

ANTEGRADE X RETROGRADE NAILING IN FEMORAL FRACTURES: A STUDY ON CONSOLIDATION AND INFECTION

HASTE ANTERÓGRADA X RETRÓGRADA EM FRATURAS FEMORAIS: UM ESTUDO SOBRE CONSOLIDAÇÃO E INFEÇÃO

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ABSTRACT

Objective: Osteosynthesis with intramedullary nailing is considered the method of choice to treat diaphyseal femur fractures in adults. The objective of this retrospective study was to evaluate the bone healing time and incidence of infection in patients with diaphyseal femur fractures treated surgically with retrograde and antegrade intramedullary nailing. **Methods:** The medical records of 123 patients from two university hospitals dated 2011-2013 were evaluated, with 126 diaphyseal femur fractures having been found. The most frequent treatment was antegrade intramedullary nailing (51%), of which 38% involved reaming (n=25). **Results:** We found evidence of 92% healed fractures at 12 months postoperatively. Complications included chronic osteomyelitis in one patient and femoral neck fracture in another patient, both after reamed antegrade nailing. Pyoarthritis of the knee associated with osteomyelitis affected two patients after reamed retrograde nailing and one patient after unreamed retrograde nailing. **Conclusion:** We did not observe a significant difference in bone healing rates with the use of reamed or unreamed antegrade or retrograde nailing. Complications included the presence of infection with an incidence similar to that reported in the literature, and of particular significance, unrelated to the type of approach. **Level of evidence III, Retrospective comparative study.**

Keywords: Femoral Fracture. Fracture Fixation. Femur. Fracture Healing. Pseudoarthrosis. Fracture Fixation, Intramedullary.

RESUMO

Objetivo: A osteossíntese com haste intramedular é considerada o método de escolha para tratamento das fraturas diafisárias do fêmur em adultos. O objetivo deste estudo retrospectivo foi avaliar o tempo até a consolidação e a incidência de infecção em pacientes com fratura diafisária do fêmur, operados com haste intramedular retrógrada e anterógrada. **Métodos:** Foram avaliados os prontuários de 123 pacientes de dois hospitais universitários entre os anos de 2011 e 2013, tendo sido encontradas 126 fraturas diafisárias do fêmur. O tratamento mais frequente foi com haste intramedular anterógrada (51%), das quais 38% (n=25) eram fresadas. **Resultados:** Com 12 meses de pós-operatório, evidenciamos 92% de consolidação. Entre as complicações, observamos um paciente com osteomielite crônica e um com fratura do colo do fêmur, ambos submetidos à haste intramedular anterógrada fresada e piartrite do joelho, associada à osteomielite em dois pacientes submetidos à haste intramedular retrógrada fresada e em um paciente após a utilização de haste intramedular retrógrada não fresada. **Conclusão:** Não observamos diferença significativa entre a taxa de consolidação com o emprego das hastes retrógradas e anterógradas, fresadas ou não fresadas. Dentre as complicações, observamos a presença de infecção em incidência similar à da literatura e particularmente sem relação com a via de acesso escolhida. **Nível de evidência III, estudo retrospectivo comparativo.**

Descritores: Fraturas do Fêmur. Fixação de Fratura. Fêmur. Consolidação da Fratura. Pseudoartrose. Fixação Intramedular de Fraturas.

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INTRODUCTION

Intramedullary nailing has been the osteosynthesis method of choice to treat diaphyseal femoral fractures in adults.^{1,2} Compared to other treatments, intramedullary nailing is less aggressive to tissues, may reduce fragments without approaching the fractured area, and is associated with less bleeding, high consolidation rates, and fewer complications.^{2,3}

Intramedullary nails can be inserted by a proximal (antegrade) or distal (retrograde) approach.^{4,5} Disadvantages of the proximal approach include difficult insertion of the stem in obese patients and risks of femoral head necrosis or fracture, implant-related pain, gluteus medius insufficiency, and heterotopic ossification around the hip.^{6,7} Disadvantages of the distal approach include the need to open the joint to introduce the nail, knee pain, mobility restriction,

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The study was conducted at Irmandade da Santa Casa de Misericórdia de São Paulo, São Paulo, SP, Brazil.

