MEASUREMENTS OF ANTERIOR-POSTERIOR KNEE LAXITY: A COMPARISON OF THREE TECHNIQUES

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INTRODUCTION:
Several non-invasive techniques have been developed to assess knee joint instability, however their accuracy for clinical assessment remains unclear. Radiostereometric Analysis (RSA) has proven to be an accurate and precise tool to evaluate anterior-posterior (A-P) knee laxity (1). RSA quantifies knee laxity by reconstructing the locations of tantalum beads that are surgically implanted in the tibia and femur as the knee is loaded. Thus, RSA provides a “gold standard” that can be used to evaluate other less invasive techniques. The objective of this study was to compare A-P laxity values as measured using RSA (RSA Biomedical AB, Umea Sweden), the KT-1000 Knee Arthrometer (MedMetrics Corp, San Diego CA), and planar stress analysis, an x-ray technique described by Staubli (2). The hypotheses were: 1) A-P laxity values between measurement techniques are equal, and 2) correlations exist between A-P laxity values of the RSA and the KT-1000 and RSA and planar stress analysis.

METHODS:
14 Subjects who underwent anterior cruciate ligament (ACL) reconstruction participated in the study. It was approved by the Institutional Review Board and all subjects granted their informed consent prior to participation. During surgery, 5 to 6 tantalum beads (0.8 mm diameter) were inserted into both the distal femur and proximal tibia (a minimum of 3 beads is required in each bone). The subjects returned for their scheduled follow-up visits at 3, 6, and 12 months. 25 follow-up visits have been completed to date.

The A-P laxity values for the reconstructed knees were evaluated at each follow-up using the three measurement techniques. Subjects were supine with their knees flexed to 20°. A-P laxity was defined as the total A-P translation of the tibial eminence and the cluster of tantalum beads relative to the femoral cluster. The KT-1000 (3) was used by an experienced examiner following the manufacturer’s instructions. For the planar stress analysis and RSA, the knee was positioned within the RSA calibration cage (Cage 10; RSA Biomedical AB). The loads were applied to the knee with a pneumatic actuator. After several loading cycles were performed to pre-condition the knee, simultaneous biplanar films (A-P and sagittal views) were taken as the anterior- and posterior shear load were applied. For planar stress analysis, only the sagittal plane films were evaluated. The posterior aspects of the medial and lateral, femoral and tibial condyles were identified and digitized. A-P laxity was calculated as the average displacement of the femoral condyles with respect to the tibial condyles between the anterior and posterior loads (2). For RSA, the tantalum beads were identified, digitized, and reconstructed from both views. A-P translations were then calculated by determining the motion of the tibial eminence and the cluster of tantalum beads relative to the femoral cluster between the same anterior and posterior loads (1).

A two-way analysis of variance, blocked on subjects, was used to compare the A-P laxity values of the three measurement techniques (Hypothesis 1). Linear regressions were also performed to establish relationships between the arthrometer, planar stress analysis, and RSA (Hypothesis 2). The RSA A-P laxity value was considered the independent variable while those of the other two methods were the dependent variables.

RESULTS:
Hypothesis 1: The mean A-P laxity values for the three techniques were significantly different (p<0.001). The means (+/- 1 standard deviation) were: 11.1 (2.47) , 9.6 (2.88), and 7.3 (1.99) mm for the arthrometer, planar stress analysis, and RSA techniques, respectively.

DISCUSSION:
Three commercially available knee laxity measurement techniques that are commonly used in clinical research to evaluate ligament and graft function were evaluated. The 2-D analyses of the planar stress technique and the arthrometer over-estimated the true laxity values. The extremely low coefficient of determination between RSA and the KT-1000 arthrometer questions the use of the device to evaluate A-P laxity in clinical research studies where precise measurements are required. The error for the RSA technique for measuring A-P knee laxity has been reported to be +/- 0.8 mm (1). However, factors such as the patients ability to relax and changes in knee flexion angle (+/- 6° for the patients in this study) that occur during loading could introduce additional errors. However, we do not feel that this is a major concern since these problems are inherent to the other devices as well. RSA has the advantage of measuring direct bone to bone motion. Limitations for the arthrometer include the interference of the soft tissue surrounding the bones and that tibiofemoral motion is referenced to the patella. The planar stress analysis is limited, in part, by the examiner’s ability to accurately identify bony landmarks on the X ray. Although RSA is invasive and labor intensive, it provides the best means to evaluate A-P knee laxity.

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