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Original Article

The features of bridge-type plate and its application in the management of radial head fracture

Wei Chen[1,2*], Zongyou Yang[1,2*], Yunwei Cui[1,2], Jiayuan Sun[1,2], Lei Liu[1,2], Pan Hu[1,2], Xiaodong Cheng[1,2], Yanjiang Yang[1,2], Yingze Zhang[1,2]

[1]Department of Orthopaedic Surgery, The Third Hospital of Hebei Medical University, Shijiazhuang 050051, Hebei, P. R. China; [2]Key Laboratory of Biomechanics of Hebei Province, Shijiazhuang 050051, Hebei, P. R. China. [*]Equal contributors.

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Abstract: The paper aims to introduce the bridge-type plate and study the outcomes of radial head fractures of Mason type-II and type-III treated by open reduction and internal fixation with bridge-type plate. The bridge-type plate is reshaped from mini-plate, whose feature is that the proximal one-third of the plate is bent outward. Twenty three cases with radial head fracture consisted of 13 cases of Mason type-II and 10 cases of type-III treated operatively with bridge-type plate from March 2006 to June 2009 were followed up. Early exercise was encouraged in all patients. Follow-ups assessments of the elbow function were carried out. All fractures were treated operatively with bridge-type plates successfully. Early exercise started averagely 1.9 days after operation. The patients regained full or nearly full range of motion of the elbow joint and forearm. According to Morry assessment, all patients achieved good (four 4 cases) or excellent (19 cases) functional recovery of elbow joint. The patients returned to their daily life and previous occupational work. Satisfactory elbow joint motion can be achieved in patients with radial head fractures of Mason type-II or type-III managed by open reduction and internal fixation with bridge-type plate following early exercise.

Keywords: Radial head facture, bridge-type plate, open reduction and internal fixation

Introduction

Radial head fractures are the most common fractures of the elbow [1]. It accounts for 17-44% of all elbow injuries [2] and involves with 5-10% of elbow dislocations [3, 4]. Eighty five percent of fractures occur in adults aged between 20 and 60 years (mean age: 30-40 years) and the ratio between males and females is approximately 1:2 [1]. Excellent functional recovery is the main goal of the treatment of radial head fracture. Various methods have been proposed to treat this injury. However, it is a challenge for orthopedic surgeons to provide the optimal one. Twenty three cases of displaced radial head fractures were reduced and fixed with bridge-type plates with the advantage of no violation of the annular ligament. Satisfactory functional recovery of the elbow joint was reported.

Patients and methods

Patients

Between March 2006 to June 2009, thirty one patients with radial head fractures were treated with the bridge-type plate in our department. Eight patients were lost for follow-up duo to address changing, telephone changing or death. Finally, twenty three cases consist of fourteen right fractures and nine left ones were included. There were fifteen males and eight females with a mean age of 36.5 years (range, from 21 to 65 years). Twenty cases were injured during falling onto the ground on the outstretched hand with extended elbow and three cases were injured due to the direct impact on the elbow. The lateral and anteroposterior radiographs of the elbow were taken to assess the severity of radial head fractures (**Figure 1**).

Figure 1. The Mason type II radial head fracture. A: The anteroposterior view; B: The lateral view.

Based upon Mason classification, there were 13 cases of type-II and 10 cases of type-III fractures. Severe comminuted Mason type-III fractures (with more than three fracture fragments or grossly comminuted) were excluded from the study. Besides radial head fractures, patients with other part of radial fractures, or ulnar fractures were also excluded from the study.

Bridge-type plate

The bridge-type plate is reshaped from the common mini-plate. The proximal one-third of the plate is bent outward, which looks like an arch and is described as bridge-type plate (**Figure 2**). During operation, the proximal end of the plate is attached to the proximal radium and the distal two-thirds contact directly the cortex of the radium, which leaves hollow space beneath the arch of the proximal one-third of the plate.

