Injury, Int. J. Care Injured xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

Injury

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

Full length article

Femoral intertrochanteric nail (fitn): a new short version design with an anterior curvature and a geometric match study using post-operative radiographs

Shi-Min Chang*, Sun-Jun Hu, Zhuo Ma, Shou-Chao Du, Ying-Qi Zhang

The Department of Orthopaedic Surgery, Yangpu Hospital, Tongji University School of Medicine, Shanghai 200090, People's Republic of China

ARTICLE INFO

Article history:
Received 14 September 2017
Received in revised form 2 November 2017
Accepted 15 November 2017

Keywords:
Femoral intertrochanteric fracture
Short cephalomedullary nail
Femur anterior bow
Greater trochanter
Geometric match
Nail tip impingement

ABSTRACT

Objective: Femoral intertrochanteric fractures are usually fixed with short, straight cephalomedullary nails. However, mismatches between the nail and the femur frequently occur, such as tip impingement and tail protrusion. The authors designed a new type of short femoral intertrochanteric nail (fitn) with an anterior curvature (length = 19.5 cm, r = 120 cm) and herein report the geometric match study for the first of 50 cases.

Methods: A prospective case series of 50 geriatric patients suffering from unstable intertrochanteric fractures (AO/OTA 31 A2/3) were treated. There were 15 males and 35 females, with an average age of 82.3 years. Post-operatively, the nail entry point position in the sagittal greater trochanter (in three categories, anterior, central and posterior), the nail-tip position in the medullary canal (in 5-grade scale) and the nail-tail level to the greater trochanter (in 3-grade scale) were measured using X-ray films.

Results: For the nail entry point measurement, 5 cases were anterior (10%), 38 cases were central (76%), and 7 cases were posterior (14%). For the distal nail-tip position, 32 cases (64%) were located along the central canal axis, 13 cases (26%) were located anteriorly but did not contact the anterior inner cortex, 2 cases (4%) showed less than one-third anterior cortex thickness contact, and 3 cases (6%) were located posteriorly with no contact. For the proximal nail-tail level, there were no protrusions over the greater trochanter in 15 cases (30%), protrusion of less than 5 mm in 29 cases (58%), and protrusion of more than 5 mm in 6 cases (12%). The fitness was very high, as 96% cases showed no tip-cortex contact, and 88% cases showed less than 5 mm proximal tail protrusion.

Conclusion: The newly designed femoral intertrochanteric nail has a good geometric match with the femur medullary canal and the proximal length in the Chinese population.

Introduction

Geriatric per/inter-trochanteric fractures, mainly due to osteoporosis, remain a surgical challenge worldwide. Most geriatric hip fractures require surgery to prevent bed-related complications and mortality. In recent years, various types of short straight cephalomedullary nails, including Gamma-3, PFNA, InterTan, etc., have been commonly used in unstable per/intertrochanteric fractures in geriatric patients [1]. However, complications related to nail design were also noted, such as a mismatch between the short straight nail and the anterior bow of the femur, which is manifested as abnormal contact between the nail-tip and the anterior cortex (impingement) [2,3], and over-protrusion of the proximal nail-tail outside the greater trochanter [4].

Asian people usually have a shorter stature, with a smaller trochanteric area, a narrower intramedullary canal, and a larger anterior curvature of the femoral shaft [5]. To accommodate the anatomic characteristics of Asians, cephalomedullary nails have been modified in several aspects, for example, Gamma-3 and PFNA-II (Asian version). However, all of the short type nails (less than 240 mm in length) are straight in the sagittal plane. For the most commonly used normal size PFNA-II (200 mm length and 10 mm diameter), Chang et al. found the presence of distal tip-cortex impingement in 40% cases in the Chinese population [2]. In addition, the impingement rate was reported to be as high as 70% in Hispanic Colombians [3]. Moreover, Hu et al. reported proximal

* Corresponding author at: Department of Orthopedic Surgery Yangpu Hospital, Tongji University School of Medicine 450 Tengyue Road Shanghai 200090, People's Republic of China.
E-mail address: shiminchang11@aliyun.cn (S.-M. Chang).

https://doi.org/10.1016/j.injury.2017.11.017
0020-1383/

nail tail protrusion in PFNA-II over the greater trochanter (> 5 mm in 60.8% of cases) to cause lateral hip pain or greater trochanter syndrome [4]. Clearly, there is a mismatch between the short straight nail and the curved femoral shaft in size and morphology.

For better fitness between the short cephalomedullary nail and the femur, we made further adaptations and designed a short curved femoral intertrochanteric nail. In this paper, we performed a geometric match study using the post-operative radiographs of the novel femoral intertrochanteric nail (FIT nail, fitn) in the first 50 patients who underwent per/inter-trochanteric fracture fixation.

The new short curved nail

The short curved femoral intertrochanteric nail (FIT nail,) is shown in Fig. 1. The nail is manufactured by Wego Orthopaedics Co. Ltd, China.

For the shorter stature (body height) and larger anterior bowing in Asians (especially old females), three adaptations were made on the basis of former short straight nails: (1) the proximal segment was 16.5 mm in diameter and 100 mm in length (shortened by 5 mm) to prevent nail-tail over-protrusion to the great trochanter. (2) The distal segment was available in two sizes, 65 mm and 95 mm in length and 9 mm and 10 mm in diameter, respectively. The distal segment of the nail was built with an anterior curvature (radius = 120 cm), to avoid the nail-tip impingement. (3) The distal nail-tip was opened in a cross slot for further accommodations to the anterior and/or lateral bowing of the femur.

