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Review

How to enhance the stability of locking plate fixation of proximal humerus fractures? An overview of current biomechanical and clinical data

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ABSTRACT

Background: The complication rate after locking plate fixation of proximal humerus fractures is high. In addition to low bone mineral density, a lack of medial support has been identified as one of the most important factors accounting for mechanical instability. As a result of the high failure rate, different strategies have been developed to enhance the mechanical stability of locking plate fixation of proximal humerus fractures. The aim of the present article is to give an overview of the current biomechanical and clinical studies that focus on how to increase the stability of locking plate fixation of proximal humerus fractures.

Methods: A comprehensive search of the Medline databases using specific search terms with regard to the stability of locking plate fixation of proximal humerus fractures was performed. After screening of the articles for eligibility, they were subdivided according to clinical and biomechanical aspects.

Results: Medial support screws, filling of bone voids and screw-tip augmentation with bone cement as well as the application of bone grafts are currently the most frequently assessed and performed methods. Although the evidence is weak, all of the mentioned strategies appear to have a positive effect on achieving and maintaining a stable reduction even of complex fractures.

Conclusion: Further clinical studies with a higher number of patients and a higher level of evidence are required to develop a standardised treatment algorithm with regard to cement augmentation and bone grafting. Although these measures are likely to have a stabilising effect on locking plate fixation, its general use cannot be fully recommended yet.

Contents

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Introduction

Fractures of the proximal humerus are the fourth-most common fracture among geriatric patients after distal radius, proximal femur and vertebral fractures [1,2]. Because the geriatric population is growing continuously, an increase in the incidence of these fractures should be expected [3]. Locking plate fixation is a standard procedure for the treatment of proximal humerus fractures [4]. However, complication rates of up to 49% have been reported [4–9]. A low bone mineral density (BMD) and a lack of medial support have been identified as the two most important factors for the stability of locking plate fixation [10–12]. In their clinical study, Krappinger et al. demonstrated that low BMD is associated with a significantly higher risk of implant failure and loss of reduction after locking plate fixation [12]. With regard to medial support, Gardner et al. were the first to describe the correlation between a lack of medial support and a loss of reduction after fixation of proximal humerus fractures [10]. Accordingly, Jung et al. found significantly worse results after locking plate fixation of fractures with medial comminution [13].

To overcome these problems, many efforts have been made in recent years, and clinical and biomechanical studies have focussed on three principles to increase the stability of locking plate fixation of proximal humerus fractures: augmentation of screw tips in regions of low BMD, the use of medial support screws (calcar screws) and autograft or allograft augmentation in fractures with comminution of the medial column [14–26].

The aim of the present article is to give an overview of current biomechanical and clinical studies that focus on how to increase the stability of locking plate fixation of proximal humerus fractures in order to help develop a standardised treatment strategy for this complex and challenging injury.

Methods

The Medline database was searched using the keyword ‘proximal humerus fracture’ in combination with either ‘stability’, ‘medial support’, ‘augmentation’, ‘cement’, ‘bone graft’, ‘autograft’ or ‘allograft’. Only those articles published in the English language were included. After screening, the eligible articles were separated into three groups: (1) medial support screws, (2) cement augmentation and (3) bone grafts. In addition, they were further subdivided into biomechanical and clinical studies.

At first, the basic principles of medial support screws, cement augmentation and bone grafts and the rationale for their use in proximal humerus fracture are explained, and then the results of the included studies are described and evaluated with regard to their clinical relevance.

Results

Medial support screws

Gardner et al. suggested parameters to define whether medial support of a proximal humerus fracture was restored during surgery [10]. A fracture is considered to have medial support if (1) the medial column is intact, anatomically reduced and not comminuted; (2) the shaft is impacted into the head fragment; or (3) an oblique locking screw is placed directly into the inferomedial quadrant of the proximal humeral head fragment to within 5 mm of the subchondral bone. Because medial comminution can often be observed in complex proximal humerus fractures, medial support screws play a key role in locking plate fixation (Fig. 1). Through the placement of the screw into the inferomedial aspect of the humeral head, it counteracts the varus deforming forces acting on the head fragment, and therefore it reduces the risk of secondary loss of reduction and subsequent varus collapse.

Biomechanical data

Biomechanical studies on the use of medial support screws in locking plate fixation are rare. To date, only two biomechanical studies on locking plate fixation with medial support screws have been published. Most recently, Katthagen et al. evaluated the effect of medial support screws on fixation strength in an unstable two-part fracture model [20]. Two locked inferomedially directed calcar screws were inserted, and stiffness testing was performed under rotation, axial loading and loading in abduction and adduction. No significant differences could be found in either direction when compared with fixation without medial support screws. Only after the insertion of a corticocancellous allograft did the stiffness and failure loads increase significantly under axial loading and adduction. However, no effect on torsional stiffness or stiffness in abduction was observed. By contrast, Bai et al. found a significant increase in axial and shear stiffness after the fixation of a simulated unstable two-part fracture with two additional calcar screws [15]. The addition of calcar screws had no effect on the stiffness of fractures with an intact medial cortex. Similarly, in cases with varus deformity, calcar screws had no significant effect on stiffness, regardless of the integrity of the medial cortex. In both studies, cyclic loading and load-to-failure testing were performed, and all of the fractures were fixed using PHILOS plates (Synthes, Oberdorf, Switzerland).

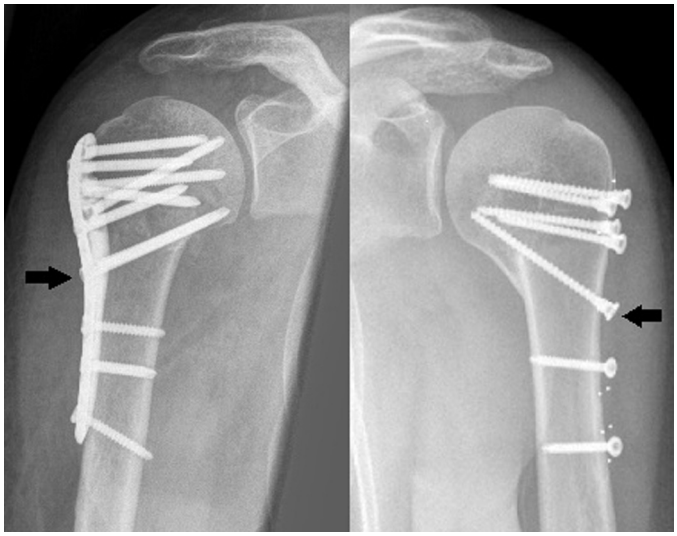

Fig. 1. Medial support screws (black arrow) used in locking plate fixation of proximal humerus fracture to support the medial column.