Validation of a Mobile Phone Application for Measuring Knee Range of Motion

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INTRODUCTION: Knee range of motion (ROM) is an important indicator of knee function. Clinically, knee ROM is typically evaluated visually or with a goniometer. Outside the clinical setting, patients may not be able to accurately assess their knee ROM, which may impair their recovery following traumatic injury or total knee arthroplasty. This study aims to validate a mobile phone application developed to measure knee ROM compared with visual and goniometer ROM measurements performed in an orthopaedic clinic setting.

METHODS: A mobile application was developed to measure knee ROM utilizing the gyroscope sensor embedded in all Android smartphones. IRB approval was obtained and patients ≥18 years old presenting to an orthopaedic clinic for a knee complaint were approached to participate in the study. Knee ROM was measured bilaterally by the treating surgeon using three techniques: 1) visual, 2) goniometer, and 3) mobile application. Patient demographics and Kellgren-Lawrence classification were obtained when available. In order to only evaluate native knees, any knees with prior arthroplasty procedures were excluded from statistical analysis. Knee ROM measurements were compared between the three groups based on 1) flexion and 2) extension using a one-way ANOVA with post-hoc Tukey test utilizing an alpha = 0.05.

RESULTS: Eighty-four knee ROM measurements (40 left, 44 right) in 47 patients (mean age: 66.4 ± 11.2 years, 57.4% female, mean BMI: 32.0 ± 6.3) were analyzed. Mean Kellgren-Lawrence classification was 2.9 ± 1.1, although 22 asymptomatic knees were not classified due to lack of available radiographs. For flexion measurements, the mobile application (117.6 ± 14.7°) was not statistically significantly different from visual (116.1 ± 13.6°) or goniometer (116.2 ± 13.6°) measurements. For extension measurements, the mobile application (-4.8 ± 7.3°) was statistically significantly different ($p < 0.01$) from visual (-1.9 ± 4.1°) measurements on post-hoc analysis, while no differences were detected compared to the goniometer (-3.1 ± 5.8°) measurements.

DISCUSSION AND CONCLUSION: Our study demonstrated that a mobile application for evaluating knee ROM was non-inferior compared to visual and goniometer-based measurements performed in clinic by an orthopaedic surgeon. Differences in extension measurements observed may be due to reduced variability of visually performed extension measurements and operator error due to thigh positioning during mobile application measurements. Such an application has value in the patient rehabilitation setting, while also improving health equity and accessibility to tools for improving knee function. Future studies will implement this application in the hands of patients, particularly exploring if the application is a useful adjunct for 1) accelerating rehabilitation or postoperative recovery and 2) detecting early complications such as postoperative stiffness or arthrofibrosis.