Osteoporotic Ankle Fractures: An Approach to Operative Management

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Abstract: The incidence of osteoporosis is increasing as the elderly population grows. Because these patients remain active, fragility fractures of the ankle are becoming more common. The literature indicates a relatively high complication rate for non-operative management of ankle fractures in this patient cohort, leading surgeons to face challenges unique to patients with poor bone and skin quality. This article discusses techniques to address osteoporotic ankle fractures and reviews the current literature relevant to this issue. [Orthopedics. 2013; 36(12):936-940.]

Osteoporosis is an asymptomatic systemic disease characterized by deterioration of the microarchitecture of bone and low bone mass, which ultimately predisposes patients to fractures secondary to low-energy mechanisms. The incidence of osteoporosis is increasing rapidly as the population ages. Ankle fractures are one of the most commonly occurring fractures, and fragility fractures of the ankle are becoming proportionally more common in the elderly population, especially among women.1,2 The World Health Organization3 established that osteoporosis is diagnosed with a T-score of less than -2.5 (ie, the bone mineral density is 2.5 SDs below the young adult average bone mineral density) obtained by dual-energy x-ray absorptiometry scan or by the presence of a fragility fracture. A patient with a T-score between -1.0 and -2.5 is considered to have osteopenia. The etiology behind decreasing bone density differs from patient to patient but primarily relates to the disruption of homeostasis between osteoclasts and osteoblasts. Receptor activator of nuclear factor-kappa-B ligand (RANK-L) is a key cytokine involved in this homeostasis and is mainly produced by osteoblasts and bone marrow stromal cells. Coordination between RANK-L and its receptor, RANK, expressed on osteoclasts is a major mediator of osteoblast-osteoclast coordination and bone turnover.4 Once bone homeostasis is disrupted, the architecture changes, and ultimately the structural properties of the bone are altered.5 Trabecular bone structure is affected first, due to its high metabolic rate.6 Cortical thinning then follows, having a drastic impact on overall bone strength. Osteoporotic fractures are difficult to treat in general due to poor hardware purchase, and fractures of the weight-bearing lower extremities create an even greater challenge. Previously, the trend was to treat all osteoporotic ankle fractures nonoperatively due to the high complication rate.7,8 Rates of malunion or nonunion in patients older than 60 years treated by closed reduction and cast immobilization are as high as 48% to 73%.7,9 More recent studies have shown significantly greater functional outcomes with operative treatment of ankle fractures in elderly patients.10,11 A construct providing greater stability is particularly important in elderly patients because it is often difficult for them to adhere to a strict nonweight-bearing protocol.

This article reviews the different strategies used in treating osteoporotic ankle fractures.

Strategies for Treating Osteoporotic Ankle Fractures

Locking Plates

Locked plating has been one of the most helpful techniques in addressing fractures in osteoporotic bone. Locking plates create a fixed-angle construct similar to a blade
plate or an external fixator (Figure 1). The advantages of locking plate constructs have been shown in various anatomic sites, both weight-bearing and nonweight-bearing, throughout the body, including the cervical spine, mandible, distal radius, and femur.\textsuperscript{12-15} Traditional plate constructs can fail over time, with consecutive loosening of individual screws. However, locking plates tend to fail in a more catastrophic way, with all the screws failing at once. To avoid penetration of the ankle joint, screws in the distal fibula are able to obtain purchase in only a single cortex. Kim et al\textsuperscript{16} demonstrated the advantage of locking plates in cadaveric distal fibulas and determined that fewer unicortical screws are needed to achieve the same biomechanical stability found with an increased number of traditional unicortical nonlocking screws.

Some currently available newer plates provide an increased number of options for locked screw placement in the distal fibula. These plates are precontoured and low profile for a more anatomic fit and are especially useful when there is significant comminution with small fragments distally. Zahn et al\textsuperscript{17} showed that fixation strength with a precontoured locking plate was independent of bone mineral density (BMD), whereas fixation strength of nonlocking screws was dependent on BMD. The plates’ more elaborate design results in an increased cost compared with the standard one-third tubular plates.

