Acta Biomed 2014; Vol. 85, N. 2: 135-143

Original Article

Causes and treatments of lag screw's cut out after intramedullary nailing osteosinthesis for trochanteric fractures

Gabrile Gazzotti, Giovanni Matino, Cristian Tsatsis, Gian Luigi Sacchetti, Paolo Baudi, Fabio Catani

Ortopedia e Traumatologia, Azienda policlinico - universitaria di Modena, Università delgi Studi di Modena e Reggio Emilia

Summary. *Background.* Superior cut-out of a lag screw remains a serious complication in the treatment of trochanteric or subtrochanteric fractures and it is related to many factors: the type of fracture, osteoporosis and the stability of fracture reduction. Little is known about the outcome after revision surgery for complications of the gamma nail. We assessed the outcome in patients who had revision surgery because of lag screw's cut out after gamma nailing for a trochanteric fracture. *Material and Method.* We present a study of 20 consecutive patients who underwent treatment after 20 cut-out of the lag screw fixation of a trochanteric fracture with Gamma Locking Nail from September 2004 to November 2010. In 16 patients hip prothesis was performed, in 1 the removal of the implant and in 3 the reosteosynthesis. We reviewed 13 patients: 10 total hip arthroplasty, 2 endoprothesis and 1 reosteosynthesis of nail and lag screw (mean follow up: 26 months, mean age: 73 years old), 7 patients died. Patients were reviewed retrospectively by an independent observer. Clinical evaluation was performed, Oxford score and Harris Hip score were measured. X-Ray examination was performed after a minimum of 12 months of follow up. *Results.* Mean Harris Hip Score mean was 67 and mean Oxford score was 32 in hip prothesis group (12 patients). We had several complications, Implant-related complications were: 2 ipometria > 2cm, 2 recurrent hip arthroplasty dislocations (1 reoperated), 4 persistent thigh pain. In only 4 patients none complications were observed. Another patient, who had been subjected to reosteosinthesis, obtained better results (HHS:95, Oxford score:45) but with a 2 cm ipometria and occasional pain in the thigh. *Conclusion.* Cut out after gamma nail is consequent to biological or mechanical causes. Treatment of this complication is hip prosthesis (parzial or total hip arthroplasty), reosteosynthesis of the lag screw and/or the nail and the removal of the implant. Conversion to total/parzial hip arthroplasty may be a demanding operation with a higher complication rate respect to the standard, while reosteosynthesis is possible in selected patients and early cutting out.

Key words: Subclinical hypothyroidism, overet hypothyroidism, lipid, CRP, homocysteine, PON-1

Introduction

Fixation of trochanteric hip fractures using intramedullary "Y" nail has been performed since 1988 (10,11,13,15,16). The intramedullary nails have become more and more popular due to the biomechanical and clinical advantages and today it is a wide-spread technique, with more than one million of patients treated since the introduction of the implant (22,23,25,27). This is due to several advantages, such as minimal invasive technique allowing for short skin incisions and less blood loss compared with other techniques which require more surgical exposure. Moreover this technique presents a reduced infection rate, a minimal tissue damage, a shorter operating time and early weight bearing (28,33,34). The intramedullary position of the Gamma Nail provides a short lever arm for the cephalic screw, still allowing

controlled impaction of the fracture. Nail introduction involves few but fundamental steps, which must be carefully respected, in order to avoid implant failure (20). The mechanism of the cut-out of the lag screw (local failure of the cancellous bone of the femoral head), although not yet fully understood, may depend on a number of factors, such as positioning of the lag screw in the femoral head, quality of the cancellous bone, jamming of the lag screw, delayed healing of the fracture, lag screw insertion technique and design of the lag screw. The lag screw must be positioned in the lower half of the femoral neck lapping against the medial cortex. In the axial view the screw must be perfectly placed on the midline of the femoral neck. Surgical complications associated with the wrong insertion of the nail and wrong placement of the lag screw may also lead to misalignment of the fracture and subsequent lag screw cut-out of the femoral head. In most cases, an incorrect lag screw position causes the system failure. If the screw is too short or anterior, there is a high probability of cut out and varus malunion. Avascular necrosis of the femoral head after trochanteric fractures or nonunion of the fracture are other biological uncommon complications which may cause the failure of fracture fixation (7). The treatment of this complication are several (30): conversion to partial or total hip arthroplasty, reosteosynthesis of the lag screw and/or the nail and the removal of the implant (32). We assessed our experience about the causes of this complication and the outcome in patients who had revision surgery because of lag screw's cut out after Gamma nailing for a trochanteric fracture

