Measurement of the knee flexion angle with a smartphone application is precise and accurate

JENNY JY

Center for Orthopedic and Hand Surgery, University Hospital, Strasbourg, France

jean-yves.jenny@chru-strasbourg.fr

Introduction: The knee range of motion is a relevant information during clinical examination of the knee. Measurement of the maximal extension and flexion angle is routinely performed during clinical examination of the knee, and these items have a significant influence in any knee scoring system. This measurement is generally performed by visual analysis or with manual goniometers, but it has been extensively demonstrated that these techniques are neither precise nor accurate, with substantial variation up to 10 degrees. More sophisticated techniques, such as accelerometers, electronic goniometers or gait analysis are only possible in experimental studies and not in a routine setting. Smartphone technology might offer a new way to perform this measurement with increased accuracy. We hypothesize that the measurement of the knee flexion angle with this new Smartphone technology will differ from the reference measurement with an navigation system.

Material: 10 patients participated to the study. Inclusion criterion was the implantation of a with operated on for total knee replacement (TKR) for end-stage knee osteoarthritis with help of a navigation system. There was no exclusion criterion. 3 men and 7 women, with a mean age of 69.5 years, were analyzed.

Methods: The navigation system is able to measure very accurately the knee flexion angle. The Smartphone application allows measuring this angle in two steps 1) recording the reference position by putting the Smartphone on the operating table, 2) recording the knee flexion angle by putting the Smartphone against the tibial crest. Two observers participated to the study. The first observer performed two independent sets of measurements by positioning the knee under visual control in full extension, at 0°, 30°, 60°, 90° of knee flexion and at maximal flexion, and recording both navigated and Smartphone measurements of the knee flexion angle at each step; the second observer performed only one set of measurements with the same process. The intra- and inter-observer variability was assessed by calculation of the intra-class correlation coefficient (ICC). Navigated and Smartphone data were compared by a paired Student t-test at a 5% level of significance. The linear correlation coefficient between the two measurement techniques was calculated. The agreement between the two measurement techniques was assessed according to the Bland-Altman technique.

Results: The mean paired difference between all navigated and Smartphone measurements was -2° (range, -16 to 11°) ($p=0.02$). There was a significant correlation between navigated and Smartphone measurements ($r^2=0.98$, $p<0.001$). The coherence between navigated and Smartphone measurements was good ($r^2=0.01$), with only 4 paired differences higher than 10°. The ICC between the two sets of measurements by the operating surgeon was 0.81. The ICC between the first set of measurements by the operating surgeon and the set of measurements of the assistant surgeon was 0.79.

Discussion & Conclusion: The basis hypothesis of the present study was not confirmed. There was no significant difference between the measurement of the knee flexion angle with the smartphone application and with the navigation system. Furthermore, there was a good intra-observer and inter-observer reproducibility of the smartphone measurements. Consequently, the smartphone application may be considered as precise and accurate. Using this technology to assess the knee range of motion allows an accurate scoring of this item, which is significant in all scoring systems. The accuracy may be higher than other conventional measurement techniques, and specially visual assessment which is most commonly used in the routine practice. Furthermore, this technology may be used to monitor the rehabilitation course by the physiotherapeutist or even the patient him- or herself, avoiding unnecessary postoperative visit or suggesting the occurrence of arthrofibrosis.

Summary: The Smartphone application allows improving significantly the precision and the accuracy of the measurement of the knee flexion angle without technical difficulties.