

Analysis of Intraoperative Exposure to X-rays and Surgical Time in Different Techniques for Fixation of Transtrochanteric Fractures of the Femur*

Análise da exposição intraoperatória ao raio X e do tempo cirúrgico em diferentes técnicas de fixação das fraturas transtrocanterianas do fêmur

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Abstract

Objective The present study aimed to evaluate and compare the total surgical procedure time and intraoperative X-ray exposure during different techniques for fixation of transtrochanteric fractures of the femur in elderly patients, using extra-medullary and intramedullary methods based on cephalic traction screws.

Methods The Orthopedics and Traumatology Service from our hospital evaluated 107 patients with transtrochanteric fractures, including 34 males and 73 females, with age ranging from 61 to 101 years old. Fracture fixation was performed with a dynamic hip system (DHS) in 21 patients, a standard proximal femoral nail (PFN) in 55 subjects, and a standard gamma nail in 31 patients. All procedures were performed by the same surgeon and his team of nursing assistants, along with the same radiology technician using the same image intensifier. Total surgery time (in minutes) and X-ray emission (in centigrays [cGy]) were evaluated.

Results Transtrochanteric fracture fixation with PFN provides a significantly shorter surgical time ($p=0.013$) in comparison to the 2 other techniques. Intraoperative exposure to X-rays was significantly lower when using DHS ($p=0.015$) as a fixation method when compared with gamma nail and PFN.

Conclusion Although PFN resulted in the shortest surgical time, DHS was associated with the lowest X-ray exposure levels within the studied sample.

Keywords

- ▶ cancer
- ▶ femoral fractures
- ▶ internal fixators
- ▶ neoplasms, radiation-induced
- ▶ X-rays

* Study developed at the Orthopedics and Traumatology Service, Hospital São Jose do Avaí, Itaperuna, RJ, Brazil.

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Resumo

Objetivo Avaliar e comparar o tempo total do procedimento cirúrgico e a exposição ao raio X no intraoperatório em diferentes técnicas de fixação das fraturas transtrocanterianas do fêmur em pacientes idosos, utilizando técnicas extramedulares e intramedulares baseadas em parafuso de tração cefálico.

Métodos Foram avaliados no serviço de ortopedia e traumatologia do nosso hospital 107 pacientes com fraturas transtrocanterianas, sendo 34 do sexo masculino e 73 do sexo feminino, com idade mínima de 61 anos e máxima de 101 anos. As fraturas fixadas, utilizando a técnica com dynamic hip system (DHS, na sigla em inglês) somaram 21 pacientes; em 55 pacientes, foi utilizado o proximal femur nail (PFN, na sigla em inglês) standard; e em 31 idosos, foi optado pelo uso do gama nail standard. Todos os procedimentos foram realizados pelo mesmo cirurgião acompanhado de sua equipe de auxiliares de enfermagem, assim como pelo mesmo técnico de radiologia manuseando o mesmo intensificador de imagens. Foram avaliados o tempo total da cirurgia (em minutos) e a emissão de raios X medida em centigrays.

Resultados A fixação das fraturas transtrocanterianas com PFN proporciona um menor tempo cirúrgico com uma diferença estatística significativa ($p = 0,013$), quando comparada com as demais técnicas utilizadas entre os grupos envolvidos. Foi observada, também, uma menor exposição intraoperatória aos raios X ($p = 0,015$), a qual foi estatisticamente relevante quando utilizado o DHS como método de fixação comparado com o gama nail e o PFN.

Conclusão Apesar do PFN ter o menor tempo de cirurgia, a técnica do DHS se mostrou com menores níveis de exposição dentro da amostra estudada.

Palavras-chave

- ▶ câncer
- ▶ fraturas do fêmur
- ▶ fixadores internos
- ▶ neoplasias induzidas por radiação
- ▶ raios X

Introduction

Transtrochanteric fractures occur from the base of the femoral neck up to 2.5 cm distally to the lesser trochanter.¹ They are extracapsular injuries. These fractures mostly affect elderly patients who suffer falls from their own height or young people submitted to high-energy traumas.^{2,3} The majority of these fractures should be surgically treated. Synthesis can be performed with intramedullary nails (proximal femoral nails [PFNs] and gamma nails) or extramedullary plates (dynamic hip system [DHS]). These three techniques are based on fixation with a sliding cephalic traction screw. Clinical outcomes from these techniques are similar, providing stable fracture fixation, early mobilization, bone consolidation with a low complication rate, and a quick return to usual activities.^{1,3-5}

Diagnosis and treatment are contingent to imaging tests, including radiography and computed tomography (CT) scans. These resources increase diagnostic accuracy, leading to more specific treatments for each type of fracture, that is, the selection of the best fixation technique.