Material and Method

At Policlinico of Modena since September 2004 to November 2010 20 patients underwent treatment after 20 cut-out of the lag screw fixation of a trochanteric fracture with Gamma Locking Nail: 17 Gamma 3 Nail Stryker®, 2 Gamma Long Nail Stryker® and 1 Uninail Lima®. 16 patients were female, 4 male. According to AO classification there were 6 A1 fractures, 7 A2 and 7 A3. The fractures were also classified as stable or unstable according to the classification of Evans: 11 fracture were stable and 9 unstable. The causes of cutting out was mechanical in 10 patients [fig1] (8 malposition of the lag screw, 1 malriduction of the fracture and 1 malriduction of the fracture and implant breakage), biological in 5 patients (1 nonunion, 4 necrosis of

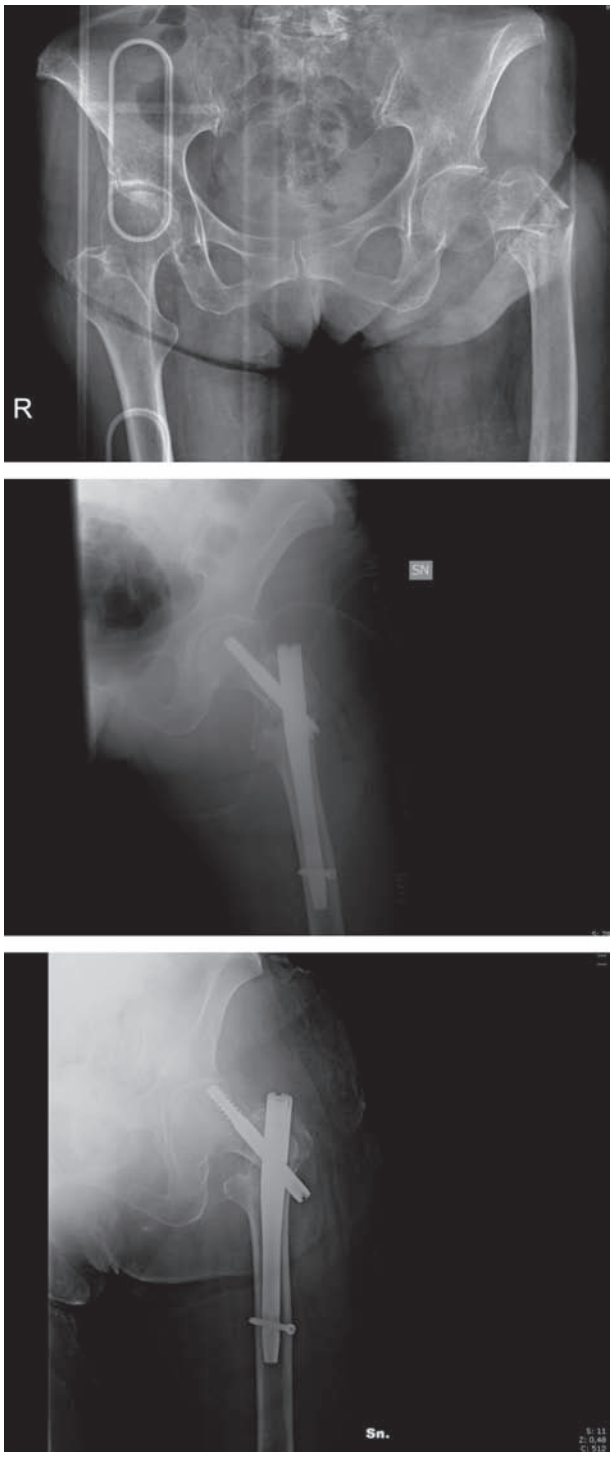

Figure 1. Mechanical causes of cutting out

the femoral head) [fig2] and mixed (mechanical and biological) in 5 patients (1 nonunion and malriduction of the fracture, 1 nonunion and malposition of the lag screw, 2 necrosis of the femoral head and malriduction, 1 nonunion and implant breakage) [fig3]. The time of cutting out from surgery was <60 days in 12 patients and >60 days in 8 patients. Possible treatments are several. Re-osteosynthesis is indicated in younger

