Three-dimensional Position Capture Of The Lower Extremity Mechanical Axis Alignment Correlates Significantly With Radiographical Measurement In Patients With Symptomatic Knee OA.

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INTRODUCTION

Osteoarthritis (OA) is the most prevalent form of arthritis affecting more than 27 million Americans [1] with the knee the most affected weight-bearing joint [2]. Static alignment of the lower extremity is used to determine the load distribution of the knee. The mechanical axis alignment (MAA) refers to the angle formed by a line drawn from the center of the femoral head to the center of the femoral intercondylar notch and a line drawn from the center of the tibial spines to the center of the ankle joint [3]. MAA is typically measured from frontal plane full length standing radiographs of the lower extremity. The purpose of this study was to determine if static standing measurements utilizing a three-dimensional motion capture system could estimate the MAA as compared to the gold standard (full length standing radiographs).

METHODS

Participants self-identified the more symptomatic knee, and all testing was performed on that knee. Participants completed self-report measures including the Western Ontario and McMasters Universities Osteoarthritis Index (WOMAC) and baseline visual analog scale (VAS) for current knee pain. In order to be eligible for the study, participants needed to report knee pain on most days, have a WOMAC pain subscore of 4 or more, report moderate pain on at least 1 listed activity in the WOMAC and demonstrate radiographic evidence of knee OA in the test knee (Kellgren-Lawrence (K-l) grading scale = 1 to 4).

Radiographic Exam: An anterior-posterior weight-bearing knee radiograph was used to identify presence of tibiofemoral OA. The participant's knee was flexed to 15 degrees, and the beam was centered on the joint space. Severity of tibiofemoral OA was measured using the K-L grading scale Participants with K-L score of 1 to 4 were eligible for the study.

Participants also completed a standardized full length lower extremity weight-bearing radiograph. The participant stood with equal weight on both lower extremities without footwear, positioned so that the tibial tubercles faced forward and the midheel and second digit of each foot were aligned with pieces of tape placed perpendicular to the frontal plane. The x-ray beam was centered on the test knee at a distance to allow visualization of the hip and foot. The same physician determined the K-L grade and measured the MAA of all participants.

Three-dimensional position capture: Participants performed standing static trials in bare feet. Participants were positioned with feet shoulder width apart and toes pointed forward. Passive reflective markers were placed by the same researcher on the following boney landmarks: sacrum, bilateral ASIS, mid thigh, medial and lateral epicondyle of the femur, mid tibia, medial and lateral malleolus, heel, and 2nd head of the metatarsal. Marker data was captured using ViconPeak motion analysis system and software (ViconPeak Performance Inc, Denver, CO). Eight infrared cameras recording at 60 Hz captured the position of the reflective markers during two 2-second trials. The average hip-knee-ankle (AVGHKA) angle was determined by Kin-Calc formula (Peak Performance) and defined as the angle between the hip joint center to the knee joint center, and a line from the knee joint center to the ankle joint center. Joint centers were determined by dividing half the distance between medial and lateral markers taking into account the size of the marker.

All statistical computations were performed using SPSS 16.0 software (SPSS, Inc, Champaign, IL). Central tendencies were used to describe the sample. Simple linear regression was used to determine the correlation between the mechanical axis alignment as measured by radiograph (MAA) and the average hip-knee-ankle angle (AVGHKA) as measured by three-dimensional position capture.

RESULTS AND DISCUSSION

Thirty-nine individuals (26 females and 13 males) with varying knee OA severity (K-L grade 1 = 13; 2 = 4; 3 = 13 and 4 = 9) and mean BMI = 31.4 (29.4 – 33.3 CI) participated in this study. Intrarater reliability of radiographic measurement of the mechanical axis of the knee was very good (ICC = .98 - .99). A significant correlation was found between MAA and AVGHKA (R =.683, $p < .001$, Fig. 1). The MAA as measured on radiographs ranged from 11° valgus to 19° varus. The AVGHKA angle ranged from 11° valgus to 14° varus.

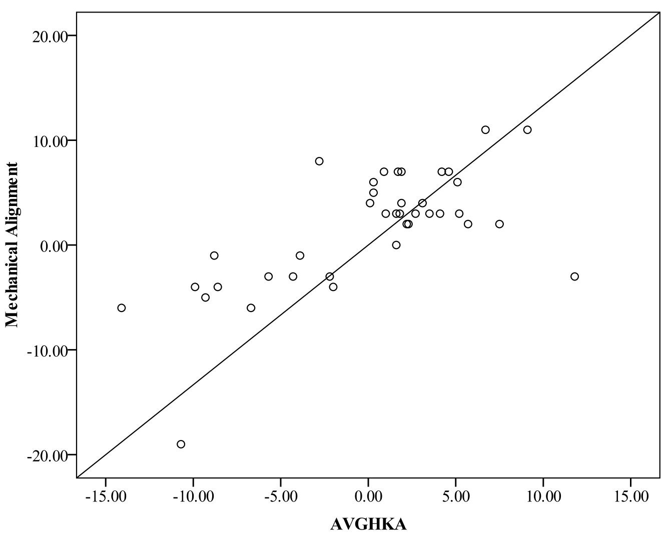

Figure 1: Mechanical axis alignment from radiographs (mechanical alignment) are moderately correlated with 3-D position capture (AVGHKA). Solid line depicts regression line.

The 3D position capture method was able to explain 47% of the variance in the mechanical axis alignment as measured by radiographs (R^2=.469; $p < .001$). The strength of the relationship found in this study between the two methods of mechanical axis measurement was not as strong as previously reported [4]. This may be a result of slightly higher BMI, the addition of valgus knee deformities and smaller sample size in the current study.

CONCLUSIONS

Three-dimensional position capture method of measuring lower extremity mechanical axis alignment in those with symptomatic knee OA is moderately correlated with the gold standard of radigraphically measured alignment. For those who routinely perform 3-D gait analysis, the position capture method is advantageous because it is time and cost effective as well and eliminates exposure to radiation for the subject. Further research with this new method needs to be performed using those with valgus knee alignment.

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