The introduction and development of image intensifier technology improved surgical procedures due to a better visualization for fracture reduction and implant positioning. In addition, image intensifier technology decreased surgical times, further improving clinical and functional outcomes.^{3,6,7}

However, exposure to ionizing radiation has medium- and long-term negative consequences.⁸ The accumulated radio-

active load may cause and/or potentiate cancers due to the so-called stochastic effects; for instance, the likelihood of cancer is proportional to the radiation dose received.^{9,10}

Transtrochanteric fractures require radiographic images for diagnosis and treatment; as such, patients are exposed to radiation twice. Therefore, the present study compared different surgical treatments for transtrochanteric fractures of the femur, all with similar outcomes,¹¹ to determine which has the shorter procedural time and lower radiation exposure to all involved personnel,⁸ minimizing this harm.

Materials and Methods

This is a qualitative and quantitative study with a sample of 107 patients who underwent surgery for transtrochanteric femoral fractures correction at the Orthopedics and Traumatology Service of our institution from January 1 to December 31, 2017. Data on the type of fracture from each patient were collected using a protocol and classified by the authors of the present research. The sample consisted of 73 (68.2%) females and 34 (31.8%) males, with an average age of 81 years old, maximum age of 101 and minimum age of 61 years old. The type of implant used for fracture fixation, number of x-rays required for fixation, and surgical time were also determined.

Differences between techniques were determined by a nonparametric hypothesis test, the Mood median test. All procedures were performed by the same surgeon, the same

General descriptive analysis of X-ray exposure level (cGy.cm²).

Differences between techniques were determined using a nonparametric hypothesis test, the Mood median test. Since our sample does not have a normal distribution (as previously shown), the test was based on median values of exposure levels between groups (► **Figure 2**).

- H0: Median values of exposure levels are equal (conservative hypothesis)
- Ha: At least one median value of the exposure levels from the groups is different from the other two.

The test allows us to affirm, with 95% confidence, that there is a statistically significant difference in at least one of

the median values. H0 is rejected and Ha is accepted with a p-value equal to 0.015.

Median values show that gamma nails and PFNs have a higher level of exposure compared with DHS; however, we cannot statistically state that gamma nails are associated to a higher level of exposure than PFN, because their median values are statistically equal (note that their intervals overlap).

We also show boxplots, which are graphs used to visually compare two or more groups. The horizontal line dividing the boxes is the median value, whereas the vertical lines indicate the boundaries of continuous data (► **Figure 3**).

The following boxplots show data distribution as a form of representation. The line connecting the samples indicates the mean value, and the horizontal line at the center of each block is the median value (► **Figures 4 and 5**).

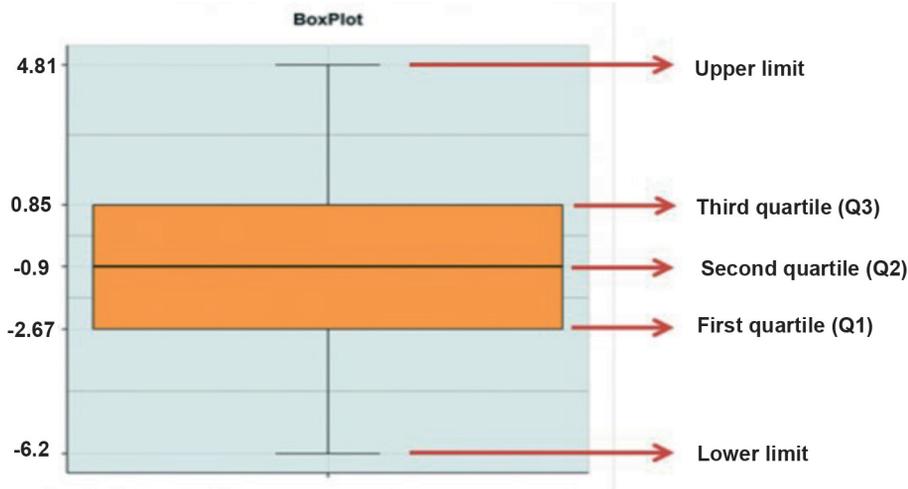


Fig. 3 Explanatory boxplot. Source: research data.

