Management of Geriatric Elbow Injury

Naoko Onizuka, MD, PhD, MPH[a,b], Julie Switzer, MD[a,b], Chad Myeroff, MD[c,*]

KEYWORDS

• Geriatric trauma • Elderly • Elbow trauma • Distal humerus fracture • Olecranon fracture
• Elbow dislocation • Terrible triad injury • Radial head fracture

KEY POINTS

- Approximately 4.1% of all fractures in the elderly involve the elbow.
- Most elbow injuries in geriatric patients occur as the result of low-energy mechanisms such as falls from standing height.
- Elbow injuries in elderly patients present complex challenges because of insufficient bone quality, comminution, articular fragmentation, and preexisting conditions, such as arthritis.
- Medical comorbidities and baseline level of function must be heavily considered in surgical decision making.

MANAGEMENT OF GERIATRIC ELBOW TRAUMA

Introduction

Approximately 4.1% of fractures in the elderly involve the elbow.[1] Elderly patients are at risk for elbow injuries following low-energy falls. Such injuries occur secondary to deconditioning, muscle weakness, gait and balance deficits, poor vision, and concomitant osteopenia or osteoporosis.[2] In 1 study of 287 patients, it was determined that nearly 70% of patients who sustain an elbow fracture fall directory onto their elbow because they cannot break the fall with an outstretched arm.[3] Older patients with elbow trauma tend to be more fit than those with proximal humerus fractures but less fit than those with distal radius fractures.[3] Regardless of a patient's underlying state of health or age, elbow injuries in the elderly can impact mobility, function, and ultimately, independence.

DISTAL HUMERUS FRACTURE

Epidemiology

Distal humerus fractures comprise approximately 2% of all fractures but represent one-third of elbow fractures.[1] Distal humeral fractures have an estimated incidence of 5.7 per 100,000 persons per year.[4] Most distal humerus fractures in geriatric patients occur from low-energy injuries, such as falling from standing height.[5] They have a bimodal age distribution, with peak incidences between 12 and 19 years and those aged 80 years and older.[6]

Clinical Assessment

It is imperative to understand the patient's medical and physical frailty and level of independence, including gait assistance, living situation, and level of function. The physical evaluation includes assessing the ipsilateral shoulder and wrist. Skin needs to be carefully examined for abrasions, fracture blisters, skin tenting, and open wounds.[7] Open elbow injuries are common and should be treated with standard open fracture protocols that involve removing gross contamination, soft tissue coverage, splinting, early antibiotics, and timely surgical irrigation and debridement.[7–9] Neurologic examinations must be performed and accurately documented preoperatively and postoperatively. Incomplete

[a] Department of Orthopaedic Surgery, University of Minnesota, 2512 South 7th Street, Suite R200, Minneapolis, MN 55455, USA; [b] Department of Orthopaedic Surgery, Methodist Hospital, 6500 Excelsior Boulevard, Saint Louis Park, MN 55426, USA; [c] TRIA Orthopedic Center, 155 Radio Drive, Woodbury, MN 55125, USA
* Corresponding author.
E-mail address: Chad.M.Myeroff@healthpartners.com

Orthop Clin N Am ■ (2021) ■–■
https://doi.org/10.1016/j.ocl.2021.05.009

ulnar neuropathy is present in 26% of patients with Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association (AO/OTA) type C distal humerus fractures at the time of presentation.[10] Vascular injuries should be ruled out by examining the distal pulses, capillary refill, and color.[7,10]

Imaging

Standard anteroposterior and lateral radiographs of the elbow are necessary for diagnosis, classification, and surgical templating. Radiographs of the joints above and below are essential as concomitant distal radius fractures are not uncommon (case 2, see Fig. 5; case 3, see Fig. 10).[11] In elderly patients who have highly comminuted fractures, a computed tomographic (CT) scan is helpful to identify and visualize fracture patterns.[10,12]

Classifications

There are several classification systems, but the AO/OTA classification is used most frequently (Fig. 1).[13,14] Type A fractures are extra-articular and may involve the epicondyles or occur at the distal humerus metaphyseal level. Type B fractures are partial articular and include unicondylar fractures or fractures of the articular surface involving the capitellum, trochlea, or both. Type C fractures are complete articular fractures. In type C fractures, there is no continuity between the articular segments and the humeral shaft.

Treatment

The treatment of distal humerus fractures in older patients can be challenging.[15,16] High degrees of comminution, insufficient bone stock, underlying osteoarthritis, and preexisting medical comorbidities weigh heavily on treatment decision making.

Nonoperative treatment

Nonoperative treatment is generally reserved for patients who are medically unfit to undergo surgery. In patients for whom anesthesia or surgery-related risks are too high, conservative treatment is considered to be appropriate.[17,18] Low-demand patients with severe osteoporosis, patients with poor-quality skin, or patients with nondisplaced fractures may also be managed with nonoperative management (case 1, see Fig. 1; Figs. 2 and 3).[17] They can be managed with immobilization for 2 to 3 weeks followed by early mobilization.[17]

Open reduction and internal fixation

In the active patient, nonoperative treatment often results in loss of function and disability because of prolonged immobilization.[7,19–21] Nauth and colleagues[19] demonstrated that patients treated nonoperatively have almost 3 times the risk of an unacceptable result (relative risk = 2.8, 95% confidence interval, 1.78–4.4). In a study of 497 patients, Obert and colleagues[20] reported the conservative treatment group's complication rates were 60%. In this analysis, the main complication was malunion. Thus, anatomic reduction and rigid internal fixation with early physiologic motion is considered the gold standard for most fractures of the distal humerus (case 2, Figs. 4–7).[6,19–30]

Good to excellent outcomes of open reduction and internal fixation (ORIF) for distal humerus fractures in elderly patients have been reported. A retrospective cohort study of distal humerus fractures in patients older than 70 years of age reported an average flexion arc of 20.9° to 127°, average pronation and supination of 68.3° and 75.3, respectively, and a mean Mayo Elbow Performance Score (MEPS) of 88.7.[31] Similarly, Ducrot and colleagues[32] retrospectively studied 43 elderly patients (mean age of 80) who were treated with locking plate fixation. They reported a mean flexion arc of 23° to 127° and satisfactory functional recovery, with 95% good and excellent results. Clavert and colleagues[33] reported satisfactory results with a mean MEPS of 87 in elderly patients with ORIF. Complication rates were reported in a wide range (19% to 53%) and included neuropathies, mechanical failure, elbow stiffness, nonunions, deep infections, or wound dehiscence.[20,33–38]

An olecranon osteotomy is commonly used for AO/OTA type C fractures, as it allows visualization of the distal humerus articular surface.[39] The complications associated with an osteotomy include nonunion/malunion (3.3%) and hardware irritation (10%–82%).[40,41] Kaiser and colleagues[42] reported a limited columnar fixation and olecranon-sparing approach for intraarticular fractures in an elderly population as a valid treatment option with similar elbow motion, function, and pain relief when compared with ORIF with an osteotomy. This approach may be used in geriatric patients who are medically unwell or who have such poor bone quality that anatomic reduction with an olecranon osteotomy would be challenging. Avoiding an osteotomy may allow not only more aggressive rehabilitation but also arthroplasty as an intraoperative fallback.

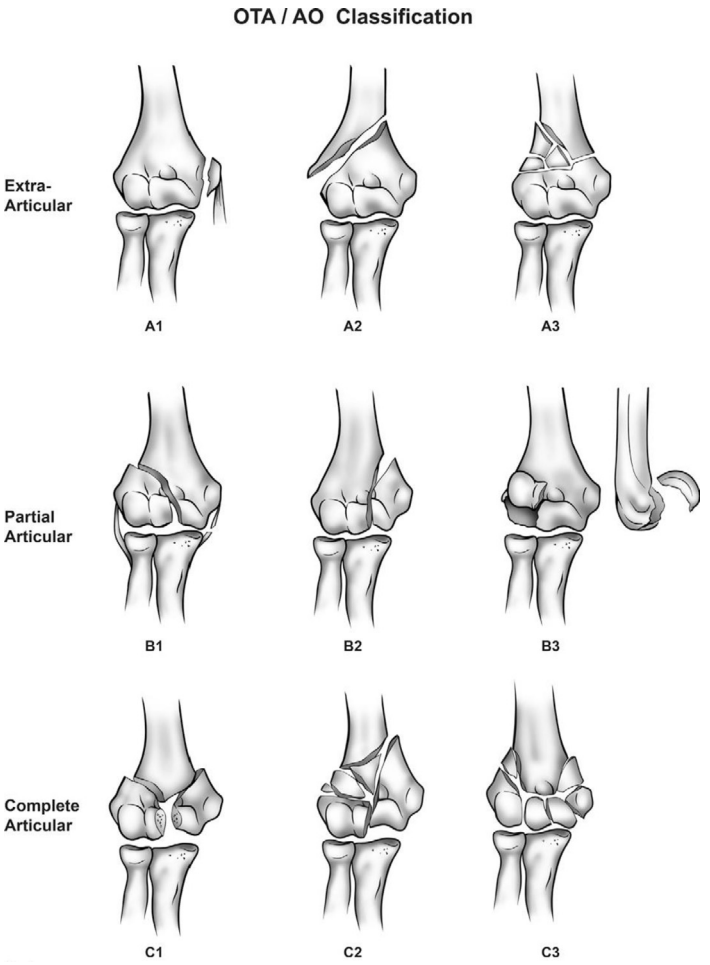

Fig. 1. The AO/OTA classification of distal humerus fractures.

Total elbow arthroplasty

Distal humerus fractures present complex challenges in the elderly patient because of osteopenia, comminution, articular fragmentation, and preexisting conditions of the elbow, such as osteoarthritis or rheumatoid arthritis. In those patients with these common diagnoses, rigid internal fixation and early mobilization can be challenging. In certain low, transcolumnar or coronal shear fractures in older patients with severe osteopenia, comminution, or preexisting arthritis, total elbow arthroplasty (TEA) has become a recognized alternative treatment. However, it is imperative to choose only low-demand patients for this intervention to minimize risk of failures, such as loosening, polyethylene wear, and periprosthetic fracture. The evidence for patient selection, complications, and functional outcomes is still conflicting.[15,43–49]

As a principle, it is recommended to perform ORIF on all adult patients fit for surgery with a reconstructible fracture pattern to reserve TEA for low-demand patients with unreconstructible fractures (case 3, Figs. 8–12). Several studies have compared ORIF and TEA for distal humerus fractures. However, sample sizes in these studies were limited, and inconsistent results have been reported. Egol and colleagues[46] reported good outcomes with either TEA or ORIF with no significant difference in functional outcomes, whereas McKee and colleagues[50] and Morrey[51] reported TEA had improved functional outcomes based on the MEPS and concluded TEA is a preferred alternative in elderly patients with complex distal humeral fractures. Varecka and Myeroff[52] reported that the outcomes of TEA for distal humerus fracture in the elderly included a physiologic range of motion (ROM; 26°–125°), adequate function (average MEPS, 87), and an acceptable implant survival rate of 94% at an average of 38.5 months. Although it has been reported that patients who undergo ORIF have a

Fig. 2. Case 1: a 60-year-old woman with a past medical history of cerebrovascular disease with diminished right upper-extremity function sustained a low-energy fall. She had an extra-articular right distal humerus fracture (see Fig. 2). Originally, surgery was planned, but the soft tissue was not suitable with perceived high risk of deep infection. The patient's bone quality was poor, and the reliability of fixation was a concern. She underwent nonsurgical treatment with 3 weeks of splint and then a removable brace for another 3 weeks.