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iatrogenic injury to the anterior cruciate ligament, and risk of septic arthritis.⁸ Advantages with the antegrade approach include greater availability of nail types, familiar technique, and absence of joint violation associated with the fracture treatment.^{6,9} Indications for the retrograde use of the implant include possible simultaneous fixation in the same operative field in cases of bilateral femoral fractures or simultaneous proximal/diaphyseal fractures using two implants, in addition to stabilization of floating knee using the same access path, shorter surgical time due to less manipulation required to position the patient, and the possibility of performing the procedure on a radiotransparent table, in case of polytraumatized patients.^{5,7} In terms of consolidation rates and complications, both techniques present similar clinical outcomes according to the literature.^{1,2,9} Based on these considerations, the aim of this study was to perform a radiographic evaluation of the consolidation and clinical evaluation of the relative infection rates of diaphyseal femoral fractures operated on with either retrograde or antegrade, reamed or unreamed intramedullary nailing.

MATERIAL AND METHODS

Between January 2011 and December 2013, a total of 157 diaphyseal femoral fractures were treated with intramedullary nailing at two teaching hospitals in Brazil (Hospital Central da Santa Casa de São Paulo and Hospital Estadual Dr. Albano da Franca Rocha Sobrinho). The protocol of the study was approved by the Ethics Committee for Research Involving Human Beings of the Santa Casa de São Paulo (CAAE: 41444915.2.0000.5479, approval 02/11/2015). The study was conducted according to the criteria set by the Declaration of Helsinki (1995). Hospital Estadual Dr. Albano da Franca Rocha Sobrinho was a co-participating center in this study. The radiographic images of the participants were obtained from digital image storage systems maintained by both centers (Impax and Synapse). The inclusion criteria comprised a minimum age of 18 years (considered a proxy for mature bone), diaphyseal femoral fracture treated definitively with antegrade or retrograde intramedullary nailing, and a follow-up ≥ 1 year. The exclusion criteria were fractures in pathological bone or extending proximally or distally to the joint, and cases with consolidations that could not be evaluated in the radiographs obtained. In all, 31 cases were excluded from the analysis.

The radiographs were obtained at 4, 6, 8, and 12 months of follow-up and were evaluated by three independent readers, who were orthopedic surgeons and Full Members of the Brazilian Society of Orthopedic Trauma.

Fractures were considered consolidated when observed to have bone continuity in three of the "four cortical" areas by at least two of the three readers. The minimum follow-up was 12 months, which is also the minimum time to establish a diagnosis of pseudoarthrosis.¹⁰ The requirement of subsequent surgery to treat post-traumatic osteomyelitis or remove the implant was considered diagnostic of infection.

The data collected included the patients' age and sex, AO fracture classification, and time to fracture consolidation. We also collected information on whether reaming was carried out or not and whether the implant was performed with a proximal (antegrade intramedullary nail, AIMN) or distal (retrograde intramedullary nail, RIMN) approach. The type of approach used in the procedures depended on the surgeons' preferences and the patients' characteristics. All AIMNs were inserted through the trochanteric fossa, while the RIMNs were inserted using a medial parapatellar and intercondylar approach. Static interlocking fixation was performed in all cases, regardless of the type of approach, and included fastening with two proximal and two distal screws relative to the location of the fracture.

Statistical Analysis

The data were analyzed with SPSS v.17 (IBM Corp., Armonk, NY, USA), Minitab 16 (Minitab, Inc., State College PA, USA), and Excel Office 2010 (Microsoft Corp., Washington, USA). Analysis of variance (ANOVA), chi-square test and the equality of two proportions test were applied, considering a significance level of 0.05.

