



Considerations in the Treatment of Osteoporotic Distal Radius Fractures in Elderly Patients

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Abstract

Purpose of Review With the incidence of distal radius fractures increasing in the elderly population, we sought to summarize the current orthopedic and medical management of these fractures in the elderly osteoporotic population.

Recent Findings The number of osteoporotic patients undergoing surgical fixation for distal radius fractures has increased in recent years. This is likely due to the improved outcomes seen with volar locking plates, as well as an increase in the number of fellowship-trained hand surgeons. Despite this potential improvement in acute fracture management, a majority of these patients are underdiagnosed and undertreated for their underlying osteoporosis or endocrinopathies. The implementation of fracture liaison services and the ability of the treating orthopedist to recognize this gap in patient care result in a higher number of patients initiating appropriate treatment.

Summary It is vital that when discussing acute fracture management, a thorough discussion is had with patients regarding functional outcome and the benefits of both surgical and non-operative management. As these fractures become more prevalent and a greater percentage undergo surgical intervention, the economic burden of distal radius fractures will continue to rise. It is imperative that the treating surgeon view these fractures as sentinel events that are predictive of future hip and vertebral fractures. While relatively new, the use of fracture liaison services to help aide in proper screening and treatment of osteoporotic patients is of great value. Non-pharmacologic therapy such as physical therapy, smoking and alcohol cessation programs, and dietary modifications are crucial in treating patients with osteoporosis. While bisphosphonates remain the first-line treatment in patients with osteoporosis, novel therapies show promise for future use.

Keywords Distal radius fractures · Osteoporosis · Elderly

Introduction

Distal radius fractures (DRF) are the most common upper extremity fracture (16%) and second most common overall fracture in elderly patients (18%) [1–3]. The incidence of these fractures is increasing, and disproportionately so in patients older than 65 [1, 2]. Improved implant technology and higher

rates of fellowship-trained hand surgeons likely contribute to observed increases in rates of operative management for these injuries [4–6]. Furthermore, the climbing incidence of DRF coupled with trends toward operative management contribute to their significant economic burden [7–9].

DRFs in the elderly are most often a result of underlying abnormalities in bone metabolism and present earlier than hip and vertebral fractures. Viewing elderly DRF as a sentinel event provides an opportunity for early diagnosis and treatment of underlying osteoporosis and other endocrinopathies, preventing future fragility fractures of the hip and spine, associated with higher morbidity [10, 11, 12, 13]. While these underlying conditions have historically been underdiagnosed and undertreated, recent efforts in establishing fracture liaison services have been effective in addressing this care gap [14–17]. Although the optimal treatment for the acute management of DRF in the elderly population is a matter of debate, the initiation of osteoporosis management and

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prevention of future fracture burden is accepted as a critical healthcare initiative.

Epidemiology/Risk Factors

DRFs are the second most common fracture in the elderly population (defined as age greater than 65) [3]. Many studies have noted an increased prevalence of DRF, particularly among the elderly population, and while this change is attributed to an aging population, its etiology is likely multifactorial [3]. Additional risk factors for DRF include female gender, white race, osteoporosis, hypovitaminosis D, and increased activity level [3, 18–21]. Furthermore, higher cognitive function may increase the likelihood of DRF versus hip or vertebral fracture as these patients are more likely to fall forward on an outstretched limb as opposed to their sides or back [22–24]. Seasonality has also been proposed as a risk factor for DRF in the elderly population. In cold weather climates, there appears to be an increased prevalence of DRF in the winter months, particularly with snow, ice, or lower temperatures [25, 26–28].

Acute Orthopedic Management

Initial management of DRF in the osteoporotic patient parallels accepted treatment methods in the general population. A thorough history and physical examination is necessary, including injury-specific factors such as mechanism of injury, hand dominance, smoking history, and functional status. Standard anteroposterior, lateral, and oblique radiographs of the affected wrist should be obtained, with particular attention paid to loss in radial height (mean: 11 mm), radial inclination (mean: 23°), volar tilt (mean: 11°), intra-articular fracture extension, articular step-off (> 2 mm), and ulnar variance [29, 30].

