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Effectiveness of sonography assisted minimal invasive plate osteosynthesis (MIPO) compare with fluoroscope assisted in femoral shaft fracture: A cadaveric study

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ABSTRACT

Introduction: A minimal invasive plate osteosynthesis (MIPO) has an advantage of biological soft tissue preservation that consists of preserving bony blood supply, fracture hematoma and less soft tissue damage which leads to decreasing of infection rate and rapid bone healing. However, the radiation exposure is still a disadvantage of this technique. A sonography that provides dynamic real time imaging may be used as an alternative technique for assisting MIPO. The aim of this study was to compare the effectiveness of MIPO in femoral shaft fracture between the sonography assisted and the fluoroscopy assisted.

Methods: Twenty-eight cadaveric limbs were subjected to create femoral shaft fracture. Then, sonography assisted reduction with temporary external fixation and MIPO were performed. Images of the sonography and the fluoroscopy were recorded including before reduction, after reduction and after MIPO in order to identify fracture displacements in anteroposterior and mediolateral directions. Moreover, the anterior and posterior distances from edge of the bone to the plate were measured to confirm plate position. The effectiveness of this technique was defined as the proper plate position and acceptable alignment after fixation. All distances from the sonography and the fluoroscopy were also analyzed and compared using Pearson correlation and Bland-Altman method to assess the agreements between two tests.

Result: All of the subjects were met the criteria for acceptable alignment. We found only three femoral shaft fracture (11%) operated with MIPO by sonography assisted that showed slipped plate off femoral bones. According to Pearson correlation, there were good to excellent agreements in term of measuring fracture displacement before (Pearson Correlation >0.7) and after reduction (Pearson Correlation >0.7) between these two tests. There was moderate agreement regarding to evaluation of plate position (Pearson Correlation 03.–0.7). When we compared two methods of measurement using Bland-Altman plot, there were no statistical significant difference ($P < 0.05$).

Conclusion: Images from the sonography could provide visualization of the fracture during reduction and MIPO as accurately as the radiography. Thus, the sonography assisted MIPO in femoral shaft fracture can be done effectively comparing with radiographic assisted.

Introduction

The plate fixation technique for treatment of long bone fractures has become popular and is widely used. Over the past decade, however, a new percutaneous plate and screw fixation technique has been developed called minimal invasive plate osteosynthesis (MIPO). This technique can be used to treat long bone fractures at various sites with excellent clinical outcomes, e.g., femoral shaft fractures [1], humeral shaft fractures [2–4] and tibial shaft fractures [5].

MIPO has the advantages of biological soft tissue preservation including preservation of the bone blood supply and fracture hematoma, less soft tissue damage which leads to a decrease in infection rates and more rapid bone healing. For femoral shaft

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fractures, intramedullary nailing is still a standard treatment. Nevertheless, MIPO is an alternative treatment in patients where intramedullary nailing is contraindicated, including patients with an extremely narrow medullary canal, patients with malunion bone, patients with periprosthetic or peri-implant fractures, and patients with skeletal immaturity.

With MIPO, however, fluoroscopic examination is necessary for checking the bony alignment after reduction and the plate position. The accompanying radiation exposure of the surgical team and the patient is a disadvantage of this technique as that exposure can cause health problems such as cancer, cataracts and genetic mutations [6–10].

Ultrasonography, which is currently well developed, is another option for assisting surgery. Advances in ultrasound imaging have permitted more accurate, dynamic, multiple plane, and real time images which are helpful for assisting surgery. In addition, using ultrasonography to assist surgery can avoid exposure to radiation [11].

Many recent studies of ultrasound assisted procedures and surgeries, including in the field of orthopedics, have found satisfactory clinical outcomes comparable to standard radiographic assistance, e.g., ultrasound assistance in intramedullary nailing of femoral shaft fractures [12], the use of ultrasound to check soft tissue interposition at the fracture site [13], ultrasound assistance in the reduction of distal radius fractures [14], and the use of ultrasound to detect failed plates and screw loosening in distal radius fractures [15]. However, there has been no study of ultrasound guided plating percutaneous fixation.

The objective of this study was to determine the effectiveness of sonography assisted MIPO in femoral shaft fractures compared with radiographic assisted MIPO, and to investigate the feasibility of using this alternative technique in actual clinical situations.