RESULTS

Of the 157 diaphyseal femoral fractures retrieved in the search, 126 (123 patients) met the inclusion criteria and were included in the analysis. The mean age of this cohort was 29 years (median 27 years, range 18–67 years) and most patients (85%) were men. The AIMN was the most used osteosynthesis technique (n=65, 51.6%) and reamed nailing was used in 25 of these cases (38.5%). The RIMN technique was used in the remaining 61 cases (48.4%), of which 35 involved reaming (57.4%). (Table 1)

The fractures were all classified as AO-32¹¹ and included the three classification types according to the complexity of the fracture line. The most frequent types were A3 (n=37), A2 (n=22), and B3 (n=17). The remaining 50 fractures were distributed as shown in Figure 1. Type 32B fractures were more frequently associated with pseudoarthrosis (n=7) when compared with types 32A and 32C, regardless of the approach used in the procedure.

On the postoperative evaluation, 55 fractures showed consolidation at 4 months and 91 at 6 months. A total of 104 fractures showed consolidation at 8 months, corresponding to a consolidation rate of 82.5%, regardless of the type of approach or use of reamed or unreamed nailing. At 12 months, 92% of the fractures (n=116) had consolidated and 8% had pseudoarthrosis (n=10). (Table 2)

Patients without radiographic consolidation were divided into three groups: reamed AIMN (n=3), unreamed AIMN (n=4), and unreamed RIMN (n=3). No cases of nonunion were observed among fractures treated with reamed RIMN. (Table 3) The p values of the analysis of the time to consolidation according to the approach and reamed versus unreamed nailing are shown in Table 4.

The complications observed in our cohort included osteomyelitis in one patient and ipsilateral femoral neck fracture in another patient (both treated with reamed AIMN) and knee pyoarthrosis associated

Table 1. Distribution of diaphyseal femoral fractures according to the surgical approach and use of reamed versus unreamed nailing.

| | Reamed nailing (n) | Unreamed nailing (n) | Total (n) |
|-------------------|--------------------|----------------------|-----------|
| Proximal approach | 25 | 40 | 65 |
| Distal approach | 35 | 26 | 61 |

Abbreviation: n – number of fractures.

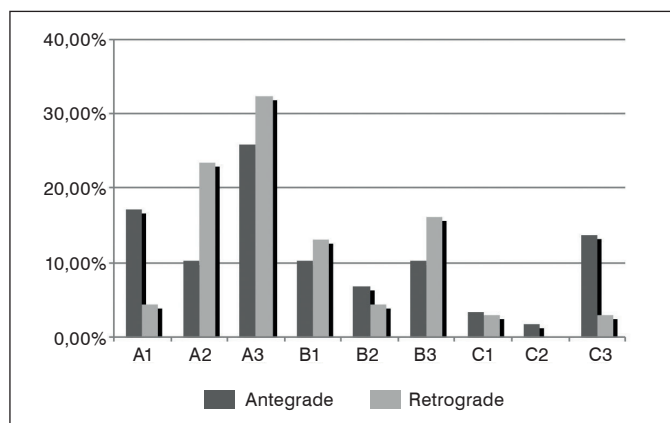


Figure 1. Distribution of diaphyseal femoral fractures according to AO classification and type of osteosynthesis used in the procedure.

Table 2. Distribution of consolidation rates of diaphyseal femoral fractures according to the surgical approach and use of reamed versus unreamed nailing.

| Consolidation | 4 months | | 6 months | | 8 months | | 12 months | |
|----------------------|----------|-----|----------|-----|----------|-----|-----------|------|
| | n | % | n | % | n | % | n | % |
| Retrograde, reamed | 14 | 56% | 21 | 84% | 24 | 96% | 25 | 100% |
| Retrograde, unreamed | 11 | 43% | 17 | 68% | 21 | 81% | 22 | 88% |
| Antegrade, reamed | 10 | 40% | 18 | 72% | 21 | 84% | 22 | 88% |
| Antegrade, unreamed | 17 | 44% | 31 | 79% | 33 | 84% | 35 | 89% |

Abbreviation: n – number of fractures.

