Postoperative Malrotation After Closed Reduction and Intramedullary Nailing of Femoral Shaft Fractures

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Abstract

Background: Closed reduction and intramedullary nailing is an established procedure in the treatment of diaphyseal femoral fractures. Postoperative malrotation of the femur is a complication that can be assessed with computed tomography (CT). A rotational difference >15° to the contralateral side appears in 17 to 35% of literature reports, and correlates with a reduced clinical outcome. Hence, an anatomical reduction of the femur plays an important role.

Methods: One-hundred and seven cases of unilateral femoral shaft fractures were investigated. All fractures were treated with closed reduction and intramedullary nailing. All patients underwent computed tomography postoperatively, analyzing rotational differences. In cases with a rotational difference of > 15°, an indication of revision surgery was posed. Twenty-three patients were female and 84 male. The average age was 32.5 ± 14.4 years. The age ranged from 14 to 94 years.

Results: In the postoperative CT scan, according to Waidelich, an average femoral malrotation of 11° ± 9.16° to the healthy side was determined. In 16 cases (14.9%), 11 males (13.1%) and 5 females (23.8), a femoral malrotation larger than 15° (average: 23.23° ± 6.02°) was detected.

Conclusions: Femoral malrotation after closed reduction and intramedullary nailing is a delicate topic and occurs commonly. Postoperative computed tomography could in addition to the clinical examination identify critical postoperative deviations and lead to a correction of femoral malrotation in a revision surgery. Despite extensive efforts, an intraoperative adjustment of the rotation could not be achieved anatomically in more than 10% of all cases. As a consequence, after closed reduction and femoral nailing, a postoperative CT scan to detect femoral malrotation is recommended.

Keywords: Femoral Shaft Fracture, Femoral Malrotation, Rotational Difference

1. Background

The incidence rate of the femoral shaft fractures is 10 to 37; related to 100,000 inhabitants and year (1, 2). There are three age-related peaks in frequency of femoral shaft fractures: in children aged one to four years, as well as in male patients between the ages of 15 and 30 and female patients over 75 years (3). Femoral shaft fractures occur in 30% of cases together with multiple injuries (3).

Intramedullary nailing is considered to be the gold standard for treating a femoral shaft fracture in adults (4, 5). Depending on the fracture type, the patient age and the soft tissue injuries, plate osteosynthesis is also applied (6). Advantages of intramedullary nailing are small incisions, reliable fracture healing, and a rapid mobilisation of the patient (7). Rotational malalignment during closed reduction and intramedullary nailing of the fracture is the most common adverse event (6, 8-12). The intraoperative assessment of the torsion through anatomic landmarks, both clinical and radiological, is challenging and could precisely be assessed only postoperatively with computed tomography (13-17).

The intraindividual femoral rotational difference average was from 2° to 5°. In 95% of the adults, the intraindividual rotational difference of both legs was less than 11° and less than 15° in 99% (15-17). Studies showed that a malrotation of more than 15° could lead to an increased strain on the adjacent joints of the extremity (10, 14).

2. Objectives

The purpose of this single-center retrospective cohort study, was to determine the amount and the extend of...
a postoperative femoral rotational difference using postoperative computed tomography. The hypothesis of the study was that despite a careful intraoperative clinical and radiological control, a relevant femoral malrotation after intramedullary nailing is evident.

3. Methods

Patients with unilateral femoral shaft fractures were enrolled in the study between 2007 and 2014. Exclusion criteria were fractures of the femora in the past, bilateral femoral fractures, pregnancy or open epiphyseal plates.

All fractures were treated with closed reduction and antegrade intramedullary nailing. The surgery was performed with the patient in supine position on a standard table without extension. Implants used for the osteosynthesis were unreamed antegrade femoral nails including unreamed femoral nail (UFN) and lateral femoral nail (LFN) (DePuy-Synthes, Johnson and Johnson, USA).

The internal and external rotation of the contralateral femur was determined preoperatively in 90° flexion of the hip in supine position. A standardized radiological control of the reduction and the torsion was carried out intraoperatively using the cortical-step-sign (18). A clinical control of the torsion with 90° of flexion of the hip was performed intraoperative after locking the nail. In case of a clinical evident intraindividual rotational difference, a revision was performed immediately. Routinely, in all cases, a postoperative CT scan (Somatom Plus 4 Expert, Siemens, Erlangen), after the procedure described by Waidelich, was conducted in order to analyze a femoral rotational difference (17). In order to minimize the radiation exposure of the patient, only representative scans were put through the femoral head, the trochanter areas as well as through the condyles (Figure 1). The evaluation was carried out by two independent experienced radiologists.

A femoral malrotation greater than 15° in combination with a clinical rotational difference required correction 16. The revision surgery was performed by removing the distal locking bolt and rotating the distal fragment. After a clinical and radiological control of the torsion, the nail was locked again.

4. Results

This study examined intramedullary osteosynthesis of a total of 107 patients with unilateral femoral fractures. Twenty-three patients were female and 84 male. The average age was 32.5 ± 14.4 years. The youngest patient was, at the time of therapy, 14 years old, while the oldest patient was 94 years old. In the postoperative CT scan, according to Waidelich et al. (17), an average femoral malrotation of 11° ± 9.16° (minimum 0°, maximum 44°) to the healthy side was determined (Figure 2).

