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Femoral offset following trochanteric femoral fractures: a prospective observational study

Benjamin Buecking[a], Christoph Kolja Boese[a,b], Vinzenz Seifert[a], Steffen Ruchholtz[a], Michael Frink[a], Philipp Lechler[a,*]

[a] Center for Orthopaedics and Trauma Surgery, University of Giessen and Marburg, Marburg, Germany
[b] Department of Orthopaedic and Trauma Surgery, University Hospital of Cologne, Cologne, Germany

KEYWORDS

femoral offset
femoroacetabular impingement
hip biomechanics
hip fracture
proximal femoral nailing

List of abbreviations:
AP – anteroposterior
ASA - American society of anaesthesiologists
CCD - caput-collum-diaphyseal
FH – femoral head circumference
FO - femoral offset
FO_P – projected femoral offset
FO_{RC} - rotation-corrected femoral offset
HR - hip rotation
MMSE - mini–mental state examination
RCF - rotation-correction-factor as assessed by the tangent function
THA – total hip arthroplasty
γ_p – projected gamma angle of the implant
γ_t – gamma angle of the implant

ABSTRACT

Background: Reconstruction of the femoral offset reportedly improves outcome following total hip arthroplasty, but little is known of its influence following hip fractures. We aimed to establish the effect of the femoral offset on the medium-term functional outcome in elderly patients who had sustained trochanteric fractures requiring proximal femoral nailing.
Patients and Methods: We measured the rotation corrected femoral offset (FO_{RC}) and relative femoral offset (FO_{RL}) on plain anteroposterior radiographs of the hip in 188 patients (58 male, 130 female) with a trochanteric fracture who underwent proximal femoral nailing at our institution. The primary outcome measure was the Harris hip score (HSS) 6 and 12 months postoperatively; the Barthel index was assessed as a secondary outcome.
Results: The mean FO_{RC} after surgery was 58 mm (±11 mm), while the mean FO_{RL} was 1.21 (±0.22). At final follow up, we found significant inverse relationships (Spearman's rank correlation coefficient, ρ) between FO_{RC} and FO_{RL} and the functional outcome assessed by the HSS (FO_{RC}: ρ = -0.207, p = 0.036; FO_{RL}: ρ = -0.247, p = 0.012), and FO_{RL} and the Barthel index (FO_{RC}: ρ = -147, p = 0.129; FO_{RL}: ρ = -0.192, p = 0.046). A consistent trend was observed after adjustment for confounding variables.
Conclusions: Our results underline the biomechanical importance of the femoral offset for medium-term outcomes in elderly patients with trochanteric fractures. In contrast with the published findings on total hip arthroplasty, we found an inverse correlation between functional outcome and the extent of the reconstructed femoral offset.
Level of Evidence:
Level I – Prognostic study.

Introduction

The incidence of hip fracture in elderly patients is expected to double by 2050 [1]; the management of hip fracture presents a key challenge to clinicians and healthcare providers now and in the future [2]. There has been a strong focus on the reduction of short- to medium-term mortality rates over the last decades [3], but more recently there is growing clinical and scientific interest in optimizing functional outcome following these injuries.

The importance of the reconstruction of hip anatomy has been proven for elective total hip arthroplasty (THA) [4]; however, the biomechanical factors determining the functional outcome following internal fixation of hip fractures remain unclear [5]. Femoral offset, defined as the distance from the center of rotation of the femoral head to a line bisecting the long axis of the femur, represents the biomechanical lever arm of the hip abductor muscles [6]. The restoration of the correct length of the femoral offset in THA reportedly correlates with reduced rates of postoperative limping, impingement, leg length discrepancy and dislocation [7].

The aim of this prospective observational study was to examine the influence of postoperative femoral offset on the functional outcome of patients treated for a trochanteric fracture.

Patients and methods

We prospectively enrolled 188 consecutive patients who had sustained a trochanteric fracture and were treated by proximal femoral nailing in our level one trauma center (a university hospital) between April 1, 2009 and September 30, 2011. Exclusion criteria were multiple trauma and malignancy-associated fractures. The patients underwent surgery on a traction table in the supine position under general anesthesia performed by experienced

The study has been performed at the Center for Orthopaedics and Trauma Surgery, University of Giessen and Marburg, Marburg, Germany.

* Corresponding author at: Center for Orthopaedics and Trauma Surgery, University of Giessen and Marburg, Baldingerstraße, 35043 Marburg, Germany. Tel.: +06421/58-61741; fax.: +06421/58-66721.

E-mail address: lechler@med.uni-marburg.de (Philipp Lechler).

trauma surgeons. In 153 cases a proximal femoral nail with a caput-collum-diaphyseal (CCD) angle of 130° (Zimmer Natural Nail System, Cephalo-medullary Nail, Zimmer, Inc., Warsaw, IN, USA) was implanted according to the manufacturer's instructions. Thirty-five patients were implanted with a proximal femoral nail with a CCD of 125° (Trochanteric Gamma3™ Locking Nail, Stryker Corporate, Kalamazoo, MI, USA) using the same operative technique. The correct positioning of the lag screw in the center of the femoral neck was confirmed by fluoroscopy focused at 1,000 mm (Siremobil compact GE OEC 9900 C-arm, Siemens Medical Solutions, Erlangen, Germany). Full weight-bearing was allowed immediately postoperatively, and all patients were treated according to a standardized postoperative therapeutic protocol. Peri- and postoperative surgical complications and requirement for revision surgery were recorded. Functional outcome was assessed 6 and 12 months postoperatively by means of the Harris hip score (HHS) and the Barthel index. Details of the follow-up protocol are shown in Fig. 1.

