>
<td></td>
<td>2.4 ± 2.1**</td>
</tr>
<tr>
<td>Triceps complications</td>
<td></td>
<td>2.4 ± 2.4**</td>
</tr>
<tr>
<td>Bushing wear</td>
<td></td>
<td>2.3 ± 3.4‡</td>
</tr>
<tr>
<td>Disassembly</td>
<td></td>
<td>2.3 ± 3.5‡</td>
</tr>
</tbody>
</table>

* Incidence as weighted mean ± SD.
** Total number of TEAs = 2938.
*** Total number of TEAs = 703.
† Total number of TEAs = 1071.
‡ Total number of TEAs = 865.
Figure 1  Lateral radiographs of an unconstrained TEA design demonstrating significant loosening of humeral components.

Figure 2  Instability of prostheses: AP radiograph of unconstrained design demonstrating medial dislocation of articulating surfaces.

Figure 3  AP radiograph of semi-constrained TEA shows evidence of significant loosening resulting from deep infection.

Figure 4  Lateral radiograph of a fully-constrained TEA design demonstrating significant loosening.
Figure 5  AP radiographs of semi-constrained TEAs (A) and (B) demonstrating wear of bushings with the associated osteolytic process.
Figure 6 Instability of prosthesis: Lateral view of a semi-constrained design demonstrating disassembly of the pin and lock mechanism.
Open Reduction and Internal Fixation vs Arthroplasty

- Frankle et al
  - Retrospective study
  - Women over age 65 treated with TEA (12 cases) or ORIF (12 cases)
  - ORIF
    - Excellent 4
    - Good 4
    - Fair 1
    - Poor 3, requiring TEA
    - Mean Mayo elbow score 87.5
  - TEA
    - Excellent 11
    - Good 1
    - Mean Mayo elbow score 98
# Mayo elbow performance score

## Function

**Pain (Maximum 45 points)**
- None (45 points)
- Mild (30 points)
- Moderate (15 points)
- Severe (0 points)

**Mean**

**Range of motion (maximum 20 points)**
- Arc $>100^\circ$ (20 points)
- Arc $50^\circ$ to $100^\circ$ (15 points)
- Arc $<50^\circ$ (5 points)

**Mean**

**Stability (maximum 10 points)**
- Stable (10 points)
- Moderately unstable (5 points)
- Grossly unstable (0 points)

**Mean**

**Function (maximum 25 points)**
- Able to comb hair (5 points)
- Able to feed oneself (5 points)
- Able to perform personal hygiene tasks (5 points)
- Able to put on shirt (5 points)
- Able to put on shoes (5 points)

**Mean**

**Mean total (maximum, 100 points)**
Open Reduction and Internal Fixation vs Arthroplasty

- Charissoux et al
  - Patients older than 65 years treated with ORIF (172 cases) or TEA (44 cases)
  - ORIF
    - Mean age 77y
    - Excellent or good 77%
    - Complications 20%
    - Re-operations 13%
    - Mean Mayo elbow score 84
  - TEA
    - Mean age 81y
    - Excellent or good 83%
    - Complications 14%
    - Re-operations 6%
    - Mean Mayo elbow score 77
Open Reduction and Internal Fixation vs Arthroplasty

- The Canadian Orthopaedic Trauma Society
  - Multicenter, prospective, randomized, controlled trial
  - 40 patients older than 65 years
  - 5 patients changed from ORIF to TEA during surgery because fracture could not be repaired
  - 25 subjects treated with ORIF had higher Mayo elbow score than TEA at all time points
  - Disabilities of the Arm, Shoulder, and Hand score not significantly different at 1 or 2 years
New Classification of Distal Humeral Fractures

1. Extra-articular
2. Predominantly Intra-articular
3. Predominantly Articular

Figure 1: New classification for fractures of distal humerus. AP, Anteroposterior.
**Management algorithm**

- **Type I** (Solely extra-articular)
  - ORIF
    - Posterior approach
    - No olecranon osteotomy
- **Type II** (Predominantly intra-articular)
  - ORIF with olecranon osteotomy
- **Type III** (Predominantly articular)
  - Fit & active
    - ORIF with olecranon osteotomy
  - Elderly
    - Osteopenia
    - Arthritis
    - Total elbow arthroplasty

**Figure 2** Management algorithm for fractures of distal humerus using new classification as functional tool. *ORIF*, Open reduction–internal fixation.
Algorithm for Management of Displaced Distal Humeral Fractures

Figure 7  Algorithm for management of displaced distal humeral fractures regarding fixation (ORIF) versus arthroplasty (TEA).
Types of Elbow Prosthesis

Figure 2 A. Unlinked, nonconstrained, condylar elbow prostheses: Roper, Lowe, Kudo. B. Semiconstrained, more anatomic elbow prostheses of Souter and Ewald. C. Linked elbow prostheses (sloppy hinges) with axle or snap-fit mechanism: prostheses of Schlein and Inglis (Tri-axial), Pritchard-Walker-2 prosthesis, Dee 2 prosthesis, and that of Coonrad. D. Linked elbow prostheses (sloppy hinges) with flanges on humeral condyles: Mayo-Coonrad 2 and GSB III.
Fig. 1. Coonrad-Morrey total elbow system. (Courtesy of Zimmer, Warsaw, IN; with permission.)