Fig. 3. Case 1: A 60-year-old woman with radiographs at 3-month visit. Elbow ROM was 10° to 95°, supination 20°, pronation 90° at the 3-month visit.

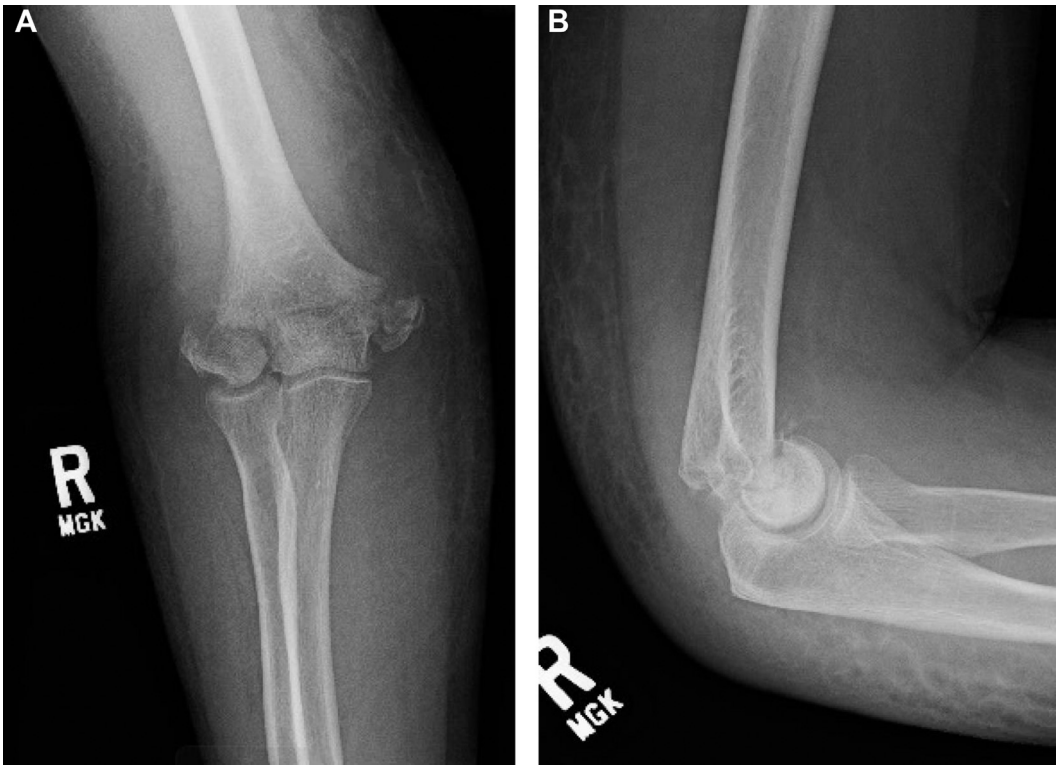

Fig. 4. Case 2: A 59-year-old woman who presented 6 days after a fall on ice, in which she sustained a right elbow injury. The radiograph revealed a right distal humerus intraarticular fracture (see Fig. 4) and right distal radius fracture (see Fig. 5). She underwent distal humerus ORIF with dual plating and olecranon osteotomy (see Fig. 6) and distal radius ORIF (see Fig. 7). She had an anterior subcutaneous transposition of the ulnar nerve but required a transfer of her anterior interosseous nerve to her right ulnar motor nerve for ulnar neuropathy.

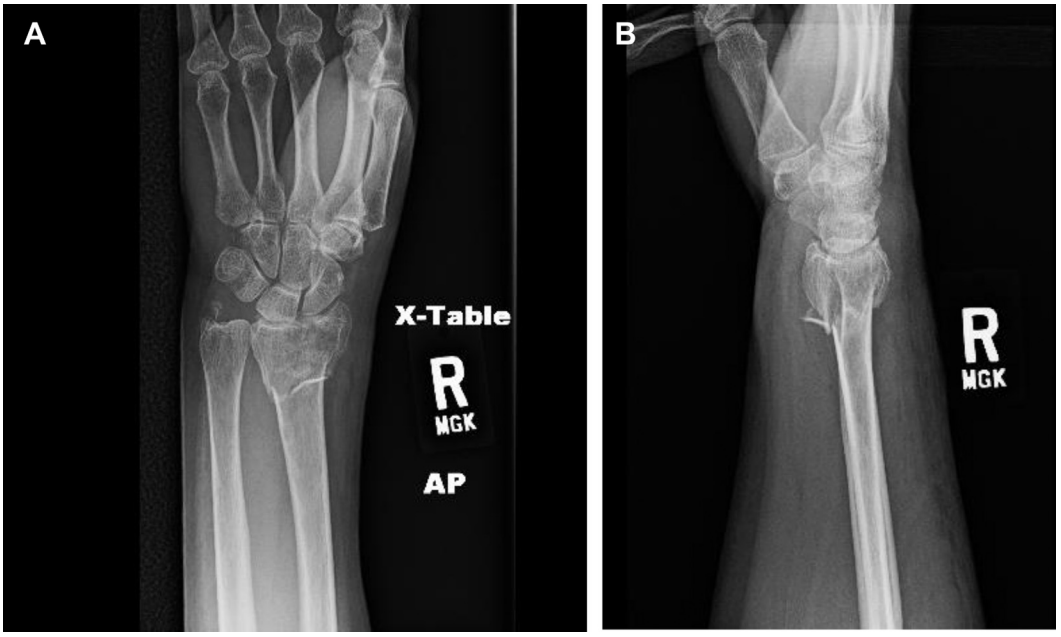

Fig. 5. Case 2: A 59-year-old woman.

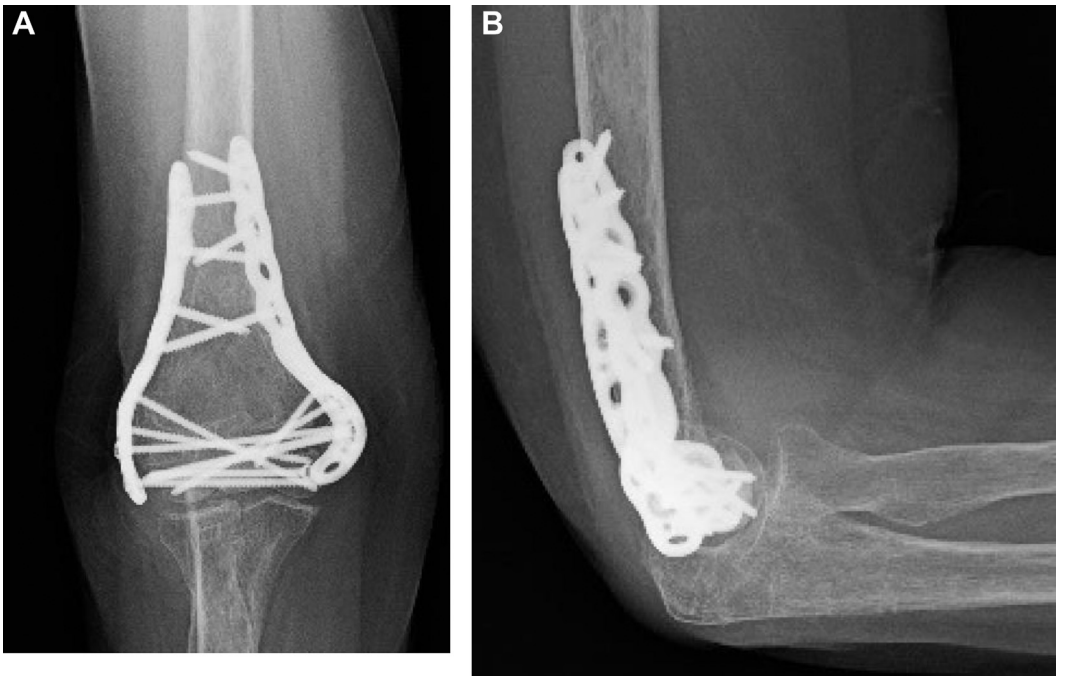

Fig. 6. Case 2: A 59-year-old woman with elbow ROM of 26° to 132°, supination 90°, pronation 90° at 10 months postoperatively.

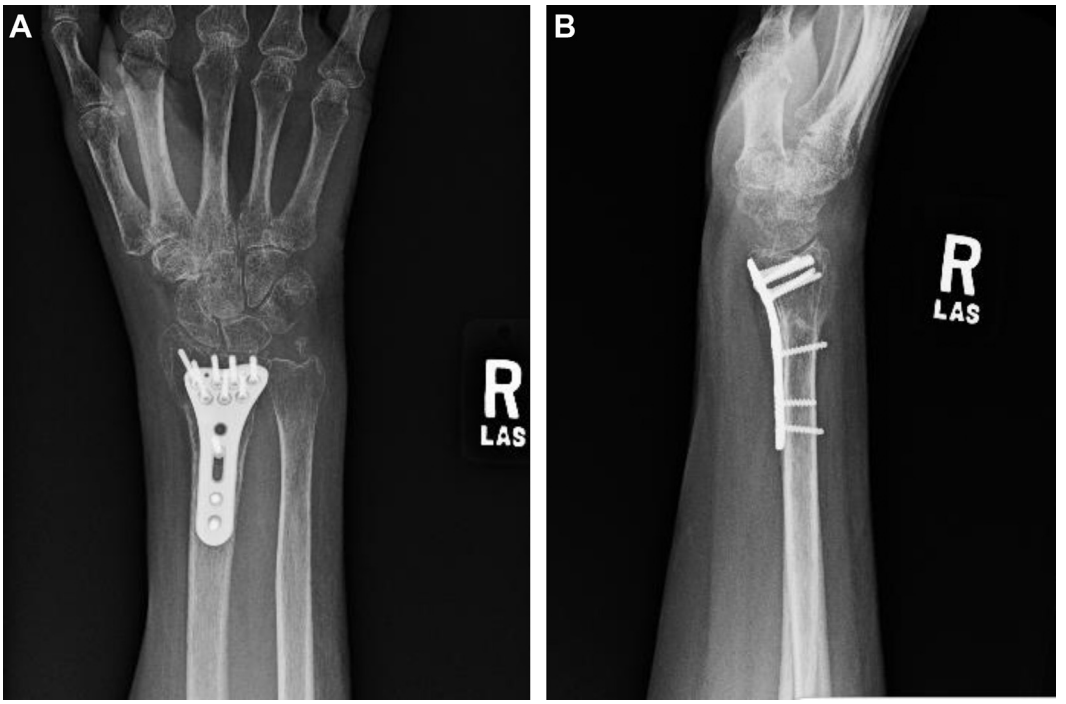

Fig. 7. Case 2: A 59-year-old woman.

