Locking Plate Fixation for Proximal Humerus Fractures

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Locking plates are increasingly used to surgically treat proximal humerus fractures. Knowledge of the bone quality of the proximal humerus is important. Studies have shown the medial and dorsal aspects of the proximal humeral head to have the highest bone strength, and this should be exploited by fixation techniques, particularly in elderly patients with osteoporosis. The goals of surgery for proximal humeral fractures should involve minimal soft tissue dissection and achieve anatomic reduction of the head complex with sufficient stability to allow for early shoulder mobilization. This article reviews various treatment options, in particular locking plate fixation.

Locking plate fixation is associated with a high complication rate, such as avascular necrosis (7.9%), screw cutout (11.6%), and revision surgery (13.7%). These complications are frequently due to the varus deformation of the humeral head. Strategic screw placement in the humeral head would minimize the possibility of loss of fracture reduction and potential hardware complications.

Locking plate fixation is a good surgical option for the management of proximal humerus fractures. Complications can be avoided by using better bone stock and by careful screw placement in the humeral head.

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Figure: Schematic results of dual-energy X-ray absorptiometry of the proximal humerus with regions of interest (1, proximal; 2, central; 3, distal; 4, lateral; 5, medial; 6, shaft). The regions of same grading of coloration showed no significant difference in bone mineral density. The darker the coloration, the higher the bone mineral density value. (Reproduced with permission from Hepp P. Biology and biomechanics in osteosynthesis of proximal humerus fractures. Eur J Trauma Emerg Surg. 2007; 33:337-344. Copyright © 2007, Springer.)
Fractures of the proximal humerus are an increasingly common injury, accounting for 4% to 5% of all fractures and 45% of all humeral fractures. They are the third most common fracture in people older than 65 years, after hip and distal radius fractures. The highest incidence occurs in women between the ages of 80 and 89 years. As the number of osteoporosis-related fractures increases, a three-fold increase in the incidence of proximal humerus fractures over the next 30 years is projected.

Court-Brown et al reported that “a proximal humerus fracture often occurs in a fit elderly independent patient who is a net contributor to society but who might well be converted to a degree of social dependency by the fracture.” This underlines the importance of treating this fracture appropriately not only to ensure a good functional outcome for the patient, but also to reduce the economic burden on a health care service.

Approximately 20% of proximal humerus fractures require surgical intervention, and these surgically treated fractures are often 3- or 4-part fractures. The goals of surgery for proximal humeral fractures should involve minimal soft tissue dissection and achieving anatomic reduction of the head complex with sufficient stability to allow for early shoulder mobilization. Surgical options include percutaneous Kirschner wires, T-plates, angled plates, cloverleaf plates, intramedullary nails, tension band wires, and primary prosthesis. Locking plates are being increasingly used by surgeons for these fractures, especially in patients with poor bone stock. This article describes the bone quality of the proximal humerus and the various treatment options, in particular locking plate fixation.

Bone Quality of the Proximal Humerus

The cancellous bone mass in the proximal humerus reduces with age, and the trabecular network is limited in older patients. This is due to decreased osteoblastic activity and occurs up to the ninth decade. Overall decrease in bone mass leads to a reduction in trabecular thickness and trabecular connectivity. Tingart et al compared the cortical thickness of the proximal humerus diaphysis with the bone mineral density (BMD) of the proximal humerus and found that a low BMD was highly predictive if the sum of the cortical thickness of the medial and lateral diaphysis cortices was < 4 mm.

Knowledge of the distribution, microarchitecture, and mechanical quality in the humeral head allows the bone stock to be used effectively. Hepp et al and Lill et al reported a variation in bone strength in different humeral areas of the head. The medial and dorsal aspects of the proximal humeral head were found to have the highest bone strength. These regions had a high trabecular volume, trabecular thickness, and amount of trabecular nodes. The schematic results of dual-energy X-ray absorptiometry of the proximal humerus demonstrating the areas with high BMD are shown in Figure 1.

Liew et al analyzed the effect of screw placement on fixation in the humeral head and found that screws in the center of the head provided optimal screw strength; they emphasized that the anterosuperior region of the head should be avoided. This was also supported by an observational study examining the trabecular patterns in the humeral head, which showed that the inferior, central, and posterior regions had increased trabecular density.

Treatment Options

Eighty percent of proximal humerus fractures are neither displaced nor markedly unstable and are treated conservatively. In the remaining 20%, the fracture fragments are displaced, unstable, and may cause disruption to their blood supply. The treatment of these fractures remains a challenging problem, with no consensus about the most appropriate management.
4-part fractures of the proximal humerus often warrant operative intervention. Various surgical treatment options exist, such as percutaneous K-wires, T-plates, angled plates, cloverleaf plates, intramedullary nails, tension band wires, primary prostheses, and locking plate fixation. Conventional large fragment plates, such as the T-plate or cloverleaf plate, require contouring to fit and provide poor results in weak osteopenic bone. A complication rate of approximately 40% has been reported, which includes subacromial impingement, screw loosening, and avascular necrosis. Tension band wiring was a common method used to treat proximal humerus fractures, but some studies have shown no difference in functional outcome when compared with patients treated conservatively.