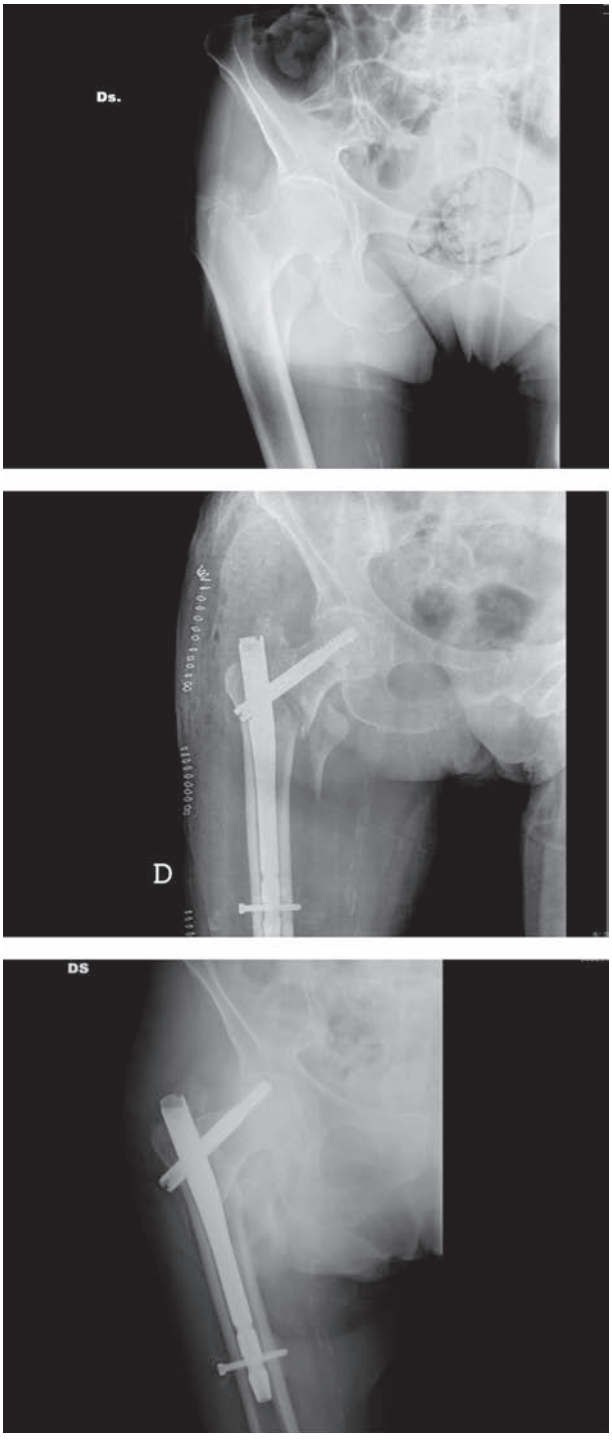

Figure 2. Biologial causes of cutting out

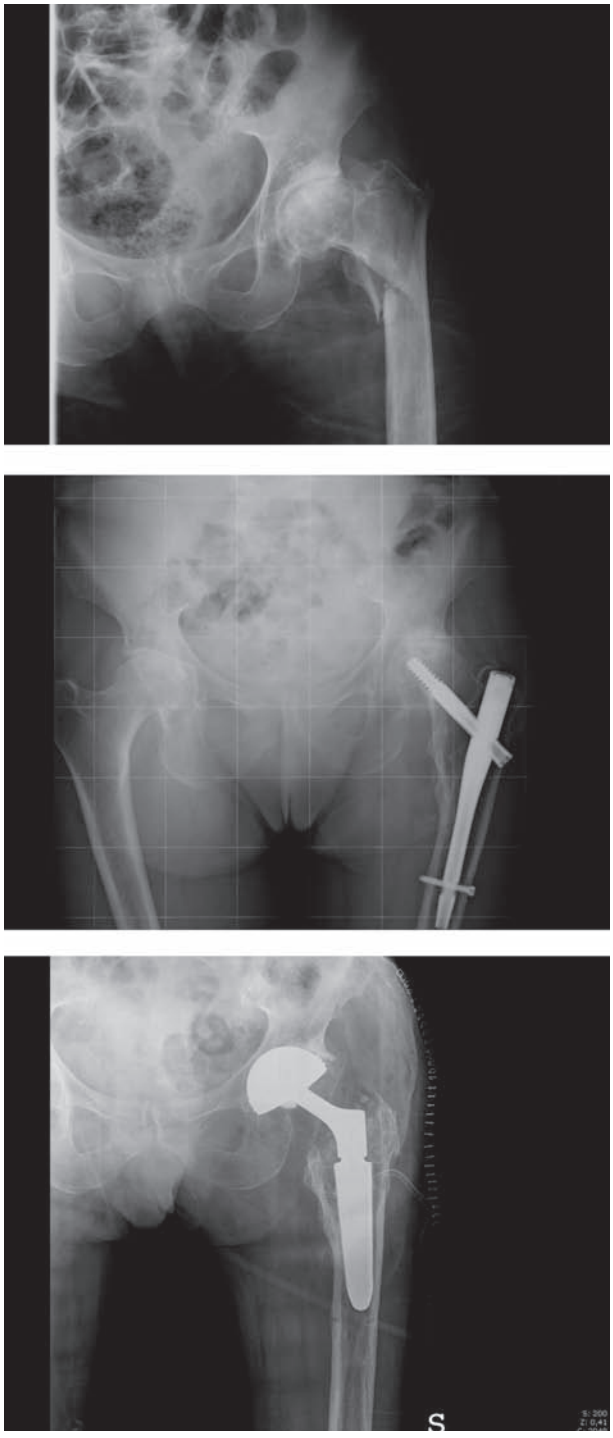

Figure 3. Mecanical and Biologial causes of cutting out

patients and early cutting out and when there isn't femoral head necrosis. Hip arthroplasty is indicated in older patients as salvage procedure: endoprothesis is preferred in patients > 70 years old, when the acetabolar bone is healthy; while total hip replacement is indicated also when major hip stability of the implant is required. The removal of the implant is required in older and bedridden patients with comorbilities. The treatment performed was: in 1 patient the removal of the implant, in 3 cases the reosteosynthesis (in 2 cases only of the lag screw) and in 16 patients hip arthroplasty: 13 total and 3 partial hip arthroplasty. We reviewed 13 patients: 12 hip arthroplasty (10 total hip arthroplasty: 8 cementless straight modular stem and 2 cementless revision modular stem and 2 endoprothesis: 2 cemented long stem bipolar hemi-arthroplasty) and 1 reosteosynthesis (removal of the nail and new osteosinthesis with a Gamma Long Nail Stryker® and metallic cerclage), 7 patients died, one of them while still in hospital. The mean follow up was 27 months (min 12, max 60) and the mean age was 73 years old (min 22, max 88). Patients were reviewed retrospectively by an independent observer. Clinical evaluation was performed, Oxford score and Harris Hip score were measured. X-Ray examination was performed at a minimum of 12 months of follow up: a standard antero-posterior pelvis and lateral hip. In hip replacement group we evaluated: loosening of the component and presence/absence of heterotopic ossification; in reosteosinthesis patient: healing of the fracture and correct position of the lag screw.

