# Study on guidance systems for implantable elements. Improvements to the distal targeting system of blocked intramedullary nails

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**Abstract.** *The paper presents an experimental study on the design of a device that would help a better screw fixation of the tibia intramedullary locked nail. The first part of the paper presents a series of information related to the anatomy, biomechanics and pathology of the tibia, as well as some aspects related to the joints and muscles around the tibia and fibula. A particular emphasis was placed on diaphysis fractures of the tibia, which also involve the use of blocked intramedullary nail. Information related to the technique used to immobilize diaphysis fractures by orthopedic or surgical technique are also presented. The last part of the work is dedicated to the distal holes in the sagittal plane in order to determine the movement of the nail on the intramedullary canal of the tibia using vector graphics.*

**Keywords**: intramedullary nailing, diaphysis fractures, vector graphics, orthopaedics, distal targeting.

## Introduction

The human skeleton is a structure made up of 206 pieces that include long bones, short bones and flat bones. This structure performs various functions in the human body such as: support function, locomotion, protection, hematopoiesis and storage function. Although modern science and technology have made progress, with them seems to advance the number of people with health problems, unhappy and suffering (Ștefăneț, 2007).
The treatment of diaphyseal fractures of the leg is complex, orthopedic by plaster immobilization and / or surgically by osteosynthesis with blocked, unblocked or elastic centromedullary nails; screw plates; external fixator, thus in the choice of therapeutic methods must take into account the morphopathological characteristics of the fracture (number, location, type of fracture, etc.), age, general condition of the traumatized, the presence of shock, especially if the fracture is part of a polytrauma and not lastly, the logistics of the service and the expertise of the surgical team, which directly influences the results (Buciu, 2014).

### *Diaphyseal fractures*

The diaphysis of the long bones corresponds to the middle portion, located between the two epiphyseal extremities (Fig. 1.1). A cross section of the diaphyseal axis allows us to observe that the diameter of the diaphysis is not constant, the medullary canal progressively widening towards the extremities. The diaphyseal medullary canal does


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not contain hematopoietic bone marrow (located in the epiphyses), but fatty bone marrow and vessels of medullary origin.

**Figure no.1. Tibial fractures and diaphyseal fibula.**
Source: (Buzdea, M.)

The cortical bone follows a different evolution during the life of the individual. Thus, aging leads to a progressive physiological resorption of the cortex. This decrease in cortical thickness also occurs in pathological cases, such as during prolonged immobilization leading to osteoporosis of immobilization, much more pronounced in the case of spongy bone than cortical bone.

***Treatment of diaphyseal fractures***
Surgical treatment includes two major concepts: rigid osteosynthesis with plaque or static fixator that leads to the formation of an endosteal callus and performs a bone reconstruction by osteonal remodelling. Elastic osteosynthesis with centromedullary pins or nails has the disadvantage of damaging the endomedullary vessels, but leads to the formation of a periosteal peripheral callus and the early resumption of axial mechanical stimulation favorable to osteonal reconstruction.
Internal osteosynthesis with open focus screws are indicated in long spiro or oblique fractures. Screw plates are rigid implants, used in case of transverse fractures or with minimal comminution. The compression of the fracture focus is achieved by using self-compressing plates.
Internal osteosynthesis with closed focus uses implants (pins, rods) inserted in the medullary canal at the level of the epiphysis, at a distance from the focus of the diaphyseal fracture. The rigid centromedullary rods (Kuntscher, Grosse, Kempf) are inserted into the medullary canal with the help of the bore (which calibrates the middle portion of the medullary canal, which leads to a better stabilization of the assembly).

## Methodology

***The test bench***
A bench (Fig. 2) was built to immobilize the bones with a vise, which is on one side of the bench and a pulley on the opposite side to extend the bone. A weight between 1

and 2 kilograms was used for the extension. The base of the bench is made of a polished and lacquered wooden board.

**Figure no. 2. The bench made for bone immobilization**
Source: Authors' own contribution

***Inserting the nail into the channel***
This section contains the research methods used by the author, the main research hypotheses, and the arguments for defining them. The author should explain the qualitative and quantitative methods used and how the research has been designed and performed.
The author should make references to some previous research similar to the present one, if that is the case. Also, the author should mention the software programs used for processing statistical data, if it is the case.
With the help of a self-tapping screw and a drill with a diameter of 10 mm, the channel was opened through the entry point located in front of the tibial plate. After drilling, the channel was reamed so that the rod could be inserted using only physical force.
The first part of the guide system was mounted on the rod, which is fixed with a screw with a clamp in the proximal part of the rod. By pushing and with left / right twisting movements the rod will be inserted into the centromedullary canal to its distal end. There are cases where it is necessary to use the hammer that attaches to the proximal end of the rod in order to be able to insert the rod.

***Fixing the bone in the test bench and making the distal holes in the sagittal plane***
Initially, the bone is placed in the vise and fixed in the antero-posterior plane in its proximal part between the vise jaws. In the distal plane, the bone is fixed with the help of a pin to which a horseshoe is attached, which is fastened with a cable that crosses the pulleys and has the weight at the opposite end to achieve the extension of the bone.
After mounting the distal guide, 2 other guides will be inserted on it, with the aim of:

- The first has the role of protecting the soft tissue (muscles and skin)

- The second one attached inside the first one has the role of channeling the drill for drilling.
- The drill with which the holes were made has a diameter of 4.2 mm and a length of 310 mm.

## Results and discussions

For this study, 10 images obtained from the 5 bones were processed, so the image of the first and second distal holes in the sagittal plane was taken from each bone. On the guide that serves to protect the soft tissue, the camera was inserted on a length of about 9 cm and the first hole in the bone was photographed as well as the position of the rod in relation to it.
This procedure was repeated for each hole of all the bones separately.

**Table no 1.** ***Deviations of holes in the Cartesian XOY coordinate system***

| **Distal holes** | **Bone no. 1** | | **Bone no. 2** | | **Bone no. 3** | | **Bone no. 4** | | **Bone no. 5** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | X | Y | X | Y | X | Y | X | Y | X | Y |
| **Proximal (mm)** | 0,34 | -1,21 | 3,04 | 4,06 | 0,00 | 4,98 | -3,02 | -3,70 | -1,40 | 0,90 |
| **Distal (mm)** | 1,82 | -0.39 | -2,27 | 4,71 | 0,20 | 0,10 | 1,70 | 4,33 | 0,99 | -0,60 |

Source: Authors' own research.

## Conclusion

The continuous development of this field is particularly important for maintaining a good health of the population. Continuous research to improve the mechanisms created by bioengineers in prosthesis / orthosis contributes to increasing the quality of life of people who need such devices.
Open leg fracture is the most common of the open fractures. The severity of open leg fractures is related to the demands of this anatomical segment, to the fact that the tibia, most often affected, is superficial and exposed, for much of its length and of course closely related to the particular biomechanics of this segment.
The mechanical system currently used does not completely eliminate the use of the C-arm with Roentgen radiation, as in some cases it may be strictly necessary. The current method used is invasive for both the patient and the medical staff involved in the surgical process, so we want to improve this method by creating non-invasive conditions, with maximum efficiency and minimizing the operation time.
Following the results of the measurements performed as well as the known problems related to the large number of degrees of freedom that the assembly has, it is desired that the system be improved in terms of reducing the number of parts required for the construction of the guide and a more stable fixation in the points.

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