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Using Motion Capture and MRI to Accurately Determine the Hip Range of Motion in Everyday Life

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Introduction

Today, there is no clear consensus as to the amplitude of movement of the "normal hip". Knowing the necessary joint mobility for everyday life is important to understand different pathologies and to better plan their treatments. Moreover, determining the hip range of motion (ROM) is one of the key points of its clinical examination. Unfortunately this process may lack precision because of movement of other joints around the pelvis. Our goal was to perform a preliminary study based on the coupling of MRI and optical motion capture to define precisely the necessary hip joint mobility for everyday tasks and to assess the accuracy of the hip ROM clinical exam.

Methods

MRI was carried out on 4 healthy volunteers (mean age, 28 years). A morphological analysis was performed to assess any bony abnormalities. Two motion capture sessions were conducted: one aimed at recording routine activities (stand-to-sit, lie down, lace the shoes while seated, pick an object on the floor while seated or standing) known to be painful or prone to implant failures. During the second session, a hip clinical exam was performed successively by 2 orthopedists (2 and 12 years' experience), while the motion of the subjects was simultaneously recorded (Fig. 1). These sequences were captured: 1) supine: maximal flexion, maximal IR/ER with hip flexed 90°, maximal abduction; 2) seated: maximal IR/ER with hip and knee flexed 90°. A hand held goniometer was used by clinicians to measure hip angles in those different positions.

Fig. 1: Simultaneous measurement of the passive hip ROM by motion capture and orthopaedist using a hand held goniometer

Hip joint kinematics was computed from the markers trajectories using a validated optimized fitting algorithm which accounted for skin motion artifacts (accuracy: translational error ≈ 0.5mm, rotational error < 3°). The resulting computed motions were applied to patient-specific hip joint 3D models reconstructed from their MRI data (Fig. 2). Hip angles were determined at each point of the motion thanks to two bone coordinate systems (pelvis and femur). The orthopedist's results were compared.

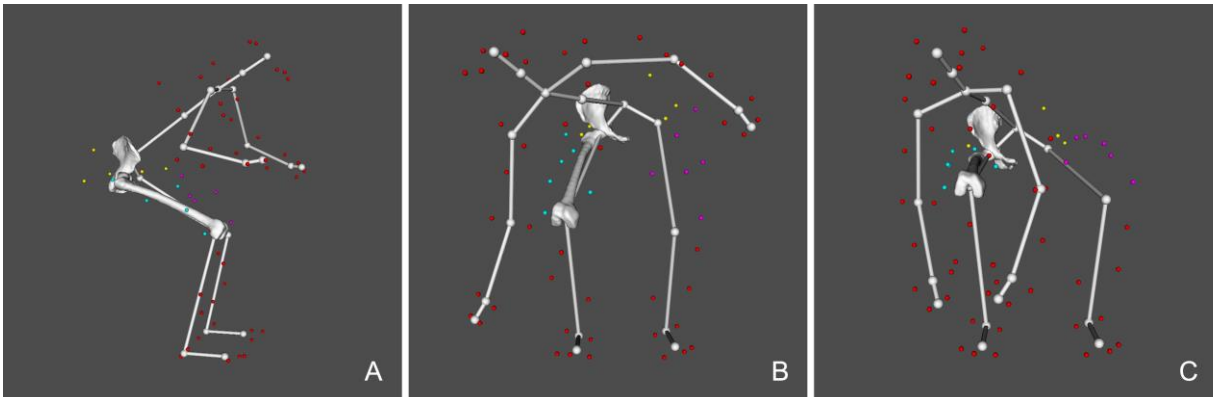

Fig. 2: Examples of computed postures (here the right hip): A) stand-to-sit, B) pick an object on the floor while standing, C) lace the shoes while seated

Results

All subject's hips were morphologically normal. For all movements, a minimum of 95° hip flexion was required (mean range 95° – 107°), lacing the shoes and lying down being the more demanding. Abduction/adduction and IR/ER remained low (± 20°) and variable across subjects. Regarding the clinical exam, the error made by the clinicians varied in the range of ± 10°, except for the flexion and abduction where the error was higher (flexion: mean 9.5°, range -7° – 22°; abduction: mean 19.5°, range: 8 – 32°). No significant differences between the errors made by the two examiners were noted (mean error for each examiner: 7.4° vs. 8.4°).

Conclusion

Daily activities of a "normal hip" involve intensive hip flexion, which could explain why such motion can yield hip pain or possible implant failure. This information should be considered in the surgical planning and prosthesis design when restoring patient mobility and stability. The clinical exam seems to be a precise method for determining hip passive motion, if extra care is taken to stabilize the pelvis during flexion and abduction to prevent overestimation of the ROM. Further studies including more subjects are required before attesting the accuracy of this test.