IMPROVED TRACKING OF HIP ROTATION USING A PATELLA MARKER

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Summary/conclusions
A marker placed on the patella allows for more accurate measurement of hip rotations than traditional thigh wands. In controlled trials of isolated hip internal-external rotation, the patella marker detected 97% of the actual range of motion, compared with 59% for a distal thigh wand and 41% for a proximal thigh wand. The patella marker produced the smoothest hip rotation curves and the smallest hip rotation range in walking, and results from the patella marker did not depend on walking speed. These results suggest that the patella marker is less vulnerable to wobbling, inertial effects, and soft tissue movement than traditional thigh wands.

Introduction
Gait analysis is an important tool for treatment decision-making in orthopaedics. Hip rotation measurements from gait analysis are used in planning the femoral derotation osteotomy procedures. Accuracy in the measurement, therefore, is critical. Although thigh wand markers have traditionally been used to track hip motions, it has been reported that they produce large variability in hip rotation measurements between different laboratories and greatly underestimate the rotation movement mostly due to the existence of soft tissue artifacts [1,2]. We hypothesized that a marker placed over the patella would be less affected by soft tissue movement and would therefore produce more accurate hip rotation measurements. This study investigated effectiveness of the patella marker in comparison with traditional thigh wands.

Statement of clinical significance
If the patella marker provides more accurate hip rotation data than thigh wands, it will enhance the clinical usefulness of gait analysis, particularly in decision-making and surgical planning for femoral osteotomy.

Methods
Eleven healthy adults (Ht: 165.4 ± 7.6 cm, Wt: 63.2 ± 11.0 kg) performed controlled hip internal and external rotations while standing with 90-degrees of knee flexion and full hip extension to allow for calculation of a "gold standard" hip rotation [2]. Data were captured and quantified by a Vicon Motion Analysis System (Vicon Oxford Metrics, Limited, Oxford, England) using a standard Vicon marker set with knee alignment devices. The gold standard measurement (Gold) was calculated using additional markers placed on the fibular head and lateral malleolus to track rotation of the tibia. Three different thigh markers were used: a distal wand placed on the lateral aspect of thigh at 80% of total femur length (Dist), a proximal wand placed on the lateral aspect of thigh at 50% of total femur length (Prox), and a patella marker placed over the patella (Pat). Data were collected with all markers in place, and hip rotations for the same trial were calculated using the Gold, Dist, Prox, and Pat markers. Similar data were collected during walking, except that measurement of a gold standard was not possible.

The mean right hip rotation range of motion from each marker set was computed and compared to each other for both motions. One-way Repeated Measures ANOVAs and Scheffe's post hoc tests were utilized to determine the statistical significance.

Results

For the controlled hip rotation trials, the mean hip rotation ranges for Gold, Pat, Dist, and Prox were 58.7± 10.3°, 56.7 ± 9.8°, 34.2 ± 8.9°, and 23.7 ± 5.3°, respectively (Figure 1). Expressed as a percentage of the Gold Standard, the hip rotation ranges were 97%, 59%, and 41% for Pat, Dist, and Prox, respectively. The Statistics revealed significant differences ($P<0.0001$) between all conditions except Gold and Pat.

For walking, the mean hip rotation range was 13.5 ± 3.9° for Pat, 23.1 ± 4.7° for Dist, and 14.7 ± 8.0° for Prox (Figure 2). The results yielded a statistically higher mean ($P=0.0003$) in Dist compared to others. The hip rotation curves tended to be smoother for Pat compared with Dist and Prox (Figure 3). Hip rotation range tended to increase with walking speed for Dist, to a lesser extent for Prox, and not at all for Pat (Figure 4).

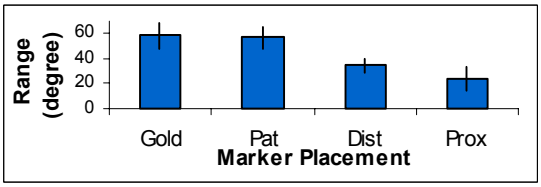

Fig 1. Hip rotation range during controlled trials

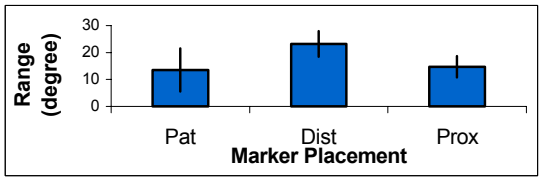

Fig 2. Mean hip rotation range during 1 gait cycle

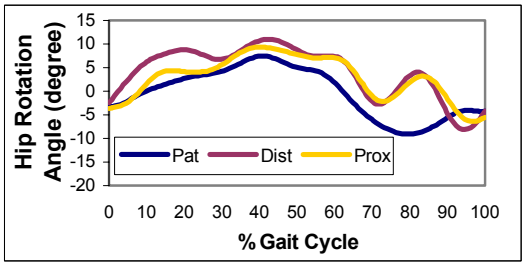

Fig 3. Hip rotation curves based on the three markers

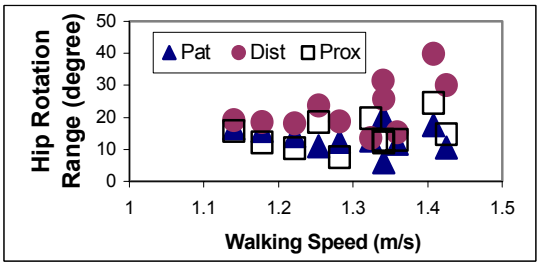

Fig 4. Hip rotation range as a function of velocity

Discussion

The patella marker demonstrated a greater potential in detecting hip rotation movement (97% of gold standard range) compared to the distal and proximal thigh wands (59% and 41% of gold standard range, respectively). The results for the thigh wands are similar to those reported previously by Lamoreux (70% for distal wand and 40% for proximal wand) [2]. Less soft tissue lying between the patella marker and the bone might have allowed the marker to track more direct movement of bone while the thick layer of soft tissues hindered this ability in the wands. It should be noted that the patella marker can only be used in conjunction with knee alignment devices.

In walking, the thigh wands produced relatively higher ranges of motion regardless of their poor rotation tracking capacity in the controlled tests. The rotation ranges of the wands, especially the distal wand, displayed sensitivity to walking speed. Their augmented ranges in walking, therefore, could possibly be explained by artifacts that are magnified with increased walking speed. The patella marker, on the other hand, was insensitive to walking speed and also produced the smoothest hip rotation curves. These results suggest that the patella marker is less vulnerable to wobbling, inertial effects, and soft tissue movement than traditional thigh wands.

References: [1] Gorton et al. (2001) Gait & Posture, 16 (S1), 65-66.
[2] Lamoreux (1991) Proceedings of the International Society of Biomechanics, Perth, 372-373.

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