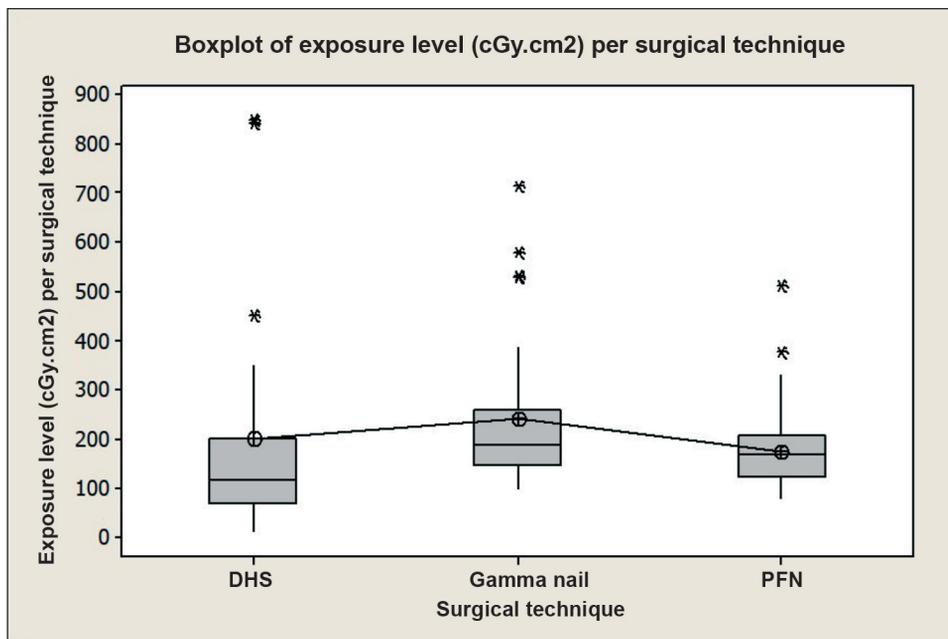


Fig. 4 Boxplot comparing surgical techniques. DHS, Dynamic hip system; PFN, proximal femoral nail. Source: research data.

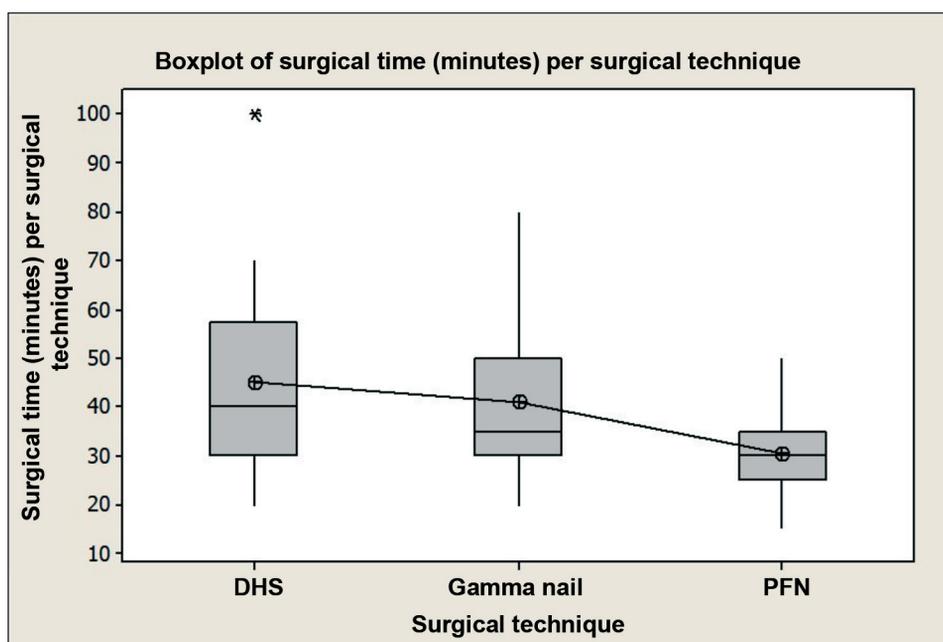
Mood Median Test: Tempo cirurgia (min) versus Técnica Cirúrgica