Surgical procedure

Open reduction and internal fixation (ORIF) is performed to treat the radial head fractures with the bridge-type plates. During operation, the posterolateral approach with the elbow joint flexed in a pronated position is selected to avoid the posterior interosseous nerve injure [1, 3, 5]. The interval between the anconeus muscle and the extensor carpi ulnaris is separated to expose the lateral collateral ligament complex. If not injured, the annular ligament is left intact. The capsule is then detached from the muscular layer and incised to expose the fracture. The soft tissue attachments of the fracture fragments are preserved, where possible. The articular hematoma is removed. The fracture is reduced, and the fragments are sometimes held to reduce by temporary K-wires. Then if injured, the annular ligament is repaired. The bridge-type plate is placed on the nonarticulated portion of the radial head which is referred to as the safe zone and can help avoid injuring the posterior interosseous nerve [6, 7]. The screws are inserted into the subchondral bone through the proximal holes of the plate. However, care must be taken not to voilate the articulation. Care should also be taken to avoid screw tip penetration through

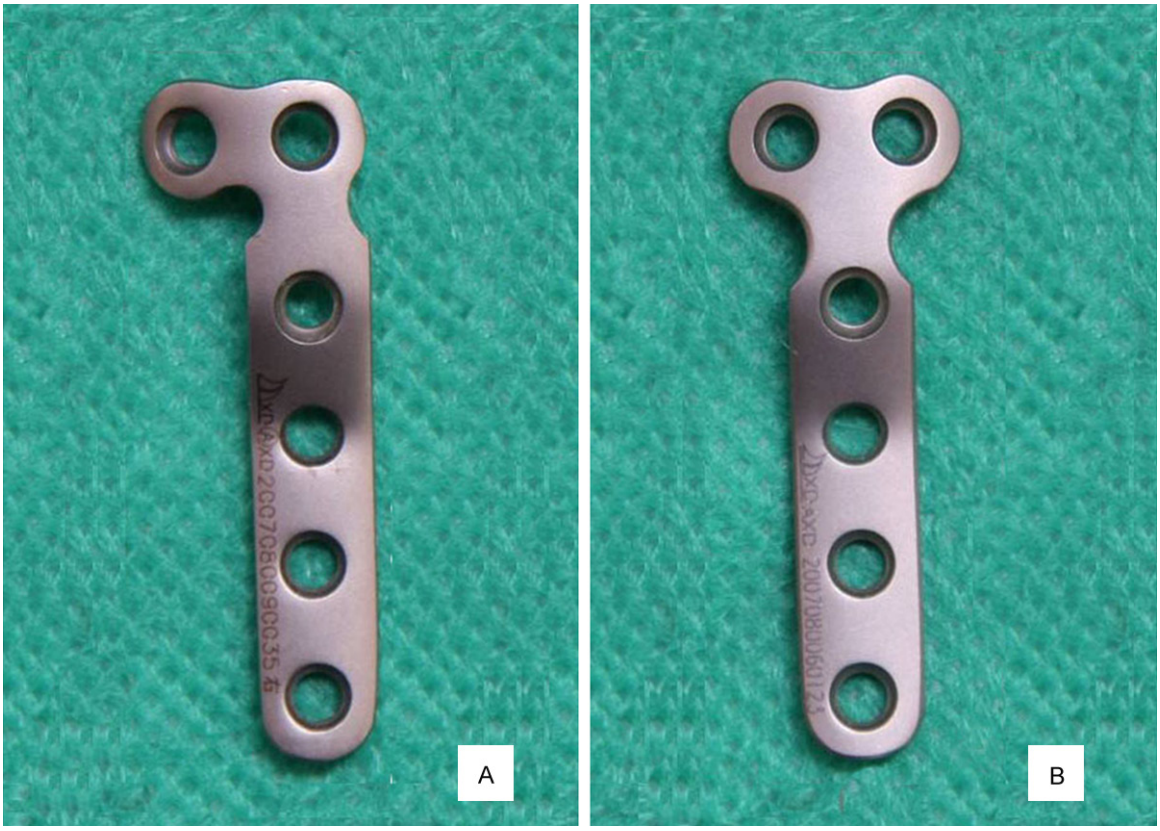

Figure 2. The photographs of the bridge-type plates. A: The L-shaped plate; B: The T-shaped plate.

