Injury, Int. J. Care Injured 45 (2014) 1632–1636

Contents lists available at ScienceDirect

Injury

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

Radiological outcome and intraoperative evaluation of a computer-navigation system for femoral nailing: A retrospective cohort study

Nael Hawi *, Emmanouil Liodakis, Eduardo M. Suero, Timo Stuebig, Musa Citak, Christian Krettek

Trauma Department of the Hannover Medical School (MHH), Carl-Neuberg-Str. 1, 30625 Hannover, Germany

ARTICLE INFO

Article history:
Accepted 31 May 2014

Keywords:
Femoral nailing
Computer-assisted surgery
Navigation
Antetorsion
Computed tomography

ABSTRACT

Aim: Intraoperative determinations of femoral antetorsion and leg length during fixation of femoral shaft fractures present a challenge. In femoral shaft fracture fixations, a computer-navigation system has shown promise in determining antetorsion and leg length discrepancies. This retrospective cohort study aimed to determine whether the use of computer navigation during femoral nailing procedures reduced postoperative femoral malrotation and leg length discrepancy, as well as the number of revision cases. We also sought to determine whether radiation exposure time was reduced when computer navigation was used.

Materials and methods: Of 246 patients treated for femoral shaft fractures between 2004 and 2012, we selected those that received postoperative computed tomography for rotation and leg length control. We included 24 patients who received navigation-assisted treatments and 48 who received unassisted treatments, matched for age, sex, and fracture type. All patients were treated by femoral nailing.

Results: The groups showed significant differences in the mean (standard deviation (SD) delay before surgery (navigation-assisted vs. unassisted groups: 8.5 ± 3.2 vs. 5.2 ± 5.8 days; $P < 0.05$) and surgery times (163.7 ± 43.94 vs. 98.3 ± 28.13 min; $P < 0.001$). The groups were significantly different in the mean (SD) radiation exposure time (4.43 ± 1.35 vs. 3.73 ± 1.5 min; $P = 0.042$), and were not significantly different in the postoperative femoral antetorsion difference ($8.83 \pm 5.52^\circ$ vs. $12.4 \pm 9.2^\circ$; $P = 0.056$), or in the postoperative length discrepancy (0.92 ± 0.75 vs. 0.95 ± 0.94 cm; $P = 0.453$). Four (16.7%) navigation-assisted and 15 (31.25%) unassisted surgeries got revision for torsion and/or length corrections.

Conclusion: Our results showed that, compared to unassisted femoral surgery, the computer-navigation system did not improve postoperative results or reduce radiation exposure. In the future, improvements in handling and application could facilitate the workflow and may provide better postoperative results. Currently, computer navigation may provide advantages for complicated or sophisticated cases, such as complex three-dimensional deformity corrections.

Level of evidence: Level III.

Introduction

Malrotation after intramedullary nailing of femoral shaft fractures remains an unresolved problem. Malrotations $>15^\circ$ are both cosmetically undesirable and clinically symptomatic. Thus, they require operative revisions. This complication occurs in up to 28% of surgeries [1,2]. Other complications of femoral nailing include angular malunion, nonunion, and leg length discrepancy with the contralateral leg [3]. Femoral antetorsion is the angle in the axial plane between the femoral neck and the posterior femoral condyles. Physiological antetorsion varies from -4° to 35° [4]. Intraindividual physiological femur torsion differs up to 15° from that of the contralateral side, and this is taken as the acceptable limit for a postoperative antetorsion difference [5].

Intraoperative measurement of antetorsion remains a clinical challenge. Several techniques describe ways to estimate and determine antetorsion during surgery. These techniques include the following: radiopaque cables, a grid system, a lesser trochanteric method, the cortical dimension of the fracture side, or a bilateral clinical assessment [6–9]. Some of these methods are

* Corresponding author. Tel.: +49 1761 5326964.
E-mail address: hawi.nael@mh-hannover.de (N. Hawi).

http://dx.doi.org/10.1016/j.injury.2014.05.039

associated with prolonged intraoperative fluoroscopy. Moreover, interpretation of the results can be relatively subjective, due to the fact that two-dimensional radiography cannot capture the exact geometry of the femur. Other authors have described ultrasound-based methods and new angles for use with conventional measurement tools to measure correct antetorsion [10,11]. These methods have not yet been adopted into clinical practice.