Results

In the hip arthroplasty group (12 patients) mean Harris Hip Score (HHS) was 67 (min 38, max 93) and mean Oxford score (OXS) was 32 (min 18, max 47). Total hip arthroplasty group mean scores were better, mean HHS is 72 (min 38, max 93) and OXS score is 44 (min 19, max 47), than partial hip arthroplasty group (2 patients), mean HHS is 44 (min 43 max 45) and OXS is 22 (min 18, max 25). 9 patients were trasfused up to 4 weeks postoperatively (2 , 3 or 4 blood units). We had several early and later complications. General complications in the postoperative period up to 2 weeks after operation occurred in 2 patients: 1 urosepsis with bad general condition and dementia and 1 temporary cardiac failure. Implant-related complications were: 2 ipometria > 2cm, 2 recurrent hip arthroplasty dislocations (1 reoperated), 4 persistent thigh pain. In only 4 patients none complications were observed. At X-ray examination none heterotopic ossification and 1 aseptic mobilization was revealed (tab.1). The patient revalued, who had been subjected to reosteosinthesis of the nail and lag screw + metallic cerclage, was a young 27 years old man with a subtrocanteric fracture A3. The failure of the synthesis was mechanical: malriduction of the fracture and implant breakage 2 months post-operatively. At a 60 months follow up he obtained better results: HHS:95 and Oxford score:45. At clinical evaluation he revealed a 2 cm ipometria and he reported occasional thigh pain. He is currently ambulating and has returned to independent activities of daily living. At X-ray examination the fracture was healed and the lag screw was in perfect positioning.

