Minimally invasive percutaneous plate osteosynthesis (MIPPO) technique applied in the treatment of humeral shaft distal fractures through a lateral approach

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Abstract The minimally invasive percutaneous plate osteosynthesis (MIPPO) technique through the anterior approach has been successfully used in the treatment of humeral shaft fractures and has gained satisfactory clinical outcome. An anatomical study and a preliminary clinic report were performed to evaluate the feasibility of applying the MIPPO technique in the treatment of humeral shaft distal fractures through the lateral approach. This study was done on 14 arms from seven fresh cadavers. The results of this study showed that it is possible to treat humeral shaft distal fractures by using the MIPPO technique through the lateral approach. The results of using the MIPPO technique through the lateral approach in the treatment of humeral shaft fractures in 22 patients were also reviewed.

Résumé L'ostéosynthèse par plaques par voie mini-invasive (technique MIPPO), après abord antérieur est utilisée avec succès dans le traitement des fractures diaphysaires humérales et permet d'obtenir un bon résultat clinique. Une étude anatomique et une étude clinique préliminaires ont été réalisées pour évaluer la faisabilité de l'utilisation de la technique MIPPO dans le traitement de ces fractures distales par voie latérale. Cette étude a été réalisée sur 14 membres supérieurs de 7 cadavres frais. Les résultats de cette étude montrent qu'il est possible de traiter la fracture de l'humérus distal en utilisant la technique MIPPO par

voie latérale. Cette technique, transposée chez 22 patients présentant une fracture de ce type a également été réalisée et évaluée.

Introduction

Minimally invasive percutaneous plate osteosynthesis (MIPPO) has been widely applied to treat long bone shaft fractures in recent years because of its technical advantages and satisfactory clinical outcomes [2, 11, 17]. The plate is inserted by a percutaneous approach with separate proximal and distal incisions. This method causes less soft tissue disruption and preserves the fracture haematoma and blood supply to the bone fragments.

In general, there are four conventional surgical approaches to the humeral shaft: posterior, anterolateral, anterior, and anteromedial [1, 9, 10]. Open plate fixation has generally used only the anterolateral and posterior approaches [5, 6]. The anterolateral approach is suitable for proximal and middle third fractures, whereas distal third fractures are best treated using the posterior approach. The anteromedial approach is less useful because of intervening neurovascular structures. The anterior approach is a safe and feasible way to use minimally invasive percutaneous plate osteosynthesis (MIPPO) in the treatment of humeral shaft fractures proven by Dr. T. Apivatthakakul and colleagues. However, the anterior approach might only be suitable for proximal and middle third fractures. This is partly because, in the case of fractures with a small distal fragment, theoretical fixation on the anterior face of the humerus is impossible. If a narrow LCP [3, 4, 13–16] is chosen, moulded with a slight anterior inclination at its distal end and inserted through a lateral approach in the case of humeral distal fracture, it could be placed on the lateral column of the humeral shaft and fit the

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anterior face of the lateral column, thereby avoiding the coronoid fossa.

The lateral approach, however, has been rarely used until now in the treatment of humeral shaft fractures with MIPPO. This is partly because inserting plate through a lateral approach in humeral shaft fractures could be a dangerous procedure with respect to radial nerve injury.

The purpose of the study was to determine the feasibility of applying the MIPPO technique in the treatment of humeral shaft distal fractures through the lateral approach and to observe the anatomical relationship between the radial nerve and the plate during supination and pronation of the forearm so as to determine which position of the forearm is safest for the radial nerve in the distal humerus. The lateral approach was then applied in the treatment of humeral shaft fractures (including distal fractures) with the MIPPO technique in 22 patients and the results are presented.

Materials and methods

This study was made on 14 arms from seven fresh cadavers that were obtained from 48 hours to 120 hours after death; eight were male and the others were female. The procedures were performed in a semi-reclining position with the arm dependant and the wrist beside the operating table.

- Lateral approach
 - The distal incision of 2–3 cm was made between the brachioradialis and brachialis muscles (Kocher's distal access).
 - The proximal incision of 3–5 cm was made below the acromion (Fig. 1).
- Before the LCP plate was inserted, one muscle pad should be interposed in order to avoid the LCP plate touching the nerve directly.

Fig. 1 The distal incision of 2–3 cm was made between the brachioradialis and brachialis muscles

Fig. 2 The closest distance measured between the lateral border of the plate and the radial nerve in full supination of the forearm was 2.5–5.3 mm

- An LCP plate was moulded with a slight anterior inclination at its distal end so that it fits the anterior face of the lateral column, thereby avoiding the coronoid fossa.
- In the case of fractures with a small distal fragment, the plates were always introduced in the distal to proximal direction.
- The wound was closed without drains or external immobilisation.

In addition, 22 patients with 23 humeral shaft fractures who attended from November 2001 to July 2004 were included in the study after they had signed a statement of informed consent. Their ages were from 24 to 62 years old. The following data were collected for each patient: operative time, time to union, secondary procedures, and complications.

