The Knee xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

The Knee

Smartphone assessment of knee flexion compared to radiographic standards

Matthew J. Dietz [b,*], Daniel Sprando [a], Andrew E. Hanselman [b], Michael D. Regier [c], Benjamin M. Frye [b]

[a] Washington and Jefferson College, 60 South Lincoln Street, Washington, PA 15301, USA
[b] Department of Orthopaedics, West Virginia University, PO Box 9196, Morgantown, WV 26506-9196, USA
[c] Department of Biostatistics, West Virginia University, PO Box 9190, Morgantown, WV 26506-9190, USA

ARTICLE INFO

Article history:
Received 10 September 2015
Received in revised form 17 November 2016
Accepted 27 November 2016
Available online xxxx

Keywords:
Smartphone
Accelerometer
Motion
Measurement

ABSTRACT

Background: Measuring knee range of motion (ROM) is an important assessment for the outcomes of total knee arthroplasty. Recent technological advances have led to the development and use of accelerometer-based smartphone applications to measure knee ROM. The purpose of this study was to develop, standardize, and validate methods of utilizing smartphone accelerometer technology compared to radiographic standards, visual estimation, and goniometric evaluation.

Methods: Participants used visual estimation, a long-arm goniometer, and a smartphone accelerometer to determine range of motion of a cadaveric lower extremity; these results were compared to radiographs taken at the same angles.

Results: The optimal smartphone position was determined to be on top of the leg at the distal femur and proximal tibia location. Between methods, it was found that the smartphone and goniometer were comparably reliable in measuring knee flexion (ICC = 0.94; 95% CI: 0.91–0.96). Visual estimation was found to be the least reliable method of measurement.

Conclusions: The results suggested that the smartphone accelerometer was non-inferior when compared to the other measurement techniques, demonstrated similar deviations from radiographic standards, and did not appear to be influenced by the person performing the measurements or the girth of the extremity.

1. Introduction

The measurement of postoperative knee range of motion (ROM) after total knee arthroplasty (TKA) is a key piece of information that allows surgeons to evaluate patient satisfaction, success of a knee prosthesis, and patient function after surgery. Functional flexion of 90–105° is necessary to perform activities of daily living [1]. Patients that demonstrate flexion below these values may require an intervention such as specialized braces, manipulation under anesthesia, and even revision surgery. Therefore, it is important that knee range of motion is accurately evaluated [1].

Abbreviations: ROM, range of motion; TKA, total knee arthroplasty; ANOVA, analysis of variance; HSD, Honest Significant Difference; ICC, intraclass correlation; CI, confidence interval; PGY, post-graduate year; Attend, attending.

* Corresponding author.
E-mail address: mdietz@hsc.wvu.edu (M.J. Dietz).

http://dx.doi.org/10.1016/j.knee.2016.11.014
0968-0160/

Radiographic measurement has been accepted as the most accurate method of evaluating knee flexion [1,2]. However, due to radiation exposure and the need for repeated examinations, this method is not clinically feasible. As a result, knee ROM has traditionally been evaluated using visual estimation or long-arm goniometry [1–4]. Recent smartphone technology, however, has led to the development of accelerometer-based applications that have the potential to be used for measuring ROM [3]. As a clinical tool for measuring ROM, the accuracy, intraobserver, and interobserver reliability has not been established compared to radiographic assessments. Furthermore, no standard exists for the use or positioning of the smartphone when obtaining measurements.

The purpose of this study was to develop, standardize, and validate a method of utilizing smartphone accelerometer technology. Based on the identification of an optimal location at which a smartphone could be placed, the smartphone accelerometer, accuracy of visual estimation, and long-arm goniometer were compared against radiographic assessment for measuring knee ROM. Additionally, the impact of leg circumference on the smartphone's ability to accurately measure range of motion and the experience level of the observer were assessed.

2. Material and methods

This study was approved by the Institutional Biosafety Committee prior to initiation. Two cadaveric specimens of different sizes disarticulated at the hip were obtained from the institutional Human Gift Registry. A small cadaver leg (upper leg circumference: 40.6 cm and lower leg circumference: 27.9 cm) and large cadaver left leg (52.7 cm upper and 37.5 cm lower) were utilized. Two custom devices were constructed so that each leg could be positioned in reproducible angles allowing for unobstructed views of the lower extremity (Figure 1a & b). These devices also allowed for rotation of the hip around a fixed axis recreating various angles of knee flexion.

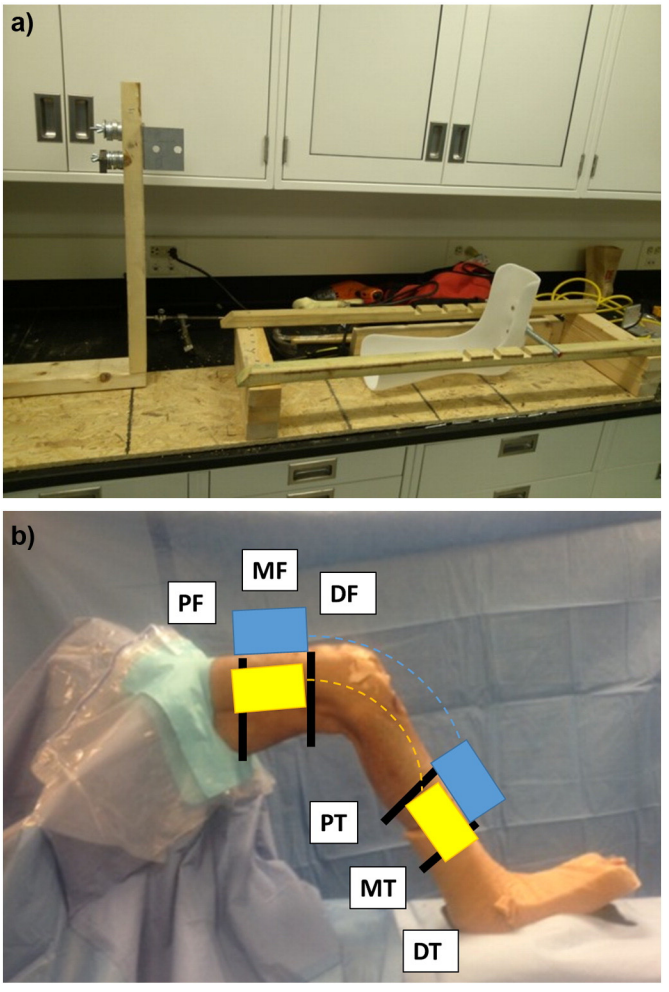

Figure 1. a) Custom device allowing for articulation of the hip around a fixed axis and positioning of the foot to create various flexion angles. b) This device allowed for observation of the leg with an unobstructed view. The femur and tibia were divided into thirds (proximal femur — PF, middle femur — MF, distal femur — DF) and (proximal tibia — PT, middle tibia — MT, distal tibia — DT). The smartphone was either placed on the anterior leg (blue rectangle) or on the side of the leg (yellow rectangle). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Please cite this article as: Dietz MJ, et al, Smartphone assessment of knee flexion compared to radiographic standards, Knee (2016), http://dx.doi.org/10.1016/j.knee.2016.11.014