

# Alternatives In Fixation For Osteoporotic Bone

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*Given the decreased bone mineral density and poorer bone healing potential in people with osteoporosis, achieving adequate fixation can be challenging for osteotomies or arthrodesis procedures in this patient population. Accordingly, these authors review the literature and assess a range of fixation options including traditional plate fixation, cannulated screws and locking compression plates.*



Today's foot and ankle surgeons have at their disposal an abundance of osseous fixation methods and devices. Each of these various techniques offers both advantages and disadvantages depending upon the surgical scenario.

Patients with osteoporotic bone specifically represent an inherently challenging surgical experience. Surgeons must consider this pathology when selecting the type of fixation they will utilize. In addition to this being a consideration for osteotomy/arthrodesis fixation as patients with osteoporotic bone are by default more likely to develop fractures, one must take into account fixation techniques. Another factor to keep in mind is the possibility of osteoporotic fractures. Although osteoporotic fractures classically occur in the vertebra, hip, and wrist, they can also occur in the more distal lower extremity.<sup>1,2</sup>

Current estimates suggest that approximately 10 million Americans have osteoporosis while another 33.6 million have low bone density. However, these estimates may be low.<sup>3,4</sup> Traditionally, when one thinks of a patient presenting with osteoporosis, a thin, older female patient profile comes to mind. However, in addition to gender and age, a number of social factors such as poor diet, smoking, lack of physical activity and immobilization can predispose a patient to decreased bone mineral density and poorer bone healing potential.<sup>5</sup> Furthermore, various metabolic and hormonal changes can also increase the risk of bony changes, and all of these factors can affect both men and women of any age.<sup>3</sup>

Osteoporosis is defined as a decrease in bone mass and strength with deterioration of bone tissue and subsequent changes in bony architecture. These factors cause an increased risk of fracture or poor bony healing outcomes. One can clinically diagnose osteoporosis when the bone mineral density of the hip or spine is less than or equal to 2.5 standard deviations below the normal mean. Osteopenia, on the other hand, is defined as 1 to 2.5 standard deviations below the normal bone density mean. Typically, the calcaneus is the indicator of bone mineral density for the entire foot.<sup>6</sup>

Individuals with osteoporotic bone are inherently at a high risk of developing fractures and historically have demonstrated poorer outcomes with conservative management of these fractures.<sup>7</sup> Generally, conservative care requires immobilization and limited activity, both of which may be detrimental for long-term outcomes for the patient.

## Keys To Successful Fixation Of Fractures

The utilization of plates and screws for osseous fixation is a classic and successful technique. However, using fixation with plates and screws involves an additional insult to the local osseous blood supply of the fracture/osteotomy and arthrodesis fragments. These disruptions to the local blood supply increase the risks of delayed union and infection.<sup>8</sup> Patients with osteoporotic bone undergoing reconstructive and trauma procedures of the foot and ankle present unique challenges for foot and ankle surgeons.

Adequate reduction and utilization of stable fixation are key elements for the successful fixation of fractures. In particular for those patients with poor bone stock, researchers have determined that an early return to activity postoperatively results in improved outcomes.<sup>9</sup> Researchers have also linked longer periods of non-weightbearing to additional decreases in bone mineral density. Conversely, research has shown that an earlier return to weightbearing with load-bearing exercise improves bone density.<sup>6</sup>

Typically, screw and plate fixation are the protocol for fixation in osteoporotic bone, but some research has demonstrated the efficacy of more biological type of fixation techniques. Researchers have demonstrated that the holding strength of screws in osteoporotic bone may be decreased by up to 10 times, leading to the utilization of alternative types of fixation and possible augmentation of fixation with bone cement.<sup>2</sup>

A variety of research regarding the fixation of upper extremity fractures in osteoporotic bone has occurred because this is where the majority of these fractures happen. However, one can apply these principles to the lower extremity as well.

## What The Literature Reveals About Plate Fixation And Osteoporotic Bone

Plating is one of the most commonly utilized techniques for fixation of osteoporotic bone. Proposed methods for improved fixation have included long plates, which allow for greater distance between the fracture/osteotomy site and the farthest screw position as well as an improved resistance to rotational loading.

