The Marchetti bundle nail for femoral shaft fractures: a review of 56 cases

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Summary. *The aim of this retrospective study of 56 cases was to determine the risks and the limits of the Marchetti bundle nail in the treatment of femoral shaft fractures. According to the AO classification, 25 fractures were in category A, 20 in category B, 7 in category C and 4 were distal metaphysio-diaphyseal fractures with intercondylar separation classified as 33C2. Intraoperative complications were not directly related to the type of nail. Postoperative complications included nonunion, delayed union, malunion such as axial deformity, and shortening. We conclude that the Marchetti bundle nail is a successful method for the treatment of femoral shaft fractures taking into consideration the short operation time, the efficacy of distal locking and the lack of preliminary reaming. Moreover, it is clear that our results were prejudiced due to our learning experience with this new implant. Proximal locking should only be carried out when indicated, in order to prevent delayed union. It may be combined with interfragmental screw fixation, and this is useful in the treatment of complex supracondylar fractures.*

Résumé. *Le but de ce travail est de déterminer les résultats et les limites du clou fasciculé de Marchetti dans les fractures de la diaphyse fémorale. Nous avons ainsi revu nos 56 premiers cas. Selon la classification AO nous avons traité 25 fractures de type A, 20 de type B, 7 de type C et 4 fractures complexes métaphysio-diaphysaires avec séparation intercondylienne classées 33 C2. Les complications per-opératoires rencontrées ne sont pas liées au*

type de clou. Les complications post-opératoires comprennent 1 pseudarthrose, 3 retards de consolidation, 2 cals vicieux angulaires et 4 raccourcissements. En conclusion le clou de Marchetti présente des avantages certains, à savoir la rapidité opératoire, l'absence d'alésage du foyer, l'efficacité du verrouillage distal. Le verrouillage proximal ne doit être effectué que s'il est nécessaire, pour éviter tout retard de consolidation. L'association du clou et d'un vissage compressif interfragmentaire est possible et utile pour traiter les fractures métaphysodiaphysaires complexes. Il est clair enfin que nos résultats sont pénalisés par l'apprentissage de la méthode.

Introduction

Numerous publications have established the reliability of Küntscher closed intramedullary nailing for the treatment of fractures of the shaft of the femur, and this is confirmed by low rates of infection and of non-union [1, 2, 14]. The role of "interlocking" in preventing the risk of shortening and torsional instability is well proven [3, 4, 7, 9]. Locked nailing is now the treatment of choice for femoral shaft fractures throughout the world.

Controversy still exists over the need for preliminary reaming of the medullary canal. Küntscher [10] stated that the elastic recoil of a slotted cloverleaf nail allows firm fixation at the narrowest part of the medullary canal. However, it is well known [8] that the stability of a nailed fracture depends mainly on a triple point system. Furthermore, in locked nailing appropriate stability

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is assured by the locking screws and thus smaller nails are usually used. Therefore, in almost all cases it should not be necessary to ream the fracture site before introducing a locking nail, except in order to allow its insertion.

The most widely adopted procedure for distal locking is by guided or free screw insertion. It is an effective method but it significantly prolongs the operation time which is an undesirable drawback in polytraumatised patients. Reaming can be detrimental to endosteal vascularisation and enhances the risk of the fat embolism syndrome [13].

The Marchetti bundle nail does not require reaming, and distal locking is ensured automatically by the introduction of the secondary nails. These are restrained under tension during their insertion, and then diverge as a result of their intrinsic elastic properties.

Patients and methods

This retrospective study is based on the first 56 nails used between February 1993 and December 1995. During this period all femoral shaft fractures, whatever their degree, were treated by Marchetti nailing, except in 2 cases where the surgeon chose to insert a Grosse Kempf nail.

There were 39 men and 14 women with a mean age of 29.2 years (range: 15–84). Three patients had bilateral femoral fractures. Injuries resulted mainly from traffic accidents (29 cars, 15 motorcycles, 1 pedestrian) and there were also 4 domestic accidents, 1 sports injury, 2 occupational accidents and 1 self-inflicted injury from a high fall.

