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# Clinical implications of impingement of the anterior femoral cortex after cephalomedullary nailing

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ABSTRACT

*Background:* Cortical impingement is a common complication after cephalomedullary nailing, but the evidence about its consequences is very limited. The aim of this study was to assess the clinical implications of cortical impingement on patients treated with cephalomedullary nails.
*Methods:* A cohort study was carried out at a Level I academic Institution with consecutive patients treated with cephalomedullary nails during 2010 and 2013. Demographic and nail variables were recorded as well as cortical impingement was determined on the radiographs. Clinical outcomes such as pain, femoral fractures, and delayed or nonunion of the fracture were detected during the follow-up. The follow-up was divided into short- (6–12 months), medium- (12.1–36 months), and long-term follow-up ($\geq$36.1 months). Descriptive statistics were used, and Chi-square or Fisher's exact tests measured the association between categorical variables. The Mann–Whitney *U* test was performed to evaluate differences between cortical impingement in terms of pain, and pain and the follow-up categories.
*Results:* A total of 119 patients were analyzed with a mean age of 74.8 years $\pm$ 17.1, and a mean follow-up of 23.5 months $\pm$ 12.1. Overall the pain was present in 61 (51.2%) cases, and it was observed in 28/59 (47.4%) and 33/60 (55%) of the patients with presence or absence of cortical impingement respectively. There was not a statistically significant association between cortical impingement and pain ($p = 0.20$), neither differences were detected between pain and the follow-up groups ($p = 0.48$). Out of 59 cases with cortical impingement, femoral fractures were observed in two patients (3.3%), and delayed union of the fractures was seen in two patients who did not present impingement. Since patients with delayed union received treatment as soon as it was diagnosed, no cases of nonunion of fractures were identified.
*Conclusions:* Cortical impingement of the anterior cortex of the femur was not associated with the presence of pain, so that other causes should be assessed to explain the pain after 6 months of being treated with a cephalomedullary nail. Femoral fractures, and delayed union or nonunion of the fracture may occur theoretically in patients with cortical impingement.



## Introduction

Cephalomedullary nails have increased their frequency of use in the treatment of hip fractures in elderly [1], specifically to manage unstable proximal femoral fractures [2]. Those nails have shown intraoperative complications such as nail impingement or cortical impingement of the anterior cortex of the femur; terms used as synonyms exclusively to refer to the contact between the nail tip of the nail and the anterior femoral cortex [2,3].

The proportion of cortical impingement varies depending on the length of the nail, and the population. Impingement with long cephalomedullary nails have been documented in Americans and Europeans between 6.8% and 24% [4–6], and in Hispanics between 12.5% and 32.3% [2,7]. Cortical impingement with short nails has not been found in Americans or Europeans with the last generations of nails [2,4–11], but in Asian and Hispanic population it has been found as high as 34% and 65% respectively [2,12]. Nail impingement is more common in Hispanics and Asians due to a mismatch between the curvature of their femur and the radius of curvature (ROC) of the intramedullary nails commercially available, which means that the nails are very straight and do not fit the curvature of the femur of these populations [1,2,13].

Besides cortical impingement, other outcomes haven been reported after cephalomedullary nailing with long and short nails. Specially, postoperative pain has been found in a wide range that goes from 1.7% to 61% [3,14–18], and other outcomes such as postoperative fracture, nonunion and delayed union of the fracture

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have been reported up to 5.7%, 2.8% and 6.5% respectively [17,18]. However, the clinical implications of cortical impingement have not been clearly established by the literature, and only sporadic findings or hypotheses in studies have attributed to nail impingement clinical implications such as higher rate of thigh pain, femoral fractures, delayed union or nonunion of fractures [2–8,19,20]. Particularly, pain is a great concern because it has shown that it significantly impacts quality of life (QL) after surgery for hip fracture [21], and in patients with cortical impingement QL could be more impaired due to increased pain [2].

For the reasons previously mentioned, the aim of this study was to assess the relationship between nail impingement of the anterior cortex of the femur and thigh pain, along with describing other clinical implications of cortical impingement. The main working hypothesis was proposed that patients with nail impingement would present greater postoperative pain than those without impingement after cephalomedullary nailing.

## Materials and methods

An ambidirectional cohort study was carried out at a Level I academic medical center with consecutive patients treated with cephalomedullary nails from 2010 to 2013. Patients who underwent cephalomedullary nailing due to hip fracture, and with a minimal follow-up of 6 months were included. Excluded criteria were constituted by patients who did not allow a proper clinical evaluation such as patients with some neurological diseases, medical history or concurrent acetabular or knee fractures, intramedullary nail removal during the first 6 months postoperatively, and intraoperative perforation of the anterior femoral cortex after cephalomedullary nailing. Furthermore, patients who presented in-hospital mortality or mortality during the first six postoperative months were also excluded.

