

## A comparative analysis of four implants used to treat a supracondylar periprosthetic fracture of osteoporotic femur

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A total knee arthroplasty (TKA) is in rare cases followed by an extra-articular fracture of distal femur. It happens mostly in elderly patients with osteoporosis and can be stabilized only by a surgical treatment. Several implant types are used by orthopedic surgeons for its management. In this study we compare a response to axial load and torque for four implants: Distal Femoral Nail (DFN), Locking Compression Plate (LCP), Angled Blade Plate (ABP) and Dynamic Compression Screw (DCS).

The geometry of femur with fracture and the implants is the same one as in the previous studies [2, 3]. Both compact and spongy bone are modelled by 3D elements. The gap of a simple extra-articular fracture is 2 mm wide. There is no callus formed. The finite element models with the implants are shown in Fig. 1.



Fig. 1. The frontal (left) and lateral (right) view of model of femur with TKA (green), fracture (black) and implants from left to right: DFN (red), LCP (dark blue), ABP (pink) and DCS (light blue)

The material parameters of osteoporotic bone were taken from Jimenez-Cruz et al. [4]. The screws, the spiral blade and the implants are made of titanium alloy.

Two types of load were used as in the previous study [3] – the uniaxial load on the femoral head and the torque. The loading conditions correspond to those of Brinkman et al. [1]. For both loads, a rigid body was formed at the surface of the femoral head and the greater trochanter and all degrees of freedom of the distal part of the femoral component were fixed. In case of the uniaxial load, a force corresponding to the body mass of 80 kg was applied on the center of femoral head in the direction of mechanical axis and all other degrees of freedom were fixed. For torque, a moment of 5 Nm was applied on the center of femoral head about the mechanical axis and all other degrees of freedom except the movement in axial direction were fixed.

The von Mises stress distribution in the implants and the displacement of femur in all three main directions were analyzed for the four implants and the two loading conditions.

The results of uniaxial load are similar to those of the previous studies [2, 3]. In case of DFN there is an increased stress in the middle of the spiral blade in the area in contact with the nail and in the nail in the area around and above the fracture location. Von Mises stress in the three external implants is the highest in the area below the lowest nail in the diaphysis. The screws are loaded mainly in the area of their intersection with compact bone. The displacement in all cases is the most prominent in the sagittal plane, the femoral mid-shaft bends ventrally in all cases. The medio-lateral movement and the compression in the direction of axial load is significantly lower.

With torque about mechanical axis, the greater trochanter rotates dorsally for all implants. The femoral mid-shaft undergoes at least twice as large rotation along the mechanical axis in case of LCP over the remaining three implants. Also the stress reaches significantly higher values in LCP implant, especially below the level of the screws in the diaphysis and at the level of upper three screws on the condyle.

The most important difference among the four implants is in the rotation along the mechanical axis in case of LPC under torque consequently causing notably higher stress in the implant.

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