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The primary aim of this work was to develop novel model-based mJSW measurement methods using a 3D reconstruction and validate the accuracy and precision of these methods. The model-based measurement results were compared to conventional mJSW measurement results. This thesis contributed to the development, validation and clinical application of model-based mJSW measurements for the natural knee and for total knee prostheses (TKAs).

The first chapters of this thesis (Chapter 2 and 3) focus on the in vitro validation of the model-based mJSW measurement for TKAs for model-based RSA and standard radiographs respectively. These studies showed that the model-based mJSW measurement is robust to variations in phantom positioning and prosthesis design. The best accuracy and precision was found for RSA (0.1 mm and 0.2 mm respectively). For standard radiographs, the accuracy and precision were superior to the conventional measurement methods.

The purpose of Chapter 4 was to investigate whether the measurement outcome is different in weight-bearing (WB) and non-weight-bearing (NWB) images due to knee laxity. This was investigated with 23 TKAs from an ongoing RSA study. The mJSW measured for the condyles was significantly larger in NWB images (difference of 0.28 mm medially and 0.20 mm laterally). In conclusion, mJSW are influences by
knee laxity for NWB images.

In Chapter 5 the validation of the model-based mJSW measurement for plain radiographs is continued with an in vivo study. The actual thickness of 15 retrieved inserts was compared to the mJSW measured in pre-operative radiographs. This study showed that the model-based measurement had a higher accuracy and a similar precision compared to the conventional measurement. It seems that the measurement outcome is influenced by differences in femoral contact location or loss of femoral contact.

Model-based techniques can also be used to measure the TKA wear volume. In Chapter 6, simulations were conducted to assess the robustness of this measurement technique. The current error in 3D pose estimations in RSA imposes a considerable impact on the precision of volumetric wear measurements. The measurement was validated with inserts of which the wear volume was known. Results showed that at most 56% of the true wear volume was detected. The use of the measurement with the current technology is not recommended.

Chapter 7 shifts focus to the validation of mJSW measurements for the natural knee. In this case, statistical Shape Models (SSMs) are used to reconstruct the patient specific tibia and femur based on stereo images. It is shown that the SSM-based mJSW measurement method has a higher robustness but lower detectible mJSW difference than the conventional 2D method. Further research is required into improvements such as the use of a larger training set or smarter correspondence algorithms based on edge orientation or feature detection.

In conclusion, this work presents convincing evidence that the mJSW measurement accuracy and precision is improved using model-based measurement techniques in RSA images as well as in standard AP radiographs. The next steps towards clinical application are to improve the measurement software and to conduct further research on the influence of knee flexion and implant design on the reliability of mJSW as surrogate for the insert thickness.