Table 3. Distribution of cases with nonunion of diaphyseal femoral fractures according to the surgical approach and use of reamed versus unreamed nailing.

| Nonunion | 4 months | | 6 months | | 8 months | | 12 months | |
|----------------------|----------|-----|----------|-----|----------|-----|-----------|-----|
| | n | % | n | % | n | % | n | % |
| Retrograde, reamed | 15 | 44% | 5 | 16% | 1 | 4% | 0 | 0% |
| Retrograde, unreamed | 14 | 56% | 8 | 31% | 4 | 18% | 3 | 12% |
| Antegrade, reamed | 15 | 60% | 7 | 28% | 4 | 16% | 3 | 12% |
| Antegrade, unreamed | 22 | 55% | 8 | 21% | 6 | 15% | 4 | 10% |

Abbreviation: n – number of fractures.

Table 4. P values of the analysis of the time to consolidation according to the approach and reamed versus unreamed nailing (Tables 1 and 2).

| | | 3-4 months | 4-6 months | 6-8 months | 8-12 months |
|----------------------|-------------|------------|------------|------------|-------------|
| Reamed, retrograde | 4-6 months | 0.031 | | | |
| | 6-8 months | <0.001 | 0.157 | | |
| | 8-12 months | <0.001 | 0.037 | 0.312 | |
| | > 12 months | <0.001 | 0.034 | 0.303 | - x - |
| Unreamed, retrograde | 4-6 months | 0.044 | | | |
| | 6-8 months | 0.001 | 0.221 | | |
| | 8-12 months | <0.001 | 0.053 | 0.461 | |
| | > 12 months | <0.001 | 0.053 | 0.461 | 1.000 |
| Reamed, antegrade | 4-6 months | 0.023 | | | |
| | 6-8 months | 0.001 | 0.306 | | |
| | 8-12 months | <0.001 | 0.157 | 0.684 | |
| | > 12 months | <0.001 | 0.157 | 0.684 | 1.000 |
| Unreamed, antegrade | 4-6 months | 0.002 | | | |
| | 6-8 months | <0.001 | 0.554 | | |
| | 8-12 months | <0.001 | 0.192 | 0.470 | |

with osteomyelitis in two cases (reamed RIMN) and in one case (unreamed RIMN). All these patients required further surgical procedures for additional treatment and removal of the implant, along with prolonged antibiotic therapy.

DISCUSSION

After intramedullary nails were initially described by Küntscher in 1939,¹² they emerged as an excellent method to treat diaphyseal femoral fractures, yielding high consolidation rates (85 to 99%) and few complications.^{1,9,13} However, when associated with the development of pseudoarthrosis, multiple procedures may be required to manage this complication, increasing costs and compromising the patient's rehabilitation.

Causes of nonunion in diaphyseal femoral fractures include factors associated with the trauma itself or with the patient and the surgical procedure. Smoking, obesity (body mass index >30 kg/m²), use of nonsteroidal anti-inflammatory drugs, and late weight-bearing gait are patient-related factors described in the literature.¹⁰ Factors associated with the surgery include the use of reamed or unreamed nailing, the

diameter of the nail, the quality of the fracture reduction, and the approach used to insert the nail, while factors associated with the trauma include the mechanism and energy of the trauma itself, the AO classification of the fracture, and the involvement of soft tissues. Tornetta & Tiburzi analyzed 83 fractures treated with reamed intramedullary nailing and 89 managed with unreamed nailing and found a significantly shorter consolidation time among patients undergoing reamed compared with unreamed nailing.¹ This finding differed from ours. (Figure 2) However, the group receiving unreamed AIMN in our study had the lowest consolidation rate at 4 months (44.7%), which was significantly different when compared with other moments of the study (p=0.002).

Selvakumar et al.¹⁴ randomized 102 closed diaphyseal femoral fractures to reamed (n=52) and unreamed (n=50) nailing and found nonunion rates of 0% and 8%, respectively. A multicenter study by the Canadian Orthopaedic Association also compared the nonunion rates of 224 patients with fractures treated with intramedullary reamed and unreamed nailing. The study found 7.5% of nonunion in 107 fractures in the unreamed group and 1.7% in 121 fractures in the reamed group.¹⁵