For non-displaced DRF, initial closed management consists of either a removable wrist splint or a plaster/fiberglass splint/cast. For displaced fractures, closed reduction is typically performed under a hematoma block with local anesthesia in the emergency department. Following reduction, the patient is placed in either a short-arm splint/cast or in a sugar-tong splint with post-reduction radiographs to assess alignment. A repeat neurovascular assessment should always be performed following reduction. In the elderly population, particular attention should be paid to skin quality, as skin tears are more common. Patients are made non-weight bearing in the affected extremity and given proper analgesic medications. Follow-up for fractures that undergo closed reduction is typically within 1 week. Repeat radiographs are obtained at that time to assess the adequacy and maintenance of reduction.

Definitive Orthopedic Management

Definitive management of osteoporotic distal radius fractures has been a recent subject of debate. For decades, treatment was based on studies that included young, healthy patients whose bone characteristics do not resemble an elderly and osteoporotic population [31–33]. Weak cortices of elderly osteoporotic patients are unlikely to maintain alignment with closed reduction yet offer poor screw purchase for internal fixation [34, 35]. Furthermore, it is unclear whether radiographic alignment is predictive of functional outcome. Some studies have failed to demonstrate a relationship between radiographic deformity and functional outcomes in elderly patients [35–37]. The introduction of volar locking plate technology has improved surgical outcomes compared to traditional dorsal plating, but still exposes patients to risks inherent to surgery [13, 38–42]. It also offers the theoretical advantage of a faster return to function which may be important in the elderly patient living independently [43]. Overall, the approach to management is patient and fracture-specific and should remain focused on the primary goal of restoring a functional hand and forearm [43].

Non-Operative Management

Non-operative management typically consists of application of a lightweight cast and serial monitoring over 6–8 weeks to ensure adequate return of function. At our institution, patients are typically followed up at 1-year post-injury to ensure maximal recovery although this is not always necessary. Cast immobilization is often inadequate to maintain radiographic reduction in the osteoporotic population, with only an estimated 30% of patients maintaining adequate reduction 5 weeks after injury [34]. Despite this shortcoming, most elderly patients tolerate wrist deformity well, and multiple studies have shown that the loss of flexion/extension arc that occurs with residual radiographic deformity is of limited clinical significance in the elderly population [35–37].

Operative Management

In 1989, Lafontaine et al. developed criteria to predict DRF stability and guide indications for surgical management [44]. The Lafontaine criteria are based off of original injury radiographs and include (1) dorsal angulation > 20° or > 5-mm radial shortening by ulnar variance, (2) dorsal metaphyseal comminution, (3) intra-articular involvement, (4) concurrent ulnar fracture, and (5) age over 60 years (Table 1) [44]. Mackenney et al. recently published similar criteria to predict radiographic malunion and instability which noted patient age, metaphyseal comminution, ulnar variance, and patient independence among the most important predictors of radiographic malunion and instability [45]. In both cases, patient

Table 1 Lafontaine criteria; three or more criteria are predictive of fracture instability and need for surgical fixation

Lafontaine criteria
1. Dorsal angulation > 20° or > 5-mm radial shortening by ulnar variance
2. Dorsal metaphyseal comminution
3. Intra-articular involvement
4. Concurrent ulnar fracture
5. Age over 60 years

age was an important criterion in predicting fracture instability and deformity. Surgical options include locked volar plating, dorsal plating, external fixation, and percutaneous pinning. Osteoporotic bone presents challenges to traditional fixation methods due to its inability to resist pullout of screws or other fixation devices, resulting in potential loss of reduction and alignment. Overall, patients with osteoporosis have been shown to have worse overall functional outcomes with surgical fixation than non-osteoporotic patients [46]. However, surgical management of distal radius fractures in the elderly has advanced significantly with the advent of locking-plate technology. While both dorsal and volar fixation for DRF may achieve adequate reduction and functional outcomes, studies suggest that volar locking plates are associated with improved grip strength, lower pain scores, and a lower complication profile when compared to dorsal plating (Fig. 1) [13, 38–40, 47].

