Locking Plates on Femoral Fractures: A Systematic Review

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ABSTRACT

Femoral fractures are a challenging medical and social problem as they may occur at any age. All the available osteosynthesis types can be used to treat such injuries. However, despite the disadvantages, fixation with plates has been the most common and developed. The PubMed and EMBASE databases were used to perform a systematic review of the English literature to assess the functional results and complications associated with proximal humerus locking plates. All institutional, author, and journal information was concealed to minimize reviewer bias. Fixation of proximal humerus fractures with proximal humerus locking plates is associated with a high rate of complications and reoperation. Further study is needed to determine what technical errors and patient characteristics are risk factors for failure of this now common fixation technique.

INTRODUCTION

Many fixation techniques have been described from tension banding, intramedullary nailing, and plate fixation. Displaced and comminuted fractures of the proximal humerus pose difficult management problems for the orthopaedic surgeon. There is different consensus concerning the best treatment option for each patient, either by non-operative management, internal fixation or by prosthetic replacement. Open reduction and internal fixation of displaced proximal humerus fractures is indicated in patients with 2- and 3-part fractures with significant displacement, and in some 4-part fractures, especially in younger patients. In biomechanical analysis, locking plates demonstrate significantly greater torsional stability in a cadaveric model, suggesting better clinical performance compared to non-locking plates. Clinically, many studies have shown that locking plates provide high rates of union for displaced proximal humerus fractures. The purpose of this study was to critically evaluate the literature relating to locking plate fixation of displaced 2-, 3- and 4-part proximal humerus fractures to determine the expected outcomes and complication rate from this procedure.1,2,3

METHODS

To minimize reviewer bias and cover all reports in the literature, we established a rigorous review procedure by following strictly published protocols. The PubMed search engine and EMBASE database were utilized with the search terms: proximal humerus fracture, open reduction internal fixation, shoulder fracture, bone plate, fracture fixation, fracture healing, shoulder surgery, osteosynthesis, shoulder joint, bone screw, shoulder dislocation, shoulder fracture therapy, shoulder fracture rehabilitation, shoulder fracture surgery, proximal...
humerus fracture, closed reduction, and external fixation. The search was originally performed in June 2009 and then repeated in October 2009 to include the most recent literature. The selected studies were limited to English only. The results of the search were critically evaluated and assigned to one of the three categories: relevant, possibly relevant, or irrelevant. Inclusion criteria for the study included: proximal humerus fractures due to trauma (excluding pathologic fractures); patients greater than 18 years of age; more than 15 patients in the study or subgroup of interest, at least eighteen months follow-up, at least one relevant functional outcome score such as range of motion, pain, patient satisfaction, or complications; quality outcome score of at least a 5/10 according to a previously published scoring system.

Results

The electronic search through the PubMed and EMBASE databases yielded 61,306 citations, by mapping to the described terminology, searching for related articles, and by expanding on the preferred terminology. From this initial search, 133 studies were found to be possibly relevant. Following critical review, there were twelve studies that satisfied the inclusion criteria and were subject to further analysis. All twelve studies included for analysis can be classified as level IV evidence case series based on the Centre for Evidence-Based Medicine published guidelines. Four studies were performed prospectively while five studies were retrospective reviews of clinical database records. The remaining three studies did not indicate whether the data was collected prospectively or retrospectively. None of the studies included a control group, randomization, or blinding.

There was a high level of correlation between the reviewers in terms of study inclusion (k = 0.84). In 11 of 12 studies, both reviewers agreed with study inclusion and scored the studies with greater than 5 out of 10 possible points. One study was scored as 4/10 by one reviewer and 6/10 by the other reviewer, and was included in the study. There were 514 patients with proximal humerus fractures included in our study. Of these 66.3% (341) were female and 33.7% (173) were male. The average age was 62 years. The average follow-up was 29.2 months. By fracture type there were 34.0% (175) two part fractures, 44.7% (230) three part fractures, and 21.2% (109) four part fractures.

The standard deltopectoral approach was used in all 12 studies, but one study included cases where a deltoid splitting approach was also used. The PHILOS plate (Synthes, Paoli, PA) was the most common plate used, while the LCP plate (Synthes, Paoli, PA) was the second most common. Other plates were also used in smaller numbers and include the HOFER plate (Hofer GmbH, Aldrans, Austria), the AxsOS plate (Stryker, Selzach, Switzerland), and the periarticular proximal humerus locking plate (Zimmer, Warsaw, Indiana).

The rehabilitation protocols differed considerably between studies. Six studies immobilized patients immediately post-operatively for a duration ranging 5 days to 3 weeks. Five studies did not immobilize their patients for any period of time and 1 study did not comment on post-operative immobilization. Two studies allowed only early pendulum exercises for early range of motion, 3 studies passive range of motion, 4 studies active assist range of motions, and 2 studies active range of motion. All studies that commented on rehabilitation protocols allowed active range of motion at 6 weeks.