Demographic variables were recorded and features of the fractures and nails were also collected. The AO Foundation and Orthopaedic Trauma Association (AO/OTA) fracture classification system was used to classify the fractures, which included proximal and diaphyseal fractures of the femur with the designations 31A, 32A and 32C, and their corresponding subdivisions [22]. Laterality of the fracture was also gathered, and characteristics of cephalomedullary nails were reviewed on surgical records such as type, manufacturer and length.

The cohort of patients were treated with long and short cephalomedullary nails, specifically with trochanteric fixation nail (TFN) – DePuySynthes – and Gamma3™ nail – Stryker. The surgical procedures were performed by 12 surgeons with experience in trauma using a standardized surgical technique. In general terms, the surgical technique consisted in the following steps under fluoroscopic guidance: 1. Fragment reduction and alignment, and identification of the starting point on the greater trochanter 2. Insertion of the guide wire, followed by reaming and introduction of the nail manually 3. Insertion either of lag screw (Gamma3™) or helical blade (TFN) with a proper assessment of its position 4. Distal locking and 5. Intraoperative radiological assessment by taking a perfect axiolateral hip projection (ALHP) and a perfect the lateral femoral x-ray (LFXR) when patients were under anesthesia [23].

Impingement was assessed by an orthopaedic surgeon on patient's radiographs, ALHP and LFXR. Cephalomedullary nail impingement was defined as a nail tip that contact the anterior cortex of the femur on a postoperative lateral radiographs of the femur (Fig. 1). An ALHP had the follow characteristics: 1) the lesser trochanter in profile medially, 2) the greater trochanter superimposed on the femoral shaft, 3) the femoral neck in the center of the collimated field and not foreshortened, and 4) the articulation of the acetabulum with the head of the femur entirely demonstrated and well penetrated [24]. Similarly, a LFXR had to prove the follow specifications: 1) symmetry of the epicondyles with the femoral condyles in profile, 2) the intercondylar eminence of the tibia is seen within the intercondylar fossa of the femur, and 3) the medial and lateral femorotibial joint is demonstrated open with good spacing between the femur and tibia [25].

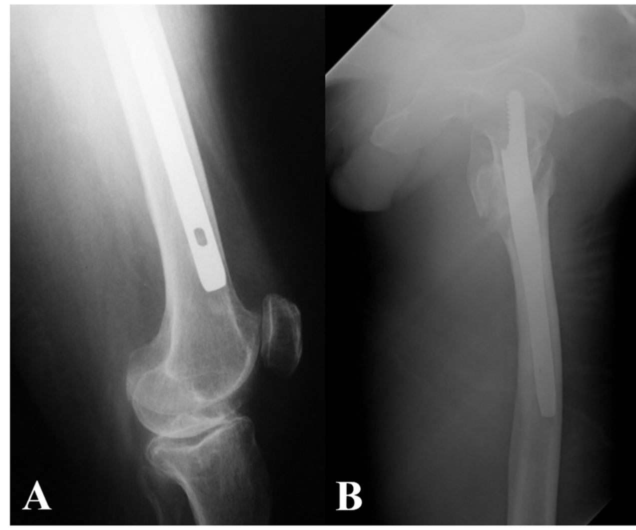

**Fig. 1.** Cortical impingement with a long (A) and short (B) cephalomedullary nail.

The medical follow-up consisted in assessing patients clinical- and radiologically during the outpatient clinical appointments on second and eighth postoperative week, and then every 12 weeks until 1 year was completed. Thereafter, patients had medical follow-up every year. The follow-up was able to be more frequent in some patients depended on the medical status and the surgeon preference. The follow-up completed by the patients was divided into three categories as follows: short- (6–12 months), medium- (12.1–36 months), and long-term follow-up (≥36.1 months). During the hospital stay the rehabilitation began with walking training using external aids such as walker or crutches, allowing progressive postoperative weight-bearing. In parallel early mobility of the hip, knee and ankle was urged. As a referral Institution when the patients went back to their hometowns, they continued physiotherapy up to three months postoperatively to achieve independence in walking and daily life activities.

The documentation of the pain variable was taken from the last follow-up appointment, and it was assessed using the five-grade verbal rating scale (VRS), which presents the following distribution: 0—no pain, 1—slight pain, 2—moderate pain, 3—severe pain, and 4—unbearable pain [26]. The pain location was divided into three parts as follows: upper third (hip and proximal femur), middle third (middle third of the femur) and lower third (distal femur and knee). Quality of the pain was evaluated as constant or intermittent pain, in other words "pain that comes and goes" [27]. Since patients were referred to the Hospital from other cities of the State, a telephone interview was necessary for patients who were not able to attend to the last follow-up to record the pain variable.

Additional variables were measured during the postoperative period of follow-up such as delayed union, non-union, and femoral fracture. Delayed healing of the fracture was defined in time between 1 and 8 months, and non-union was stated as a fracture that has not completely healed within 9 months of injury and that has not shown progression toward healing over 3 consecutive months on serial radiographs [28,29]. Femoral fracture definition covered peri-implant, shaft and distal fractures on the radiographs, and it was identified on an anterior-posterior (AP) and a lateral