**The Quick and Convenient Method of Closed Femoral Intramedullary Nailing by the Innovative Set for Close Reduction of Long Bone Fractures**

**Abstract**

**Introduction:** The preferred method in fixation of some long bone fractures is using intramedullary nailing. The benefit of this method lies in its higher biomechanical stability, as well as preventing additional surgical trauma to the fracture site. Despite these benefits, few surgeons use this method, because it is time consuming, risky (performing x-ray fluoroscopy) and also tedious.

**Method:** Seven male patients with diaphyseal femoral fractures, with an average age of 32.28 years, underwent closed femoral nailing surgery by the innovative set. The duration of operation, fracture type and site were evaluated.

The innovative solution: To align the bone fragments and make the guide stick cross the fracture site through closed method, the present close reduction set was designed to enable crossing the guide stick through the fracture site on regular operation theater’s bed in a short time without fluoroscopy, with the least possible trauma and disturbance in the reduction stage.

**Results:** All patients with diaphyseal femoral fracture, underwent nailing surgery, while total duration of the surgery was 116.57 minutes on average; and duration of the innovative set application and cross the guide stick to the bottom of the distal canal was 21.85 minutes.

Conclusion: The results indicated that closed intramedullary nailing of femoral fractures without performing fluoroscopy, is possible for patients with utter convenience in an appropriate time period.

Keywords: close reduction, interlocking, long bones, femur

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**Introduction**

The preferred method of fixing some fractures in the long bones is the use of intramedullary nailing. The benefit of this method lies in its higher biomechanical stability, as well as preventing additional surgical trauma to the fracture site\(^1\). These intramedullary nails can enter the canal from one end of the bone, without the need to open the fracture site. During the procedure, if the fracture site has to be opened, in addition to many other disadvantages, this main advantage will also be lost\(^{1-4}\). But such a closed method is time consuming, risky (because of radiography) and tedious. Because of these difficulties, closed nails are done with fewer frequency in the global statistics of femoral nailing surgeries. Although this nailing method is preferred, sometimes in femoral diaphyseal fractures simpler methods are used by surgeons. To solve this problem, which is mainly for aligning the bones and crossing the guide stick from the fracture site closely, a surgical set was designed to enable reduction stage and closed crossing of the guide wire from the fracture site in the routine nailing procedure be performed in a short time, with the least additional trauma, and on regular beds of operation rooms.
Methods

In this clinical trial the new surgical set was used for seven patients with hip fractures. Among the patients admitted to the orthopedic ward of Shahid Kamyab Hospital, those who were candidates of anterograde femur nailing, whose fractures were not segmental, were selected non-randomly. All the patients were informed about the process of operation and gave consent for participation.

To fix the patients’ fractures, interlock intramedullary nails were used. The length and diameter of the nail to stabilize the fracture was determined before surgery by measuring the bone fragments of the fractured bone as well as the intact bone of the patient, which was evident in the taken radiographies. The appropriate nail’s length was calculated from lateral epicondyle to the tip of greater trochanter. During operation, time was recorded at four points of the process. The moment, the skin was cut in the patient’s buttock area (time 0), the moment the guide wire was inserted correctly into the upper medullary canal (time 1), the start of using the new reduction set at this stage and crossing the guide to the end of the distal canal (time 2), and the end of the procedure (time 3).