The femoral shaft fracture was the sole injury in 25 cases; 31 patients had polytrauma or multiple fractures and needed emergency care with special attention to cardiopulmonary function, abdominal problems and the central nervous system.

Fractures were classified according to the AO system [12]: 25% were simple fractures, 20% were wedge injuries produced by flexion or torsion, and 7% were complex and comminuted (Table 1). There were also 4 cases of complex distal metaphysiodiaphyseal fractures with intercondylar separation, classified as 33C2.

Fractures were located in the proximal third of the femoral shaft in 13 cases, in the middle third in 31 and in the distal third in 12.

There were 48 closed fractures and 8 were open, 4 Grade II and 4 Grade IIIA according to the Gustilo grading system [6]. Open fractures were cleaned, irrigated, left open and covered with a sterile dressing.

Fifty-two patients were operated on within 24 hours of the accident, 2 within 48 h and 2 more than 48 h after the injury. The main criterion for surgical timing was the desire to avoid the fat embolism syndrome. At present we much prefer to fix a femoral fracture as soon as possible, usually within the first 24 h, as a fat embolism syndrome is most likely to occur between 12 and 36 h after injury [14].

Operative technique

The patient was placed on a traction table either in the lateral position, especially for proximal fractures and when the patient's clinical condition allowed (23 cases), or supine (33 cases).

Table 1. Type of fracture according to A O classification. Four fractures were classified as 33 C2

	1	2	3
A	1	6	18
B	0	18	2
C	2	2	3

All but 5 of the procedures performed were closed intramedullary nailing. A direct reduction was performed in 1 Grade IIIA open fracture. In the 4 comminuted fractures of the distal femur with intercondylar involvement, interfragmental compression by 2 or 3 lag screws was performed prior to the insertion of the bundle nail, using a small lateral incision.

The entry point for the nail is at the tip of the greater trochanter. This avoids damage to the posterior circumflex artery and to the hip capsule [11]. Reamers were generally used only to prepare the proximal 13 cm of the femur, but in 3 cases a particularly narrow medullary canal necessitated reaming of the entire shaft.

Insertion of the nail is performed without the use of a guide-wire. With good orientation of the introducer handle the fracture site can be traversed without major difficulty, even in comminuted or segmental fractures. The locking wire is then pulled out, thus releasing the pre-bent secondary nails which automatically assume their locking position. A nail with 5 secondary nails is chosen for medullary cavities of less than 12 mm, while a nail with 6 secondary nails is used for medullary cavities of over 12 mm.

Postoperative management

Progressive weightbearing was allowed after a few days for all isolated fractures. Weight was limited to the painful threshold for simple fractures, and to 10 kg for 4–6 weeks for the very unstable injuries. In polytraumatized patients the delay depended on the associated lesions. No additional immobilisation was used except in 1 case where skeletal traction was maintained for 3 weeks in order to prevent shortening.

Review

Analysis of the postoperative radiographs concentrated on 3 points namely the quality of the reduction, the relation of the nail to the medullary canal, and the divergence of the secondary nails. All patients were checked by regular clinical and radiological examination. One polytraumatized patient died on the 16th day after injury from multiple organ failure. Six patients who lived in another region were lost to follow-up, although fracture consolidation is known to have occurred in all cases. However, they were not included in our analysis of the results.

Union and consolidation were assessed on radiographs by the presence of callus at the fracture site and subperiosteally. In all cases full weightbearing was possible before radiographic union. The adequacy of reduction was gauged from the final radiographs as regards angulation and length.

Results

The nailing procedure occupied an average of 63 min (range: 30–100). Proximal locking was performed in 45 out of the 56 cases.

Table 2. Intra-operative and post-operative complications

	n of cases
Intra-operative	3
Fracture of femoral neck	1
Incorrect position	1
Fracture of medial cortex	1
Post-operative	9
Non union	1
Angular deformities	2
Shortening	4
Stress shielding	2
Infection	0
Palsy	0

Intra-operative complications (Table 2) were noted in 3 patients and were more often related to technical errors than to the type of nail. They included 1 incorrect positioning in a proximal comminuted fracture, 1 iatrogenic fracture of the femoral neck, and 1 fracture of the medial cortex.