**Posterolateral Plating**

Placing the plate on the lateral aspect of the fibula allows only unicortical screw purchase distally to avoid joint penetration. Compared with bicortical screw purchase, this unicortical screw purchase leads to a weaker construct, especially in osteoporotic bone. Placing the plate more posteriorly on the fibula allows the screw trajectory to aim more anteriorly away from the joint and achieve bicortical purchase, thus increasing the stability of the construct (Figure 2). During the application of the plate, the plate can create an axilla with the cortex at the apex of the fracture. The plate in this position prevents displacement of the fracture and provides the opportunity to add a compression screw across the oblique fracture through the plate. This antiglide plating technique works best with an oblique fracture and has shown greater strength compared with lateral locked plating.\textsuperscript{18} In short oblique cadaveric distal fibula fractures, Schaffer and Manoli\textsuperscript{19} showed better biomechanical properties with a posterior antiglide plate compared with a lateral plate.

Frequently, osteoporotic bone is found in the elderly population, who tend to have poorer skin quality. Placing the plate in an antiglide fashion prevents prominent screw heads laterally that could irritate the wound or the skin in the late postoperative phase after swelling has decreased. The peroneal tendons can cover the screw heads posteriorly, but this can lead to irritation of the tendons. Although the antiglide plate can outperform the lateral plate in a biomechanics laboratory, clinically the antiglide plate has been shown to be associated with an increased rate of hardware removal secondary to peroneal tendon irritation.\textsuperscript{20}

**Injectable Cement**

By definition, osteoporotic bone has a decreased amount of dense bone for screw purchase. Multiple studies have investigated various injectable cements to increase the density, and therefore the pullout strength, of screws. Polymethylmethacrylate (PMMA) has been used in cases of severe osteoporosis.\textsuperscript{21,22} Polymethylmethacrylate can be used for individual stripped screws; the stripped screws are removed from their holes, the cement is injected into the stripped screw holes, and the screws are reintroduced into the holes but not completely tightened. The ce-
ment is allowed to set, and the screws are subsequently tightened. Alternatively, the cement can be introduced and allowed to set completely before inserting the screw. The hardened cement can then be drilled and tapped before inserting the screw.22

Although PMMA provides a relatively inexpensive, ubiquitous, and strong augmenting lattice for screw purchase, it has poor biocompatibility, is nonresorbable, and is highly exothermic. A more biocompatible option is an osteoconductive material such as calcium-phosphate cement. Calcium-phosphate cement is progressively replacing PMMA as an option in traumatology.23,24 Recent in vitro and in vivo (rabbit model) studies have shown that using calcium-phosphate cement has increased the pullout force of cancellous bone screws.25,26 An in vitro study comparing augmentation with tricalcium phosphate cement vs PMMA vs no augmentation showed comparable pullout strengths between tricalcium phosphate cement and PMMA.27 Both tricalcium phosphate cement and PMMA showed a 4-fold increase in pullout strength compared with no augmentation in the osteoporotic cancellous bone model. The techniques described above for PMMA can be used for osteoconductive bone cement.

Tension Band Wiring

The technique of tension band wiring is frequently used in olecranon and patellar fractures to turn tensile forces created by muscle contraction into compression along the fracture site. The technique can be used in a different context in relation to fragility fractures about the ankle. Fractures of the medial malleolus that have significant comminution or fragments that are too small to accept screw fixation can be reduced and fixed using K-wires. The tension band wire can then be passed under the K-wires (and under the deltoid ligament) and wrapped around a screw placed proximally in the tibia (Figure 3). The tension band wire can be placed in a figure-8 fashion and tightened by twisting the opposing ends.