Discussion

The introduction of the Gamma nail in the treatment of trochanteric fracture was designed to combine the advantages of locking intramedullary nailing and of the lag screw fixation (40,41). Additionally, the use of an intramedullary device should decrease the arm bending level and the torsion force, resulting in a low implant stress (20). Subsequent prospective studies (9,12,14,21,24,29,37) revealed the disadvantages of the gamma nail, such as a higher incidence of complications compared with dynamic hip screw devices, including fracture of the femur below the implant and cutting-out of the implant from the femoral head. Cutting-out of the implant has been thought to be due to improper positioning of the lag screw, malriduction of the fracture or to biological causes such as nonunion or necrosis of the femoral head (17,18,19,26). Several factors have been studied which potentially contributed to the mechanism of cutting-out of the lag screw after gamma nail internal fixation. Kawaguchi et al (1) reported that the degree of osteoporosis, the type of fracture, and the accuracy of reduction don't contribute to cutting-out while the

Table 1. Result

Patient	Gender (Male/ Female)	Age (years)	Fracture Classification (Evans, AO)	Causes of cutting out (mechanical, biological, mixed)	Time of cutting out (months)	Treatment	Follow up (months)	Harris Hip Scores (min 0- max 100)	Oxford score (min 0, max 48)	General Complications	Implant related complications
SS	M	44	Stable, A1	mixed (nonunion and malriduction)	6	Total hip arthroplasty: cementless straight modular stem + acetabular cup	46	93	46	Postoperative anaemia	no
IF	F	74	Unstable; A3	biological (femoral head necrosis)	23	Total hip arthroplasty: cementless straight modular stem + acetabular cup	34	82	40	Postoperative anaemia	no
CQ	F	80	Stable; A1	mixed (femoral head necrosis and malriduction)	80	Total hip arthroplasty: cementless straight modular stem + acetabular cup	35	92	47	no	no
CE	F	88	Unstable; A3	biological (femoral head necrosis)	40	Total hip arthroplasty: cementless straight modular stem + acetabular cup	13	65	19	Postoperative anaemia	Persistent thigh pain
SL	F	75	Stable; A1	mechanical (malriduction)	35	Total hip arthroplasty: cementless straight modular stem + acetabular cup	40	38	20	Postoperative anaemia	Hip arthroplasty several dislocation (Revision arthroplasty)
BO	F	82	Stable; A1	mixed (nonunion and malposition ofb the lag screw)	42	Total hip arthroplasty: cementless straight modular stem + acetabular cup	14	88	42	no	Ipometria >2cm

Table 1 (Continued)

SM	F	65	Stable; A2	mechanical (malposition of the lag screw)	45	Total hip arthroplasty: cementless straight modular stem + acetabular cup	24	77	31	Postoperative anaemia	no
MO	F	85	Unstable; A3	mixed (malriduction and femoral head necrosis)	40	Total hip arthroplasty: cementless straight modular stem + acetabular cup	25	68	23	Postoperative anaemia	Persistent thigh pain
DA	F	81	Stable; A2	mechanical (malposition of the lag screw)	38	Total hip arthroplasty: revision modular stem + acetabular cup	14	62	35	Postoperative anaemia	Persistent thigh pain
RG	F	77	Unstable; A3	mechanical (malposition of the lag screw)	36	Total hip arthroplasty: revision modular stem + acetabular cup	17	54	36	no	Hip arthroplasty dislocation
BF	F	86	Stable; A1	mechanical (malposition of the lag screw)	22	Endoprothesis: cemented long stem bipolar hemiarthroplasty	12	45	18	Postoperative anaemia Temporary cardiac failure	Persistent thigh pain
TG	F	85	Unstable; A3	mechanical (malposition of the lag screw)	22	Endoprothesis: cemented long stem bipolar hemiarthroplasty	12	43	25	Urosepsis and dementia Postoperative anaemia	Ipometria >2cm

location of the lag screw in the femoral head is crucial in causing the cut out lag screw. This study has revealed an optimal position of the Asiatic gamma nail implant to avoid cutting-out of the lag screw from the femoral head. It is recommended that a lag screw is inserted as deeply as possible as seen on the antero-posterior view, and in the center as seen on the lateral view. When the lag screw is placed improperly, the cut-out index calculated upon the radiographs should help predict the risk of cutting-out. Also Haynes et al (2) supported this theory: the position of the lag screw within the femoral head is an important factor in the success or failure of the implant. Wu et al (3) completed studies into femoral head position highlighting the importance of correct placement of the screw. His study suggests screws placed in the upper third of the femoral head would be more likely to cut-out. Pascarella et al (4) substained it is necessary to follow the fundamental steps: correct patient position on fracture table, accurate preoperative fracture reduction, precise nail

