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Unstable lateral femoral fractures: elements predictable of failure

Analysis of critical aspects related to the fracture pattern and nailing in order to obtain healing

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Conflict of interest
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Summary

Objective. Lateral femoral fractures are common events, especially in old frail patients. They can be stable or unstable on the basis of specific features. Optimal treatment requires preoperative evaluation of the fracture pattern and appropriate choice of implant and surgical technique. The aim of this study was to detect variables related to fixation failure in unstable lateral femoral fracture.

Methods. We retrospectively evaluated 136 patients treated with intramedullary proximal femur nail (PFN) between January 2016 and December 2017 at our hospital. All fractures were classified according to the AO/OTA classification; the type and length of nail, nail collodiaphyseal angle, type of distal locking and use of steel wire cerclage were recorded. These variables were statistically analysed to evaluate any correlation with the onset of complications, i.e., biological and/or mechanical failure.

Results. At the first follow-up at three months, we found 13 failures (9.6%). At 6 months, 38 patients were lost to follow-up and we identified 3 failures as pseudoartrosis. Statistical analysis showed a significant correlation between the type of fracture and failure. No significant differences were detected for the other parameters.

Conclusions. When treating a lateral unstable femoral fracture with proximal femoral nail, the only variable significantly related to failure seems to be the fracture pattern. Thorough knowledge of the implant still remains essential to obtain a good result.

Key words: femoral fracture, nailing, unstable fracture, synthesis failure, PFN

Introduction

Trochanteric and subtrochanteric fractures are commonly defined as extracapsular or lateral femoral fractures. They are most frequently found in old frail patients affected by osteopenia and osteoporosis after a low energy fall, but also in young persons after high energy trauma. They are very common, representing approximately 50% of all proximal femoral fractures [1].

The goal of treatment, surgical in almost all cases, is prompt and stable surgical fixation in order to reduce mortality and morbidity associated with long term immobilisation and its consequences i.e., pressure ulcers, thrombosis, thrombophlebitis, pulmonary embolism, infections and delirium.

The fixation devices most frequently used for treatment of lateral femoral fractures include intramedullary nail (IMN) and dynamic hip screw (DHS). In selected cases, joint arthroplasty can also be taken into consideration; femoral trochanteric fixation plate and steel wire cerclage can be added to gain more stability.

Lateral femoral fractures are further divided in stable and unstable fractures on the basis of specific features. Unstable fractures include those that present one of the following features: extension to the lesser trochanter, reverse fracture line, intertrochanteric comminution with a large posteromedial fragment, fracture of the greater trochanter, lateral cortex breach, or extension to the femoral neck area and piriformis fossa. Based on the aforementioned findings, fracture types 3, 4 and 5 according to the Evans-Jensen classification can be defined as unstable [2,3].

Optimal surgical treatment requires preoperative evaluation of the fracture pattern and stability. The correct choice of implant and surgical technique is crucial to achieve stable fixation in order to allow early weight bearing and avoid fracture non-union.

The aim of this study is to assess if there is a relationship between specific risk factors, related both to the fracture pattern and surgical treatment, and the onset of complications. We present the results obtained with the use of intramedullary nails for unstable lateral proximal femur fracture in a single trauma centre, comparing them to the recent literature.

Materials and methods

Patients

We retrospectively evaluated patients with unstable lateral femoral fracture treated with intramedullary proximal femur nail (PFN) between January 2016 and December 2017 at our hospital, a Level III trauma centre. The inclusion criteria were: age > 50 years, isolated femoral fracture, extracapsular intertrochanteric and subtrochanteric fracture. Patients affected by severe systemic pathologies, pathological fractures and patients who have suffered polytrauma were excluded. All fractures were classified according to the AO/OTA classification, being divided in 31A2.2, 31A2.3, 31A3.1, 31A3.2 and 31A3.3. The other variables collected were the type of nail, nail length, nail collodiaphyseal angle (CDA), type of distal locking (static or dynamic) and reinforcement with steel wire cerclage. Each variable was individually related to the onset of complications.

Ethics

All procedures described in this study conform to the standards defined by the Helsinki Declaration (1975) and its recent updates. We acquired informed consensus from all patients participating in the study. Approval by the Ethics Committee was not necessary due to its retrospective nature, being a review of globally accepted clinical practice.

