Introduction:
For younger patients many surgeons recommend femoral neck endoprostheses as an alternative to stemmed implants in THA. Due to their only metaphyseal anchorage several advantages are quoted:
i) mainly a less invasive primary surgery
ii) in case of a revision a simply removable implant
iii) as well as the preservation of the femoral diaphysis for the fixation of the revision implant (Scholz & Grundei, 1996; Thomas & Grundei, 1999).

A determinant factor for the long term stability of an implant is the load transmission to the bone stock. Because so far only few information about the stress transmission of femoral neck prostheses is available, an experimental study was performed. Aim of the study was the comparison of bony strain patterns of two different femoral neck prostheses and a standard cementless hip stem before and after implantation.

Methods:
So called 'composite femora' (Sawbones Europe), with stiffness characteristics close to human femora (Cristofolini et al., 1996), were used because of their good reproducibility due to identical structure and geometry. For the experiments these bones were coated with a layer of the photoelastic material PL-1 (Measurements Group).

Two different designs of femoral neck prostheses (only intraosseous anchorage (type CUT) vs. lateral traction screw (type CIGAR)) and a cementless standard hip stem (type GHE) were compared (all implants from ESKA Implants, see figure 1).

Figure 1: Radiographs showing the two types of femoral neck prostheses (type CIGAR and CUT) and the cementless GHE hip stem (from left to right)
The static test load, consisting of the resulting hip joint force (Bergmann et al., 1993) and muscle forces (abductors, tractus iliobialis), was applied by a universal testing machine and additional weights. Using the photostress analysis, the implant related bony strain alterations were measured along the cortical surface (medial, ventral, lateral, and dorsal). Each type of implant was tested within three composite femora. The statistical analysis was based on a 99 % confidence-interval, determined by unresected femora.

Results:
The unresected femurs showed an excellent match of their bony strain pattern. Depending on the fixation principle, the implantation of the femoral neck prostheses caused highly significant changes in strain at the lateral peri-implant cortical bone. The implant type CIGAR lead to a change from pre-operative tension to compression above the lateral traction screw (below trochanter major) (see figure 2). Only mild increased strain at this subtrochanteric area was seen after implantation of the implant type CUT with inner contact to the lateral cortical bone (see figure 2).

Along the medial cortical bone below the resection plane reductions in strain were measured for both types of femoral neck prostheses (see figure 3). In contrast, the cementless GHE hip stem caused more marked stress shielding along both the medial and lateral cortical bone (see figure 2 and 3).

No significant changes in bony strain were detected for any implant at the ventral and dorsal aspect.

Figure 2: Strains along the lateral cortical bone after implantation of the various implants in comparison with the 99% confidence-interval, determined by unresected femora
Discussion:
With both types of femoral neck prostheses bony strain changes were limited to the trochanteric region of the femur. The results after implantation of a cementless hip stem showed more pronounced stress shielding effects which are considered to be an important factor for resorptive bone remodelling. Looking at the femoral neck prostheses the intraosseous fixation mechanism came off better regarding post-operative strain distribution than the implant with the lateral traction screw. The design with the traction screw led to a changeover of pre-operative tension to compression at the lateral subtrochanteric region.

References:
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Bergmann G. et al. J. Biomech. 26, 969-990, 1993

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