Fig. 8. Case 3: An 88-year-old right-hand–dominant woman, who sustained a fall while rising from her couch. She sustained a left elbow fracture-dislocation (see Fig. 8; Fig. 9) and ipsilateral distal radius fracture (see Fig. 10). She underwent a left TEA (see Fig. 11), left ulnar nerve decompression and transposition, and distal radius dorsal spanning bridge/ORIF (see Fig. 12). Left elbow ROM was 0° to 140° at 6 months postoperatively.

higher risk of complications compared with TEA, complications with TEA are often more severe.[20,52] The complications with TEA include periprosthetic fracture (1%), implant fracture (1%), and deep wound infection (2%).[52]

Thus, although TEA may provide improved early function and similar overall outcomes when compared with ORIF in appropriately selected patients, it can cause devastating complications, and appropriate hosts must be carefully selected.[52]

OLECRANON FRACTURES

Epidemiology

Fractures of the olecranon account for 20% of all proximal forearm fractures and 10% of all upper-extremity fractures.[53,54] The common mechanism is a direct fall onto the elbow.[54] For isolated fractures of the olecranon, the Mayo classification (Fig. 13) is preferred.[55]

Management

Nonoperative treatment

Closed treatment is the gold standard in elderly, low-demand patients with displaced and nondisplaced, isolated olecranon fractures. Several studies have reported excellent functional results and championed nonoperative management of displaced olecranon fractures as a viable treatment option for lower-demand patients with multiple comorbidities.[56–58] Duckworth and colleagues[57] conducted a retrospective cohort study of 43 elderly patients with isolated Mayo-2 olecranon fracture (mean displacement, 10 mm) who underwent nonoperative treatment. They showed nonoperative management of displaced olecranon fractures to be a viable treatment option for lower-demand patients with multiple comorbidities with a flexion arc of 18° to 126°, Disabilities of the Arm, Shoulder, and Hand (DASH) 2.9, 91% satisfaction, 17% push-off weakness despite an 88% nonunion (or fibrous union) rate.[57] In a similar

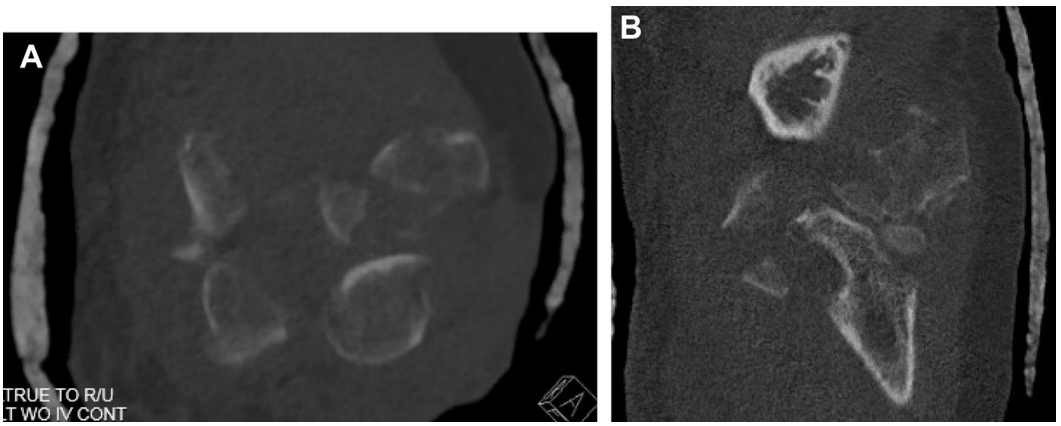

Fig. 9. Case 3: An 88-year-old woman.

Fig. 10. Case 3: An 88-year-old woman.

study, Gallucci and colleagues[58] reported 4/5 push-off weakness with nonoperative care. Subsequently, Duckworth and colleagues[59] conducted a randomized trial of 19 olecranon fractures in the elderly (aged $\geq$ 75 years) to compare nonoperative versus operative management (either tension-band wiring [TBW] or fixation with a nonlocking plate) and reported no difference in the mean DASH scores between the groups at all times, although the trial was stopped prematurely

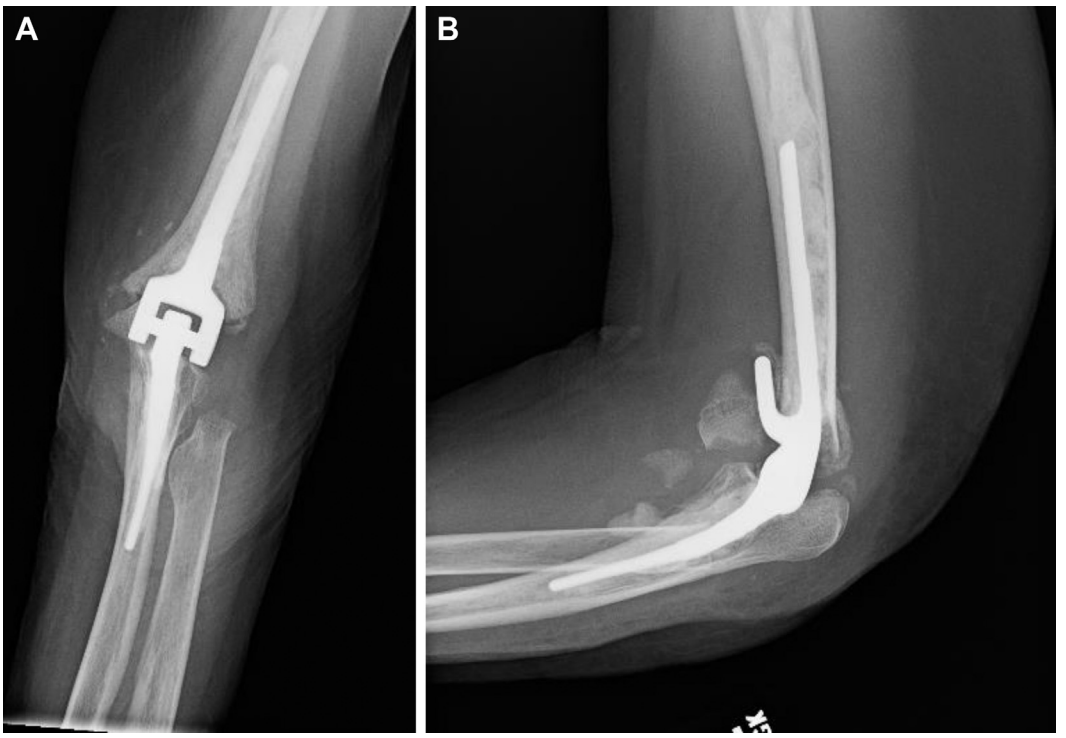

Fig. 11. Case 3: An 88-year-old woman.

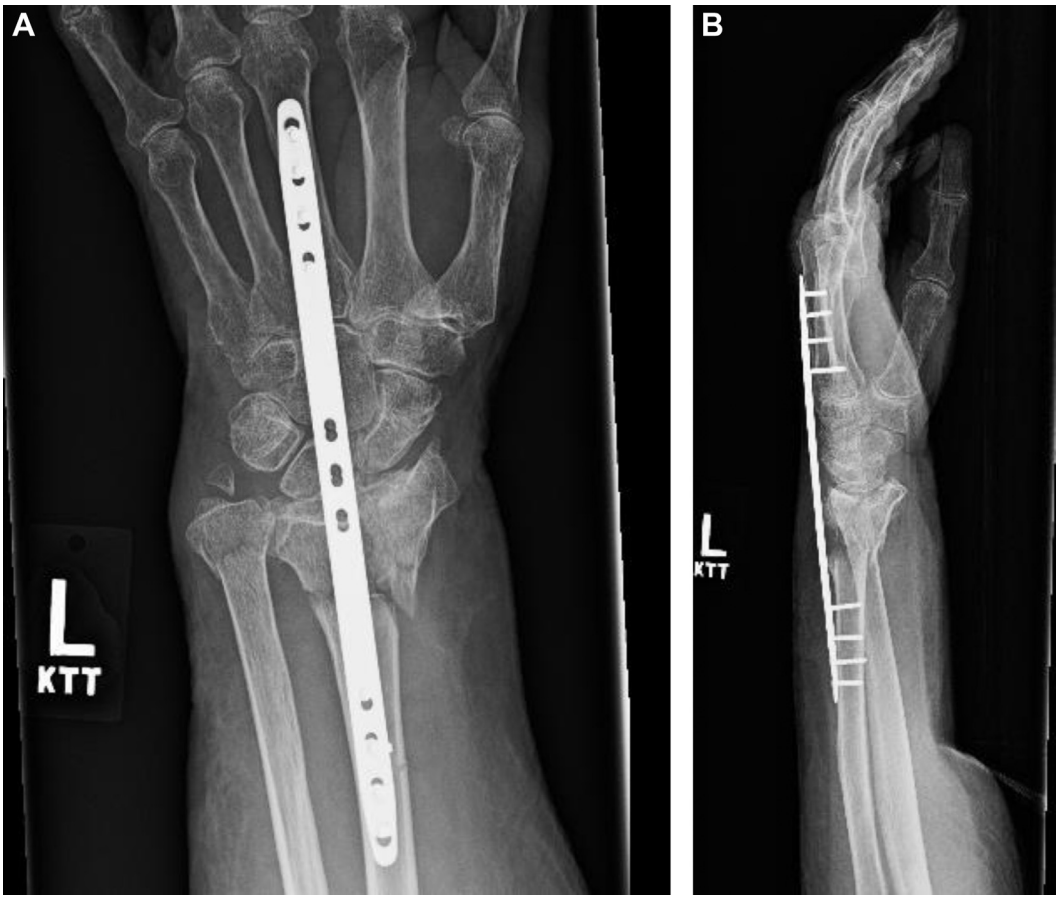

Fig. 12. Case 3: An 88-year-old woman.