Surgery and recovery

All patients underwent spinal anaesthesia or general anaesthesia with antalgic Bi-block. They were positioned on a specific operating table with the fractured lower limb in traction, adduction and intra-rotation in order to gain reduction. When the fracture reduction was satisfactory, i.e., correction of varus deformity, length and rotation were obtained, the chosen nail was implanted following the nail surgical technique. The type of PFN implanted were Gamma3® (Stryker®, 2825 Airview Boulevard, Kalamazoo, MI, USA), Natural Nail® (Zimmer® Biomet, 345 East Main Street Warsaw, IN, USA), Trigen Intertan® (Smith & Nephew, Inc., Memphis, TN, USA) and Endovis BA® (Citieffe s.r.l. Calderara di Reno, Bologna, IT) with no specific preference. Gamma Long (Stryker©, Kalamazoo, MI, USA) was implanted only when the fracture rime involved the subtrochanteric region or in case of inverse fracture patterns (all of 31A3). Most patients were allowed immediate weight bearing and physical therapy for recovery, except for those with a suboptimal reduction of the fracture due to the loss of calcar and medial support; in these cases, weight bearing was delayed until radiological signs of union were present.

Follow-up

All cases were clinically and radiographically evaluated at 3 and 6 months from surgery, assessing fracture healing and the appearance of any biological and/or mechanical complication. The evaluation of all cases was carried out by a single orthopaedic specialist.

Statistical analysis

The descriptive statistical analysis of variables was performed to interpret data collection. Fisher and Chi square tests were used to evaluate the correlation between variables. A p-value < 0.05 was considered statistically significant. The software used was SPSS Statistics.

Results

Among all patients with a diagnosis of unstable lateral femoral fracture treated with PFN, 136 met the inclusion criteria, and all were evaluated at 3 months. At the time of surgery, the mean age was 82.39 years (min 56 max 101 years); 115 patients were females (85%) and 21 were males (15%). In 52.4% of cases the fracture affected the right femur, and in 47.6% the left femur. According to the AO/OTA fracture classification system, we reported the following data: 52 cases of 31A22, 54 cases of 31A23, 7 cases of 31A31, 6 cases of 31A32 and 17 of 31A33. At the first follow-up, at 3 months, we found 13 failures (9.6%) (Fig. 1): 12 cases were delayed unions, and one case was a mechanical failure

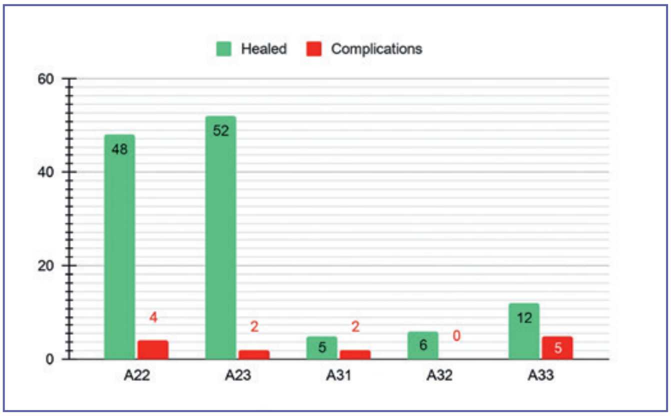

Figure 1. Correlation between fracture type and total number of fractures at 3 months.

due to lag-screw cut-out. Statistical analysis showed a significant correlation between the type of fracture and failure, with the 31A3 type related to increased risk (p-value = 0.02). No statistically significant differences were detected for the following parameters: type of nail (p-value = 0.97), nail length (p-value = 0.19), CDA (p-value = 0.98), type of distal locking (p-value = 0.11), or use of steel wire cerclage (p-value = 0.46). The p-value was obtained by Fisher test or Chi square test according to the sample size.
At 6 months, 38 patients were lost to follow-up; the remaining 98 patients were re-evaluated. We identified 3 failures as pseudoartrosis (3.0%) (Fig. 2) that needed surgical treatment to obtain clinical healing and functional recovery: 2 were treated with nail dynamisation and one with total hip replacement after nail explant.