This innovative set includes a mechanical system to distract bone fragments, which allows moving the fragments while under tension by its mobile arms, for which it is called dynamic distractor. This system is connected from the top -through screwing a special cannulated screw (about 10 to 13 millimeters diameter) into the femur entrance canal- to upper bone fragment (the connector screw), and from the bottom (by a connector plane of four 5-mm holes for shanz screws) to outer surface of lateral femoral condyle. These two components of the set (cannulated screw and connector plane) act as connectors of the distractor to upper and lower parts of the bone to be in the control of the dynamic distractor device. The dynamic distractor device is connected to these two connectors through the upper and lower arms and while distracting the fracture segments and correcting the shortenings, allows aligning the parts for reduction and crossing the guide wire from the fracture site. Guide wires, which were first positioned inside the cannulated connector screw inside the upper canal, are guided to the lower canal after alignment by the dynamic distractor device. The guide tip hitting the shanz in midpoint of the distal canal confirms the correct entry. To successfully complete the first task of the set the guide should cross the fracture site and reach to the end of canal. To perform the remaining stages of the intramedullary canal, the dynamic distractor device is disconnected, only the cannulated screw (upper connector) is opened, and the entrance of femoral canal will be accessible, while the guide wire remains inside the medullary canal. (Fig 1)
The surgical procedure
All the patients were operated on a regular bed of operation room in lateral position using the classic intramedullary nailing method. The skin was cut classically for introducing to the medullary canal from the top onto the buttock. The medullary canal was opened and the guide wire was introduced from the canal entrance into the upper segment of medullary canal. Then, on the guide wire, the cannulated connector screw, which is self tapping, was screwed into the trochanteric part of the femoral bone using a special cannulated driver to reach the maximum grip. The upper connector of the set was connected to the bone on the guide from the top. Then the lower connector plane, which looks like the lateral femoral condyle, was connected to the lateral condyle using three localized land marks from the outer skin of the femoral condyles by four 5-mm shanz screws. The three land marks included: the tuberosity of lateral femoral epicondyles, the highest point of the outer edge of the patellar groove, and the midpoint of the femur trunk thickness, just above the upper patellar pole. To determine the coronal plane of the femur, which was due to introduce the shanz screws parallel to it, we inserted a 2-mm pin from the lateral to medial on the anterior femur flat part, just above the patellar groove from the outer skin to the inner skin. When entering the shanz to the connector plane, this pin indicated the correct coronal plane. The lower connector attachment was also completed by inserting these shanz screws.

The distractor device was set proportional to the femur length and connected through its upper and lower arms to the corresponding points in the connectors. The intramedullary nail, prepared for the length and diameter of the patient’s bone, was used to be positioned on the two of the connector planes’ shanz through its interlock holes as an outer guide on the skin to show the distraction amount and movement direction of the parts needed for reduction. With the lower arm’s moving handle, which allows movement in three axes, the distal segment of the fracture was distracted and moved in the proper direction. In facilitating the movement of the distal part during distraction, we attached a second connector plane to the bone, at 3 mm of the fracture site on the skin by two 3-mm pins; from the middle part, the lower arm manipulation force is transmitted through this auxiliary axis with a better efficiency to the distal bone and moves it easily in the desired direction. When the upper end of interlock guide nail on the skin came, adjacent and parallel to the upper connector, the internal fractured bone was aligned and made end-to-end. At this moment, we pushed the guide from top to bottom to properly enter the distal canal. The accuracy of the crossing was confirmed by the tip of guide hitting the shanz inside the canal.

To prepare the canal, first the distractor device was disconnected, then the connector cannulated screw and the connector plane of the auxiliary arm was opened adjacent to the fracture site to continue the classic operation. After the complete reaming of the medullary canal using the “guide replacing tube”, we changed the ball tip guide with a simple guide. When inserting the nail, the guide nail was removed from the connector plane and fastened to the classic nail tool and placed inside the site of femural canal. As the nail reaches the shanz, the first two shanz screws, located in the distal interlock screws, were removed so the nail tip reaches the end of the canal. (Fig 2)
Upon reaching the nail tip to the final shanz at the bottom of the medullary canal, the holes created in the bones by upper shanz were right at the level of the nail interlock holes, and the plane was aligned with the remaining shanz plane by rotating the nail placement handle. Interlocking screws were placed right there without the need to create additional holes. After placing the distal interlock screws in order to control the correct rotation before inserting proximal screws, we crossed the pin guide from the anterior femoral neck plane to determine the angle of the femoral neck plane and, by adjusting the appropriate anteversion of this pin proportional to the remaining shin, which shows the coronal plane of the femur, we placed the upper interlocking screws. With this method, malrotation at the fracture site was avoided.

In all the seven cases, the guide wires crossed the fracture site in closed method. During the surgery, no additional trauma was created in the canal entrance area. The cannulated screw had the correct path on the guide. The screw was secured up to about 3 centimeters to the screw’s head to find the maximum grip. In the osteoporotic patients, the screws were screwed down deeper. During the procedure into the femoral metaphysis, four holes were created by shanz, two of which were used to place the interlock screws. We controlled the process by using fluoroscopy during the procedure, whenever we doubted the accuracy of progress. If the fracture has a big spike, it is best to align in such a way that the spike of the distal segment plays the guiding role for arrival of guide wire into the distal medulla. Therefore, it is important to determine the position of the spike of the distal segment in preoperative radiography.