Mood median test for Tempo cirurgia (min)

Chi-Square = 8,75 DF = 2 P = 0,013

Técnica Cirúrgica	N<=	N>	Median	Q3-Q1	Individual 95,0% CIs
DHS	6	15	40,0	27,5	(-----*-----)
GAMA	13	18	35,0	20,0	(-----*-----)
PFN	35	20	30,0	10,0	(-----*)

Overall median = 30,0

Fig. 5 Mood median test for surgical time versus surgical technique. Source: research data.**Fig. 6** Time versus technique boxplot. DHS, Dynamic hip system; PFN, proximal femoral nail. Source: research data – based on data from the Orthopedics and Traumatology Service from our institution.

Asterisks above each block are outliers, that is, “points outside the curve” with a very different behavior from the other points.

The test allows us to affirm, with 95% confidence, that there is a statistically significant difference in at least one of the median values. H_0 is rejected and H_a is accepted with a p -value equal to 0.013.

Median values indicate that DHS is associated with a longer surgical time compared with PFN; however, we cannot affirm that DHS and gamma nails are statistically different. Similarly, gamma nails and PFNs present statistically equal median values (► **Figure 6**).

Discussion

The increased average life expectancy resulted in an expansion in surgeries for fractures of the proximal third of the femur, along

with more studies to determine the best way to perform them. The estimated superiority in surgical time is associated with elevated intra- and postoperative complication rates in elderly patients, who are the most involved in this type of surgery. In contrast, shorter surgical times generate lower bleeding rates, hemodynamic instability, and anesthetic exposure.

In a study conducted at a multidisciplinary Government Hospital in India, Sharma et al.³ compared clinical and radiological outcomes from patients with stable intertrochanteric fractures treated with PFN or DHS. The authors concluded that PFN provided significantly shorter surgical times ($p < 0.01$), smaller incisions and, consequently, a lower rate of surgical wound-related complications.

Zhang et al.¹² also compared surgical techniques using DHS and PFN to treat transtrochanteric fractures. Both studies concluded that there is a statistically significant difference regarding surgical time, and all statistical analyzes

corroborate that the PFN-type intramedullary nail is statistically associated with a shorter time when compared with DHS, an extramedullary technique.

Since the discovery of x-rays, the use of ionizing radiation for intraoperative assistance has been expanded with image intensifier devices. There is an increasing concern about radiation emissions involved in medical procedures due to their medium- and long-term negative effects. It is known that using appropriate personal protective equipment (PPE) and keeping the maximum possible distance from the x-ray beam represent effective solutions to maintain a reasonably safe level of exposure. The present study also demonstrated that the selected technique reduces radiation exposure in these work environments.

Sharma et al.³ compared x-ray exposure using DHS (extramedullary technique) and PFN (intramedullary technique). The average exposure was 48.7 mGy/cm² with DHS and 71-mGy/cm² with PFN, with a significant difference ($p < 0.001$). For Rashid, who also compared these techniques, the average exposure was 668 mGy/cm² with DHS and 1,040 mGy/cm² with PFN, with a notable difference ($p < 0.001$). These findings are consistent with our study, which found a statistically significant difference ($p = 0.015$) when comparing an average exposure of 115 mGy/cm² with DHS versus 168 mGy/cm² with PFN, an increase in exposure close to 50% between both surgical techniques in these 2 studies.

Conclusion

Transtrochanteric fractures fixation using PFN had a shorter surgical time. However, DHS provided lower X-ray exposure, which was statistically significant when compared with gamma nails and PFNs, benefiting both the patient and health professionals involved in the procedure.

Therefore, based on this discussion and technical comparisons, the surgeon must decide which technique to use according to skill, experience and, of course, material availability at the institution. The surgeon needs to understand the risks and benefits of each technique, as well as their peculiarities, to make the best possible choice for both the surgical team and, especially, for the patient.

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Conflict of Interests

The authors have no conflict of interests to declare.

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