Discussion

The primary aim of the surgeon treating an extracapsular femoral fracture is to obtain adequate reduction and stability allowing patients, especially older ones, for early recovery. Thus, optimal reduction and choice of the appropriate type of fixation device is crucial. Kaufer proposed five variables in order to determine the relationship between strength of the implant and fracture composition, which are bone quality, geometry of fragments, fracture reduction, implant use and positioning of the device. The first step in the decision process is to recognize fractures that are prone to non-union or delayed union; according to the aforementioned variables, severely comminuted and/or unstable fractures with loss of medial wall are at greatest risk. In fact, failure is typically associated with varus collapse and diaphyseal medialisation due to application of axial forces. Varus malreduction has been widely associated with fixation failure with a higher rate of cut-out [4]. In a recent study, Hoffmann et al. reported a significantly increased rate of hardware failures in patients with a shaft-neck angle < 125° [5]. An important finding of our study was that the type of fracture most prone to complications was 31A33 according to the AO/OTA classification with a p-value = 0.02, and therefore wedge or multifragmentary reverse fracture are predictors of failure.
Regarding the type of implant, the use of intramedullary devices has gained consensus in the last decades and it is now widely accepted for its biomechanics characteristic and minimal soft tissue dissection. The control of rotational and axial stability is essential in unstable trochanteric fracture [6].
In our cohort, the outcomes resulting from the use of PFN were satisfactory and confirmed the results obtained by other authors [7-9]; we had an overall complication rate of 9% at 3 months, which was reduced to 3% at 6 months.
Considering the type of intramedullary devices, various companies have manufactured their own PFN devices, which have been classified by Russell into four classes: 'Y' or impaction nails, dynamic compression nails, two screw dynamic compression nails and linear compression integrated nails [10]. Almost all our patients were treated with nails that provided dynamic compression, i.e., Gamma3 or Zimmer Natural Nail System. This class of nails has been widely compared to sliding hip screw (SHS) in the treatment of intertrochanteric fractures with good results in terms of complications, union and functional results [11,12]. The complications most frequently reported with these devices are cut out and femoral shaft fracture at the tip of the nail [13]. In our study, we reported 2 cases of cut out at 3 months; we had one fracture below the tip of the nail which was not mentioned among the complications, being the result of a direct trauma.
A recent biomechanical study by Luo et al. reported significant differences between the Gamma3 nail and Intertan nail (linear compression integrated nail) in axial and torsional forces [14]. This can explain our only case of cut out, which developed in an unstable 31A3 intertrochanteric fracture that failed at axial load. No differences in terms of healing were detected comparing the different type of nails implanted in our group of patients (p-value = 0.97).

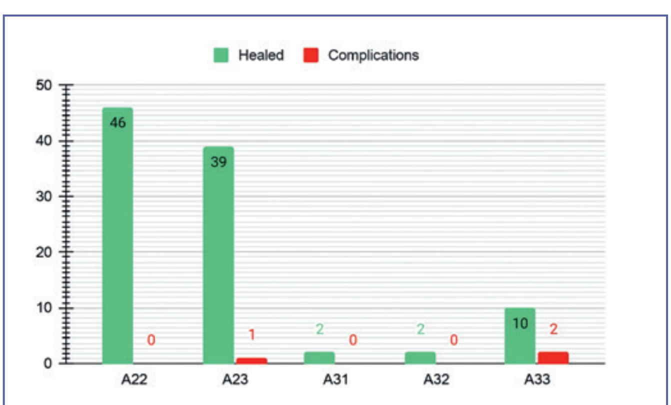

Figure 2. Correlation between fracture type and total number of fractures at 6 months.

Regarding the choice of the nail collodiaphyseal angle (CDA), we did not find any difference in terms of complications (p-value = 0.98).

Currently, long and short PFN are available for the treatment of proximal femoral fractures, and the increasing use of these devices has raised some controversy regarding nail length. While in subtrochanteric fractures the use of long nails is well-known, it is still a matter of debate for treatment of intertrochanteric fractures. When treating a fracture in elderly patients with an osteoporotic bone the use of a long nail is recommended, considering that the stress forces enveloped by the nail tip to femoral cortex can lead to peri-implant fractures with short nails [15-18]. However, a recent meta-analysis on 2431 patients treated with long or short nails divided into two groups, did not show any differences between two groups in terms of reoperation and complication rate. All nails implanted belonged to the new generation device, which are better adapted to femoral anatomy and biomechanics. Nevertheless, some authors focus on the increased morbidity and mortality of long nail patients due to the higher technical complexity, blood loss and longer procedure [19]. Indeed, blood transfusion in femur fracture is a well-known risk factor for mortality in elderly patients [20].

In our cohort, no significant differences were obtained in terms of mechanical and/or biological complications comparing long and short nails (p-value = 0.19); however, we did not evaluate morbidity and mortality related to blood loss and procedure timing.