Materials and methods

This research was performed on twenty-eight fresh cadaveric limbs at Maharaj Nakhorn Chiang Mai University hospital between January 2012 and December 2013. The fresh cadavers, nine males and five females, were obtained within 72 h. of death. Only cadavers age over 15 years and with no previous history of femoral shaft fracture or previous operations with plating or nailing were included. Cadavers were excluded if they had malunion or malalignment or any pathological condition of the femoral shaft which could be identified using a fluoroscope. First, a femoral shaft fracture was created in the cadaveric limbs. To create a fracture site, a small (approximately 5 cm) transverse incision on the medial aspect of the thigh was made at the mid-femoral level as determined by Vernier caliper. Fractures were created in both femurs of each cadaver using an electric saw to create a fissure in the cortex, followed by the use of an osteotome to break the entire bone at mid shaft. After that, the incision was sutured and covered with an iodine-impregnated drape (3M™ Ioban™ 2 Antimicrobial Incise Drapes).

After the fracture sites had been prepared, an ultrasound study was done at the fracture site to obtain images for measuring displacement in the AP and medial-lateral directions (0.00 cm). All sonographic studies were done by a musculoskeletal radiologist (N.P.) using the M-Turbo ultrasound system with a SonoSite M-Turbo HFL38x transducer with a 13–6 MHz 38-mm broadband linear array which is suitable for the musculoskeletal system.

To measure the fracture displacement in the anteroposterior direction, an ultrasound probe was placed perpendicularly to the anterior cortex of the femur at the level of the fracture site and the probe orientation should be parallel to the longitudinal axis of femoral bone with marker on probe point proximally (Fig. 1). The same procedure was followed for measuring the fracture displacement in the mediolateral direction by rotating the ultrasound probe ninety degree to the lateral aspect of the thigh which was perpendicular to the lateral cortex of femoral bone and the orientation should again be parallel to the longitudinal axis of femoral bone with marker point proximally (Fig. 2).

A fluoroscope was then used to collect radiographic images for measuring displacement in AP and lateral views (0.00 cm). We tried to minimize the magnifying error of the fluoroscope by placing a coin (2.00 cm in diameter) on the site of the image intensifier as a calibrator. All fluoroscopic studies were performed at the same distance, 20 cm away from the axis for femoral shaft. Displacement in each of the fluoroscopic images was measured using the ImageJ program developed by the US National Institutes of Health (Fig. 3).

After measurement, closed reduction and temporary fixation with external fixator was performed with sonographic assistance. Data on fracture displacement after reduction with both the sonographic and the fluoroscopic studies was obtained in the manner described above.

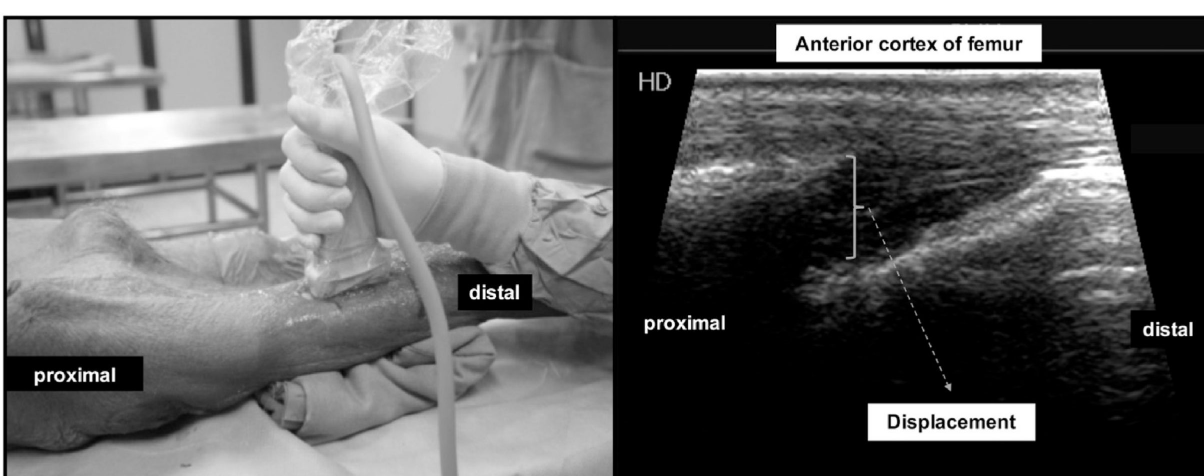

Fig 1. Ultrasound probe orientation in assessing fracture displacement in the anteroposterior (AP) direction.