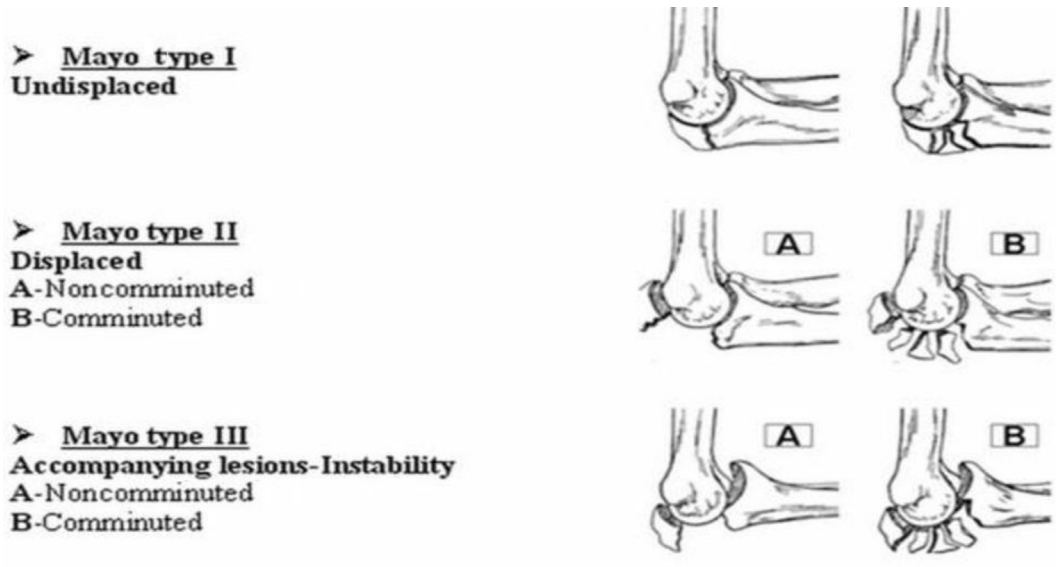

Fig. 13. The Mayo classification for olecranon fracture.

as the rate of complications (9/11%, 81.8%; 6 patients had loss of reduction, 3 patients required removal of hardware, 1 patient required excision of draining sinus) in the operative group was considered to be unacceptable.[59] It should be noted that no locking plate technology was used in the treatment of these short, metaphyseal fractures in the elderly despite the known unacceptable failure rate of TBW in this setting, reported previously by the same investigators and others.[59]

Operative treatment

The goal in surgical management is anatomic reconstruction of the sigmoid notch in order to enable early functional rehabilitation of the elbow and thereby inhibit posttraumatic stiffness and optimize extension strength (case 4, Figs. 14 and 15). TBW or plate fixation is frequently used for stable displaced fractures (Mayo type II). However, there have been conflicting findings regarding the outcomes and complications after operative fixation of olecranon fractures in elderly patients. The TBW technique is an acceptable option in simple transverse fractures with an intact dorsal cortex in young patients with good bone (Mayo type IA-IIA). However, the biomechanical limitations become evident in comminuted fractures, and in osteoporotic bone. Umer and colleagues[60] reviewed 79 operatively treated elderly olecranon fractures, in which TBW was used in 87%. They reported the following adverse outcomes, including 14% wound problems, 16% persistent pain, 44% hardware problems (19% hardware removal), and 75% stiffness.[60] Duckworth and colleagues[61] performed a randomized clinical trial comparing plate fixation to TBW in 67 patients. Despite being biased toward younger patients in the TBW group, TBW was associated with twice the complication rate (63% vs 38%; $P = .042$), twice the hardware removal rate (50% vs 22%; $P = .021$), and twice the loss of reduction (27% vs 13%; $P = .206$). In a systematic review, Ren and colleagues[62] found more complications for TBW when compared with plate fixation and therefore recommended olecranon fracture plating as the contemporary treatment of choice. Higher rates of prominent hardware with the need for removal following TBW were found in several studies over the last decade.[63,64]

The management of comminuted and unstable fractures (Mayo IIb–IIIb) using locking compression plates via the dorsal approach has been well established in recent studies.[65–68] Wise and colleagues[68] reported low failure and complication rates using modern fixation principles and locked plating. They reported an 11% (4/36) major complication rate with only 3 mechanical failures, an 88% union rate (all patients who did not have a major complication went onto union), and a 120 flexion-extension arc of motion in their retrospective review of elderly

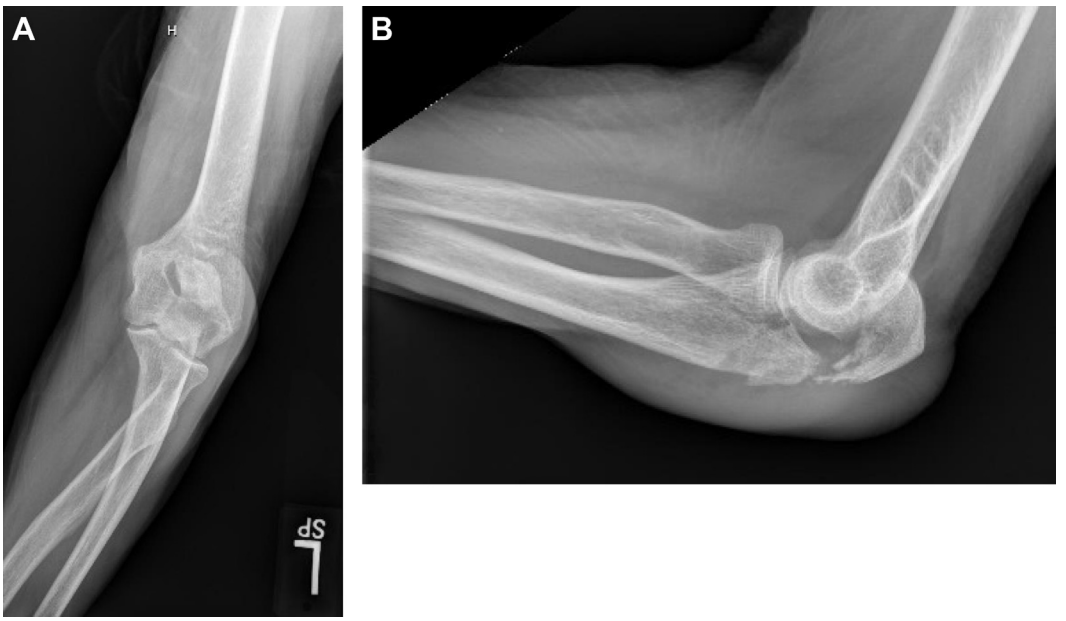

Fig. 14. Case 4: A 74-year-old woman with osteoporosis, diabetes, and hypothyroidism sustained a ground level fall resulting in a Mayo IIb olecranon fracture. She underwent ORIF with a triceps detensioning suture adjunct.

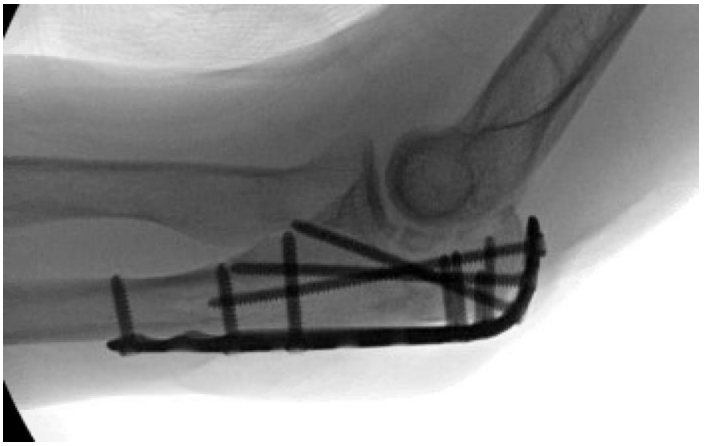

Fig. 15. Case 4: A 74-year-old woman.

patients greater than 75 years old treated with locked plating and early motion. Interestingly, upper-extremity gait dependence was associated with failures. Although not the "gold standard," precontoured locked plating and early mobilization is an effective and safe treatment for comminuted olecranon fractures in select geriatric patients, who are safe for surgery and comply with restrictions.[66–68]

In addition, especially for small tip fractures and/or in highly comminuted osteoporotic bone in the elderly, the use of an "off-loading triceps suture" (eg, with a nonabsorbable, high-tensile suture) has been shown to neutralize the distraction forces caused by the extensor mechanism and to decrease the risk of fixation failure.[69]

Most surgical complications are implant related because of soft tissue irritation. Complications such as ulnar neuropathy, deep infection, implant failure, or delayed/nonunion are relatively rarely reported. However, an uneven reconstruction of the articular surface can cause sequelae such as limited elbow ROM and posttraumatic arthritis.[70]

RADIAL HEAD FRACTURES

Epidemiology

Radial head fractures are the most common fractures of the elbow, with most fractures occurring in women older than 50 years of age. They constitute approximately one-third of all elbow fractures and approximately 2.5 to 2.8 per 10,000 people per year.[71–74] Over the last decades, the radial head is increasingly recognized as an essential stabilizer of the elbow.[75] Most radial head and neck fractures are minimally displaced and are isolated injuries. These fractures typically have a good functional outcome with nonsurgical treatment. More displaced and comminuted fractures commonly have associated injuries to the collateral ligaments. They may have associated fractures of the coronoid, capitellum, or proximal ulna as well.[76]

Assessment

A careful examination of an ROM is performed because the loss of forearm rotation is one of the primary indications for surgical intervention. In particular, the distal radioulnar joint and interosseous membrane should be palpated and assessed for both tenderness and instability.[7] Anteroposterior and lateral radiographs are typically sufficient to diagnose most displaced radial head fractures. Nondisplaced fractures may initially be challenging to diagnose, and they may only be suspected by the presence of an anterior and posterior fat pad sign. CT can be helpful to characterize the size, location, and displacement of radial head fractures. It is also useful to assess concomitant injuries of the coronoid, the capitellum, and the presence of associated osteochondral fragments.[7]

Classification

Several classification systems have been used to describe radial head fractures. The Mason classification and its subsequent modifications are commonly used. Mason's classification describes nondisplaced fractures (type I), partial fractures with displacement (type II), and comminuted and displaced fractures involving the entire radial head (type III) (Table 1).[71] Morrey modified the Mason classification and included the extent of articular fragment displacement (>2 mm) and fragment size (≥30% of the articular surface) (Fig. 16).[77] Johnston added a fourth

Table 1 The Mason classification for radial head fractures	
Type 1	Fissure or marginal fractures without displacement
Type 2	Marginal sector fractures with displacement
Type 3	Comminuted fractures involving the whole head of the radius

type, which describes a radial head fracture with the dislocation of the elbow.[78]

Treatment

Nonoperative treatment

Nondisplaced or minimally displaced radial head fractures without a block to forearm rotation are treated nonsurgically.[79] The treatment includes immobilization for up to 2 or 3 days for comfort. Active motion is then encouraged with the use of a sling as needed between exercises. The natural course of Mason type I fractures is benign in general; however, persistent complaints have been reported in 20% of cases.[80]

Operative treatment

Operative treatment is indicated for most of these unstable radial head injuries and any isolated fractures with significant articular displacement, articular comminution, or mechanical block to motion.[81,82] Treatment options include radial head fragment excision, radial head excision, ORIF, and radial head arthroplasty. Fragment excision is indicated in patients with a block to forearm motion by a small (<25% of the articular diameter) non-reconstructible displaced articular fracture of the radial head without instability.[83] Excision of any kind should never be performed in an instability pattern, and rarely, acutely. ORIF is indicated in patients with displaced, noncomminuted fractures of the radial head. In osteoporotic bone, even simple patterns can be fraught with impaction and relatively quick resorption. A radial head arthroplasty is the favored surgical treatment in patients with a comminuted (>3 parts) fracture, with poor bone quality, and with unstable elbow injuries or mechanical obstruction.[84] Radial head replacement had fewer complications than ORIF patients (13.9% vs 58.1%) and higher satisfaction rates (91.7% vs 51.6%) in Mason type III radial head fractures patients.[85]

ELBOW DISLOCATION/TERRIBLE TRIAD INJURY

Epidemiology

The elbow is the second most commonly dislocated joint in the adult population, with a reported rate of 5 to 6 per 100,000 person-years in the US population.[86,87] Elbow dislocation associated with radial head and coronoid fractures has been referred to as the "terrible triad injury"; it represents a pattern of complex elbow instability that has historically been associated with a poor prognosis.[88–90]

Mechanisms

Elbow dislocations are typically the result of a fall on an outstretched hand. The soft tissue injury begins on the lateral side of the elbow with the injury of the lateral collateral ligament (LCL) and then proceeds through the capsule to the medial side with the medial collateral ligament (MCL) being disrupted last.[91,92] A fall onto an outstretched arm with supination, valgus, and

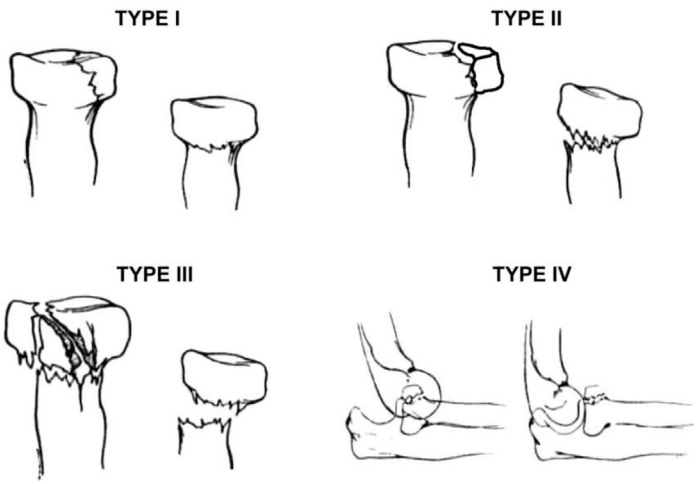

Fig. 16. The Broberg-Morrey modification of the Mason classification.