The quality of reduction was good except in 2 cases when malunion occurred. The fit of the nail was good in 34 cases, fair in 19 and poor in 3. The divergence of the nails was considered good in 25 cases, fair in 24 and poor in 3. In 4 cases a postoperative bone gap disappeared over a few weeks following progressive weightbearing.

In 4 cases the introduction of the secondary nails into the cancellous distal bone resulted in 10–25 mm shortening of the shaft. This occurred in 1 mid-shaft B2 fracture in a young patient fixed with too short a nail (20 mm), 1 distal B2 fracture in a 70-year-old patient (25 mm), 1 transverse fracture in an elderly paraplegic patient (15 mm), and 1 C3 fracture in a 37-year-old patient (10 mm).

Bone union was achieved in 48 patients at an average of 93 days (range: 45–120). There were no infections or neurological complications. Open fractures consolidated without any septic problems.

One nonunion occurred in a polytraumatized patient who suffered from a mid-shaft transverse fracture which was treated with a locked nail, leaving a small bone gap. Partial weightbearing was not possible until after 2 months because of neurological problems. Despite this late loading the gap persisted and breakage of the nail occurred during the third month of treatment. Replacement with a Grosse Kempf nail was successful.

Three delayed unions were seen; one consolidated in 5 months with fatigue failure of 2 of the 5 secondary nails. The other 2 fractures healed without dynamisation.

There were 2 malunions, 1 with 10° varus and the other with 8° valgus. They resulted from op-

erative malalignment and were not due to a secondary displacement.

Additional operations were necessary in six patients for the following reasons:

- Incorrect insertion of the nail in a proximal fracture;
- a distal spiral fracture in a 70-year-old patient with a poor reduction;
- dynamization in order to obtain consolidation in 2 cases;
- stress shielding complications occurred in two patients who had distal transverse fractures. They achieved bone union after 3 months but later complained of pain in the upper thigh. Radiographs showed periosteal new bone formation, and one of the patients also had endosteal osteolysis. Laboratory tests were normal. Removal of the nail in 1 patient and removal of the proximal screw in the other gave total relief of pain.
- all patients recovered full knee movement although one, who sustained a fracture of the lateral condyle of the same femur, required manipulation under anaesthesia.

Discussion

The Marchetti bundle nail has many advantages. It is easy to insert, there is no need for preliminary reaming of the medullary canal, and there is automatic distal locking with release of the secondary pre-loaded nails.

The rate of bone union is comparable to that of Küntscher nailing or locked nailing using screws. Marchetti reported an average delay of consolidation of 9 weeks for femoral fractures [11], but in our series it averaged 13 weeks. Our results are generally less satisfactory than those of Marchetti, the main difference between the two series being the higher rate of proximal locking required in our patients. When we started to use this technique we preferred proximal locking, expecting micro-movements at the fracture site and elasticity of the secondary nails to stimulate fracture healing [5]. It now seems clear that this was an error responsible for our relatively high number of problems with union.

Proximal locking is now used only for fractures of the proximal third of the diaphysis or for comminuted fractures. Moreover when callus does not appear within 6 weeks, or when a residual gap persists at the fracture site, it is necessary to remove the proximal locking promptly. The innate elasticity of the device is insufficient to allow

Fig. 1 a–c. A 28-year-old woman sustained fractures of both femoral shafts secondary to a fall in a suicide attempt. On the right side she presented a comminuted supracondylar fracture with intercondylar separation which was treated using a

Marchetti nail and 3 lag screws. **a** Radiographs before operation; **b** Radiographs 1 month following operation **c** Radiographs 8 months following operation

compression at the fracture site in these conditions. Marchetti's unpublished experimental data demonstrates that a force of 120 kg is required to obtain penetration of the secondary nails into the cancellous bone of the distal femoral epiphysis, but it is obvious that in osteoporotic patients less force is required. The low rate of malunion proves the effectiveness of this distal locking system.