the opposite cortex and to countersink the screw heads. Intraoperative fluoroscope is taken to confirm anatomical reduction and appropriate fixation. The flexion and extension of the elbow joint and the pronation and supination of the forearm is repeated to ensure that the fixation doesn't interfere with the elbow motion.

Postoperative management

Radiographs (**Figure 3**) of the radial head fractures are taken postoperatively to assess the reduction and fixation. No casts were applied and the arms were supported in a triangular sling until early mobilization. Early exercise of the elbow joint is encouraged in all patients as soon as pain tolerated. To patients without annular ligament injury, both the flexion and extension of elbow and the supination and pronation of forearm are recommended. If the annular ligament is injured, early postoperative exercise is the flexion and extension of the elbow joint. The pronation and supination of the forearm is not recommended since the radial head will rotates in a circular arc comprised by the annular ligament and the radial notch of the ulna, which will hinder the healing of the annular ligament. Follow-up assessments are carried out routinely at six weeks, three, six and twelve months, and two years after operation. The function recovery was assessed based upon the system proposed by Morrey [8].

Result

The operations were finished within a mean duration of 68 minutes (range, from 45 to 97 minutes). During operation, torn annular ligaments were found in six cases and repairs were conducted. The annular ligaments of the other 17 cases were not incised intraoperatively. Early exercise started averagely 1.9 days (range from 1 to 4 days) after operation. After 2-3 weeks, intensive physiotherapy started. At follow-ups, all fracture healed well and no nonunion or malunion occurred. Other operative complications such as incision necrosis, infection, avascular necrosis of radial head, degenerative changes of the elbow joint or breakage of the plate were not reported. According to the