Measurement of femoral offset

Following mobilization, standardized postoperative anteroposterior (AP) and axial radiographs of the hip were obtained in the supine position with a tube-to-film distance of 1,150 mm (see Fig. 2). Improved views were obtained if radiographs were judged to have an unacceptable degree of hip extension or flexion. Radiographs were calibrated by calculating the ratio between the true diameter of the head of the femoral nail (15.5 mm) and its projected diameter. Pictures were archived and analyzed using IMPAX and IMPAX EE software (AGFA HealthCare GmbH, Bonn, Germany). Femoral offset was defined as the perpendicular distance from the center of rotation of the femoral head to the long axis of the femoral shaft on AP radiographs, and rotation correction was performed as previously described [5]. Briefly, hip rotation leads to a variation in the projected CCD angle of the implanted femoral nail. Rotation around the femoral axis increases the projected gamma angle of the implant (γ_P). As the true gamma angle (γ_I) of the implant is known, the hip rotation (HR) can be calculated thus:

$$HR = \arccos(\tan(\gamma_P) / \tan(\gamma_I))$$

To correct for the rotation of the projected femoral offset (FO_P), the rotation-correction factor (RCF) is calculated from the following formula:

$$RCF = (\tan(\gamma_I) / \tan(\gamma_P))$$

The rotation-corrected femoral offset (FO_{RC}) is the product of FO_P and the RCF:

$$FO_{RC} = FO_P \bullet RCF$$

To further correct for the size of the patient and the dimensions of their hip, the relative femoral offset (FO_{RL}) is the ratio between the rotation-corrected femoral offset (FO_{RC}) and the circumference of the femoral head (FH):

$$FO_{RL} = FO_{RC} / FH$$

Statistical analysis

For descriptive analysis, absolute mean values and standard deviations are reported. Normality of the distribution of the data was tested using the Kolmogorov-Smirnov test. The relationship between FO_{RC} and FO_{RL} was demonstrated in a scatterplot and Spearman's correlation coefficient was calculated. To detect a correlation between femoral offset and the primary and secondary outcome measures, Spearman's correlation coefficient was calculated using a bivariate technique. To adjust for confounding variables, a multivariate analysis was undertaken that included

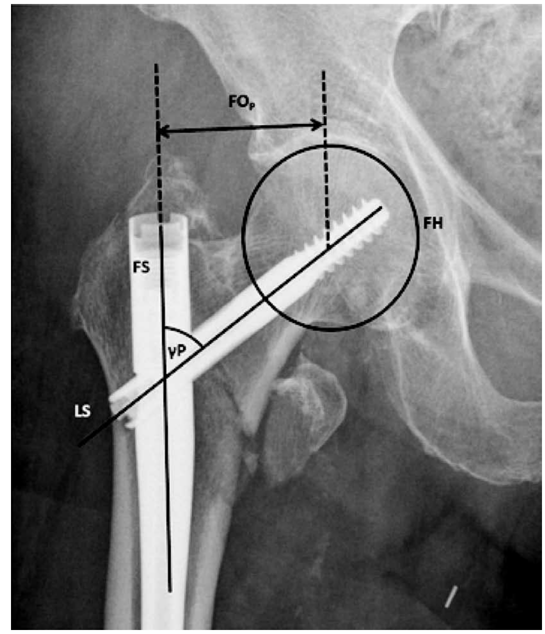

Fig. 2. Measurement of femoral offset on plain anteroposterior radiographs following proximal femoral nailing. FH – femoral head, FS – proximal femoral shaft axis, FO_P – projected femoral offset, LS – leg screw axis, γ_P – projected gamma angle of the implant.

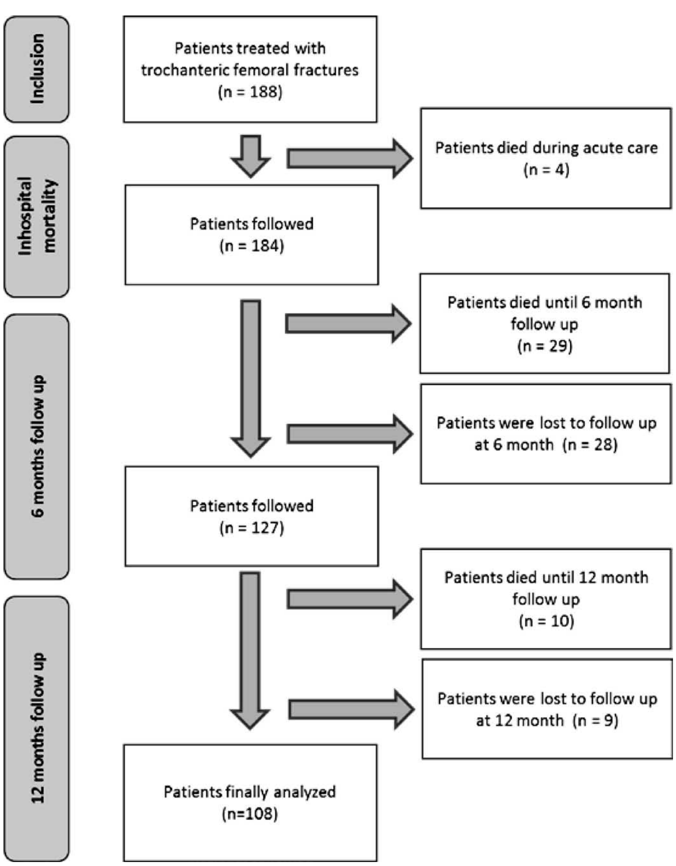

Fig. 1. Flow chart depicting the follow up of 188 patients with trochanteric femoral fractures.