Aligned with other studies,^{11,16,17} we observed a rate of pseudoarthrosis of 9.8% in the reamed group and 12% in the unreamed group, divided as follows: 5 patients after reamed AIMN, 4 patients after unreamed AIMN, and 5 patients after unreamed RIMN (p = nonsignificant for the comparison among the groups). Patients undergoing reamed RIMN had a 100% consolidation rate.^{18,19}

Our results corroborate the findings of a study by Metsemakers et al.¹⁷ evaluating 248 diaphyseal femoral fractures undergoing definitive treatment with intramedullary nailing. The rate of pseudoarthrosis in that study was 11.3% (n=28). Pseudoarthrosis was associated with the type of fracture according to the AO classification, in which type 32C was a protective factor for consolidation when compared with types 32A and 32B. Reaming, polytrauma, exposed fracture, and prior use of an external fixator did not contribute to the consolidation. In our cases, type 32B fractures presented a higher incidence of pseudoarthrosis (n=7) when compared with types 32A and 32C, regardless of the approach. No cases of nonunion were observed among type 32C fractures, which may be attributed to the small number of cases in this subgroup (n=15). Taistman et al.⁷ found no association between the AO classification of the fractures and nonunion, indicating that the classification alone is not predictive of nonunion.

Zhang et al.² carried out a meta-analysis of randomized trials including the use of intramedullary nailing in the treatment of

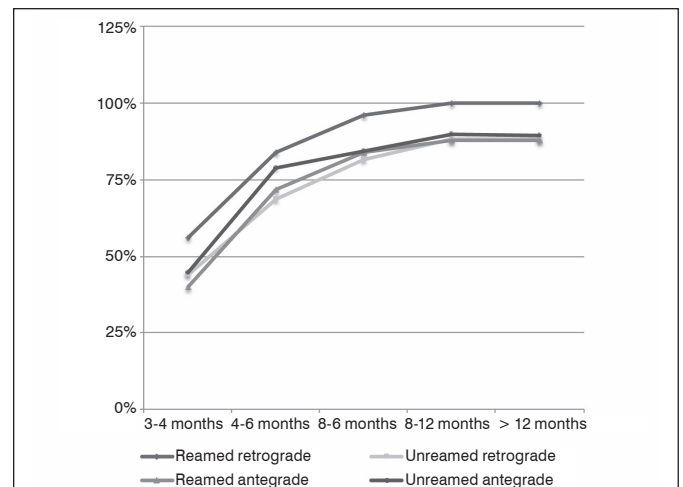


Figure 2. Time to consolidation according to the approach and reamed versus unreamed nailing in patients with diaphyseal femoral fractures.

diaphyseal femoral fractures. Only three studies (with a total of 240 diaphyseal femoral fractures) fulfilled the criteria to enter the study. The authors observed no difference in consolidation and rehabilitation rates between patients treated with the antegrade and retrograde approaches, although they noted that more studies are still needed to identify the best approach.

Theoretically, there is an increased risk of septic knee arthritis after RIMN due to the intra-articular entry point, which is not required in the AIMN approach. O'Toole et al.⁸ evaluated the risk of septic knee arthritis in 93 open fractures or fractures with a direct communication with the knee joint and observed one case of septic arthritis (1.1%) in a polytraumatized patient and two cases of osteomyelitis, yielding an incidence of 4.3%.⁹ Becher & Ziran²⁰ observed an infection rate of 5.7% related to Gustilo type 3 open diaphyseal fractures treated with RIMN and no cases of knee joint infection.²⁰

We observed in our cohort four cases of infection (3.1%), three of which were cases of septic knee arthritis related to RIMN and one was a case of chronic osteomyelitis related to AIMN. These findings are aligned with those in the literature.⁹

A potential limitation of our study is its retrospective design. Better insights would have been possible if the analysis had accounted for factors potentially contributing to the pseudoarthrosis, such as smoking, use of nonsteroidal anti-inflammatory drugs, and soft tissue injury.

CONCLUSIONS

In our cohort of patients with diaphyseal femoral fractures treated with intramedullary nailing, the consolidation rates were high and independent of the use of a reamed or unreamed approach, or antegrade or retrograde nailing. Infection occurred at a low rate (close to the rates found in the literature) and was not associated with the type of implant.

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