Injury, Int. J. Care Injured xxx (2018) xxx–xxx

Contents lists available at ScienceDirect

Injury

journal homepage: www.elsevier.com/locate/injury

Application of pre-contoured anatomic locking plate for treatment of humerus split type greater tuberosity fractures: A prospective review of 68 cases with an average follow-up of 2.5 years

Chuanzhen Hu[b,c,1], Kaihua Zhou[a,1], Fugen Pan[a,1], Qilin Zhai[a], Weifeng Wen[a], Xiaojian He[a,*]

[a] Department of Orthopaedics, Qingpu Branch of Zhongshan Hospital, Fudan University, Shanghai 201700, China
[b] Department of Orthopaedic Surgery, Shanghai Tenth People's Hospital Affiliated to Tongji University, Shanghai 200072, China
[c] Institute of Bone Tumor Affiliated to Tongji University, School of Medicine, Shanghai 200072, China

ARTICLE INFO

Article history:
Accepted 15 April 2018

Keywords:
Shoulder
Greater tuberosity fracture
Pre-contoured anatomic locking plate

ABSTRACT

Objectives: Although various implants exist for 3- and 4-part proximal humerus fractures, few implants are appropriate for humerus split type greater tuberosity fractures. The goal of this study was to assess the efficacy of pre-contoured anatomic locking plate for humerus split type greater tuberosity fractures.
Methods: A retrospective review of 68 patients with humerus split type greater tuberosity fractures treated with open reduction and internal fixation using anatomic locking plates between January 2014 and October 2016. Postoperatively, patient radiographs, functional results, and complications were reviewed.
Results: All patients got a mean follow-up of 30.5 months (range 14–46 months). Average fracture healing time was 9.4 weeks (range, 8–14 weeks). Overall mean Constant score was 86.8% (range, 70%–96%). The result was rated as excellent in 25 patients (Constant score: 92.1%), good in 38 patients (Constant score: 85.3%) moderate in 5 patients (Constant score: 71.8%) and poor in 0 cases. The excellent-good rate was 92.6%. No recurrence of dislocation occurred in the 30 cases with shoulder dislocation. All fractures healed without the complications of wound infection, subacromial impingement syndrome, nonunion, secondary displacement, and implant loosening.
Conclusion: Pre-contoured anatomic locking plate is a reliable option in treating humerus split type greater tuberosity fractures as it provides stable fixation with an early return to function. The surgical technique is easy and efficient.

Introduction

Isolated injuries of the greater tuberosity (GT) account for 2–19% of proximal humerus fractures [1,2]. AO and Neer classification systems for proximal humerus fractures are based solely on fragment displacement and do not take into account fragment size, morphology, or orientation of isolated greater tuberosity (GT) fractures [3,4]. Mutch et al. designed a very practical morphologic classification classified greater tuberosity fractures into 3 types: avulsion, split, and depression [5]. This study focuses on the split fracture type, which typically involves a large fragment with a fracture line from superomedial to inferolateral angled 50° with respect to the humeral shaft. This type accounts for 41% of GT fractures. As superior GT displacement is increasingly recognized as a significant cause of functional impairment, nowadays most authors agree that superior displacement greater than 5 mm should be treated with surgery [6]. Some authors even demonstrate that athletes or manual workers with as little as 3 mm of superior displacement may benefit from surgical reduction [7].

Three main fixation methods have been described for split-type fractures: screw fixation, suture anchors fixation and a small locking plate fixation. The screw fixation method is a simple and effective procedure. However for comminuted fractures, the screw may further damage the fracture fragments [8,9]. Suture anchors are widely used to treat proximal humerus fractures because they fix the fragment at the tendon-bone interface, minimize the risk of metal allergy, and need no removal of internal fixation. Long-term follow-up studies show satisfactory

* Corresponding author.
E-mail address: hexiaojian1@126.com (X. He).
[1] Contributed to this work equally as first author.

https://doi.org/10.1016/j.injury.2018.04.013
0020-1383/

clinical results with suture anchors. However, when the greater tuberosity fragment is comminuted, suture fixation may further decrease stability when sutures tear out of the tissue around the loop [10]. In these cases retention with an increased contact area or broader footprint is necessary. ORIF with mesh plate creates a wide footprint and thus excellent fracture healing conditions are reported [11]. Recently a biomechanical study also demonstrated that plate fixation of split type greater tuberosity fractures using a contoured locking calcaneal plate is biomechanically superior to tension-band and double-row suture-bridge fixation constructs [12]. Nevertheless, the bigger the implant the higher is the possibility of a secondary impingement [13]. Thus, in this study we present a pre-contoured anatomic locking plate of greater tuberosity to perform open reduction and internal fixation for split type greater tuberosity fractures of which demonstrated good functional results and did not lead to a secondary impingement.

Materials and methods

The indication for surgery was at least 5 mm of displacement of the tuberosity in any plane. Radiographs in three planes (anteroposterior, lateral and axillary views) were used to assess displacement of the tuberosity. Inclusion criteria were patients over 18 years of age who had a split type isolated greater tuberosity fracture according to Mutch's morphologic classification [5] and surgical treatment using the pre-contoured anatomic locking plate for greater tuberosity fracture of the proximal humerus (Double Medical Technology INC., China). Patients with fractures involving displacement of the surgical neck, lesser tuberosity of the proximal humerus, or avulsion and depression type greater tuberosity fractures were excluded. All patients were operated by a single surgeon (H.X.J) and with a single surgical technique as described below.