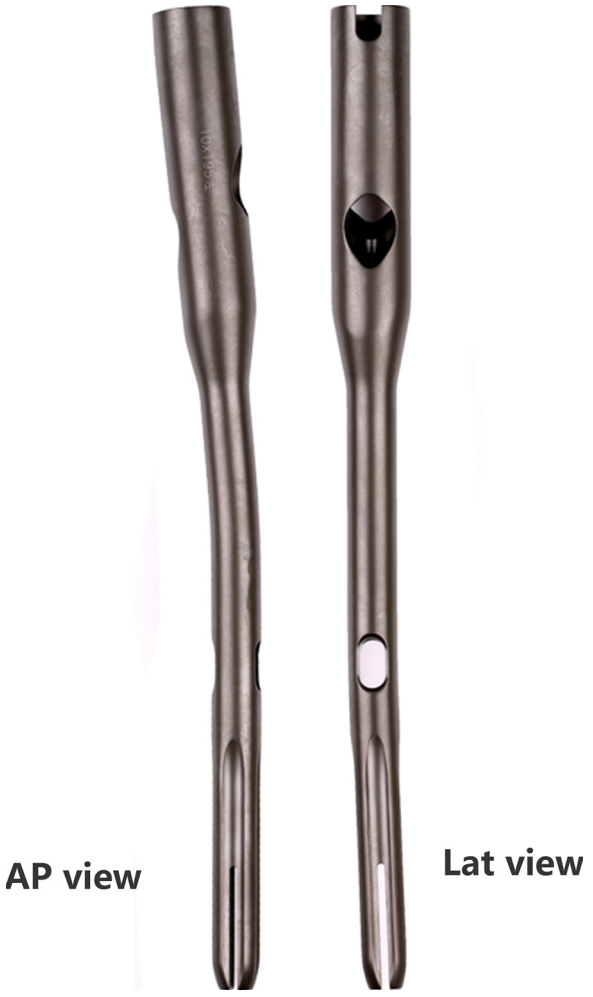

Fig. 1. The newly adapted femoral intertrochanteric nail (fitn) with a length of 195 mm and a distal diameter of 10 mm.

FIT nails have a left-sided version and right-sided version, with different distal part jigs. They are manufactured in two sizes, 165 mm long with a 9 mm and 10 mm distal diameter, and 195 mm long with a 9 mm and 10 mm distal diameter. Proximal nail-tail caps are available in three different heights, 0 mm, 5 mm, and 10 mm. The angle of helical blade was set at 130°. Compared with the short straight PFNA-II we used previously, the proximal segment was shortened by 5 mm in length to solve the problem of nail-tail over-protrusion, and the distal nail-tip was bent backward 1.5 mm and 1.8 mm in 165 mm and 195 mm long nails, respectively, to avoid anterior cortex impingement.

Patients and methods

After Institutional Review Board approval (No. LL-2015-ZRKX-014), the short curved FIT nails were first used in our hospital in November 2015. Patient or family informed consent was obtained. As a clinical rule for nail selection, we systematically chose as large a diameter and as long a nail as possible, provided the surgeon believes it can be manually inserted into the femoral canal without the need to ream the distal segment.

We collected the first 50 patient's data prospectively from November 2015 to February 2017. All fractures were classified as unstable per/inter-trochanteric fractures (AO/OTA 31 A2 and A3). There were 15 men and 35 women, with an average age of 82.3 (range, 65–94) years. The left hip was involved in 23 cases, and the right hip was involved in 27 cases. The etiology was as follows: falls from standing in 45 cases and pedestrian accidents in 5 cases.

The operation was performed on a fracture traction table. Intra-operatively, fluoroscopy was used to control the fracture reduction and implant position. Post-operatively, radiography was performed before patient discharge (Fig. 2). The quality of fracture reduction was evaluated by a scale proposed by Chang et al [6], which was based on the antero-medial cortical support and the neck-shaft alignment on AP and lateral views. The quality was categorized as excellent, acceptable, or poor [6]. The helical blade position in the femoral head was assessed by measuring the tip–apex distance (TAD).

Nail entry point measurement

On true lateral immediate post-operative fluoroscopy images, the nail entry point position on the sagittal plane, based on the distance between the nail and anterior or posterior cortex, was measured in Adobe Photoshop, using the known proximal nail diameter of 16.5 mm as the "pixel length ruler". The nail entry point position was classified into three categories, anterior, central and posterior (Fig. 3). If the nail is closer to the anterior cortex, or the posterior interval is larger than the anterior one, it is classified as the anterior entry point position.

Nail-tip position measurement

On post-operative lateral radiographs, the position of the nail tip is classified into a 5-grade scale as proposed previously [2], with reference to the central canal axis and the femoral cortex thickness (Fig. 4).

Nail-tail protrusion measurement

On post-operative AP radiographs, the distance between the nail-tail and the lateral apex of the greater trochanter was measured (Fig. 5). The nail-tail protrusion was classified into 3

Please cite this article in press as: S.-M. Chang, et al., Femoral intertrochanteric nail (fitn): a new short version design with an anterior curvature and a geometric match study using post-operative radiographs, Injury (2017), https://doi.org/10.1016/j.injury.2017.11.017