The overall healing rate in the reviewed studies was 96.6%. Of the 514 fractures in the series, 498 were considered either clinically or radiographically healed depending on the study. The outcome measure most often used was the Constant score which was used in 9 of the studies. The average constant score at final follow-up for patients who have undergone open reduction internal fixation of a proximal humerus fracture is 73.6. In eight studies that reported a constant score that was divided by fracture type, the score was least in the 4-part fracture group,
and greatest in the 2-part fracture group. The weighted average score in the 2-part group was 77.4. The average constant score was 72.4 in the 3-part group, and 67.7 in the 4-part group. The 4-part constant score was significantly less than the 2-part score (p = 0.02). The DASH score was also used in 5 of the studies with an average score of 26.6. Range of motion was reported in only 2 studies. They measured active forward flexion and active abduction. The average active forward flexion was 98 degrees. The average active abduction was 103 degrees.

There were a total of 251 reported complications. The overall complication rate was 48.8% and the reoperation rate was 13.8% (71 procedures). Excluding varus malunions the complication rate was 32.6%. The most common complications included varus malunion (16.3%), AVN (10.8%), screw perforation into the joint (7.5%), subacromial impingement (4.8%), and infection (3.5%). The most common cause for reoperation was screw perforation. There was a total of 51 cases of AVN, but only 4 patients were reported to be converted to hemiarthroplasty.

Discussion

Plate fixation is still the most preferred method in the treatment of distal femoral fractures. In most severe injuries, accompanied by the medial support loss (33-A3, 33-C2 and 33-C3 fracture types according to AO classification), the use of not only the lateral but also the medial plate to achieve stable osteosynthesis has been discussed. The surgeon can use any type of osteosynthesis for distal femur fracture treatment, plating, nailing or transosseous osteosynthesis. Although few but the available studies prove that their results are comparable. However, the majority of surgeons prefer plating. It is associated with a number of advantages. The main one is that plating is possible for any kind of fracture, what is especially important in the case of intra-articular multi-fragmented fractures of the distal femur. Plating for management of fractures of such location was first applied in the 1960s. Since then, a great variety of plates that would compare the treatment results of using one versus two plates.

Management of proximal humerus fractures remains a difficult problem for the orthopaedic surgeon. In the setting of displaced fractures, there is no consensus on the best treatment option, with some studies favouring prosthetic replacement and other studies favouring reduction and plate fixation. The heterogeneity of multiple factors in the literature, including patient population, fracture type, and outcome measures reported, makes it difficult to determine the best treatment option for a given fracture pattern. The purpose of this systematic review was to critically evaluate the literature that reviews proximal humerus fractures managed with a locking plate.

Shoulder range of motion following open reduction internal fixation with a proximal humerus locking plate is one of, if not the most important outcomes with regards to post-operative patient function. Therefore, it was surprising that only two studies specifically commented on range of motion as one of the outcomes of interest. While it is true that range of motion is a significant component of the constant score, the inclusion of other variables such as pain, strength, and ability to sleep in this score makes it only a rough proxy for true patient range of motion. Further study is needed to specifically evaluate post-operative range of motion after proximal humerus locking plate and how it relates to patient function.

Avascular necrosis is one of the most feared complications following open reduction internal fixation of proximal humerus fractures. AVN can develop as long as five years after injury. This phenomenon is supported by the observation that studies with longer follow-up usually also report higher rates of AVN. Similarly, the adverse outcomes associated with AVN including pain, decreased range of motion, and glenohumeral joint arthritis can take years to develop. This may explain why so few of the patients in this review required joint replacement surgery given the average follow-up was only 29.2
months. Fixation technique has also been implicated as a contributor to AVN, especially in plate fixation given the need for extensive soft tissue dissection. The rate of avascular necrosis seen in our review was 10%, with only a small fraction of these requiring conversion to a joint replacing device. This would appear to question the clinical significance of radiographic AVN. Gerber et al. evaluated a series of 25 patients who developed AVN following ORIF of a proximal humerus fracture at an average follow-up of 7.5 years and found the average Constant score in this group was 46.9. Similarly, Wijgman et al. reported that significantly fewer patients with radiographic evidence of AVN had a good or excellent Constant score compared to those without AVN. The most common complication seen in this review is varus malunion, which was seen in 16.3% of cases reviewed. Loss of the medial cortical buttress from fracture comminution at this location is the most important risk factor for varus malunion. Surgical technique may also play a role in the high rate of varus malunion seen. Some surgeons have advocated accepting mild varus alignment when there is medial comminution in order to allow inferomedial cortical abutment to gain stability at the fracture site. The high rate of this complication is important because a varus malunited fracture is more likely to be complicated by both screw cutout and subacromial impingement, both common problems that often require revision surgery to correct.

**Conclusion**

Fixation of proximal humerus fractures with fixed angle locking plates is a relatively new advancement in the field of orthopaedics that has rapidly increased in popularity. Biomechanical studies certainly show potential benefits over standard plating techniques including improved rigidity and stability at the fracture site, especially in cases of severe comminution or osteoporotic bone. Further advance of the technology for treating these injuries may be associated with designing an “anatomical” medial plate and a method for its minimally invasive implantation. Development of a lateral plate which could provide the stability similar to bilateral osteosynthesis seems even more prospective. Undoubtedly, such a plate would be useful in limb reconstruction surgery as well, for changing the external fixation to internal one after deformity correction and limb lengthening.

Despite promising clinical results, there remains a high rate of complications that require further surgery, suggesting that the surgical technique should be used carefully and only in well selected patients. Patients should understand the risks and limitations of this promising surgical technique to repair displaced proximal humerus fractures.

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