A number of feasibility and experimental studies were performed for computer-assisted antetorsion control [12–17]. Both Weil et al. [18] and Gosling et al. [19] demonstrated good results with a computer-navigation system for controlling femur length and rotation during fixation. The major advantages of the computer-navigation system were higher accuracy in achieving the appropriate femur axis, length, and rotation, as well as reduced fluoroscopy exposure for both the patient and the operating room staff. In 2011, Wilharm et al. [20] presented results from routine clinical use of a computer-navigation system for 40 femoral nailing procedures. They concluded that the computer-navigation system reduced malalignments and length discrepancies with the contralateral leg. Since 2004, our institute has routinely employed a computer-navigation system during surgeries.

The purpose of this study was to determine whether the use of computer navigation during femoral nailing procedures reduced postoperative femoral malrotation and leg length discrepancy, as well as the number of revision cases. We also sought to determine whether radiation exposure time was reduced when computer navigation was used.

Patients and methods

Data collection

We reviewed the medical records of 246 patients with femoral shaft fractures who were treated at our institution (Level I trauma centre) between 2004 and 2012. Patients were included in the study if they had sustained a femoral shaft fracture, had received a postoperative computed tomography (CT) scan, had undergone femoral nailing, and if the surgery had been performed by a consultant trauma surgeon. Patients were excluded if they had bilateral fractures, open fractures, open reductions, or intra-articular fractures.

We identified a total of 24 patients who underwent computer-assisted nailing of unilateral femoral shaft fractures (Brainlab Corporation, Feldkirchen, Germany). These patients were matched at a ratio of 1:2 to 48 patients who received conventional treatment by femoral nailing without computer-assisted navigation. Matching was based on sex, age, and type of fracture according to the AO Foundation's criteria. In all cases, reduction and fixation were performed by intramedullary nailing, with a time delay that depended on the pattern of injury, according to the concepts of damage-control orthopaedics [21,22]. In 19 navigation-assisted and 37 conventional cases, no further intervention was performed at the time of the femoral nailing, such as patellar or tibial fracture treatment. The complete medical record included past and present illnesses, radiological examinations, treatments, and outcomes. These data were documented electronically in the hospital computer system of our institute, and these records provided valid information for retrospective analyses.

The primary outcomes were as follows: postoperative antetorsion difference (in degrees), postoperative leg length discrepancy (in cm), radiation exposure time (in minutes), and the need for revision surgery. Potential confounders measured in this analysis included: surgery time, surgical side (left or right), time from admission to surgery (in days), surgical position (supine or lateral), and time of day (day or night).

Table 1
Demographics and fracture characteristics of the patients in this study.

	Surgery performed with navigation assistance	Surgery performed without navigation assistance
N	24	48
Age (years)	32.2 ± 13.8	31.5 ± 13.2
Gender distribution, male:female	19:5	36:12
Side distribution, left:right (*n*:*n*)	10:14	20:28
Fracture type A	5	10
Fracture type B	10	20
Fracture type C	9	18

Patients and surgery characteristics

Patient data and fracture distributions are shown in Table 1 and Fig. 1.

The nails used in surgery were unreamed, femoral nails (UFN, Synthes, Umkirch, Germany), distal femoral nails (DFN, Synthes, Umkirch, Germany), expert lateral femoral nails (LFN, Synthes, Umkirch, Germany), and long gamma nails (LGN, Stryker, NJ, USA).

Navigated technique for femoral nailing

Surgeries were performed with the VectorVision compact navigation system and VectorVision trauma 2.5 software (Brainlab, Feldkirchen, Germany) in combination with a Siemens ISO C 3D C-arm (Siemens, Erlangen, Germany). Surgeries were performed in the following steps: (1) navigation-assisted analysis of the contralateral femur; (2) application of two parallel monocortical fixator pins to the ipsilateral femur; (3) navigation-assisted

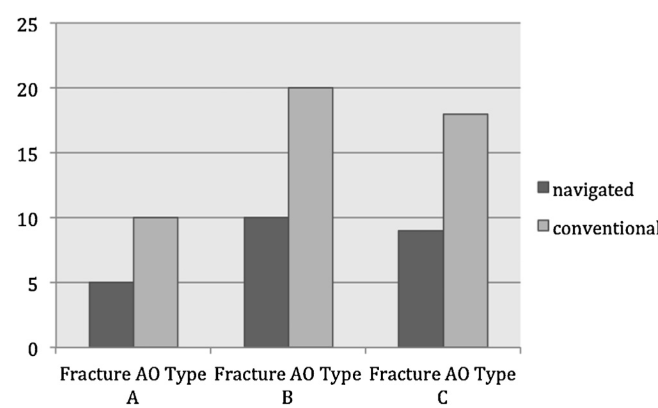

Fig. 1. Fracture type distribution according to AO classification.

Fig. 2. Navigation-assisted analysis of the ipsilateral femur.