ABSTRACT INTRODUCTION:
Implantation of total hip arthroplasty (THA) may induce remodelling of the periprosthetic bone structure. Many implant-related parameters, like material properties or implant design influence the remodelling processes. During the past years, there is a tendency to shorter hip stems to preserve femoral bone stock and to reduce the risk of proximal stress shielding.

The aim of this biomechanical study was to analyse possible biomechanical reasons for the formation of these distal hyperthrophies. Therefore we determined the primary stability, which has notable influence on long-term stability of the implant. We compared the Fitmore® stem to the well established CLS® stem.

METHODS:
A standardized neck resection was performed on eight synthetic femurs (composite bone 4th generation, size large (#3406), Sawbones®, Sweden). Four Fitmore® stems (size B 10 extended, Zimmer, Switzerland) and stems four CLS® stems (size 10, Zimmer, Switzerland) were implanted using a material testing machine (Frank-Universalprüfmaschine 81816/B, Karl Frank GmbH, Germany). The stems were pressed into the synthetic bones in a stepwise manner by 25 cycles of F1 = 2000N (to simulate the intra-operative forces while implantation) followed by 25 cycles of F2 = 4000N (to simulate the first post-operative loading situations). The implant fit was controlled by X-ray examination.

Micromotions at different points were measured, as shown in figure 1: at the stems (# 1: stem shoulder, # 2: distal stem tip) and at the femurs (# 0: Trochanter minor – served as reference, # 3: 8cm distal to the Trochanter minor, # 4: same site as # 2, # 5: 20cm distal to the Trochanter minor, # 6: same site as # 1). A high precision measuring device was used under two different cyclic load applications. An axial torque of +/-7Nm was applied to analyse the bending-behaviour of the stem (figure 2a). In a second step a varus-valgus-torque of +/-3.5Nm was applied to analyse the bending-behaviour of the stem (figure 2b).

Comparing the motions of the stem and femur at different sites allowed the calculation of relative micromotions at the bone-implant-interface.

RESULTS:
The lowest relative micromotions were detected within the proximal part of both stems near the Trochanter minor (Fitmore® = 7.50mdeg/Nm and CLS® = 6.97mdeg/Nm). Maximum relative micromotions were found at the distal tip of the stem for both designs, in which the shorter Fitmore® stem showed lower relative micromotions (11.91mdeg/Nm) compared to the CLS® (16.12mdeg/Nm), indication a proximal fixation of both stems.

During the varus-valgus-torque application, the Fitmore® stem showed absolute micromotions of 0.26 (SD ±0.07) mdeg/Nm at the proximal stem shoulder and -0.01 (SD ±0.05) mdeg/Nm at the distal tip of the stem (Fig. 4). With 1.80 mdeg/Nm in the proximal region and 8.00 mdeg/Nm distally the CLS® stem, however showed a higher flexibility compared to the Fitmore® stem.

DISCUSSION:
Both stems showed low micromotions within the proximal part of the stem. The relative motion in both groups seems to be sufficient for a tight primary stability of the stem. The proximal anchoring behaviour might not be a plausible biomechanical explanation for the formation of distal hyperthrophies.

Under medio-lateral torque application, the CLS® stem acts more flexible compares to the Fitmore® stem. Presumably the CLS® stem followed the physiological bending of the bone, whereas the shorter Fitmore® stem is closer to a rigid body. This may be due to an enlarged axial cross-section of the stem and therefore an enlarged implant stiffness of the Fitmore® compared to the CLS®. Such a rigid bending of the stem may induce high intra-femoral stresses which may possibly lead to cortical hyperthrophies.

SIGNIFICANCE:
This study showed that the CLS® stem and the Fitmore® stem biomechanically behave different under varus-valgus-torque application. The rigidity or flexibility of a stem needs to be considered as they may influence the load transfer at the implant-bone-interface and thus possibly affect the bone remodelling processes clinically. In particular shorter and thicker stems may be confronted with increased rigidity.