Patient demographics were collected from patient intake forms and the clinical notes were reviewed to derive mechanism of injury, instances of fracture dislocations, concomitant injuries, and patient comorbidities. Post-operative radiographs were reviewed to assess time to radiographic union, defined as the absence of fracture lines on all radiographic views at a given time point, as well as alignment and any implant malposition or loosening. Outcomes were assessed using the Constant and Murley method of functional assessment of the shoulder.

The implant

Pre-contoured anatomic locking plate for greater tuberosity fracture of the proximal humerus (Double Medical Technology INC., China) includes a body and head, with extension arms on both sides of the head. The plate body and the extension arm of the plate is radiused and consistent with the curvature of the greater tuberosity of the humerus. This design allows the plate to cover greater tuberosity well, avoiding damage to the surrounding tissue while further enhancing the stability of the fracture fixation. There are two binding holes in the proximal plate body for fixation with 2.4 mm or 3.5 mm locking screw or 3.5 mm normal compression screw at the greater tuberosity, one locking hole in the head extension arm on both sides for fixation with 2.4 mm locking screw at the greater tuberosity and one locking hole in the distal plate body for fixation with 3.5 mm locking screw at the humeral shaft. There are 5 multiple chamfered suture eyelets along the margin of plate head and body to pass sutures or wires for reattachment of tuberosities to guarantee rigid fixation of greater tuberosity fractures (Fig. 1). This implant was used for treatment of all enrolled patients.

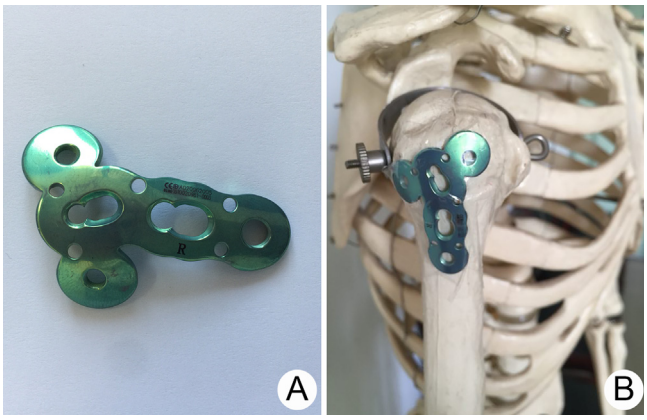

Fig. 1. Anatomic locking plate for greater tuberosity fracture of the proximal humerus (Double Medical Technology INC., China).

Surgical technique

The surgical procedure is performed through an anterior deltoid split approach. After reduction of the displaced greater tuberosity, it can temporarily be fixed with a Kirschner wire. Then the pre-contoured anatomic locking plate for greater tuberosity fracture of the proximal humerus (Double Medical Technology INC., China) is placed onto the greater tuberosity and fixed with variable screws. If a tear of the rotator cuff was found intraoperatively, a 2.5-mm nonabsorbable suture (Ethibond; Ethicon, Inc, Eppendorf, Germany) was used for repair (Fig. 2). The patient is initially kept in a sling with a passive range of motion protocol and a non-weight-bearing restriction. Passive internal rotation is limited to protect the repaired greater tuberosity fragment. A removal of the implant is optional and can be performed after 12 months.

Results

Sixty-eight patients who had humerus split type greater tuberosity fractures were treated at **Hospital with open reduction and internal fixation using pre-contoured anatomic locking plates between January 2014 and October 2016. The study group included 48 males and 20 females. The mean patient age was 38.1years (range 23–67 years). The injury was a result of traffic accident in 30 patients, fall from a height in 27 and machine stretch/contusion injuries in 11. Thirty of 68 patients (37%) sustained fracture-dislocations of the humeral head. A rotator cuff tear was found in 3 of these 30 patients. Thirty-eight patients had no dislocation. Of these 38, 8 had a rotator cuff tear. Five of the 68 patients, both of whom sustained fracture-dislocations, presented with brachial plexus palsies.

The patients were evaluated by interview, physical examination, and radiographs with a mean follow-up of 30.5 months (range 14–46 months). Average fracture healing time was 9.4 weeks (range, 8–14 weeks). At the last clinical follow-up, 63 of 68 patients had restored forward flexion range of motion to within 10° of the contralateral side. The five patients with limited forward flexion were the patients who had presented with brachial plexus palsies. No recurrence of dislocation occurred in the 30 cases with shoulder dislocation. All fractures healed without the complications of wound infection, subacromial impingement syndrome, nonunion, secondary displacement, and implant loosening.

At the last follow-up overall mean Constant score was 86.8% (range, 70%–96%). The result was rated as excellent in 25 patients (Constant score: 92.1%), good in 38 patients (Constant score: 85.3%), moderate in 5 patients (Constant score: 71.8%) and poor in 0 cases. The excellent-good rate was 92.6%. Of note, the moderate

Please cite this article in press as: C. Hu, et al., Application of pre-contoured anatomic locking plate for treatment of humerus split type greater tuberosity fractures: A prospective review of 68 cases with an average follow-up of 2.5 years, Injury (2018), https://doi.org/10.1016/j.injury.2018.04.013