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Electromagnetic distal targeting system does not reduce the overall operative time of the intramedullary nailing for humeral shaft fractures

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ABSTRACT

Introduction: We aimed to evaluate the efficacy of the use of the electromagnetic distal targeting system in treating humeral shaft fracture.
Methods: Patients were divided in: Group 1) patients that received a distal locking screw placement following the free-hand technique; Group 2) patients in which the distal locking screw was performed using the SURESHOT device.
Results: No differences were noted comparing Group 1 (freehand) [71,9 range 40–135 min] to Group 2 (SURESHOT)[70, range 25–125 min].
Conclusion: The use of the EM distal targeting system doesn't reduce the overall operative time of the humeral shaft fracture fixation using IMN.

1. Introduction

Fractures of the humeral shaft are relatively frequent accounting for 20% of humeral fractures and approximately 3–5% of all fractures.[1,2] The management of these fractures remains challenging and often controversial. Open reduction and internal fixation (ORIF) with plate and screw has traditionally been the preferred method to surgically treat humeral shaft fractures. However, plate osteosynthesis is associated with negative features, such as direct exposure of the fracture site, disruption of the periosteal blood supply, risk of radial nerve injury, increased blood loss and difficulty with complex fracture patterns.[3,4] Because of a high rate of surgical complications, intramedullary nailing (IMN) gained popularity and different authors recommend it as a standard approach for the treatment of humeral shaft fracture.[5,6] The main advantage of IMN is represented by a less invasive procedure and a high fixation stability that contribute to a high healing rate. A further advantage is the reduction of complications observed using plate and screws, such as iatrogenic radial nerve injury and increased blood loss.[7,8] On the contrary, the most important disadvantage of the use of IMN is represented by the difficulty of distal screw placement. Even if different systems of distal locking have been developed, the freehand screw placement (FH) represents the most used method for interlocking IMN and requires some level of surgical expertise. However, distal screw placement can vary significantly in terms of time to perform the procedure. In fact, this technique has been reported to delay the overall operative time, leading to an increased radiation exposure to the patient and surgical personnel.[9,10]

Recently, a new distal targeting system was commercially introduced (SURESHOT TM, Smith & Nephew, Inc., Memphis, TN, USA) that utilises a computerised electromagnetic field tracking technology to place screws during distal locking (EM technique). This system consists in a radiation-free technology that provides a 3D real-time feedback of location and orientation of the drill, relative to the nail interlocking hole. The reported merits of this new technology consist in a reduction of the operative time and a reduction of the radiation exposure.[11,12] Even if different authors have evaluated the application of this technology for femur and tibia fractures, poor data are present concerning its use for humeral shaft fracture.[11–14] For this reason, it is not clear if EM technology could effectively help surgeons in reducing the operative time during humeral IMN.

The purpose of the present study is to evaluate the efficacy of the use of the electromagnetic distal targeting system in treating humeral shaft fractures. The authors hypothesised that distal targeting system could reduce the overall surgical time for interlocking IMN compared to the standard fluoroscopic freehand technique.

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2. Materials and methods

We performed a retrospective study of all patients who underwent operative fixation of humeral shaft fractures from January 2010 to December 2016 at two major Traumatology Units of Palermo (AOUP "Paolo Giaccone" - ARNAS Ospedale Civico). Only patients that required antegrade IMN were included. Inclusion criteria were humeral shaft fracture treated with IMN requiring an IMN distal locking with at least one screw. The exclusion criteria for the study were open fractures, polytrauma, associated fractures that required ORIF in the same surgery, pathological fractures, fractures older than 2 weeks, neurovascular injury, and a history of previous humeral fractures. All patients that were treated using inflatable intramedullary nails, self-locking nails or that required two distal locking screws placement were excluded from the study.

Two independent reviewers (S. Z. and (M. B.) that were blinded to the subject and purpose of the study extracted and recorded relevant data from each medical record.

Specifically, for each patient, the following information was recorded: gender, age, accident type, localization of the fracture, concomitant injuries, intra and postoperative complications including nerve injury. X-ray images were independently reviewed and all fractures were classified according to the AO classification. In cases of disagreement in coding among fractures, a consensus was reached through discussion. Further, if an agreement was not achieved, the senior author (L.C.) was consulted for the final decision.

According to inclusion and exclusion criteria, patients were divided into two groups: Group 1) patients that received an IMN fixation with a distal locking screw placed following the free-hand technique; Group 2) patients in which the distal locking screw was performed using the SURESHOT device (Smith & Nephew, Inc., Memphis, TN, USA). For all patients, the same surgical procedure was performed. The beach-chair position was used and an anterior approach with a small rotator cuff incision was performed to allow the access of the guide-wire. After closed fracture reduction and ball-tip guide-wire positioning, the medullary canal was reamed and an intramedullary nail with a correct size was inserted in the humerus. Following freehand technique (Group 1), the distal locking screw placement was obtained using an image intensifier positioned perpendicularly to the arm. The intensifier was then adjusted in the coronal plane to achieve a perfect circle, indicating coaxial alignment of the distal locking hole. At this point, a bone awl was then moved under fluoroscopy-based image guidance and placed in the centre of the circle. A drill was next placed into the hole and checked in coronal and transverse planes. Finally, a distal locking screw was placed under fluoroscopic guidance and checked in both planes. Following the SURESHOT technique (Group 2), the distal locking screw placement was performed using the electromagnetic field tracking technology. After nail insertion and drill guide probe placement, the SURESHOT Targeter was connected to the navigation screen. Once the image of the IM nail was available, the trajectory of the Targeter was adjusted until both the green and red circles were concentric. The alignment of the circles provided the ideal direction for bone drilling (Fig. 1). At this point, the bone was drilled through the far cortex and the length was measured using the calibrations (Fig. 2). Finally, the distal locking screw was placed and checked under fluoroscopy. For both groups, proximal locking screws were inserted using the corresponding mechanical guiding systems attached to the proximal part of the nail.

For each patient, the duration of the entire procedure (expressed in minutes) was recorded. Further, the success or failure of the targeting device, defined as the capacity of distal locking screw placement or the conversion to the freehand technique, were recorded.

2.1. Statistical analysis

Data was analysed with SPSS statistical software, version 18.0 (SPSS, Inc., Chicago, IL). The first 4 procedures of each surgeon were excluded from statistical analysis to avoid arousal responses associated with the learning curve of distal screw placement using SURESHOT technology. Descriptive statistics, including means and standard deviations, were performed for each studied group. Differences of surgical time between groups were analysed using a paired Student's test. Finally, p-values less than 0.05 were considered to be statistically significant. Further, the rate of the success or failure of the targeting device was calculated.

Fig. 1. Navigation screen of the SURESHOT system.

Fig. 2. The SURESHOT Targeter used to correctly drill the bone.

3. Results

We found 250 patients that presented a surgically treated humeral shaft fracture. Of these, 132 were treated using an anterograde locking nail and reached inclusion criteria of the study. After removal, the first 4 procedures of each surgeon, 100 fractures were finally included in the present study. 49 were male, while 51 were female. The main age at time of injury was 54,5 years (range, 15–89 years). According to AO classification, 67 fractures were A, 14 were B, and 19 were C (Table 1). The most common cause of injury was traffic accident in 83 patients, while 17 patients referred a fall. The mean length of hospitalisation was 4.3 days (range: 3–7 days). No significant differences were noted between age, causes of injury and fracture type. Eight surgeons were involved in the surgical care of patients included in the study. Concerning Group 1, in 25 patients the IMN fixation was obtained using the T2