Multiple studies have demonstrated little difference in functional outcome with non-operative or surgical management in osteoporotic patients who sustain DRF, yet a number of patients do undergo corrective osteotomies for symptomatic malunions [38, 48–51]. Complications are more common among patients treated surgically, with an estimated rate of 11% versus 8% for patients treated non-operatively [41, 42].

Infection is the most common complication in patients treated surgically (11.8%), and median neuropathy (11%) is most common in those who undergo closed management [41]. Other studies, however, have demonstrated much lower infection and tendon rupture rates with use of a volar locking plate, suggesting that the difference in complication rate between surgical and non-operative treatment may be less than originally reported with dorsal plating [13, 38].

Costs and Economic Burden

With the introduction of volar locking plates, rates of surgical intervention for DRF have increased [1, 5, 6, 8, 39]. While the disability associated with any DRF carries an economic and societal cost, surgical management costs significantly more than closed management [7, 9]. In 2007, management of each distal radius fracture cost Medicare nearly \$2000 per patient, with surgical intervention costing nearly three times that of closed management [5, 8, 9]. Among surgically treated patients, internal fixation costs more than percutaneous pinning despite a faster functional recovery [52]. While management varies greatly based on regionality and fellowship training, the significant healthcare costs of DRF are climbing with rising fracture incidence and rates of surgical intervention [5].

Osteoporosis Screening and Treatment

DRFs are an important harbinger for additional fragility fractures, yet multiple studies have shown that osteoporosis is underdiagnosed and undertreated at the time of DRF [12, 47, 53]. Specifically, DRFs are associated with increased risk of subsequent hip and vertebral fractures, which are directly related to increased mortality [10, 11, 54, 55]. Despite this

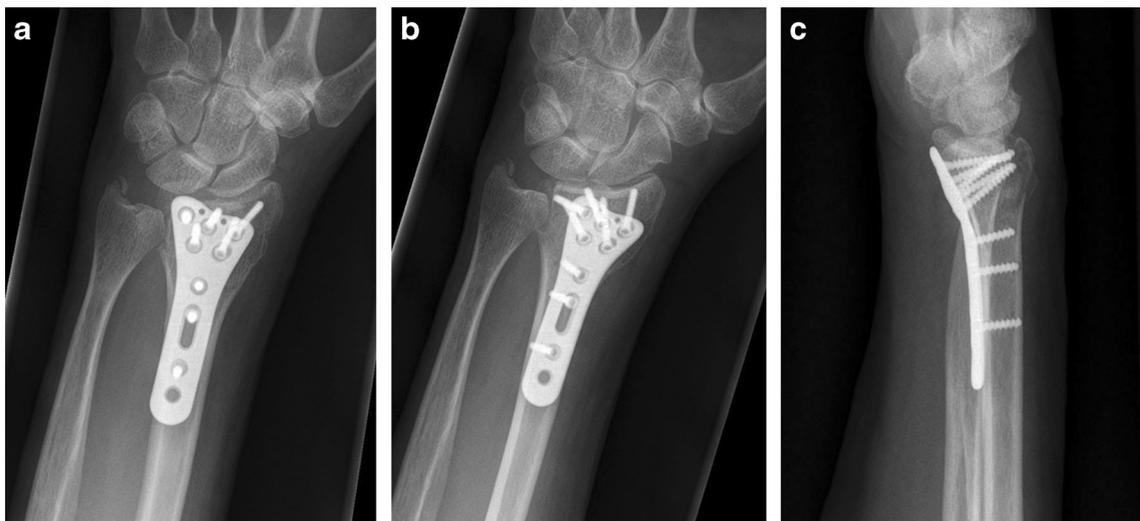


Fig. 1 a Anteroposterior, b oblique, and c lateral wrist radiographs in a 71-year-old female after open reduction and internal fixation of a distal radius fracture using a volar locking plate