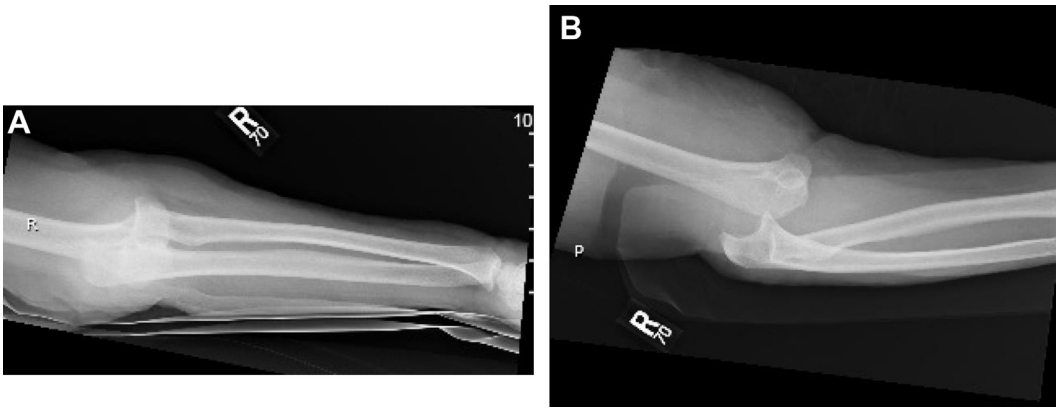

Fig. 17. Case 5: An 82-year-old woman who presented to clinic 10 days after a fall from standing height, sustaining a simple right elbow dislocation (see Fig. 15). The elbow was reduced, and a splint was applied (see Table 1). At 1 week follow-up, she was found to have a recurrent dislocation (see Fig. 16). She underwent closed reduction, and an external fixator was placed at 90° of flexion for 4 weeks (see Fig. 17; Fig. 18). Final ROM resulted in a flexion arc of 10° to 140°, pronation 90°, and supination 90°.

axial-directed force is a mechanism of terrible triad injury. It occurs by posterolateral rotatory displacement of the ulna, resulting in elbow subluxation or dislocation, a shear fracture of the coronoid with LCL injury, and radial head fracture.[7]

Treatment

Elbow dislocations

A relative consensus exists in favor of conservative treatment of simple elbow dislocations in the absence of any tendency to re-dislocate within the joint's functional arc.[93–95] Previous studies have reported good to excellent outcomes in most patients with a simple elbow dislocation.[93–95]

However, some research reported mild residual symptoms, including loss of motion, subjective stiffness, residual pain, and residual instability.[96–99] Prolonged immobilization after injury was associated with a worse result with increased flexion contracture and more severe

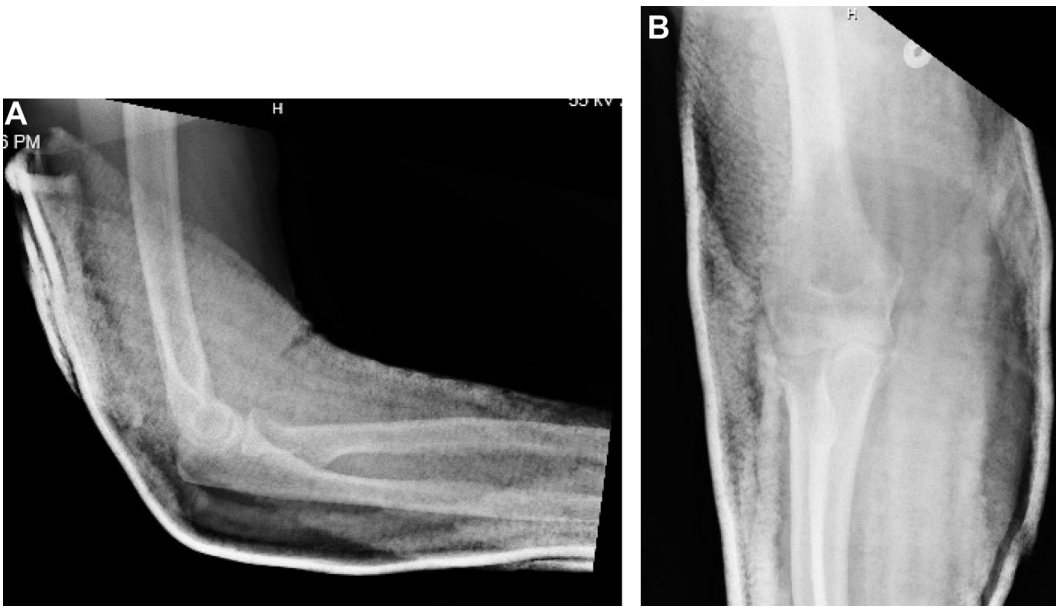

Fig. 18. Case 5: An 82-year-old woman.

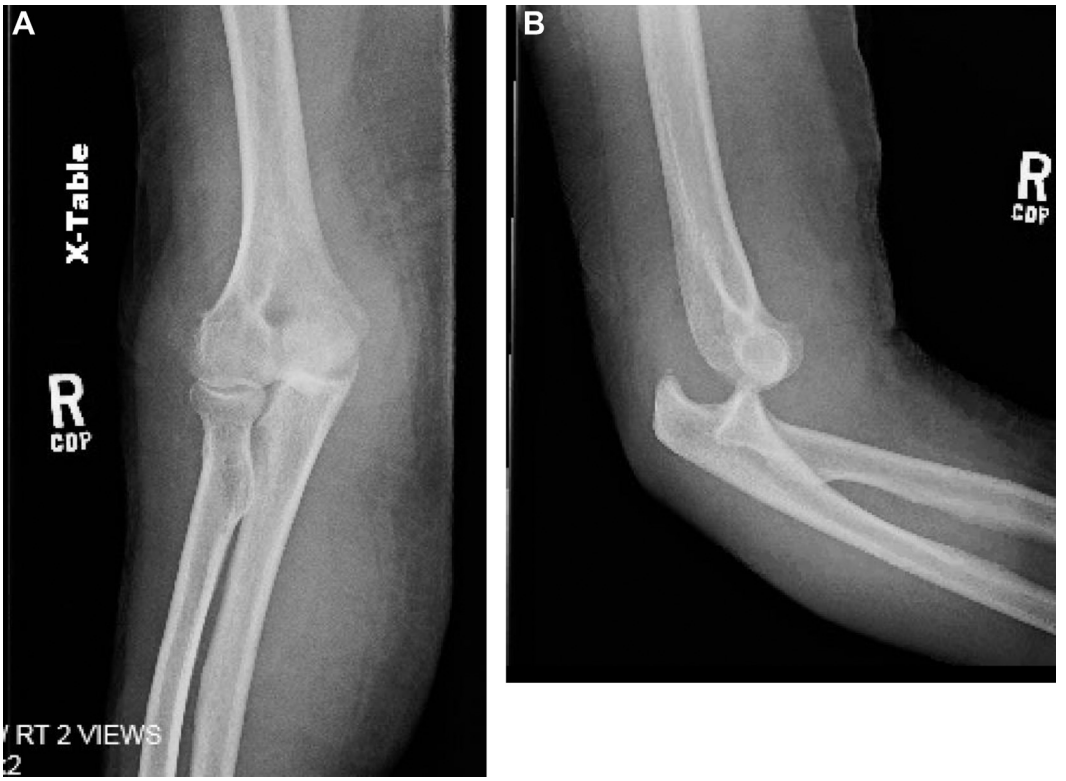

Fig. 19. Case 5: An 82-year-old woman.

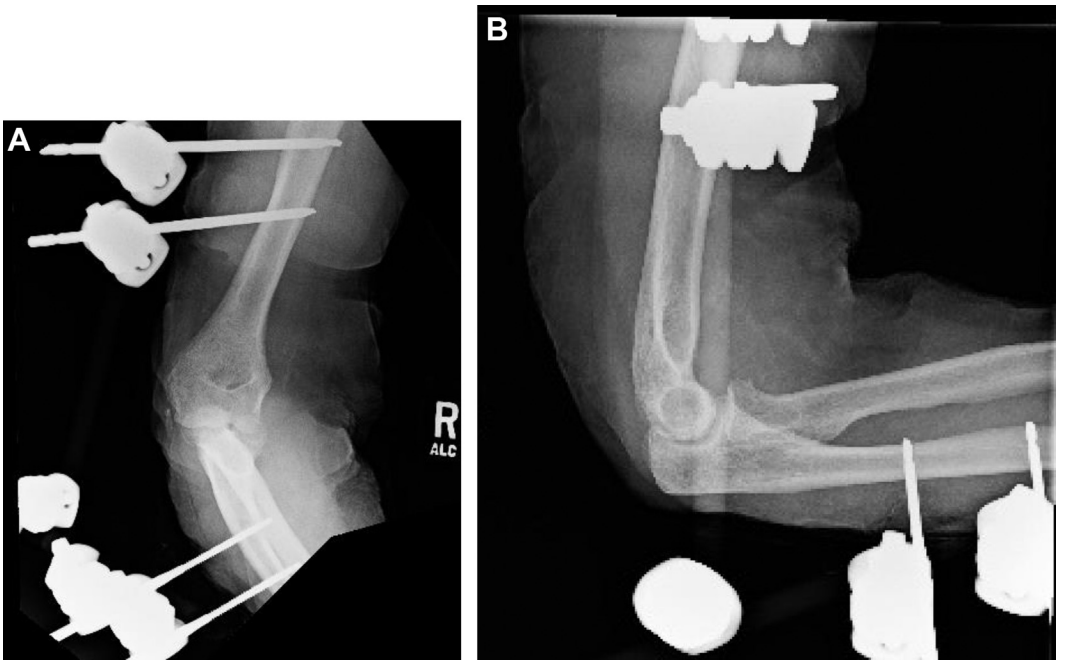

Fig. 20. Case 5: An 82-year-old woman.