Inappropriate locking may also explain the two cases of secondary pain in the upper thigh which we attributed to a stress shielding phenomenon. This explanation is supported by the radiological signs and the resolution of symptoms after removal of the nail or dynamization.

The Marchetti procedure appears to minimise the risk of the fat embolism syndrome. Early operation is also advisable, and the absence of reaming at the fracture site seems to be important. In our series, none of the 3 patients who sustained bilateral fractures of the femoral shaft presented any signs of fat embolism.

When dealing with unstable and comminuted supracondylar fractures with intercondylar separation it is useful and simple to add further fixation to the Marchetti nail. We prefer direct

compression screwing which is performed before introducing the nail, as the secondary nails then slide around the screws in the medullary canal and give good fixation (Fig. 1).

Although we had several cases of shortening at the fracture site, we have never seen a rotatory displacement. Distal locking is effective with this type of nail. A slightly modified version is now available with secondary nails which are more bent distally, improving distal expansion.

Conclusion

The Marchetti bundle nail is a safe and successful device for the treatment of femoral shaft fractures. It saves time but proximal locking should only be included when indicated, and dynamization should be started at the earliest sign of delayed union. This then usually resolves within 6–8 weeks. The association of the bundle nail with compressive interfragmental screwing offers another way of treating complex supracondylar fractures.

References

1. Babin SR, Graf P, North J, Schvingt E (1981) Le risque septique de l'ostéosynthèse à foyer fermé d'après une série continue de 1059 enclouages selon Kuntscher. *Int Orthop* 5: 271–276
2. Babin SR, Graf P, Vidal P, Sur H, Schvingt E (1983) Le risque de non-consolidation après enclouage à foyer fermé et alésage. Résultats de 1059 enclouages selon Kuntscher. *Int Orthop* 7: 133–143
3. Brumback RJ, Uwagie-Ero S, Lakatos RP et al (1988) Intramedullary nailing of femoral shaft fractures. Part II: Fracture healing with static interlocking fixation. *J Bone Joint Surg [Am]* 70: 1453–1462
4. Christie J, Court-Brown C, Kinninmonth AWG, Howie CR (1988) Intramedullary locking nails in the management of femoral shaft fractures. *J Bone Joint Surg [Br]* 70: 206–210
5. Goodship AE, Kenwright J (1985) The influence of induced micromovement upon the healing of experimental tibial fractures. *J Bone Joint Surg [Br]* 67: 650–655
6. Gustilo RB, Mendoza RM, Williams DN (1984) Problems in the management of type III (severe) open fractures. *J Trauma* 24: 742–746
7. Kempf I, Grosse A, Lafforgue D (1978) L'apport du verrouillage dans l'enclouage centro-médullaire des os longs. *Rev Chir Orthop* 64: 635–651
8. Kempf I, Jaeger JH, Clavert JM et al. (1978) L'enclouage centro-médullaire avec alésage. Critique théorique et expérimentale des principes de Kuntscher. *Rev Chir Orthop* 64: 629–634
9. Klemm KW, Borner M (1986) Interlocking nailing of complex fractures of the femur and tibia. *Clin Orthop* 212: 89–100
10. Kuntscher G (1965) Intramedullary surgical technique and its place in orthopedic surgery. *J Bone Joint Surg [Am]* 47: 809–818
11. Marchetti PG, Vicenzi G, Impallomeni C (1994) A new nail for elastic intramedullary fixation in fractures and pseudarthroses of the femur and tibia. *Orthop Int* 2: 403–416
12. Muller ME, Nazarian S, Koch P, Schatzker J (1990) The comprehensive classification of fractures of long bones. Springer, Berlin
13. Pell ACH, Christie J, Keating JF, Sutherland GR (1993) The detection of fat embolism by transoesophageal echocardiography during reamed intramedullary nailing. A study of 24 patients with femoral and tibial fractures. *J Bone Joint Surg [Br]* 75: 921–925
14. Winquist RA, Hansen ST, Clawson DK (1984) Closed intramedullary nailing of femoral fractures: a report of five hundred and twenty cases. *J Bone Joint Surg [Am]* 66: 529–539