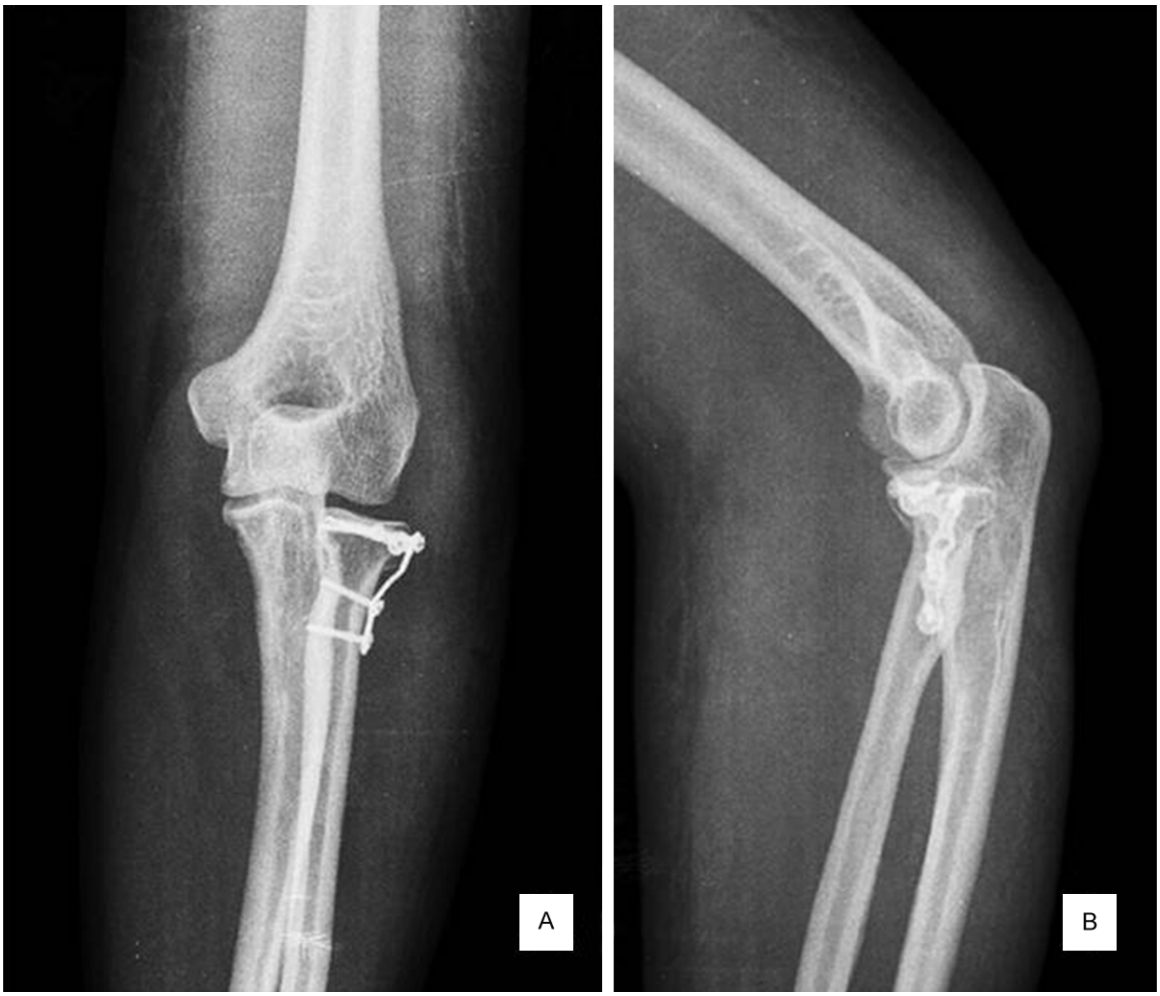

Figure 3. The radial head fracture is reduced and fixed with bridge-type plate. A: The anteroposterior view; B: The lateral view.

Morry assessment, 19 patients got excellent functional recovery. Four patients regained good functional recovery due to mild or moderate pain of the elbow. At the last follow-up, 14 patients regained full range of motion and nine patients lost 5-20 degrees of terminal extension. All patients have returned to daily life and previous occupational work.

Discussion

The treatment principle of radial head fractures is determined by the fracture type and the presence of any associated injury [1, 9-11]. Radial head fractures can occur in isolation or be associated with other elbow fractures and ligament injuries [12]. Mason type-II fractures were displaced and often accompanied with ligament injury. Conservative treatment is not the optimal choice to manage Mason type-II fractures. It is necessary to treat the radial head fracture operatively due to the concomitant soft tissue injury [13, 14]. Fractures with more than 2 mm of displacement should ideally be treated with ORIP [15]. Generally, Mason type-II radial head fractures are displaced greater than 2 mm or block normal forearm rotation and should be treated with ORIF. Thirteen cases of Mason type-II fractures were all treated with ORIP in the study.

Controversy exits as to the optimal management of Mason type-III fractures. Hotchkiss considered that Mason type-III fractures were comminuted, not amenable to ORIF [16]. Ring et al. reported that if there were more than three fragments which were associated with a greater risk of failure of internal fixation, non-