### Results

1. Seven patients with the mean age of 32.28 years with femoral diaphysis fractures underwent surgery during a total duration of 116.57 minutes. The mean consumed time of using the innovative set, from the beginning of the connection of the innovative set parts to the bone, reduction, and crossing the guide from the fracture site, and reaching the bottom of the distal canal was 21.85 minutes. The findings of the patients are summarized in table 1.

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age (day)</th>
<th>Patient’s admission until operation</th>
<th>Fracture type</th>
<th>First interval (min)</th>
<th>Second interval (min)</th>
<th>Third interval (min)</th>
<th>Total duration of operation (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>42</td>
<td>10</td>
<td>Transverse -middle one-third</td>
<td>8</td>
<td>11</td>
<td>72</td>
<td>91</td>
</tr>
<tr>
<td>2</td>
<td>23</td>
<td>2</td>
<td>Proximal one-third, the third part of butterfly</td>
<td>20</td>
<td>19</td>
<td>87</td>
<td>126</td>
</tr>
<tr>
<td>3</td>
<td>25</td>
<td>2</td>
<td>Middle one-third, the third part of butterfly</td>
<td>15</td>
<td>17</td>
<td>89</td>
<td>121</td>
</tr>
<tr>
<td>4</td>
<td>26</td>
<td>6</td>
<td>Proximal one-third</td>
<td>10</td>
<td>15</td>
<td>67</td>
<td>92</td>
</tr>
<tr>
<td>5</td>
<td>52</td>
<td>5</td>
<td>Transverse -middle one-third</td>
<td>13</td>
<td>30</td>
<td>90</td>
<td>133</td>
</tr>
<tr>
<td>6</td>
<td>38</td>
<td>23</td>
<td>Middle one-third, the third part of butterfly</td>
<td>10</td>
<td>35</td>
<td>68</td>
<td>113</td>
</tr>
<tr>
<td>7</td>
<td>20</td>
<td>12</td>
<td>Transverse -middle one-third</td>
<td>23</td>
<td>26</td>
<td>91</td>
<td>140</td>
</tr>
</tbody>
</table>

Mean 31.28 8 14.14 21.85 80.57 116.57
Discussion

Fixation of femoral fracture in closed method is difficult and time consuming. It can be performed by several methods, such as using advanced computerized navigation systems in some developed countries, but in a classic approach that fastens the patient to the distraction table, and then aligns the bone parts with the help of fluoroscopy and manipulating tools or more commonly do the same on regular operation table6,7,8. This innovative instrument was designed without the need to fasten the patient for distraction to the fracture table, so that the surgeon will have the opportunity to open the surgery, when faced with any problems, and has the advantage of not interfering with the surgeon’s routine procedure. The duration is shorter, and comparing to the several benefits for the surgeon (shorter time, no X rays, less energy consumed), the patient (no cut at the fracture site, not opening the fracture with its many advantages), and the operating theater (less materials consumed, shorter time required, fewer personnel needed, no need for a fluoroscopy device), it does not have high costs and risks. In patients who undergo delayed surgery for any reasons and cannot be reduced with manual distraction force, this method is effective and maintains the bone callus in the fracture site. The current results were obtained from patients operated at different intervals from the accident and with different types of fracture. The tools of this set were developed during the procedures. Patients with segmental fractures were not included in the study. But we suppose that due to minimal disruption of soft tissues and muscles, the effect of distraction in the anatomical axis of the bone on the soft tissue mass, can also have a favorable effect on the alignment of the third bone component. It is suggested that the effectiveness of this set be investigated on segmental fractures.

Conclusion

The use of this set resulted in a more success in close nailing of femoral fractures on regular beds of operating theaters. It also reduces the use of X-ray and duration of patient hospitalization period and surgical costs, as well as the risk of infection and bone defects. It has favorable aesthetic results in patient’s femoral skin and avoids psychological problems. We conducted this study as the first study to introduce this tool to the orthopedic community. For the development of this set to various closed nailing procedures, it is necessary to conduct more extensive and multi-central studies to develop ideas and reach more mature experiences (Fig 3).

Conflicts of interest

Dr. Hamid Farzadfard, orthopedic surgeon, designed and registered the patent in US PATENT OFFICE as a member of the Orthopedic Research Center affiliated to Mashhad University of Medical Sciences, Mashhad, Iran.

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