Distal locking screw has been demonstrated to not be necessary for stable lateral femur fracture in various biomechanical studies; however, it could be important for unstable fracture patterns in order to obtain length and rotational stability. In a recent review, Buruian et al. suggested to lock nails even in stable fractures if the patient presents a wide femoral canal, dorso-medial comminution and intraoperative fracture. They also recommended assessing the length and rotational stability of fracture moving an insertional jig nail after take out leg traction. In case of any doubt about rotational stability, a distal screw can be inserted in a dynamic hole. If both axial and rotational stability are lacking, the usage of a static cortical screw is suggested. Moreover, distal locking with a single screw rather than two is advised in order to prevent periprosthetic fractures and thigh pain due to cortical hypertrophy [21].

We did not find any significant differences in terms of complications between nails with dynamic distal locking and nails with static distal locking (p-value = 0.11).

Bone healing is connected with biological and mechanical fractures; mechanical stimulation is known to promote soft callus formation. Dynamisation has been used to manipulate the healing process when delayed healing occurs and consists in removal of the interlocking screw [22]. The type of delayed healing, role and timing of dynamisation still remain controversial considering the potential risk of angular deformities and shortening. The rate of healing with this strategy varies between 33-90% [23]; the low costs and low risks related to dymanisation compared to other approaches to pseudoarthrosis, such as bone grafting, substitution of the nail or compression plates, make dynamisation a widely shared practice. In our cohort, locking screw removal was used in 2 cases and bone healing was obtained. In both cases the use of a static distal blocking should have been avoided; to obtain fracture compression during full weight-bearing, dynamic blocking or no blocking at all are recommended (Fig. 3).

At last, recent studies recommend the reinforcement of nail fixation with steel wire or auxiliary plate when treating fractures with unstable patterns [24,25]. In our cohort, we used steel cerclage to prevent collapse when the medial wall was interrupted

Figure 3. 31A3.3 unstable fracture (a) delayed union at 3 months (b) healed fracture after dynamisation.

with fragment diastasis; the use of cerclage did not represent a risk factor for the onset of complications (p-value = 0.46).
There are some limits to this study. First, it is a retrospective study with no randomisation; the choice made by surgeons regarding the type of implant, depending on each surgeon's preference, carries a major bias. Other limitations are the small number of patients and lack of a single surgeon performing the procedure. Furthermore, we did not investigate bone quality in terms of osteopenia, especially considering that our sample has a very wide age range; this aspect is undoubtedly important for a correctly approach, as it is one of the factors related to failure.

Conclusions

The use of intramedullary devices for the treatment of lateral unstable femoral fractures provides good radiological and clinical outcomes. The only feature significantly related to failure seems to be the fracture pattern, with wedge or multifragmentary reverse fractures at high risk for complications regardless of the type of implant. Other parameters such as nail type and length, nail CDA, type of distal locking and reinforcement with cerclage were not related to an increase in the rate of complications. However, good reduction and thorough knowledge of the fixation device remain essential for the success of intramedullary fixation.