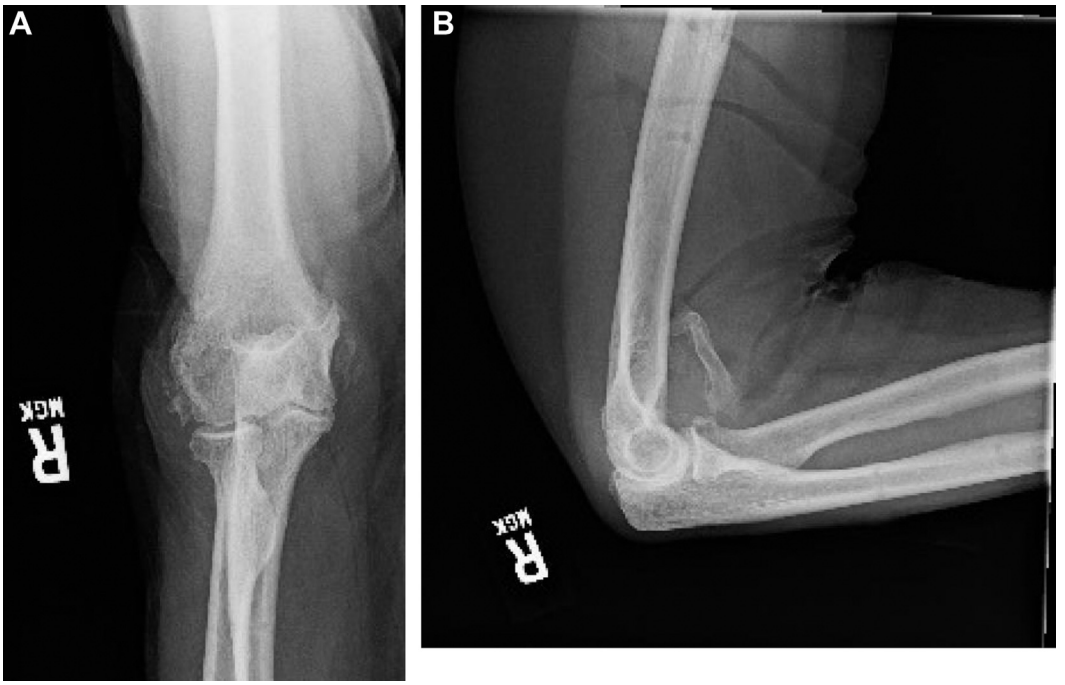

Fig. 21. Case 5: An 82-year-old woman.

residual pain.[99] The frailer patients are often quick to look past subtle functional losses but are vulnerable to loss of independence secondary to pain or instability.

The main indication for operative management is an inability to maintain a concentric elbow joint following closed reduction. Elbows that are so unstable that prolonged immobilization will be

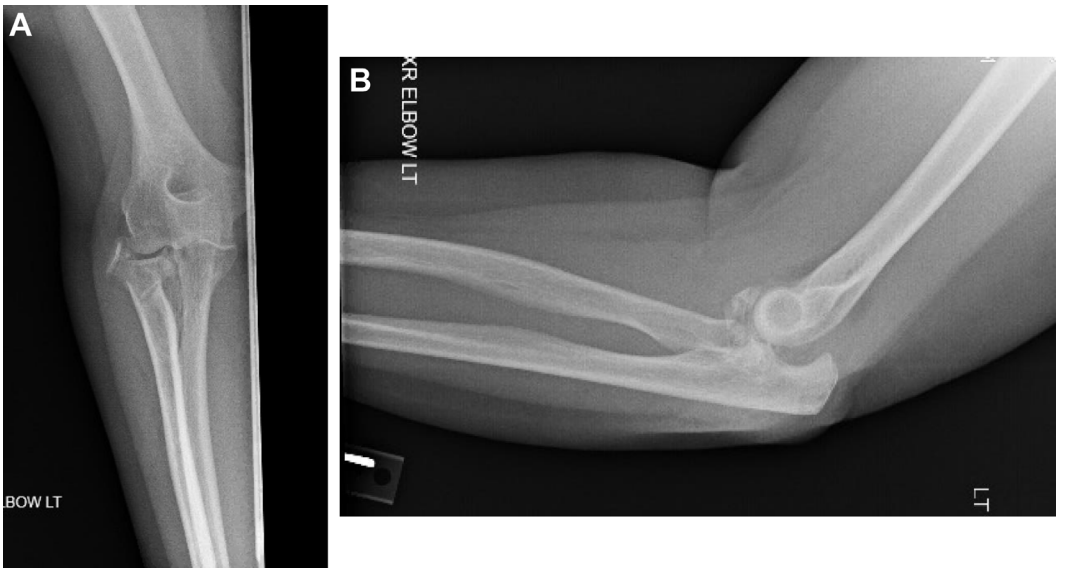

Fig. 22. Case 6: A 56-year-old right-handed woman sustained a ground level fall. Radiographs revealed left elbow dislocation with displaced radial head fracture, coronoid fracture, and olecranon fracture (see Figs. 19 and 20). She underwent ORIF of left coronoid, left olecranon, left radial head, and lateral ulnar collateral ligament repair (see Fig. 21). At 5-month follow-up, she achieved ROM of 10° to 138°, 70° supination, and 90° pronation with no pain.

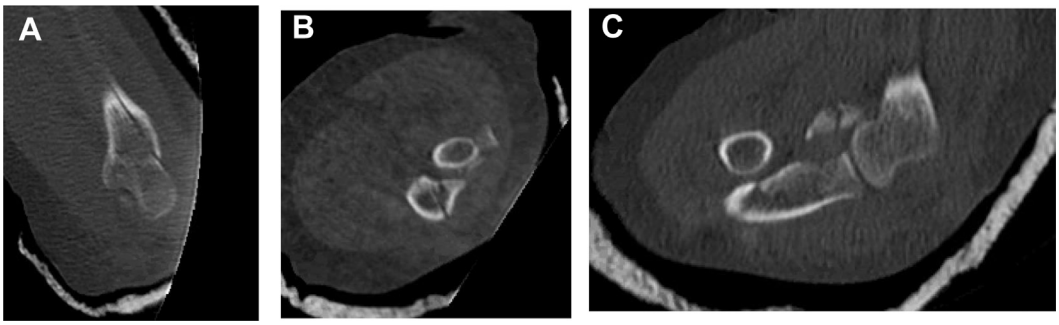

Fig. 23. Case 6: A 56-year-old woman.

required should also be considered for early surgical management to avoid stiffness. Because of soft tissue quality, simple elbow dislocation in the elderly may be more unstable, and careful follow-up is mandatory to recognize and promptly treat persistent instability with either closed reduction and external fixation or ligament repair (case 5, Figs. 17–21).

Terrible triad injury

Surgical treatment is preferred for most terrible triad injuries, as there are little contemporary data regarding the nonoperative treatment outcomes. A retrospective cohort study conducted by Chan and colleagues[100] reported nonoperative treatment of terrible triad injuries could be an option that can provide good function and restore stable elbow ROM for selected patients: (1) a concentric joint reduction, (2) a radial head fracture that did not cause a mechanical block to the rotation, (3) a smaller coronoid fracture, and (4) a stable arc of motion to a minimum of 30° of extension. When doubt exists, early mobilization abiding by lateral ulnar collateral ligament precautions and repeat radiographs 1 week later can provide reassurance.

OPEN REDUCTION INTERNAL FIXATION

A systematic approach, including fixation or replacement of the radial head, fixation of the coronoid fragment, and repair of the LCL, is usually required (case 6, Figs. 22–24). The elbow is then evaluated intraoperatively for residual instability to determine if MCL repair is required. In many cases, the coronoid can be accessed and repaired from a lateral surgical exposure, particularly if a radial head replacement is

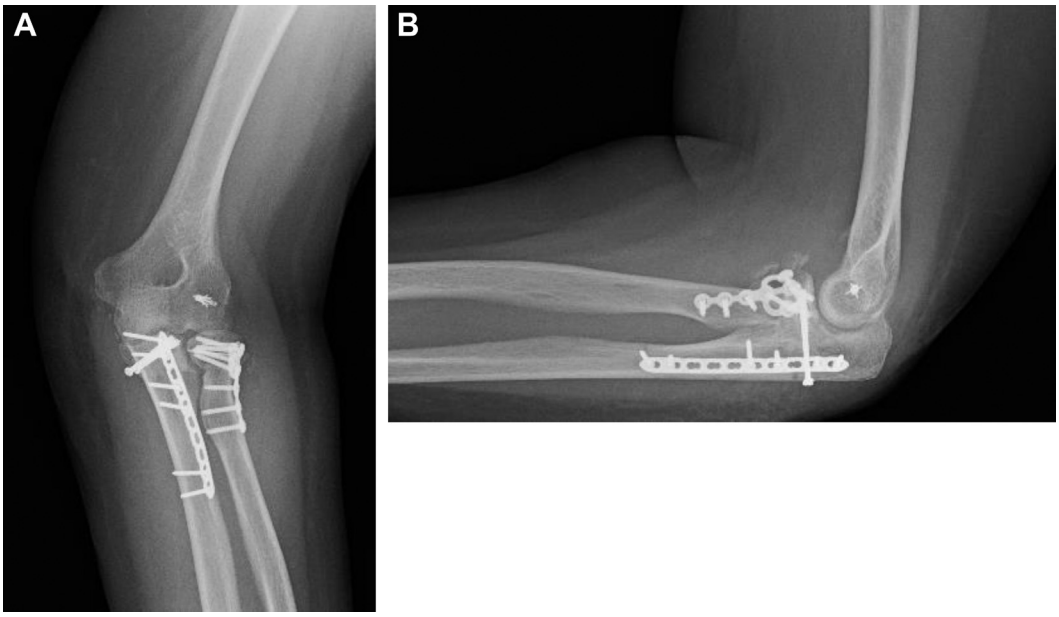

Fig. 24. Case 6: A 56-year-old woman.

required. Coronoid fractures too small or comminuted to be amenable to screw fixation can be repaired using sutures passed around the coronoid process and anterior capsule through transosseous tunnels on the dorsal ulna.

Some studies of triple triad injury reported satisfactory outcomes with few complications,[101,102] whereas other investigators have reported a high rate of symptomatic and asymptomatic complications.[103–112] Complications include stiffness (0%–22%), arthritis (0%–19.5%), ulnar nerve entrapment (0%–18%), and recurrent instability (4%–38%)[103–112] Gianicola and colleagues[113] reported that obesity, low compliance, delayed treatment, and extensive soft elbow tissue damage caused by a high-energy trauma represented negative prognostic factors that affect the surgical outcomes.

SPECIAL CONSIDERATION FOR GERIATRIC PATIENTS

Elderly patients should be evaluated and treated for the fall risk. Special attention should be directed toward identifying comorbidities and reversible illnesses that may impact the treatment recommendations and perioperative risk. In addition, a patient's preinjury functional abilities, demands, limitations related to the upper extremities, and hand dominance may affect the treatment decision making.

