ASSESSMENT OF FUNCTIONAL JOINT SPACE REPEATABILITY DURING IN VIVO DYNAMIC LOADING

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INTRODUCTION

More than 20 million Americans have osteoarthritis [1]. The recommended measure for anatomical progression of osteoarthritis is joint space narrowing [2,3], typically measured by radiography or MRI. However, these techniques are not a comprehensive measure of articular cartilage thickness because the joint is imaged in only one orientation and under static loading. Thus, conventional measures do not account for differences in articular cartilage thickness over the entire contact region during active motion or how cartilage responds to dynamic loads common in daily activities.

These shortcomings are addressed by the functional joint space (FJS) score, a measure of subchondral joint space over the entire articular surface during a dynamic loading activity. The purpose of this study was to assess the within-day and between-day repeatability of FJS scores.

METHODS

Subjects were five adult foxhounds that served as controls for a larger study. 3D knee kinematics were determined from pawstrike to .20 s after pawstrike by tracking implanted beads (accuracy $\pm$ 0.10 mm [4]) in x-ray images collected at 250 fps as the dogs ran on a treadmill [5]. Ten tests were performed over two years. Three trials were collected each test session.

Using previously published methods [6], the minimum distances between tibia and femur subchondral bone surfaces were determined for each frame of data. A single parameter, the functional joint space (FJS) score, was created to quantify the minimum joint space over the entire .20 s post-pawstrike.

FJS score was calculated over a 200 mm^2 surface area. This area was big enough to account for large regions of cartilage loss and to reduce the effect of minor irregularities in the calculated close-contact region (e.g. near the spine of the tibia, an unlikely weight bearing region). The FJS score was the average distance between the closest 200 mm^2 subchondral surface areas during the .20 s after pawstrike (Figure 1). A smaller score indicated less joint space.

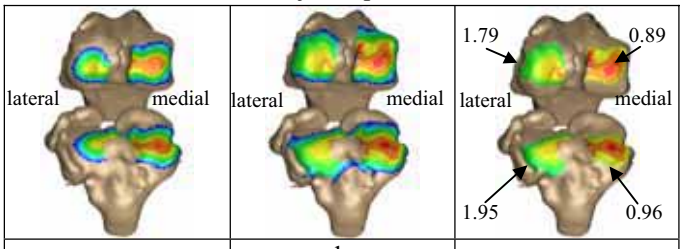

Figure 1: *Femur (above) and tibia (below) articulating surfaces colored according to minimum joint space (red=closest, blue=farthest). a) One instant of the analyzed motion. b) The closest distance between surfaces over the entire 0.2 s of motion. c) The closest 200 mm^2 area in each compartment and accompanying FJS score.*

The three trials collected each day determined FJS score within-day precision. The average FJS score for the three trials each day was used to calculate the between-day repeatability. The effect of compartment (medial, lateral) and test session (1-10) on FJS score was evaluated with a 2-way repeated measures ANOVA with significance set at $p < 0.05$.

RESULTS AND DISCUSSION

FJS scores were highly correlated between bones within each compartment (medial r=0.95; lateral r=0.95). Thus, for statistical tests, medial femur and tibia scores were averaged to make one medial compartment score, and likewise for lateral scores.

The within-day FJS score precision was 0.09 mm for both the lateral and medial compartments. This result is similar to the most precise static joint space measurements in humans [7,8]. The average between-day FJS score precision was 0.20 mm for both the medial and lateral compartments.

Average FJS scores were greater in the lateral compartment than in the medial compartment (p=.004) (Figure 2). FJS score did not change significantly in either compartment over the 10 test sessions (lateral p=.403; medial p=.637).

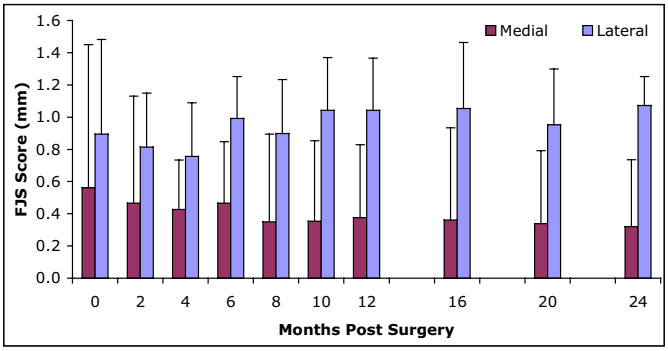

Figure 2:*Medial and lateral FJS score for the 10 test sessions.*

CONCLUSIONS

The FJS method to quantify joint space in vivo produced highly repeatable measurements both within-day and between days, making it a useful tool for serial studies. Unlike conventional joint space measurements, FJS measurements can be performed as the joint is dynamically loaded and moved through a range of motion while variable forces act on the joint. In the future, this tool may be used to serially track in vivo joint space during common activities such as walking in subjects at risk for the development of osteoarthritis.

REFERENCES

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