SUMMARY

The low contact stress (LCS) concept in total knee arthroplasty (TKA) depends on free rotation of a highly congruent bearing around a central axis. These conditions would reduce polyethylene wear and loosening stresses through a mechanism called load sharing. Our original objective was to determine axial knee rotation of the LCS knee \textit{in vivo} and compare these results to a fixed bearing (FB) TKA variant.

In order to do so, it was necessary to perform a methodological study to validate the use of a femoral tracking device for noninvasive optoelectronic motion analysis to compensate for surface marker artefact. Using model-based fluoroscopy as gold standard, the precision of the Femoral Epicondylar Frame to measure of axial knee rotation at a group level turned out to be acceptable (3.3 degrees). In a second methodological study the influence of turning on axial knee rotation was determined. Healthy subjects were measured while performing a sit-to-walk (STW) task with and without turning. The addition of a turning movement showed an increase of the range of rotation from 14 to 21 degrees, which was due to significant increases in both internal and external tibial rotation during crossover- and sidestepping, respectively.

Using the methodology from these two studies, a first clinical study was conducted with patients after replacement with either a LCS Rotating Platform (RP) knee or a NexGen FB knee. In the RP group, the range of rotation was 21 degrees and appeared to be available during STW with and without turning.
In the FB group rotation gradually increased from 12 degrees during STW without turning to 14 degrees during STW with turning. These findings may not be sufficient to proof the kinematic functioning of the LCS concept, but they do suggest that complex three-dimensional loading conditions could be helpful in exploring the geometric constraints of TKA. In a second clinical study patients with a LCS RP knee were measured either one year or five years postoperatively. It was shown that the range of 21 degrees of axial knee rotation remained constant from one to five years postoperatively. Complementary to these study results a thorough non-systematic review on the historical background and mechanical and clinical aspects of LCS RP TKA was carried out. Further kinematic, kinetic and tribologic support for the functioning of the LCS concept was found, although superior clinical results over FB variants have not been proven.

Some shortcomings or points open to discussion were identified in the available literature: (a) The original LCS RP knee was designed to promote load sharing and not to solve a kinematic conflict (e.g. patterns of rotation are unnatural); (b) studies with MB variants should make use of a uniform quantifying measure to describe femoral side condylar congruency to discriminate LCS derivatives from others; (c) Ideally, in vivo derived kinematic and kinetic parameters should be integrated in a mathematical model, which reconstructs three-dimensional loading conditions representing daily life activity; (d) Published prosthetic survival data do not exceed 20 years of follow-up, which ultimately makes comparison to FB still undecided.
With the improvement of material quality, prosthetic wear will become less of a problem. However, as long as prosthetic fixation does not improve, the onset of aseptic loosening will always be a possibility. This, and the limited knowledge of functional performance under relatively complex loading conditions, justifies keeping the LCS concept involved in further TKA development.