Optimization of a femoral stem prosthesis

Question:
For optimal biomechanical function of the hip joint, a femoral neck angle (= CCD angle) of less than 130 degrees is desirable. In addition to the higher mobility, a low CCD angle also results in a high 'offset' (i.e., greater horizontal distance to the center of rotation), which provides greater stability due to the high soft tissue tension. Earlier generations of prostheses often had CCD angles well above 135 degrees because the higher leverage at higher CCD angles was not tolerated by the state-of-the-art material technology.

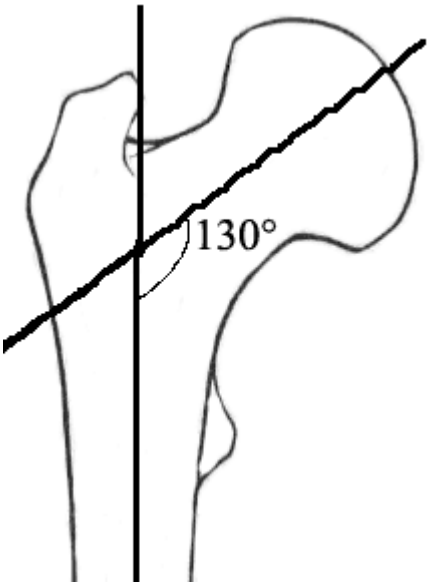

Figure 1: Determination of the CCD angle

The aim of the statistical analysis was to examine the following questions:

Are women and men different with respect to the CCD angle?
Is there a dependence of the relation CCD angle / offset on the body size?

The outcome of these questions will affect the optimal implant design:
depending on gender and body size, the chosen optimal angle will be rather specific. In turn, the age dependency is less relevant since prosthetic surgery is usually performed at a later age.

Methods/Data:
Based on a patient collective of n = 150, the natural anatomical parameters could be measured exactly. The dependence on gender and height was tested by multiple regression analysis.

Results:

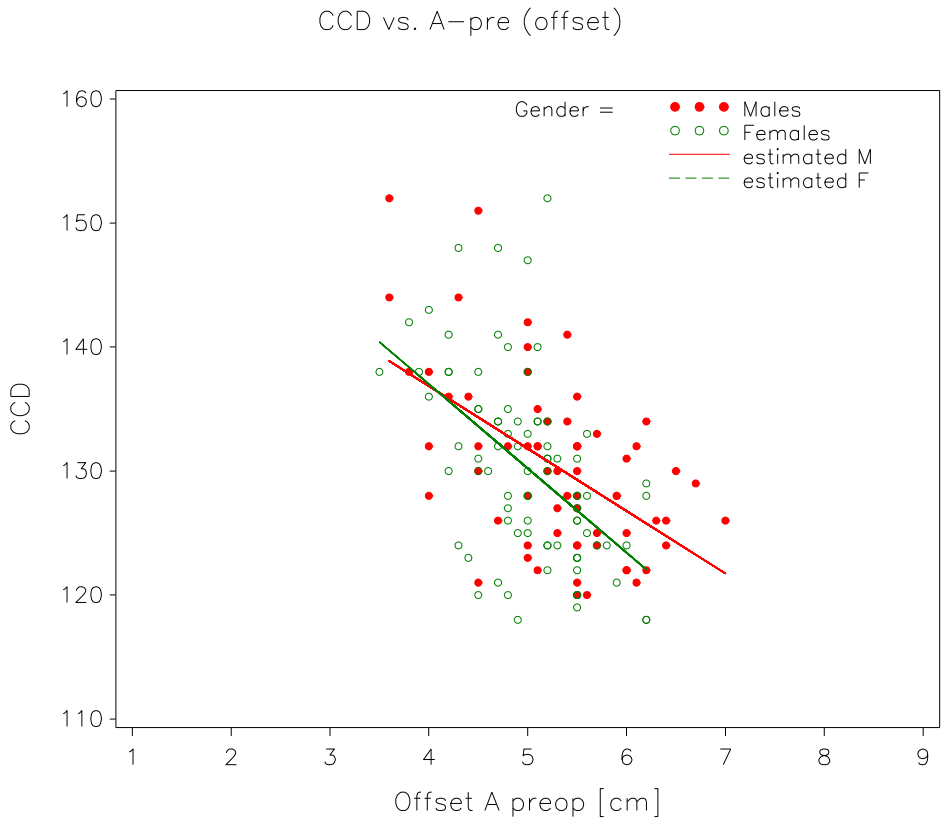

Figure 2: Scatterplot CCD-angle and Offset

The median of the CCD angle measured in the study collective is 130° degrees, that is 5° degrees smaller than the used prosthesis. There is no gender dependency, but a clear relationship to the off-set: the smaller the CCD angle, the larger the off-set (cf. Figure 1). However, there is no dependence on size, i. larger prostheses do not have larger CCD angles - due to the mass increase with potency 3 and correspondingly higher bone load, a non-linear decrease of the CCD angle would not be implausible.
However, men have a significantly greater offset than women, 5.5 mm v. 5.2 mm.

Conclusions:
By reducing the CCD angle by the optimized amount x with a corresponding increase in the offset by amount X, the prosthesis could be substantially optimized. The optimized amount x was determined on the basis of the statistical frequency distribution. The lower 95% percentile of the distribution was 128.5 degrees and only 5% of the patients had smaller CCD angles. The height of the offset can be varied on the one hand by choosing the implant size and by using different attachments.

In the new design with optimized CCD angle, the femoral prosthesis better corresponds to the natural anatomical conditions, with the following improvements:

- better mobility
- higher stability

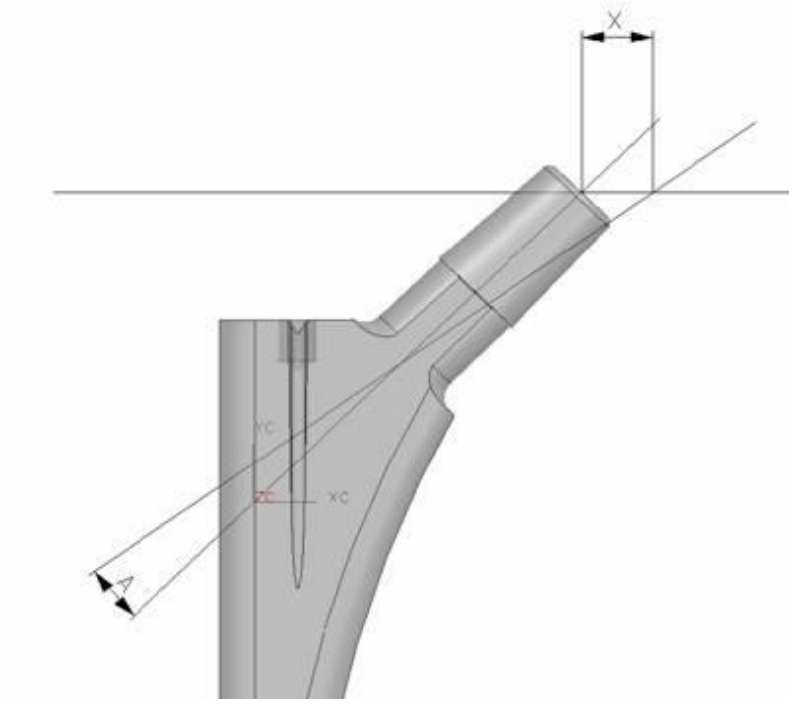

Figure 3: enlargement of CCD angle and offset of the new lateralized shaft

The publication of this project in this form has been authorized (Peter Münger, MPH, Head Clinical Affairs).