Tibio-Talar-Calcaneal Nail

The use of Steinmann pins as a temporary indirect stabilization technique is well documented, and they are currently used for extremely unstable ankle fractures.28,29 In patients with poor bone stock, poor soft tissue envelope, and a likely inability to follow nonweight-bearing instructions, a tibio-talar-calcaneal device is a viable option as primary and definitive treatment. Patients who fall into this category often have multiple comorbidities that make them poor candidates for revision surgery if their initial traditional ankle fixation method fails. Postoperatively, these patients have relatively smaller wounds and are allowed to bear weight as tolerated. Two recent studies have shown good outcomes with no wound complications following fixation of osteoporotic ankle fractures treated definitively with nails that cross the tibio-talo-calcaneal joints.30,31 Although this may not be an ideal first-line treatment for the active patient with osteoporosis, a tibio-talo-calcaneal nail is a great option for the relatively inactive patient who may not tolerate a revision surgery.

Syndesmotic Screws

The syndesmosis maintains the stability of the ankle mortise and, in effect, the stability of the ankle in general. The syndesmosis is not frequently injured in osteoporotic fractures because the bone tends to fail before the ligamentous structures; however, even without a specific syndesmotic injury, the method of syndesmotic fixation can be used to add structural integrity to lateral fibula plating.32 The notion of using tibia-pro-fibula screws makes sense conceptually because the screws are obtaining purchase in 4 cortices instead of 2. Panchbhavi et al33 investigated the use of tibia-pro-fibula screws and found that, compared with the same construct without the additional screws, they added a 9% increase in torque, a 24% increase in the amount of external rotation, and a 34% increase in energy observed before failure of the construct. Tibia-pro-fibula screws are a relatively quick, inexpensive, and technically straightforward method to increase the strength of a plate construct. The screws can be left in because complication rates can be as high as 22% with removal.34

Fibular Nail

When using a plate and screw construct to address a fracture, fixation strength is established by creating frictional force between a plate and the bone.35,36 Osteoporotic bone is more prone to having screws strip and lose purchase in the relatively weak bone, creating an overall less stable construct.37 Changing to a larger diameter of screw, a so-called “rescue” screw, to attempt to achieve better purchase does not

Figure 3: Illustration of the tension band technique in the medial malleolus. Kirschner wires are inserted in a retrograde manner, capturing as many fragments as possible. A 3.5-mm screw inserted proximally helps tension the metal wire looped around the ends of the Kirschner wires.
necessarily solve the problem. Wall et al. showed that changing from the traditional 3.5-mm screw to a 4.0-mm screw does not increase the pullout strength of the screw in osteoporotic bone. To circumvent the issue of screw pullout, a fibular nail can be used. Advantages to using a fibular nail include a smaller incision, decreased soft tissue stripping, and minimal disruption of the biology at the fracture site. A retrospective review of 24 patients with fragility fractures of the distal fibula who received a fibular nail showed that this was a successful method of treatment with low risk of complication, good restoration of function, and good patient satisfaction.9

Bugler et al. also examined the results for 105 patients treated with a fibular nail for unstable ankle fractures and found good radiological outcomes and patient satisfaction with minimal complications. There are various manufacturers of nails with different locking options, including the option to cross the syndesmosis.

Multiple or Longer Plates

When extensive comminution is present, some have advocated shortening through the zone of comminution until there is cortical contact. This is not a viable option in fractures of the fibula because even slight shortening of the fibula can cause a disruption in ankle mechanics and lead to ankle pain. To strengthen a construct, one could use—on posterolaterally and the other laterally. Longer plates with fewer screws can also be used to spread the stress load over a longer distance.

**CONCLUSION**

Because osteoporosis is an asymptomatic disease, the orthopaedic surgeon treating fragility fractures may be the first to recognize the condition and should refer the patient to the primary care practitioner for medical evaluation and management. Significant morbidity exists with casting in elderly patients, so operative treatment should be considered for questionably unstable ankle fractures. Locked plating and/or posterolateral plating are relatively universally available options for addressing ankle fractures. Tibio-talar-calcaneal nails should be considered primary definitive treatment for patients who have a low activity level or multiple comorbidities.

**REFERENCES**