Blade plates are more rigid than conventional plates but have limited proximal screw options. Their larger profile can cause impingement, and subsequent removal is necessary. Intramedullary nails are load-sharing devices with reduced lever arms for fragmentary motion. Functional outcomes have been found to be satisfactory mainly in 2-part fractures. However, the overall complication rate is high (approximately 31%), with loosening or backing out of the proximal screw being the most common problem. In a cadaveric study by Edwards et al., the locking plate was biomechanically superior to intramedullary nailing of the proximal humerus when bending and torsion forces were applied. The high early rate of failure in the proximal humeral nail–bone construct was highlighted in their study.

A complex 3- or 4-part proximal humerus fracture may be treated by primary hemiarthroplasty. Studies have shown good pain relief for the patient, but functional outcomes are variable. Primary shoulder arthroplasty for degenerative arthritis leads to a more certain outcome than that for fractures. Another option for complex proximal humerus fractures is reverse total shoulder arthroplasty, especially for elderly patients.

**Locking Plate Fixation**

Locking plates are widely used in the fixation of proximal humerus fractures. These plates were developed to provide angular stability and achieve a favorable screw–bone interface, especially in osteoporotic bone. The plate incorporates multiple locking screws in convergent and divergent directions to improve pullout strength and fixation strength. This creates a fixed angled device that acts as a single unit that captures a volume of bone. It is positioned on the lateral cortex of the proximal humerus to provide intrinsic stability to an anatomically reduced proximal humerus fracture. Medial buttress plates would compromise the blood supply to the humeral head.

Lungerhausen et al. performed a retrospective comparative study comparing patients treated with locking plates and other methods such as conventional plates and K-wires. They reported a significantly better outcome with the locking plate in the 3-part fracture group. Bjorkenheim et al. also reported better functional outcomes with locking plates in patients with 2- and 3-part fractures than in patients with 4-part fractures. Good functional outcomes using locking plate fixation for complex proximal humerus fractures have been reported in several studies.

Investigation into which factors influence the maintenance of fracture reduction after locking plate fixation of proximal humerus fractures was performed by Gardner et al. Their study showed that age, sex, and fracture type were not independently related to loss of fracture reduction. Mechanical support of the inferomedial region of the proximal humerus had a significant effect on the magnitude of subsequent reduction loss. Agudelo et al. also showed a correlation between varus malreduction and early loss of fixation. Their study supports the need for proper fracture reduction prior to fixation. Figure 2 shows loss of reduction of the proximal humerus fracture due to malreduction of the medial cortex and the lack of additional support, which would be provided by an inferomedial screw. Gardner et al. suggested that the surgeon may provide medial column support by achieving an anatomical or slightly varus stable reduction, as well as meticulously placing a superiorly directed oblique locking screw in the inferomedial region of the proximal humerus fragment.

Studies have reported that supplementing internal fixation techniques with calcium cement or synthetic bone graft substitute also reduce intrafragmentary motion.
has also provided further construct stability, especially in proximal humerus fractures with medial comminution, significant voids, and low bone stock.49,50

**Locking Plate Complication Rate**

The complication rate associated with hardware failure is significant. A systematic review of proximal humerus fractures treated using locking plates by Thanasa et al.10 analyzed the complication rate associated with this method of fixation. They reported an avascular necrosis rate of 7.9%, a screw cutout rate of 11.6%, and a reoperation rate of 13.7%. The complication rate associated with this procedure is relatively high. Several studies have emphasized the importance of medial column support of the proximal humerus to reduce the rate of possible complications.16,34,37,39

In a clinical study, Gardner et al.17 showed that a deficient medial support led to 30% screw perforations compared with 6% for fractures with an intact medial support. This highlights the importance of the inferomedial screw in supporting the medial column and maintaining fracture reduction, especially in the presence of medial comminution because this may prevent other implant-related complications from developing, such as screw penetration of the articular surface or plate breakage.

Maximum bone quality and quantity were observed in the inferior and dorsal regions of the proximal humerus by Hepp et al.13 Their study reported that surgical stabilization techniques should use the inferomedial trabecular network for screw fixation due to the increased mechanical quality of this region. Locking screw fixation exploits this inferomedial trabecular network due to its increased mechanical strength. This may be of particular benefit in osteoporotic bone and prevent hardware-related complications.

**Conclusion**

Locking plate fixation is a good surgical option for the management of proximal humerus fractures. Medial support is vital when using this method of fixation to minimize complications. Careful adherence to technical aspects, especially screw position, is vital because the use of better bone stock in the inferomedial region of the humeral head may reduce hardware complications, especially in patients with osteoporosis.

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