entry point on greater trochanter, and perfect lag screw placement in the frontal and lateral planes. Because of its material strength, design, and mechanical advantage, implant failure of the Gamma nail has been thought to be rare with reported incidences of 0.2%–5.7% in multicenter studies (5,6). Gamma nail breakage can be classified according to the site of occurrence. The commonest cause is metal fatigue secondary to delayed union or malunion of the fracture, particularly at the insertion point of the proximal lag screw. This point is the part where the forces are transmitted from the femoral neck to the nail in the diaphysis. Biological causes that determine cutting out of the lag screw are avascular necrosis of the femoral head or nonunion of the fracture. The cause of avascular necrosis of the femoral head after a trochanteric fracture has not been clearly determined and several factors have been related: a direct vascular injury, the type and location of the device employed in the surgical fixation, medical risk factors for avascular bone necrosis, or basicervical fractures. Vicario et al[7] suggested that the necrosis can be caused for three reasons: a reversible but severe decrease in the femoral head blood supply caused by the early displacement of the fracture that improves after its reduction or its fixation. Another cause is the pressure increase inside of the bone or of the capsule during surgery because of a direct effect of the insertion of the lag screw or because of the position of the leg during the fracture reduction handling. Another cause may be thermally induced necrosis of the osteocytes probably reached during the reaming of the femoral head. So after fixation of these trochanteric fractures with the Gamma Locking Nail, there is a transitory ischaemia, if the revascularisation is not enough to provide a strong support for the lag screw, it may result in late mechanical failure in these fractures. These findings are compatible with a higher incidence of cut-out of the lag screw. This complication is responsible for the highest number of revisions surgery. Lee et al (8) suggested that in early superior cut out of a lag screw in unstable intertrochanteric fractures a lag screw placed inferiorly with a laterally mounted trochanter supporting plate is an easy and safe solution. However, osteonecrosis of the femoral head and delayed union or even nonunion remain the potential problems, so he suggested this technique in younger patients and supported that in unstable intertrochanteric fractures with greater trochanter extension and a defective femoral head, its stability is inadequate. Conversion to partial or total hip arthroplasty may be a demanding operation with a higher than normal complication rate (30,32). The choice between the two type of arthroplasty depends on: age, bone stock, implant stability and healthy acetabular bone. Endoprothesis is preferred in patients> 70 years old and when the acetabolar bone is healthy; while total hip replacement is indicated also when major hip stability of the implant is required. There are increased prosthetic dislocations due to muscular insufficiency, especially in the presence of destruction of the greater trochanter or trochanter pseudarthrosis. In addition, correct adjustment of the length is technically difficult. Fixation of the greater trochanter also is problematic. This is a problem even in normal hip arthroplasty but becomes even more difficult when converting the nail to a prosthesis because of the defective zone at the site of nail entry. In the presence of acetabular disease an acetabular cup may be considered. The removal of all the implant is required in selected patients only to relieve pain. It is required in older and bedridden patients with comorbilities with high anesthetic risk and no functional post-operative requirements. The removal of the gamma nail should be performed cautiously as re-fractures can occur..

Conclusions

Most complications after gamma nail fixation can be prevented by following certain rules. Cut-out through the femoral head has been reported to be the most frequent mechanical mode of failure for internal fixation devices for treatment of trochanteric hip fractures and it is responsible for the highest number of revisions. We therefore suggest that more attention should be paid to this complication, which may be surgically preventable. Possible treatments are: conversion to partial or total hip arthroplasty, a re-osteosynthesis of the lag screw and/or the nail and the removal of the gamma nail. Conversion of the gamma nail to a hip arthroplasty is technically difficult and it is associated with a high complication

rate. Re-osteosynthesis is suggested in selected and young patients when femoral head necrosis is not detected, while the removal of the implant is indicated in bedridden patients with no functional requirements.