Table 2 Various pharmacologic therapies used in the treatment of patients diagnosed with osteoporosis

Pharmacologic therapies	
Medication class	Mechanism of action
Bisphosphonates (e.g., non-nitrogen containing: etidronate; nitrogen containing: alendronate)	Non-nitrogen containing: metabolized within osteoclasts to form a toxic ATP analogue, initiating osteoclast apoptosis Nitrogen containing: inhibits farnesyl pyrophosphate synthase disrupting protein prenylation and GTPase formation
Calcitonin	Directly inhibits osteoclast function via binding of membrane receptors causing disruption of cytoskeletal organization and loss of cellular polarity
Teriparatide (e.g., Forteo)	Recombinant form of PTH that stimulates osteoblast to form new bone
Selective estrogen receptor modulators (SERMs) (e.g., raloxifene)	Agonist on estrogen receptors in bone, inhibiting osteoclast activity
RANK-ligand monoclonal antibodies (e.g., denosumab)	Monoclonal Ig2 antibody against RANK-L, preventing RANK-L binding to RANK and activating osteoclasts

association, only 21.3% of patients with DRF undergo bone mineral density (BMD) evaluation, and fewer than 30% ever initiate medical treatment [47, 56]. The importance of early osteoporosis screening and diagnosis following a fracture cannot be overstated. When BMD studies are ordered by the treating orthopedic surgeon at an academic medical center, patients are three times more likely to undergo BMD screening and initiate appropriate pharmacologic treatment [47, 57].

To aid orthopedists in the diagnosis and medical co-management of osteoporosis, fracture liaison services have been implemented by many institutions. These multidisciplinary teams work to identify fragility fractures in emergency, inpatient, and ambulatory settings and initiate appropriate testing and management [14]. These services are associated with increased BMD screening, increased treatment initiation, lower re-fracture risk, and reduced 2-year mortality [16, 58–60]. While an initial investment is required to develop such systems, the decreased rates of acute care episodes and fracture-associated health care utilization contribute to significant system cost-saving [14–17]. Fracture liaison services have been an important step toward early osteoporosis diagnosis and multidisciplinary long-term management yet remain underutilized in the USA.

Initial screening in patients who sustain low-energy DRF should consist of BMD testing, vitamin D and calcium levels, and screening for any underlying causes of secondary osteoporosis such as endocrinopathies, hematologic disorders, or medications [61]. The World Health Organization (WHO) defines osteoporosis based off of dual-energy X-ray absorptiometry (DEXA) scan measurements at the hip and lumbar spine. Osteoporosis is defined by a T-score of ≤ -2.5 and osteopenia as a T-score ≤ -1.0 and ≥ -2.5 [62]. Beyond predicting future risk of hip, spine, and distal radius fractures, lower BMD scores may predict a greater relative risk and severity of DRF [63]. The Fracture Risk Assessment Tool (FRAX) is used to calculate the 10-year probability of fracture, using a

combination of patient risk factors and BMD score to help determine need for pharmacologic therapy [64].