Traditional plating techniques rely on friction as a means of ensuring rigid internal fixation. However, successful fixation only occurs when there is enough friction along the plate, bone and fracture fragments held together in compression.<sup>10</sup> The traditional plating technique can resist axial, torsional and bending loads when no fracture gaps exist and the surgeon properly positions the plate.

One can achieve increased resistance to screw pullout and increased torque at the bone plate interface in traditional plating with bicortical screw purchase.<sup>11</sup> Screw pullout and available torque are related to the material into which the surgeon inserts them. Systemic diseases associated with bone demineralization or generalized osteopenia present the kind of deficient bone quality in pedal cases that can fail to resist the advancing torque or screw pullout forces one encounters in a typical postoperative period.

Traditional plating techniques create potential risks in foot and ankle surgical cases in which comminution, significant gaps in bone or inherent instability of non-anatomically reduced fractures are common.<sup>11</sup> Shortcomings in traditional plating methods lead to small amounts of motion at the plate's bone-to-screw interface. This motion can loosen fixation. Lost or failed fixation directly leads to nonunion as described in Perren's "strain theory of bone."<sup>12</sup>



Research has demonstrated that using blade plates to provide improved fixation at the plate assists in decreasing the dependence of screw thread purchase on adequate fixation.<sup>13</sup> There have been mixed findings regarding whether locking or non-locking plating offers superior fixation in osteoporotic bone.

## When Should You Use Locking Plates?

Kim and colleagues theorized that osteoporotic bone does not provide an adequate foundation for traditional plating techniques, thus necessitating the use of locking plate technology.<sup>7</sup> The authors went on to evaluate the relationship between bone mineral density and plating styles, determining that there was a strong relationship among achievement of adequate fixation, traditional plating and bone mineral density. The authors found locking plates to be successful independent of the level of bone mineral density.

Zehnder and co-workers, in their comparison of locking plates with four screw angulation fixation methods, found no initial difference in load to failure rates between fixation types.<sup>14</sup> However, they did find that with increased loading, the locking plates proved to be superior to the non-locking styles.

In regard to using traditional plating in patients with decreased bone density, the theory is that the screws can loosen more easily and become separated from the plate/bone.<sup>14</sup> Yanez and colleagues offer a possible solution to this issue by applying a screw-locking element to a traditional plating system, which functions as a locking nut.<sup>15</sup> The authors found that this system provides certain advantages over locking plates, including the ability to contour the plate as well as the ability to replace pulled out screws without having to create new drill holes in the bone.

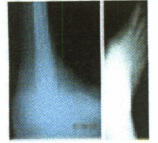
Another study of 216 patients focusing on postoperative complications of ankle fractures in an elderly population found a higher risk of hardware related complications in patients receiving locking plate fixation in comparison to standard plating.<sup>16</sup>

Locking plate fixation is advantageous when one applies it in cases of osteopenic bone, comminuted fractures or in circumstances when anatomic reduction is not necessary or possible.<sup>17</sup> Screws that lock to plates eliminate screw toggle and create a fixed angle or a single beam construct. Traditional plating can only achieve the single beam effect, if at all, with screws that have solid bicortical purchase in dense, healthy bone. The strength of the locking plate single beam is related to the sum of all screw bone interfaces. A locking plate is strongest with multiple anchoring points or multiple screws.

A locking plate construct is thought of as the ultimate external fixator in that it is a rigid structure one places extremely close to the mechanical axis of the bone.<sup>18</sup> This construct has demonstrated strength capacities four times that of traditional systems whereas screws tend to toggle.<sup>11</sup> The construct creates stable elastic fixation, allows strains of 2 to 10 percent and promotes callus formation, which leads to secondary bone healing. Secondary bone healing requires some relative motion.<sup>8,11,19</sup> Locking plates allow that residual "strain" that inevitably occurs when fixating severely comminuted or osteoporotic bone.

Locking plates also make anatomic reduction unnecessary. Anatomic reductions are paramount when employing traditional plating techniques. However, anatomic reduction involves extensive surgical exposure and soft tissue stripping. When it comes to multifragmentary shaft fractures, precise anatomical reduction is often not possible without a great risk of iatrogenic soft tissue trauma.<sup>20</sup> Vigorous soft tissue dissection potentiates the likelihood for nonunion or infection. A shift toward minimally invasive surgical techniques encourages locking plate constructs.