References

1. Kawaguchi S, Sawada K and Nabeta Y. Cutting-out of the lag screw after internal fixation with the Asiatic gamma nail. Injury Vol. 29, No. 1, pp. 47-53, 1998.
2. Haynes RC, Poll RG, Miles AW et al. Failure of femoral head fixation: a cadaveric analysis of lag screw cut-out with the gamma locking nail and A0 dynamic hip screw. Injury Vol. 28, No. 5-6, pp. 337-341, 1997
3. Wu CC and Shih CH. Biomechanical analysis of the dynamic hip screw in the treatment of intertrochanteric fractures. Arch Orthop Trauma Surg 1991; 110(6): 307.
4. Pascarella R, Cucca G, Maresca A et al. Methods to avoid gamma nail complications. Chir Organi Mov (2008) 91:133–139
5. Wee JLH, Sathappan SS, Yeo MSW et al. Management of gamma nail breakage with bipolar hemi-arthroplasty. Singapore Med J 2009; 50(1) : e44
6. Yoshino N , Watanabe Y, Takenaka N et al. Implant failure of long Gamma nail in a patient with intertrochanteric-subtrochanteric fracture. J Orthop Sci (2006) 11:638–643
7. Vicario C, Marco F, Ortega L et al. Necrosis of the femoral head after fixation of trochanteric fractures with Gamma Locking Nail. A cause of late mechanical failure. Injury, Int. J. Care Injured 34 (2003) 129–134
8. Lee PO, Yu SW, Hsieh PH et al. Treatment of early cut-out of a lag screw using a trochanter supporting plate: 11 consecutive patients with unstable intertrochanteric fractures. Arch Orthop Trauma Surg (2004) 124 : 119–122.
9. Bjørgul K, Reikerås O. Outcome after treatment of complications of Gamma Nailing. A prospective study of 554 trochanteric fractures. Acta Orthopaedica 2007; 78 (2): 231–235
10. Bojan AJ, Beimel C , Speitling A et al. 3066 consecutive Gamma Nails. 12 years experience at a single centre. BMC Musculoskeletal Disorders 2010, 11:133
11. Liu M, Yang Z, Pei F et al. A meta-analysis of the Gamma nail and dynamic hip screw in treating peritrochanteric fractures. International Orthopaedics (SICOT) (2010) 34:323 – 328
12. Pascarella R, Maresca A, Palumbi P e al. Complications of proximal femural fractures treated with Gamma Nail (short, standard, long). G.I.O.T. 2002;28:181-6
13. Yaozeng X, Dechun G, Huilin Y et al. Comparative study of trochanteric fracture treated with the proximal femoral nail anti-rotation and the third generation of gamma nail. Injury (2010), doi:10.1016/j.injury.2010.03.005
14. Hesse B, Gachter A. Complications following the treatment of trochanteric fractures with the gamma nail. Arch Orthop Trauma Surg (2004) 124: 692–698
15. Efstathopoulos N, Nikolaou V, Lazarettos JT. Intramedullary fixation of intertrochanteric hip fractures: a comparison of two implant designs. International Orthopaedics (SICOT) (2007) 31: 71 – 76
16. Jiang LS, Shen L, Dai LY. Intramedullary Fixation of Subtrochanteric Fractures with Long Proximal Femoral Nail or Long Gamma Nail: Technical Notes and Preliminary Results. Ann Acad Med Singapore 2007;36:821-6
17. Weil YA, Gardner MJ, Mikhail G et al. Medial migration of intramedullary hip fixation devices: a biomechanical analysis. Arch Orthop Trauma Surg (2008) 128:227–234
18. Lucke M, Burghardt RD, Siebenlist S et al. Medial Migration of Lag Screw With Intrapelvic Dislocation in Gamma Nailing-A Unique Problem? Report of 2 Cases. J Orthop Trauma Volume 24, Number 2, February 2010
19. Watanabe Y, Minami G, Takeshita H et al. Migration of the Lag Screw Within the Femoral Head: A Comparison of the Intramedullary Hip Screw and the Gamma Asia-Pacific Nail. Journal of Orthopaedic Trauma. Vol. 16, No. 2, pp. 104–107
20. Pascarella R, Cappuccio M, Maresca A. et al. Gamma standard, Gamma short, Gamma 3: comparison of three generations. G.I.O.T. 2008;34:6-12
21. Grimaldi M, Courvoisie Ar, Tonetti J. et al. Superficial femoral artery injury resulting from intertrochanteric hip fracture fixation by a locked intramedullary nail. Orthopaedics & Traumatology: Surgery & Research (2009) 95, 380—382
22. Sehat K, Baker RP, Pattison G et al. The use of the long gamma nail in proximal femoral fractures Injury, Int. J. Care Injured (2005) 36, 1350—1354
23. Valente M, Crucil M, Alecci V. Treatment of lateral femoral neck fractures with the Proximal Femoral Nail Antirotation (PFN A). G.I.O.T. 2009;35:79-83
24. Zeng X, Zhou Z, Jiang L. Analysis of complication factor after treatment of intertrochanteric fractures with gamma nail. Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi. 2007 Jan;21(1):9-11.
25. Chen Q, Zhou Z, Guan L. Comparison of effects between two operating methods of treating intertrochanteric hip fracture with Gamma nail fixation. Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi. 2007 Oct;21(10):1027-30
26. Friedl W, Clausen J. Experimental examination for optimized stabilisation of trochanteric femur fractures, intra- or extramedullary implant localisation and influence of femur neck component profile on cut-out risk. Chirurg. 2001 Nov;72(11):1344-52.
27. Pelet S, Arlettaz Y, Chevalley F. Osteosynthesis of per- and subtrochanteric fractures by blade plate versus gamma nail. A randomized prospective study. Swiss Surg. 2001;7(3):126-33.
28. Ding XF, Pei GX, Lin J et al. Postoperative implant-related complications after treatment of intertrochanteric fracture by gamma nail or by sliding hip screw: a meta-analysis. Zhonghua Yi Xue Za Zhi. 2008 Aug 26;88(33):2364-8.
29. Müller M, Seitz A, Besch L et al. Proximal femur fractures: results and complications after osteosynthesis with PFN

