THE EFFECT OF POSITIONING ERROR OF SCREWS ON THE STABILITY OF FIXATION

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1. Introduction
It was Jenő Manninger and co. who elaborated the method of double canulated screwing for the treatment of the fracture of the neck of the femur. Precise, covered reposition – the positioning of screws in relation to the anatomic points and to each other – is an indispensible part of a properly performed operation. This condition is ensured by the determination of the support points of screws and also the determination of the direction of screws along with the wanted reduction of the fracture in such a way that we prevent torsion in relation to the axis. If the use of a parallel guide is ignored and the insertion of screws is done by freehand targeting and by the use of an image intensifier, the chance of error increases which has a negative effect on the parallelism of screws. By studies on finite elements I wish to prove that a positioning error causes a decrease in stability and I also estimate its magnitude.

2. Method
The applied software: Finite element studies were carried out with the integral finite element module of the designing system CAD 2010 of SolidWorks, the SolidWorks Simulation software. The structure of the geometric model is like this. During the biomechanical modelling I constructed the screw for the neck of the femur in compliance with reality, however, I modelled the related cortical bone layer with a square-based prism of an area of twenty by twenty mm, with a thickness of 4 mm, into the centre of which the counterpart of the threads of thread profiles was placed. Although this bone model does not follow the real geometry of the head of the femur, but it is absolutely suitable for the detection of the effect of the positioning error which can be made while driving the screw.

Construction of the finite element net: To make a net for the models (screw and bone) I used tetrahedron items with four junctions. The global size of items was 2 mm. In case of screws for the neck of the femur local thickening of the net was performed at the driven part of the thread (here the local size of items decreased to 0.12 mm), and also in the internal threaded part of the cortical bone (here, similarly to the screw, the size of the item decreased to 0.12 mm). For a more precise follow-up I used further thickening of the net, here I decreased the size of the item to 1 mm. Edge conditions and loading: On the lower surface of the cortical bone, outside the circle with a diameter of 13 mm from the junction of the thread. To prevent a move of the layer of the bone I used a fix holding preventing any move or turning. In order to ensure a move of the implant exclusively in the direction of the axis, on its stem I used a holding of a radial direction and one preventing a turning of the angle. In case of each model, loading power was placed across

Figure 1. The initial geometric model
the lower part of the implant – in case of models carrying out straight driving perpendicularly to the surface and, in case of models simulating slant driving, parallel to the lateral side of the bone blade.

![Figure 2. Screw driven into the bone with a positioning error of 5 degrees](image)

Characteristics of materials: Characteristics of materials used in case of models and essential for the study are included in the table below. During calculations I used a linearly flexible material law.

<table>
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<th></th>
<th>E [MPa]</th>
<th>v</th>
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<tr>
<td>Cortical layer</td>
<td>16.500</td>
<td>0.3</td>
</tr>
<tr>
<td>Implant</td>
<td>200.000</td>
<td>0.26</td>
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Contact relation between contiguous items: Taking into account the actual relations between contacting items I defined the so-called No Penetration contact relation, owing to which the individual surfaces can freely move on each other, but they cannot penetrate into the other one, thus modelling the real contact relation. To the determination of the results of calculations: On demonstration of the results I maximized tension scale in 70 MPa. I carried out runs until in case of thread cut into the bone somewhere a tension exceeding 70 MPa appeared.

3. Result
In case of straight driving of screw fixing the neck of the femur: the loading power on the effect of which a larger tension – 400 N – rises, which is larger than the limit tension, whereas in case of slant driving of the screw fixing the neck of the femur this loading power is 350 N.

![Figure 3. Tensions rising in a screw in case of slant driving, illustrated in section](image)

4. Conclusion
The effect of a positioning error: In case of double canulated screwing on driving one of the screws into the bone with a positioning error of 5 degrees we found that the power required for pulling the screw out decreases by 12.5 % on the average. We also studied the effect of a positioning error in case of a so-called duplex-threaded screw fixing the neck of the femur, and we found that in the latter case it is even more significant, 13.5 – 15 %, depending on the position of running out of the end of the screw in case of an angle error. Further on I would like to continue the study by refining the biomechanical model, by the creation of the real geometry of the head of the femur.

5. References