Introduction
Orientation of an acetabular component is supposed to be important for the early as well long-term result of total hip arthroplasty (THR). Navigation techniques claim to improve the accuracy of hip cup orientation compared to the non-navigated, manual method. Aim of this in-vitro study was to compare the hip cup orientation when using different navigation systems and the non-navigated technique. In addition, the question, whether the experience of the surgeon influence the quality of cup position, should be answered.

Methods
Five navigation systems were used:

- Vectorvision®, 2, Hip 2.0, CT-based.
- Navitrack™, CT-based.
- Navitrack™, CT-free.
- Orthopilot®, Acetabular Module Version 1.1, CT-free.
- SURGETICS Station®, ESKA HIPLOGICS® Version V1.0, CT-free.

CT-scans of a human cadaver pelvis were performed. A rectangular block comprising the left acetabulum was removed from the pelvis. A negative mould of this acetabulum block was used to produce 90 positives made of polyurethane foam. Before each cup implantation a new polyurethan acetabulum was placed into the pelvis specimen. Due to the fit of the mould, the position and orientation of the artificial acetabulum relative to the pelvis was constant. The whole pelvis was placed within a dummy (Fig.1). In order to adequately simulate a real surgery, the dummy was covered like in a real surgery.

Figure 1: Setup.

An inexperienced, an experienced and an very experienced surgeon regarding manual THR (10, 70 and 480 surgeries respectively) participated. Non of the surgeons had any experiences with any of the navigation systems. For every hip cup an inclination angle of 30° and an anteversion angle of 10° was planned. Registration and calibration of the navigation systems were performed by a company representative. Each surgeon implanted five system specific hip cups using conventional manual technique and afterwards with each of the five navigation systems.

Following each surgery the acetabulum block containing the cup was removed from the hip specimen. After the surgeries the specimen was removed from the dummy and fixed on a coordinate measuring machine (Mitutoyo Messgeräte GmbH, Germany). Inclination and anteversion were determined with an accuracy of +/− 0.5°. Statistical analysis was performed by means of analysis of variance (ANOVA) using SPSS for Windows (Version 9.0.1). Independent variables were the experience of the surgeon and the implantation technique (5 navigation systems and the non-navigated method). Dependent variables were the measured inclination and anteversion angles. All statistical tests were performed with a confidence interval of 95% (α=0.05).

Results
For the navigation groups maximum differences from the planned values of up to 10 degrees were observed for the inclination angle and up to 13 degrees for the anteversion angle. For every surgeon the standard deviation of the inclination and anteversion angles were higher for the non-navigated compared to the navigated techniques (Fig. 2, Fig. 3). For the inexperienced surgeon the standard deviation of the anteversion angle was about three times higher in the non-navigated group compared to the more experienced surgeons.

Significant differences between the surgeons regarding the inclination angle were observed for one navigated group (Surgetics-Station®: p=0.047) and regarding the anteversion angle for two navigated groups (Orthopilot®: p=0.019; Surgetics-Station®: p=0.011). The inclination angle achieved with the Navitrack™ CT-based system was significantly lower (p=0.014) and with the Vectorvision® system significantly higher (p=0.042) compared to the non-navigated group. The anteversion angles of two navigation groups were significantly better compared to the non-navigated group (Navitrack™ CT based: p=0.001; Orthopilot®: p=0.019, Vector vision p=0.001).

Discussion
The use of computer navigation helps the surgeon – independent of the level of experience – to place the acetabular component with less variability regarding inclination and anteversion. The probability of extreme cup positions (as it has observed for the non-navigated group) is reduced. If the cup inclination and anteversion is clinically important, navigation techniques should be used for every THR.

![Inclination angle](image1)

![Anteversion angle](image2)