Results

Cadavers

The plates were inserted extraperiosteal beneath the brachialis in all 14 specimens. The plate was laid on the lateral surface of the humerus with a thin layer of muscle against it. There was no radial nerve entrapped by the plate in any case. The radial nerve ran close to the bone in the spiral groove on the posterior surface of the middle third of the humerus. After piercing the lateral intermuscular septum, the radial nerve was separated by a thin layer of muscle from the lateral cortex of the distal humerus. The closest distance measured between the lateral border of the plate and the radial nerve in full supination of the forearm was 2.5–5.3 mm (average 3.7 mm, Fig. 2). When the forearm was pronated, the radial nerve was noted to move

Fig. 3 When the forearm was pronated, the radial nerve was noted to move medially closer to the distal end of the plate

medially closer to the distal end of the plate (Fig. 3). The radial nerve moved to touch the plate in four specimens, while in two specimens, there were distances of 1.3 and 1.5 mm. The musculocutaneous nerve ran between the biceps and brachialis muscles and could be protected by the medial retractor. There was no entrapment of the musculocutaneous nerve by the plate in any case.

Clinical cases

Twenty-two patients with 23 humeral fractures were treated by applying the MIPPO technique through the lateral approach. All patients had intact radial nerve function before the operation. All cases were operated on using a double small approach by the MIPPO technique under fluoroscopic control, as described in the cadaveric study (Fig. 4). The plates were fixed with three to four screws in both proximal and distal fragments. The wound was closed

without drains or external immobilisation. The patients were encouraged to perform passive motion of the shoulders and elbows during the first postoperative week. Active motion was carried out from the second week after the operation without a cast or brace. The average operating time was 48 min (range, 35–90 min). The average duration of follow-up was 72.2 weeks (range, 46–60 weeks). One patient had a radial nerve dysfunction after the operation. The radial nerve had been exposed carefully, then confirmed that its damage was due to dragging. The patient's radial nerve function was fully recovered 5 months after the second operation. The average time when bridging callus could be seen at the fracture site was 6.3 weeks (range, 4–11 weeks). Union was achieved in all patients without bone grafting. The function and range of motion of the shoulder and elbow joints were satisfactory.

Discussion

In the 1980s, minimally invasive methods (MIMs) based largely on bridging-plate osteosynthesis were introduced [7, 8, 12]. Since that time, MIMs for fracture treatment have been developed continually and will be developed further. The MIPPO technique is an example of an MIM that has become more popular. Dr. T. Apivatthakakul and colleagues have verified that the MIPPO technique can be safely and efficiently applied in the treatment of humeral shaft fractures through the anterior approach.

However, the anterior approach might only be suitable for humeral shaft proximal and middle third fractures. This is partly because the coronoid fossa is in the distal part of the humerus, and in the case of fractures with a small distal fragment, theoretical fixation on the anterior face of the

Fig. 4 A 56-year-old man sustained the fracture in an accident (a). AP radiographs immediately postoperation (b). We protect the good function of the radial nerve (c)

humerus is impossible. Moreover, there has been no previous study regarding MIPPO of the humerus with a straight LCP implant using a minimally invasive lateral approach.

An LCP implant could be inserted through Kocher's distal access and through proximal access below the acromion. However, in the case of fractures with a small distal fragment, the plates were always introduced in the distal to proximal direction.

The results from the cadaveric anatomical study have shown that it is possible, safe, and convenient to perform the MIPPO technique for the humeral distal fractures by a lateral approach.

The course of the radial nerve has been well described in the literature. The nerve passes through the triangular space between the long head of triceps and the shaft of the humerus beneath the teres major muscle. It crosses the posterior aspect of the humerus at an average of 20.7 ± 1.2 cm proximal to the medial epicondyle to 14.2 ± 0.6 cm proximal to the lateral epicondyle. The nerve then pierces the lateral intermuscular septum to enter the anterior compartment where it lies between the brachioradialis and brachialis muscles. In its proximal course, the radial nerve lies on the posteromedial side of the humeral shaft. The proximal incision for the lateral MIPPO approach is therefore safe for the radial nerve. In the mid shaft, the nerve lies posterior to the humerus. The plate should thus be used as a bridge plate. In the distal humeral shaft, the radial nerve lies laterally between the brachioradialis and brachialis. By splitting the brachialis along its midline, the lateral portion of the muscle serves as a cushion between the retractor and the nerve. A Hohmann's retractor must not be used on the lateral side of the humerus in order to avoid catching the radial nerve with its tip.

The position of the forearm has an effect on the position of the radial nerve. It has been identified that pronation of the forearm made the radial nerve move more medially by a few millimeters. This suggests that the forearm should be placed in full supination during surgery in order to move the radial nerve more laterally.

The plate (LCP) is used as a splint on the outside of the bone as a bridge plate from the biomechanical point of view. Both ends of the plate are fixed to the main fragment by three to four screws. Long plates bridging an extensive zone of fragmentation with only short fixation on either end of the bone will undergo considerable deformation forces. As bending stresses are distributed over a long segment of the plate, the stress per unit area is correspondingly low, which reduces the risk of plate failure. The entire construction becomes elastic and even simple fractures can be successfully bridged. Although technically difficult,

the lateral MIPPO approach is less invasive when compared to the conventional open reduction technique. With the advantage of the locking head screw, the plate will not press directly against the bone.

Conclusion

This paper presents the MIPPO technique applied in the treatment of humeral shaft distal fractures through the lateral approach. The results obtained in this study have shown that the method described in this paper is feasible, safe, and efficient, since there was no obvious damage, nor major complications. In addition, 23 healed within a similar healing time to other methods with both good alignment and function of shoulder and elbow joints.

Advantages of applying the MIPPO technique through the lateral approach are as follows:

1. It is suitable for humeral shaft distal fractures.
2. There is no risk of axillary nerve injury.
3. The radial nerve is not at risk as long as the forearm is kept in supination during the procedure and no screws are inserted into that part of the humeral shaft where the radial nerve runs along the spiral groove.

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