In 16 cases (14.9%), 11 males (13.1%) and 5 females (23.81%), a femoral malrotation larger than 15° (average: 23.23° ± 6.02°) was detected. A reduction of the intraindividual femoral malrotation could be achieved with a subsequent surgery (Figures 3 and 4).

5. Discussion

The purpose of this study was to determine the frequency and extent of a postoperative femoral malrotation after intramedullary nailing using computed tomography.

It is well known that there is a wide range of intraindividual femoral rotational differences (16). This influences the correct anatomical rotation and therefore complicates the correct intraoperative reduction. Due to the fracture, the original femoral rotation is unknown and therefore the rotation of the healthy opposite side is used for orientation. Strecker et al. showed that intraindividual femoral malrotation is significant and in 99% of the cases can be up to 15° (16, 19).

Numerous analysis showed that an increased femoral malrotation of more than 15° led to a poor functionality of the extremity due to the additional strain, especially of the knee and hip joints (20, 21). An increased internal femoral rotation increases lateral patellar contact pressures and can therefore result in a disorder of the femoropatellar sliding process.

In order to achieve as little restrictions for the patient as possible with a good clinical postoperative result, a femoral malrotation of 15° to the healthy opposite side can be tolerated (22). A clinical examination to detect the femoral malrotation should be the first step of the analysis. Moreover, it should be analyzed if the femoral malrotation displays a clinical relevance for the patient. Studies have pointed out that the clinical examination is not sufficiently reliable to determine femoral malrotations of > 15° (23). Computed tomography scanning is still considered to be the gold standard for detection of malrotation and enables the display of hidden rotational differences (24).

The fracture morphology of the 16 patients, who were diagnosed with an increased femoral malrotation, was inhomogeneous (Table 1). Malrotations occurred in type A as well as in type B and C fractures (according to AO). An increased femoral malrotation according to type C, as published in a study, could not be demonstrated in this analysis (25).

The patients enrolled in this study were all operated in the supine position. The influence of the positioning of the patient on the results of the analysis was therefore not the
Figure 1. Measurement of the Femoral Malrotation Done According to the Method of Waidelich (17)

The angle between the lines of the greater trochanter/femoral head center and the femoral condyles are measured. A difference of the angles of both sides compared after a femoral intramedullary osteosynthesis is referred to as femoral malrotation. The present measurement showed an increased internal rotation left of 15.1° compared to the healthy side.

Table 1. Fracture Type in Correlation With the Femoral Malrotation of all Cases > 15° (in Degrees)

<table>
<thead>
<tr>
<th>Fracture Type According to AO</th>
<th>A1</th>
<th>A2</th>
<th>A3</th>
<th>A3</th>
<th>A3</th>
<th>A3</th>
<th>B1</th>
<th>B2</th>
<th>B2</th>
<th>B2</th>
<th>B3</th>
<th>C1</th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>C3</th>
</tr>
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<tr>
<td>Initial rotational difference in degrees</td>
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<td>24</td>
<td>25</td>
<td>27</td>
<td>26</td>
<td>16</td>
<td>20</td>
<td>38</td>
<td>27</td>
<td>20</td>
<td>27</td>
<td>20</td>
<td>16</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Rotational difference in degrees after revision</td>
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<td>8</td>
<td>5</td>
<td>16</td>
<td>10</td>
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<td>0</td>
<td>1</td>
<td>1</td>
<td>12</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Revised rotation in degrees</td>
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<td>15</td>
<td>18</td>
<td>8</td>
<td>15</td>
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<td>18</td>
<td>26</td>
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<td>15</td>
<td>16</td>
<td>14</td>
<td>18</td>
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</tbody>
</table>

subject of this study. The intraoperative positioning of the patient on the healthy side can simplify the radiological control of the rotation.

Our evaluation of the postoperative measurements of the malrotation illustrates, that in almost 15% of all cases despite carefully performed intraoperative clinical and radiological monitoring a femoral malrotation larger than 15° was present and a correction surgery was implemented.

5.1. Conclusions

The results show that, despite extensive efforts, an intraoperative adjustment of the rotation could not be achieved anatomically in almost every sixth case. The initial supposition of a relevant femoral malrotation after intramedullary osteosynthesis can therefore be sustained. The clinical examination of the malrotation does not replace, in our opinion, a postoperative CT control in order
to avoid subsequent complaints and an increased strain of the neighboring joints. As a consequence we recommend, after a closed reduction and antegrade intramedullary femoral nailing of a shaft fracture, in case of clinical suspicion of a malrotation, to perform a postoperative CT control. The indication for a correcting surgery should be posed depending on the clinical image in combination with the radiological measurement.

Footnote

Authors’ Contribution: All authors substantially contributed to conception, acquisition of data, and analysis and interpretation of the data. In addition, the authors participated in drafting of the article and revised it critically for important intellectual content and approved the final version to be submitted.

References


Figure 2. Femoral Malrotation of All Patients Compared to the Healthy Side, Measured in Degrees

Figure 3. The Average Femoral Malrotation of All Cases With a Deviation of > 15°, Showing the Amount of Correction (Revision) and the Postoperative Malrotation After the Revision Surgery

Figure 4. Femoral Malrotation > 15° After Initial Osteosynthesis and After Corrective Surgery

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