References

1. Mavrogenis AF, Panagopoulos GN, Megaloikonomos PD, et al. Complications after hip nailing for fractures. Orthopedics 2016;39:e108-16. https://doi.org/10.3928/01477447-20151222-11
2. Evans EM. The treatment of trochanteric fractures of the femur. J Bone Joint Surg 1949;31B:19.
3. Russel TA, Taylor JC. Subtrochanteric fractures of the femur. In: Browner BD, et al., Eds. Skeletal trauma. 2nd Ed. Philadelphia: WB Saunder 1992, pp. 1832-78.
4. Kashigar A, Vincent A, Gunton MJ, et al. Predictors of failure for cephalomedullary nailing of proximal femoral fractures. Bone Joint J 2014;96-B:1029-34. https://doi.org/10.1302/0301-620X.96B8.33644
5. Hoffmann MF, Khoriaty JD, Sietsema DL, et al. Outcome of intramedullary nailing treatment for intertrochanteric femoral fractures. J Orthop Surg Res 2019;14:360. https://doi.org/10.1186/s13018-019-1431-3
6. Babhulkar S. Unstable trochanteric fractures- issues and avoiding pitfalls. Injury 2017;48:803-18. https://doi.org/10.1016/j.injury.2017.02.022
7. Morihara T, Arai Y, Tokugawa S, et al. Proximal femoral nail for treatment of trochanteric femoral fractures. J Orthop Surg (Hong Kong) 2007;15:273-7. https://doi.org/10.1177/230949900701500305
8. Kumar P, Rajnish RK, Sharma S, et al. Proximal femoral nailing is superior to hemiarthroplasty in AO/OTA A2 and A3 intertrochanteric femur fractures in the elderly: a systematic literature review and meta-analysis. Int Orthop 2020;44:623-33. https://doi.org/10.1007/s00264-019-04351-9
9. Mittal R, Banerjee S. Proximal femoral fractures: principles of management and review of literature. J Clin Orthop Trauma 2012;3:15-23. https://doi.org/10.1016/j.jcot.2012.04.001
10. Russell TA. Introduction to proximal femoral fractures. Tech Orthop 2008;23:1-2.
11. Adams CI, Robinson CM, Court-Brown CM, et al. Prospective randomized controlled trial of an intramedullary nail versus dynamic screw and plate for intertrochanteric fractures of the femur. J Orthop Trauma 2001;15:394-400. https://doi.org/10.1097/00005131-200108000-00003
12. Ahrengart L, Törnkvist H, Fornander P, et al. A randomized study of the compression hip screw and Gamma nail in 426 fractures. Clin Orthop Relat Res 2002;401:209-22. https://doi.org/10.1097/00003086-200208000-00024
13. Bojan AJ, Beimel C, Speitling A, et al. 3066 consecutive Gamma Nails. 12 years experience at a single centre. BMC Musculoskelet Disord 2010;11:133. https://doi.org/10.1186/1471-2474-11-133
14. Luo W, Fu X, Ma JX, et al. Biomechanical comparison of INTERTAN nail and Gamma3 nail for intertrochanteric fractures. Orthop Surg 2020;12:1990-7. https://doi.org/10.1111/os.12853
15. Boone C, Carlberg KN, Koueiter DM, et al. Short versus long intramedullary nails for treatment of intertrochanteric femur fractures (OTA 31-A1 and A2). J Orthop Trauma 2014;28:e96-100. https://doi.org/10.1097/BOT.0b013e3182a7131c
16. Valverde JA, Alonso MG, Porro JG, et al. Use of the gamma nail in the treatment of fractures of the proximal femur. J Orthop Trauma 1998;350:56-61. https://doi.org/10.1097/00005131-200309001-00010
17. Lorich DG, Geller DS, Nielson JH. Osteoporotic pertrochanteric hip fractures: management and current controversies. Instr Course Lect 2004;53:441-54.
18. Hesse B, Gachter A. Complications following the treatment of trochanteric fractures. Arch Orthop Trauma Surg 2004;124:692-8. https://doi.org/10.1007/s00402-004-0744-8 2003;17:S51-6
19. Zhang Y, Zhang S, Wang S, et al. Long and short intramedullary nails for fixation of intertrochanteric femur fractures (OTA 31-A1, A2 and A3): a systematic review and meta-analysis. Orthop Traumatol Surg Res 2017;103:685-90. https://doi.org/10.1016/j.otsr.2017.04.003
20. Ercin E, Bilgili MG, Sari C, et al. Risk fac-tors for mortality in geriatric hip fractures: a compressional study of different surgical procedures in 785 consecutive patients. Eur J Orthop Surg Traumatol 2017;27:101-6. https://doi.org/10.1007/s00590-016-1843-2
21. Buruian A, Gomes FS, Roseiro T, et al. Distal interlocking for short trochanteric nails: static, dynamic or no locking? Review of the literature and decision algorithm. EFORT Open Reviews 2020;5:421-9. https://doi.org/10.1302/2058-5241.5.190045
22. Vicenti G, Bizzoca D, Carrozzo M, et al. The ideal timing for nail dynamization in femoral shaft delayed union and non-union. Int Orthop 2019;43:217-22. https://doi.org/10.1007/s00264-018-4129-y
23. Vaughn JE, Shah RV, Samman T, et al. Systematic review of dynamization vs exchange nailing for delayed/nonunion femoral fractures. World J Orthop 2018;9:92-9. https://doi.org/10.5312/wjo.v9.i7.92
24. Kulkarni SG, Babhulkar SS, Kulkarni SM, et al. Augmentation of intramedullary nailing in unstable intertrochanteric fractures using cerclage wire and lag screws: a comparative study. Injury 2017;48:18-22. https://doi.org/10.1016/S0020-1383(17)30489-8
25. Wang ZH, Li KN, Lan H, et al. A Comparative study of intramedullary nail strengthened with auxiliary locking plate or steel wire in the treatment of unstable trochanteric fracture of femur. Orthop Surg 2020;12:108-15. https://doi.org/10.1111/os.12595