Non-pharmacologic treatment of osteoporosis includes physical therapy, fall prevention, smoking and alcohol cessation, dietary modifications, and vitamin D supplementation [65–68]. The multifaceted approach to fall prevention includes minimizing polypharmacy; improving strength, flexibility, and balance with regular exercise; addressing visual impairments; and managing arrhythmias and postural hypotension [69]. Recent meta-analyses showed that smoking increased hip fracture risk in both men and women and that smoking cessation for greater than 10 years is associated with decreased hip fracture risk in women [70, 71]. While light alcohol consumption may improve bone mineral density, higher levels of consumption are detrimental to bone health [66]. Furthermore, alcohol consumption may limit dietary intake of other nutrients and contribute to falls in an elderly population. Key dietary modifications include adequate daily calcium and vitamin D intake [72]. Evidence for other dietary modifications such as decreasing sodium, increasing potassium, and increasing fruit and vegetable consumption is lacking but these changes are unlikely to be harmful [72]. The evidence surrounding vitamin D is inconclusive. While several studies have shown significantly lower vitamin D levels in patients with low-energy distal radius fractures, others have failed to find an association [20, 21, 73, 74]. The United States Preventative Task Force (USPTF) recommends vitamin D supplementation of at least 1000 U/day in patients for those that are found to be vitamin D deficient (serum vitamin D-25OH < 20 ng/ml) or insufficient (serum vitamin D-25OH < 30 ng/ml) [67].

The National Osteoporosis Foundation recommends starting pharmacologic treatment in patients with a history of hip or vertebral fracture, T-score of ≤ -2.5 , or patients with osteopenia in combination with a 10-year probability of hip fracture of at least 20% based on FRAX score [62, 64]. First-

line pharmacologic treatment consists of bisphosphonates, which inhibit osteoclast activity, and have demonstrated reduction in future vertebral and hip fractures across multiple studies [75, 76]. While the theoretical risk of bisphosphonates initially inhibiting fracture healing once existed, studies have reported no differences in bony healing in patients on or off bisphosphonate therapy at the time of fracture [77–79].

Secondary treatment options include selective estrogen receptor modulators (SERMs), calcitonin, recombinant parathyroid hormone (teriparatide), and novel RANK-L receptor monoclonal antibodies (denosumab) (Table 2).

Multiple studies have examined the effects of vitamin C on the outcomes of distal radius fractures, in particular with regard to prevention of complex regional pain syndrome (CRPS) [80–82]. While it was once thought to be beneficial to give vitamin C at the time of fracture to prevent CRPS, recent studies have shown no difference in CRPS rates with or without vitamin C administration [80–82]. Ekrol et al. have shown in a randomized control trial that CRPS occurrence, functional outcomes, and healing rates were equivalent between groups that received 500 mg vitamin C for 50 days following fracture and those that received placebo [80].

Conclusion

Distal radius fractures are becoming increasingly common, particularly within the elderly community. Risk factors include female gender, white race, increasing age, colder weather climates, and increased cognitive status. Treatment of osteoporotic DRF is two-fold, involving both the orthopedic management and more importantly the management of the underlying metabolic disease. Osteoporotic bone presents challenges for both closed and surgical management of DRF, and goals of care should be discussed with the patient prior to deciding on treatment method. There has been an increase in the number of surgically treated osteoporotic DRF in recent years, owing both to the increased percentage of the population who remain functional over 65 years of age as well as the advancement in surgical technology and technique with volar locking plates.

Medical management consists of appropriate screening, diagnosis, and treatment of underlying osteoporosis, as DRF portend a greater risk of future hip/vertebral fracture. Fracture liaison services are multidisciplinary teams that work across healthcare settings and can assist with the diagnosis and management of osteoporosis following DRF. Non-pharmacologic treatment consists of physical therapy, fall prevention, smoking and alcohol cessation, dietary modifications, and vitamin D supplementation. First-line pharmacologic therapy includes bisphosphonates, which have been shown to decrease future hip/vertebral fractures and are safe for use immediately following fracture. Second-line agents are also

available and are becoming more prevalent as further research is conducted.

As the active elderly population grows, distal radius fracture prevalence will continue to climb. By tailoring acute management to patient-specific factors and initiating osteoporosis screening and management, orthopedic surgeons can play a vital role in restoring upper extremity functionality, maintaining independence, and preventing future fragility fractures.

Compliance with Ethical Standards

Conflict of Interest Peter J. Ostergaard, Matthew J. Hall, and Tamara D. Rozental declare no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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