CLINICS CARE POINTS

- Approximately 4.1% of all fractures in the elderly involve the elbow.
- Elderly patients are at risk for elbow injuries following even low-energy falls.
- Approximately one-third of elbow injuries involves the distal humerus. Most of the distal humerus fractures in geriatric patients occur from low-energy injuries, such as falling from standing height.
- Fractures around the elbow in elderly patients are challenging because of poor bone quality, comminution, articular fragmentation, and preexisting conditions of the elbow.

DISCLOSURE

All the authors have declared no conflict of interest for this article.

REFERENCES

1. Court-Brown CM, Clement ND, Duckworth AD, et al. The spectrum of fractures in the elderly. Bone Joint J 2014;96-B(3):366–72.
2. Liman MNP, Avva U, Ashurst JV, et al. Elbow trauma. 2020 Aug 21. In: Morrey BF, editor. StatPearls. Treasure Island (FL): StatPearls Publishing; 2021.
3. Palvanen M, Kannus P, Parkkari J, et al. The injury mechanisms of osteoporotic upper extremity fractures among older adults: a controlled study of 287 consecutive patients and their 108 controls. Osteoporos Int 2000;11(10):822–31.
4. Robinson CM, Hill RM, Jacobs N, et al. Adult distal humeral metaphyseal fractures: epidemiology and results of treatment. J Orthop Trauma 2003;17(1):38–47.
5. Court-Brown CM, Caesar B. Epidemiology of adult fractures: a review. Injury 2006;37(8):691–7.
6. Miller AN, Beingessner DM. Intra-articular distal humerus fractures. Orthop Clin North Am 2013; 44(1):35–45.
7. Rockwood and Green's Fractures in Adults. 9th edition. Tornetta P, Ricci W, Charles M. Court-Brown CM, McQueen M, McKee M. LWW.
8. McKee MD, Wilson TL, Winston L, et al. Functional outcome following surgical treatment of intra-articular distal humeral fractures through a posterior approach. J Bone Joint Surg Am 2000; 82(12):1701–7.
9. Min W, Ding BC, Tejwani NC. Comparative functional outcome of AO/OTA type C distal humerus fractures: open injuries do worse than closed fractures. J Trauma Acute Care Surg 2012;72(2): E27–32.
10. Gofton WT, Macdermid JC, Patterson SD, et al. Functional outcome of AO type C distal humeral fractures. J Hand Surg Am 2003;28(2):294–308.
11. Debus F, Karaman Y, Ruchholtz S, et al. The distal radius fracture: concomitant fractures and their relevancy. Technol Health Care 2014;22(6):877–84.
12. Brouwer KM, Lindenhovius AL, Dyer GS, et al. Diagnostic accuracy of 2- and 3-dimensional imaging and modeling of distal humerus fractures. J Shoulder Elbow Surg 2012;21(6):772–6.
13. Marsh JL, Slongo TF, Agel J, et al. Fracture and dislocation classification compendium - 2007: Orthopaedic Trauma Association classification, database and outcomes committee. J Orthop Trauma 2007;21(10 Suppl):S1–133.
14. Fracture and dislocation compendium. Orthopaedic Trauma Association Committee for Coding and Classification. J Orthop Trauma 1996; 10(Suppl 1):v-154.
15. Medvedev G, Wang C, Amdur R, et al. Operative distal humerus fractures in older patients:

predictors for early complications based on a national database. HSS J 2017;13(3):212–6.
16. Patino JM. Complex distal humerus fractures in elderly patients: open reduction and internal fixation versus arthroplasty. J Hand Surg Am 2012; 37(8):1699–701.
17. Brown RF, Morgan RG. Intercondylar T-shaped fractures of the humerus. Results in ten cases treated by early mobilisation. J Bone Joint Surg Br 1971;53(3):425–8.
18. Seth AK, Baratz ME. Fractures of the elbow. In: Trumble TE, Budoff JE, Hand CR, editors. Elbow & shoulder. Philadelphia: Mosby; 2006. p. 522–31.
19. Nauth A, McKee MD, Ristevski B, et al. Distal humeral fractures in adults. J Bone Joint Surg Am 2011;93(7):686–700.
20. Obert L, Ferrier M, Jacquot A, et al. Distal humerus fractures in patients over 65: complications. Orthop Traumatol Surg Res 2013;99(8):909–13.
21. Zagorski JB, Jennings JJ, Burkhalter WE, et al. Comminuted intraarticular fractures of the distal humeral condyles. Surgical vs. nonsurgical treatment. Clin Orthop Relat Res 1986;202:197–204.
22. John H, Rosso R, Neff U, et al. Operative treatment of distal humeral fractures in the elderly. J Bone Joint Surg Br 1994;76(5):793–6.
23. Hausman M, Panozzo A. Treatment of distal humerus fractures in the elderly. Clin Orthop Relat Res 2004;425:55–63.
24. Huang TL, Chiu FY, Chuang TY, et al. The results of open reduction and internal fixation in elderly patients with severe fractures of the distal humerus: a critical analysis of the results. J Trauma 2005;58(1):62–9.
25. Korner J, Lill H, Müller LP, et al. The LCP-concept in the operative treatment of distal humerus fractures–biological, biomechanical and surgical aspects. Injury 2003;34(Suppl 2):B20–30.
26. Srinivasan K, Agarwal M, Matthews SJ, et al. Fractures of the distal humerus in the elderly: is internal fixation the treatment of choice? Clin Orthop Relat Res 2005;434:222–30.
27. Githens M, Yao J, Sox AH, et al. Open reduction and internal fixation versus total elbow arthroplasty for the treatment of geriatric distal humerus fractures: a systematic review and meta-analysis. J Orthop Trauma 2014;28(8):481–8.
28. Kaiser T, Brunner A, Hohendorff B, et al. Treatment of supra- and intra-articular fractures of the distal humerus with the LCP distal humerus plate: a 2-year follow-up. J Shoulder Elbow Surg 2011; 20(2):206–12.
29. Leigey DF, Farrell DJ, Siska PA, et al. Bicolumnar 90-90 plating of low-energy distal humeral fractures in the elderly patient. Geriatr Orthop Surg Rehabil 2014;5(3):122–6.
30. Huang JI, Paczas M, Hoyen HA, et al. Functional outcome after open reduction internal fixation of intra-articular fractures of the distal humerus in the elderly. J Orthop Trauma 2011;25(5):259–65.
31. Moursy M, Wegmann K, Wichlas F, et al. Distal humerus fracture in patients over 70 years of age: results of open reduction and internal fixation [published online ahead of print, 2020 Nov 5]. Arch Orthop Trauma Surg 2020. https://doi.org/10.1007/s00402-020-03664-4.
32. Ducrot G, Bonnomet F, Adam P, et al. Treatment of distal humerus fractures with LCP DHP™ locking plates in patients older than 65 years. Orthop Traumatol Surg Res 2013;99(2):145–54.
33. Clavert P, Ducrot G, Sirveaux F, et al, SOFCOT. Outcomes of distal humerus fractures in patients above 65 years of age treated by plate fixation. Orthop Traumatol Surg Res 2013;99(7):771–7.
34. Athwal GS, Hoxie SC, Rispoli DM, et al. Precontoured parallel plate fixation of AO/OTA type C distal humerus fractures. J Orthop Trauma 2009; 23(8):575–80.
35. Theivendran K, Duggan PJ, Deshmukh SC. Surgical treatment of complex distal humeral fractures: functional outcome after internal fixation using precontoured anatomic plates. J Shoulder Elbow Surg 2010;19(4):524–32.
36. Rebuzzi E, Vascellari A, Schiavetti S. The use of parallel pre-contoured plates in the treatment of A and C fractures of the distal humerus. Musculoskelet Surg 2010;94(1):9–16.
37. Luegmair M, Timofiev E, Chirpaz-Cerbat JM. Surgical treatment of AO type C distal humeral fractures: internal fixation with a Y-shaped reconstruction (Lambda) plate. J Shoulder Elbow Surg 2008; 17(1):113–20.
38. Patel SS, Mir HR, Horowitz E, et al. ORIF of distal humerus fractures with modern pre-contoured implants is still associated with a high rate of complications. Indian J Orthop 2020;54(5):570–9.
39. Wilkinson JM, Stanley D. Posterior surgical approaches to the elbow: a comparative anatomic study. J Shoulder Elbow Surg 2001;10(4):380–2.
40. Meldrum A, Kwong C, Archibold K, et al. Olecranon osteotomy implant removal rates and associated complications [published online ahead of print, 2020 Oct 9]. J Orthop Trauma 2020. https://doi.org/10.1097/BOT.0000000000001979.
41. Coles CP, Barei DP, Nork SE, et al. The olecranon osteotomy: a six-year experience in the treatment of intraarticular fractures of the distal humerus. J Orthop Trauma 2006;20(3):164–71.
42. Kaiser PB, Newman ET, Haggerty C, et al. A limited fixation, olecranon sparing approach, for management of geriatric intra-articular distal humerus fractures. Geriatr Orthop Surg Rehabil 2020;11. 2151459320950063.
43. Ali A, Shahane S, Stanley D. Total elbow arthroplasty for distal humeral fractures: indications,