and TGN. Unfallchirurg. 2008 Feb;111(2):71-7
30. Chen T, Li K, Wang X et al. Revision cause and effect of gamma nail fixation. Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi. 2010 Jan;24(1):78-81
31. Wagner R, Blattert TR, Weckbach A. Solution to the problem of extra-articular, femoral hip fracture by the "sliding screw-nail principle". Results of 2 different systems (classical nail and gamma nail). Unfallchirurg. 1998 Dec;101(12):894-900.
32. Hernigou P, Poignard A, Mathieu G et al. Total hip arthroplasty after failure of per- and subtrochanteric fracture fixation in elderly subjects. Unfallchirurg. 1998 Dec;101(12):894-900.
33. Tarantino U, Oliva F, Impagliazzo A et al. A comparative prospective study of dynamic variable angle hip screw and Gamma nail in intertrochanteric hip fractures. Disabil Rehabil. 2005 Sep 30-Oct 15;27(18-19):1157-65
34. 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 Aug;(401):209-22
35. Docquier PL, Manche E, Autrique JC et al. Complications associated with gamma nailing. A review of 439 cases. Acta Orthop Belg. 2002 Jun;68(3):251-7
36. Alvarez DB, Aparicio JP, Fernández EL et al. Implant breakage, a rare complication with the Gamma nail. A review of 843 fractures of the proximal femur treated with a Gamma nail. Acta Orthop Belg. 2004 Oct;70(5):435-43
37. Flint JH, Sanchez-Navarro CF, Buckwalter JA et al. Intrapelvic Migration of a Gamma Nail Lag Screw: Review of the Possible Mechanisms. Orthopedics. 2010 Apr 16:266-270. doi: 10.3928/01477447-20100225-19
38. Min WK, Kim SY, Kim TK et al. Proximal femoral nail for the treatment of reverse obliquity intertrochanteric fractures compared with gamma nail. J Trauma. 2007 Nov;63(5):1054-60
39. Boriani S, De Iure F, Bettelli G et al. The results of a multicenter Italian study on the use of the Gamma nail for the treatment of pertrochanteric and subtrochanteric fractures: a review of 1181 cases. Chir Organi Mov. 1994 Apr-Jun;79(2):193-203
40. Ovesen O, Andersen M, Poulsen T et al. The trochanteric gamma nail versus the dynamic hip screw: a prospective randomised study. One-year follow-up of 146 intertrochanteric fractures. Hip Int. 2006 Oct-Dec;16(4):293-8
41. Jaworski JM, Gaźlzik TS, Kaleta M et al. Treatment of trochanteric fractures of the femur: DHS or Gamma nail? - own experience. Ortop Traumatol Rehabil. 2003 Feb 28;5(1):53-9

Received: 24 June 2013
Accepted: 21 March 2014
Correspondence:
Giovanni Matino, MD
Ortopedia e Traumatologia, Azienda policlinico - universitaria di Modena, Università delgi Studi di Modena e Reggio Emilia
E-mail: giovamat3@yahoo.it