Fig. 2. Discovery elbow system. (Courtesy of Biomet, Warsaw, IN; with permission.)

Fig. 3. Solar elbow system. (Courtesy of Stryker, Kalamazoo, MI; with permission.)
Fig. 3. Unlinked (A), and linked (B) and (C) hemiarthroplasty versions of the Latitude System. (Courtesy of Tornier Inc, Stafford, TX; with permission.)
Hemiarthroplasty

**Figure 10** The Sorbie-Questor (Wright Medical Technology, Arlington, TN) implant is an example of an anatomic implant that can be used for hemiarthroplasty of the distal humerus.
Hemiarthroplasty

**Figure 6**  Postoperative anteroposterior (A) and lateral (B) radiographs of comminuted distal humeral fracture treated with distal humeral replacement using “triceps on” approach in elderly patient.
Figure 6  The varus-valgus angulation (top) and internal-external rotation (bottom) of the implant articulating axis with respect to the distal humeral target flexion-extension axis is shown for the (A, B) navigated and (C, D) non-navigated stage I alignment scenarios. The thick black line represents the mean angle, blue represents values within 1 standard deviation of the mean line, and yellow represents the remaining values.

Figure 7  The varus-valgus angulation (top) and internal-external rotation (bottom) of the implant articulating axis with respect to the distal humeral target flexion-extension axis is shown for the (A, B) navigated and (C, D) non-navigated stage II alignment scenarios. The thick black line represents the mean angle, blue represents values within 1 standard deviation of the mean line, and yellow represents the remaining values.
Open Reduction and Internal Fixation vs Arthroplasty

- Infirm, inactive, older patients
  - TEA or
  - Nonoperative treatment
    - The so-called “bag of bones” treatment

- Active patients
  - Prepared for both ORIF and TEA
Figure 1  The exposure for total elbow arthroplasty may consist of preserving the triceps mechanism, reflecting the triceps mechanism, or splitting the triceps mechanism. (By permission of Mayo Foundation for Medical Education and Research. All rights reserved.)
Fig 3. Surgical approach for total elbow arthroplasty. (A) Bryan-Morrey posterior incision in which the ulnar nerve is identified and protected. (B) Triceps is released from the tip of the olecranon in continuity with forearm fascia and periosteum exposing area of bone to be resected (dotted lines). (C) Humerai and ulnar bone cuts completed. Triceps is reattached to the ulna.
Figure 6  (A) Left and right: The Mayo Bryan-Morrey approach reflects the triceps from medial to lateral removing Sharpey’s fibers and elevating the anconeus from its bed.  (B) By flexing the elbow and releasing the collateral ligaments a complete exposure of the joint is afforded.  (C) With the Bryan-Morrey, as well as all of these exposures, meticulous repair of the triceps mechanism is required. This typically requires drill holes through the proximal ulna (left), a heavy suture placed with locked stitches in the triceps tendon (center), and then a circumferential type of suture to hold the triceps attachment firmly to the ulna (right).  (By permission of Mayo Foundation for Medical Education and Research. All rights reserved.)
FIGURE 1: A Illustration and B intraoperative photograph for positioning the humeral cutting guide.
Figure 1  A Coonrad Morrey prosthesis, on the right is the ulna component next to it the larger humeral component. The bushings are inserted when the elbow is in its reduced position making this a linked prosthesis.

FIGURE 2: Illustration for placement of the axis locking pins.
Figure 1 Schematic drawing of an elbow with a Coonrad-Morrey TEA in place. Note that 3.5° of varus and 3.5° of valgus are built into this design. This type of prosthesis is frequently referred to as a sloppy-hinge device.
Figure 3 A, Correct depth of insertion of ulnar component. The tip of the coronoid process (1) is resected. There is clearance between the coronoid process and the anterior flange of the humeral component (2). Flexion is unrestricted. B, Insertion of ulnar component too deeply, resulting in anterior impingement between coronoid process (1), and anterior flange of humeral component. Flexion is restricted. C, Correct depth of insertion of ulnar component. The coronoid osteophyte (1) has not been resected, resulting in anterior impingement and restricted flexion.
Post-op Management

- POP slab
- Chart drain
- Elevation
  - Pillow
  - 90/90 elevation
- X-ray
  - Elbow
  - Humerus
  - Ulna
- Physiotherapy
- Occupational therapy
**FIGURE 4.** The collar and cuff positions the elbow at 90° of flexion.

**FIGURE 5.** The nighttime extension splint. The straps around the elbow cross to pull the elbow into the splint. Caution must be used so that the straps do not compromise the posterior wound.

**FIGURE 6.** The static progressive flexion cuff is an acceptable method of helping to achieve end range of motion for elbow flexion.

**FIGURE 7.** The static progressive elbow flexion turn-buckle is the desired method for improving flexion for patients with stiff elbows.
Case Example

- F/78
- Walked unaided
- Living with a domestic helper
- Comminuted fracture right distal humerus after slipped and fell
Right Total Elbow Replacement + Ulnar Nerve Transposition

- No pain
- No neurovascular deficit
- AROM flexion 20-110 degrees
- Supination /Pronation full