In cases that are difficult to reduce anatomically, one should consider using locking plates. Current locking plate designs do not rely on friction force at the bone-plate interface. Therefore, locking designs do not impair periosteal blood flow to healing bone.<sup>19</sup> The combination of mechanical superiority and their biologically friendly nature makes locking plate fixation appealing in the surgical correction of complex foot and ankle deformities.



## Emerging Insights On Locking Compression Plates And Polyaxial Locking Plates

The development of the locked internal fixator concept has provided surgeons with technological advances that can apply to the fixation of bone fragments in lower extremity trauma or reconstruction. Locking compression plates and polyaxial locking plates are two such advances. Although they differ from early generation locking systems, they both still promote less soft tissue and blood supply damage while ensuring more rapid and predictable fracture healing. Locking compression plates feature a combination of holes that can be conventional (the compression principle), locking (the internal fixator principle) or a combination of the two.<sup>21</sup>

The polyaxial system also allows eccentric loading. This allows the foot and ankle surgeon to take advantage of many plating principles. Surgeons may use this system to facilitate conventional compression of a solid, reducible area of a fracture or osteotomy while reserving the opportunity to lock and bridge an area of significant bone grafting or comminution within the same plate.

This “lag and lock” principle involves the combination of compressing the plate to bone while the locking screws are locked to the plate. Foot and ankle surgeons can use this principle in cases in which good bone quality and bicortical screw purchase coexist with diseased or osteoporotic bone. The locking compression plates can maintain both angular stability and interfragmentary compression within one plate.

Polyaxial locking plates allow surgeons to apply the fixed angle concept in more than one axial relationship.<sup>22</sup> Previous locking constructs limited the option for screw plate locking to one 90-degree option. The polyaxial concept opens the door for screw placements in upward of a 15-degree divergence in any one direction or plane. The advancement of the polyaxial concept makes it possible to introduce multiple locking screws with an independent axis of orientation. Studies have shown that surgeons can accomplish the polyaxial concept without compromising torque to failure or pullout strengths of the implant.<sup>23</sup>

## What You Should Know About Screws And Other Fixation

Screw type can also affect fixation outcomes in osteoporotic bone. Cannulated screws offer the surgeon the advantage of precise anatomic placement but may possess decreased holding strength in comparison to non-cannulated screws.

Ramaswamy and colleagues examined the holding power of four types of small fragment, cannulated screws in normal versus osteoporotic bone.<sup>24</sup> Their study determined that the Barouk screw, which possesses more threads and a greater surface area, demonstrated a greater pullout and push out strength than the other types tested. Interestingly, the authors did find that the average pullout strength decreased by 4 to 30 percent in normal and osteoporotic bone after surgeons implanted the screws, removed them and then reinserted them.



Researchers have discussed other methods of fixation in the literature for osteoporotic bone. For example, authors have described intramedullary nailing as a viable alternative for ankle fractures in bone with decreased density. This method offers the additional benefit of a minimal incision with decreased risk of soft tissue infection.<sup>2,25</sup> Other authors have described the utilization of a nylon cavity plug in osteoporotic bone for instances in which the tapped thread in cortical bone has become stripped.<sup>25</sup>

## What About Post-Op Considerations?

Postoperative management is another key component when caring for patients with osteoporotic bone. It important to keep in mind that extended periods of immobilization or non-weightbearing may significantly impact long-term joint range of motion as well as negatively impact already depleted bone density values.<sup>26</sup> This factor is another reason for judicious application of fixation methods in these patients.

The surgeon should also keep in mind that comorbidities as well as cigarette smoking can be complicating factors and have deleterious effects on the outcomes of these patients.<sup>2,5</sup> In a study of complications after ankle fracture in elderly patients, Lynde and co-workers found 18.18 percent and 10.87 percent complication rates in patients with and without comorbidities respectively.<sup>16</sup>

## Final Thoughts

An abundance of fixation options are available for osteoporotic bone. Plating and non-plating modalities each offer their own benefits with the literature demonstrating mixed reviews of each. An expedited postoperative course offers patients earlier mobilization and all the corresponding benefits. In addition, the surgeon should keep in mind that thorough evaluation of patient comorbidities is a key factor for determining outcome.

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