union, and loss of forearm rotation, ORIF was not recommended in these cases [17]. Hotchkiss considered that the radial head fractures should be treated with excision or arthroplasty [16]. But the patients may sustain symptomatic proximal translation of the radius after having radial head resection for trauma, such as elbow and wrist pain, loss of strength, instability and cubitus valgus [18, 19]. Conversely, Ikeda et al. reported satisfactory and good results in patients who sustained comminuted Mason type-III fractures of the radial head and underwent ORIF [20-22]. Taken our experience and other authors' experience above-mentioned in treating radial head fracture into consideration, We follow the criteria that Mason type-III fractures with no more than three fracture fragments (or not grossly comminuted) can be successfully treated with bridge-type plate. During operation, temporary fixation of the fragments with K-wires facilitates the reduction and fixation. It is necessary to fix fragments successfully at one time. Avoiding repeated drilling can preserve the intact fragments and prevent intraoperative fracture. This requires direct visualization of the fragments and multiple fluroscopic reviews during operation. Anatomical reduction and rigid fixation can be achieved following these notes. Postoperative radiological examinations demonstrate anatomical reduction of the radial head fracture which proves the usefulness of the surgical procedures.

Various instruments have been applied in the management of the radial head fracture. AO mini-screws and mini-plates, Herbert screws and absorbable polyglycolide pins are used for the restoration of the fractured radial head and neck [10, 17, 23, 24]. Guha et al. described a case of a radial head fracture fixed with a modified tubular plate [25]. The plate was cut through the distal hole and the two cut ends were bent into hooks. These two hooks were engaged into two breaches made on the margin of the radial head and this provided rotational stability to the head without causing further damage. We fix the fracture with the modified bridge-type plate. During operation, two screws were inserted into subchondral bone of the radial head, which can prevent rotation of the radial head. The proximal one-third plate doesn't contact the cortex of the radium, the interspace beneath which can accommodate a part of the lateral capsular complex and annular ligament. The bridge-type plate can provide sufficient space for the edematous ligaments after repair so as to avoid potential impingement, which will facilitate the healing of the ligament. Therefore, the advantage of the bridge-type plate can ensure its optimal placement with less violation of the intact or repaired lateral capsular complex and annular ligament.

The radial head is an important valgus stabilizer of the elbow and an important axial stabilizer of the forearm, and resists varus and posterolateral rotatory instability [26-29]. The integrity of ligaments surrounding the radial head play an important role in the stability of proximal radioulnar joint and the recovery of forearm function. They can help maintain the position of the radial head and its biomechanical role. The annular ligament reconstruction was also emphasized in the treatment of chronic unreduced Monteggia injuries in children [30-32]. Therefore, it is important to avoid damaging the annular ligament furtherly. Although, the biomechanical features of the annular ligament of adults are still unclear and more studies are needed to explore its characteristics.

The principal goal of the management of radial head fractures is to maintain good elbow function and thus to retain joint stability and as normal a range of motion as possible [33, 34]. In the case series, early exercise is one of our main goals in the management of the radial head fractures. The bridge-type plate can facilitate the surgery procedure and provide rigid fixation to allow early exercise. In the treatment of the elbow dislocation with involvement of the radial head, the precondition for regaining a stable joint with good function is, above all, early exercise, stable fixation and early functional mobilization of the joint [35]. Early exercise can prevent synarthrophysis and facilitate good and excellent function recovery of the elbow joint. Compared with prolonged immobilization, early motion appears to offer advantages in elbow function [1, 9-11]. In the current study, Full range or nearly full range of elbow motion and forearm rotation was regained. Nineteen cases with excellent functional recovery and four cases with good recovery were reported. All patients can restart previous life and work.

Disclosure of conflict of interest

None.

Authors' contribution

WC and ZY were responsible for conception and design, coordinated the study, and wrote the article. YC, JS, LL, PH, XC and YY were involved in the performance of surgery and analyzed the data. YZ provided critical revisions. All authors read and approved the final article.

Address correspondence to: Dr. Yingze Zhang, Department of Orthopaedics, The 3rd Hospital, Hebei Medical University, No. 139 Ziqiang Road, Shijiazhuang 050051, P. R. China. Tel: +86-311-8860-3682; Fax: +86-311-87023626; E-mail: corresponding2012@163.com

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