surgical approach, technical tips, and outcome. J Shoulder Elbow Surg 2010;19(2 Suppl):53–8.
44. Chalidis B, Dimitriou C, Papadopoulos P, et al. Total elbow arthroplasty for the treatment of insufficient distal humeral fractures. A retrospective clinical study and review of the literature. Injury 2009;40(6):582–90.
45. Cobb TK, Morrey BF. Total elbow arthroplasty as primary treatment for distal humeral fractures in elderly patients. J Bone Joint Surg Am 1997; 79(6):826–32.
46. Egol KA, Tsai P, Vazques O, et al. Comparison of functional outcomes of total elbow arthroplasty vs plate fixation for distal humerus fractures in osteoporotic elbows. Am J Orthop (Belle Mead Nj) 2011;40(2):67–71.
47. Gambirasio R, Riand N, Stern R, et al. Total elbow replacement for complex fractures of the distal humerus. An option for the elderly patient. J Bone Joint Surg Br 2001;83(7):974–8.
48. Garcia JA, Mykula R, Stanley D. Complex fractures of the distal humerus in the elderly. The role of total elbow replacement as primary treatment. J Bone Joint Surg Br 2002;84(6):812–6.
49. Gay DM, Lyman S, Do H, et al. Indications and reoperation rates for total elbow arthroplasty: an analysis of trends in New York State. J Bone Joint Surg Am 2012;94(2):110–7.
50. McKee MD, Veillette CJ, Hall JA, et al. A multicenter, prospective, randomized, controlled trial of open reduction–internal fixation versus total elbow arthroplasty for displaced intra-articular distal humeral fractures in elderly patients. J Shoulder Elbow Surg 2009;18(1):3–12.
51. Morrey BF. Total elbow arthroplasty did not differ from open reduction and internal fixation with regard to reoperation rates. J Bone Joint Surg Am 2009;91(8):2010.
52. Varecka TF, Myeroff C. Distal humerus fractures in the elderly population. J Am Acad Orthop Surg 2017;25(10):673–83.
53. Rommens PM, Küchle R, Schneider RU, et al. Olecranon fractures in adults: factors influencing outcome. Injury 2004;35(11):1149–57.
54. Duckworth AD, Clement ND, Aitken SA, et al. The epidemiology of fractures of the proximal ulna. Injury 2012;43(3):343–6.
55. Morrey BF. Current concepts in the treatment of fractures of the radial head, the olecranon, and the coronoid. Instr Course Lect 1995;44: 175–85.
56. Marot V, Bayle-Iniguez X, Cavaignac E, et al. Results of non-operative treatment of olecranon fracture in over 75-year-olds. Orthop Traumatol Surg Res 2018;104(1):79–82.
57. Duckworth AD, Bugler KE, Clement ND, et al. Nonoperative management of displaced olecranon fractures in low-demand elderly patients. J Bone Joint Surg Am 2014;96(1):67–72.
58. Gallucci GL, Piuzzi NS, Slullitel PA, et al. Non-surgical functional treatment for displaced olecranon fractures in the elderly. Bone Joint J 2014;96-B(4): 530–4.
59. Duckworth AD, Clement ND, McEachan JE, et al. Prospective randomised trial of non-operative versus operative management of olecranon fractures in the elderly. Bone Joint J 2017;99-B(7): 964–72.
60. Umer S, et al. Olecranon fractures in the elderly. Is tension band wiring the right treatment? Inj Extra 2011;42(9):122–3.
61. Duckworth AD, Clement ND, White TO, et al. Plate versus tension-band wire fixation for olecranon fractures: a prospective randomized trial. J Bone Joint Surg Am 2017;99(15):1261–73.
62. Ren YM, Qiao HY, Wei ZJ, et al. Efficacy and safety of tension band wiring versus plate fixation in olecranon fractures: a systematic review and meta-analysis. J Orthop Surg Res 2016; 11(1):137.
63. Hume MC, Wiss DA. Olecranon fractures. A clinical and radiographic comparison of tension band wiring and plate fixation. Clin Orthop Relat Res 1992;285:229–35.
64. Schliemann B, Raschke MJ, Groene P, et al. Comparison of tension band wiring and precontoured locking compression plate fixation in Mayo type IIA olecranon fractures. Acta Orthop Belg 2014; 80(1):106–11.
65. Hutchinson DT, Horwitz DS, Ha G, et al. Cyclic loading of olecranon fracture fixation constructs. J Bone Joint Surg Am 2003;85(5):831–7.
66. Niglis L, Bonnomet F, Schenck B, et al. Critical analysis of olecranon fracture management by pre-contoured locking plates. Orthop Traumatol Surg Res 2015;101(2):201–7.
67. Erturer RE, Sever C, Sonmez MM, et al. Results of open reduction and plate osteosynthesis in comminuted fracture of the olecranon. J Shoulder Elbow Surg 2011;20(3):449–54.
68. Wise KL, Peck S, Smith L, et al. Locked plating of geriatric olecranon fractures leads to low fixation failure and acceptable complication rates. JSES Int 2021;5(4):809–15.
69. Izzi J, Athwal GS. An off-loading triceps suture for augmentation of plate fixation in comminuted osteoporotic fractures of the olecranon. J Orthop Trauma 2012;26(1):59–61.
70. Siebenlist S, Buchholz A, Braun KF. Fractures of the proximal ulna: current concepts in surgical management. EFORT Open Rev 2019;4(1):1–9.
71. Mason ML. Some observations on fractures of the head of the radius with a review of one hundred cases. Br J Surg 1954;42(172):123–32.

72. Kodde IF, Kaas L, Flipsen M, et al. Current concepts in the management of radial head fractures. World J Orthop 2015;6(11):954–60.
73. Kaas L, van Riet RP, Vroemen JP, et al. The epidemiology of radial head fractures. J Shoulder Elbow Surg 2010;19(4):520–3.
74. Duckworth AD, Clement ND, Jenkins PJ, et al. The epidemiology of radial head and neck fractures. J Hand Surg Am 2012;37(1):112–9.
75. Morrey BF, An KN. Stability of the elbow: osseous constraints. J Shoulder Elbow Surg 2005;14(1 Suppl S):174S–8S.
76. van Riet RP, van den Bekerom M, Van Tongel A, et al. Radial head fractures. Shoulder Elbow 2020;12(3):212–23.
77. Morrey BF. Radial head fractures. In: BF M, editor. The elbow and its disorders. Philadelphia: WB Saunders; 1985. p. 355.
78. Johnston GW. A follow-up of one hundred cases of fracture of the head of the radius with a review of the literature. Ulster Med J 1962;31(1):51–6.
79. Mahmoud SS, Moideen AN, Kotwal R, et al. Management of Mason type 1 radial head fractures: a regional survey and a review of literature. Eur J Orthop Surg Traumatol 2014;24(7):1133–7.
80. Smits AJ, Giannakopoulos GF, Zuidema WP. Long-term results and treatment modalities of conservatively treated Broberg-Morrey type 1 radial head fractures. Injury 2014;45(10):1564–8.
81. Al-Burdeni S, Abuodeh Y, Ibrahim T, et al. Open reduction and internal fixation versus radial head arthroplasty in the treatment of adult closed comminuted radial head fractures (modified Mason type III and IV). Int Orthop 2015;39(8):1659–64.
82. Duckworth AD, Wickramasinghe NR, Clement ND, et al. Radial head replacement for acute complex fractures: what are the rate and risks factors for revision or removal? Clin Orthop Relat Res 2014;472(7):2136–43.
83. Solarino G, Vicenti G, Abate A, et al. Mason type II and III radial head fracture in patients older than 65: is there still a place for radial head resection? Aging Clin Exp Res 2015;27(Suppl 1):S77–83.
84. Lott A, Broder K, Goch A, et al. Results after radial head arthroplasty in unstable fractures. J Shoulder Elbow Surg 2018;27(2):270–5.
85. Li N, Chen S. Open reduction and internal-fixation versus radial head replacement in treatment of Mason type III radial head fractures. Eur J Orthop Surg Traumatol 2014;24(6):851–5.
86. Stoneback JW, Owens BD, Sykes J, et al. Incidence of elbow dislocations in the United States population. J Bone Joint Surg Am 2012;94(3):240–5.
87. Kuhn MA, Ross G. Acute elbow dislocations. Orthop Clin North Am 2008;39(2):155–v.
88. Broberg MA, Morrey BF. Results of treatment of fracture-dislocations of the elbow. Clin Orthop Relat Res 1987;216:109–19.
89. Regan W, Morrey B. Fractures of the coronoid process of the ulna. J Bone Joint Surg Am 1989;71(9):1348–54.
90. Terada N, Yamada H, Seki T, et al. The importance of reducing small fractures of the coronoid process in the treatment of unstable elbow dislocation. J Shoulder Elbow Surg 2000;9(4):344–6.
91. Schreiber JJ, Warren RF, Hotchkiss RN, et al. An online video investigation into the mechanism of elbow dislocation. J Hand Surg Am 2013;38(3):488–94.
92. O'Driscoll SW, Morrey BF, Korinek S, et al. Elbow subluxation and dislocation. A spectrum of instability. Clin Orthop Relat Res 1992;280:186–97.
93. de Haan J, Schep NW, Tuinebreijer WE, et al. Simple elbow dislocations: a systematic review of the literature. Arch Orthop Trauma Surg 2010;130(2):241–9.
94. Maripuri SN, Debnath UK, Rao P, et al. Simple elbow dislocation among adults: a comparative study of two different methods of treatment. Injury 2007;38(11):1254–8.
95. Taylor F, Sims M, Theis JC, et al. Interventions for treating acute elbow dislocations in adults. Cochrane Database Syst Rev 2012;2012(4):CD007908.
96. Kesmezacar H, Sarıkaya IA. The results of conservatively treated simple elbow dislocations. Acta Orthop Traumatol Turc 2010;44(3):199–205.
97. Mehlhoff TL, Noble PC, Bennett JB, et al. Simple dislocation of the elbow in the adult. Results after closed treatment. J Bone Joint Surg Am 1988;70(2):244–9.
98. Eygendaal D, Verdegaal SH, Obermann WR, et al. Posterolateral dislocation of the elbow joint. Relationship to medial instability. J Bone Joint Surg Am 2000;82(4):555–60.
99. Anakwe RE, Middleton SD, Jenkins PJ, et al. Patient-reported outcomes after simple dislocation of the elbow. J Bone Joint Surg Am 2011;93(13):1220–6.
100. Chan K, MacDermid JC, Faber KJ, et al. Can we treat select terrible triad injuries nonoperatively? Clin Orthop Relat Res 2014;472(7):2092–9.
101. Chemama B, Bonnevialle N, Peter O, et al. Terrible triad injury of the elbow: how to improve outcomes? Orthop Traumatol Surg Res 2010;96(2):147–54.
102. Jeong WK, Oh JK, Hwang JH, et al. Results of terrible triads in the elbow: the advantage of primary restoration of medial structure. J Orthop Sci 2010;15(5):612–9.
103. van Riet RP, Morrey BF, O'Driscoll SW. Use of osteochondral bone graft in coronoid fractures. J Shoulder Elbow Surg 2005;14(5):519–23.
104. Egol KA, Immerman I, Paksima N, et al. Fracture-dislocation of the elbow functional outcome

following treatment with a standardized protocol. Bull NYU Hosp Jt Dis 2007;65(4):263–70.
105. Forthman C, Henket M, Ring DC. Elbow dislocation with intra-articular fracture: the results of operative treatment without repair of the medial collateral ligament. J Hand Surg Am 2007;32(8):1200–9.
106. Lindenhovius AL, Jupiter JB, Ring D. Comparison of acute versus subacute treatment of terrible triad injuries of the elbow. J Hand Surg Am 2008;33(6):920–6.
107. Seijas R, Ares-Rodriguez O, Orellana A, et al. Terrible triad of the elbow. J Orthop Surg (Hong Kong) 2009;17(3):335–9.
108. Winter M, Chuinard C, Cikes A, et al. Surgical management of elbow dislocation associated with non-reparable fractures of the radial head. Chir Main 2009;28(3):158–67.
109. Wang YX, Huang LX, Ma SH. Surgical treatment of "terrible triad of the elbow": technique and outcome. Orthop Surg 2010;2(2):141–8.
110. Garrigues GE, Wray WH 3rd, Lindenhovius AL, et al. Fixation of the coronoid process in elbow fracture-dislocations. J Bone Joint Surg Am 2011;93(20):1873–81.
111. Zhang C, Zhong B, Luo CF. Treatment strategy of terrible triad of the elbow: experience in Shanghai 6th People's Hospital. Injury 2014;45(6):942–8.
112. Zeiders GJ, Patel MK. Management of unstable elbows following complex fracture-dislocations–the "terrible triad" injury. J Bone Joint Surg Am 2008;90(Suppl 4):75–84.
113. Giannicola G, Calella P, Piccioli A, et al. Terrible triad of the elbow: is it still a troublesome injury? Injury 2015;46(Suppl 8):S68–76.