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Impingement Simulation Based on Virtually Reconstructed Acetabular Labrum by Patient-Specific 3-Dimensional Data

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Summary:
Virtual labrum model was reconstructed based on patient specific 3D-MRI, then evaluated the influence of labrum impingement by dynamic simulation comparing between FAI and BDDH.

Abstract:

<INTRODUCTION>
Impingement simulation based on 3D-CT is one potential solution to access the impingement point or range of motion, however, it is based on bony structures rather than soft tissue. A clinical question here is that soft tissue such as acetabular labrum should influence the impingement before bony impingement occurs. Therefore, the virtual acetabular labrum model was reconstructed based on the patient specific size data measured by 3.0 tesla Multiple Echo Recombined Gradient Echo (MERGE) MRI and performed the dynamic simulation to evaluate maximum internal rotation angle of impingement points, comparing between femoroacetabular impingement (FAI) and borderline developmental dysplasia of the hip (BDDH) cases.
<METHOD>
We retrospectively reviewed MERGE MRI findings performed as a preoperative evaluation from October 2014 to August 2017. A total of 30 hips including 15 hips of femoroacetabular impingement (FAI), 15 hips of borderline development dysplasia of the hip (BDDH). The acetabular labrum of MERGE MRI findings was evaluated by radial imaging in anterior region (2-3 o'clock), anterolateral region (1-2 o'clock), and lateral region (12-1 o'clock). Specifically, we measured of the thickness of the acetabular labrum at the rim and the width to the apex of the acetabular labrum in each region. The virtual acetabular labrum model was reconstructed using Zed Hip (LEXI) based on each specific size of MERGE MRI findings. The impingement point was identified using 3D dynamic simulation by Zed Hip. We compared of maximum internal rotation angle at 90° flexion before and after the acetabular labrum reconstruction in each disorder.
<RESULT>
The average thickness of the acetabular labrum at the rim was 4.5mm in FAI and 6.4mm in BDDH, respectively, which was significantly larger in BDDH ($p<0.001$). The average width to the apex was 6.5mm in FAI and 11.4mm in BDDH, which was significantly longer in BDDH ($p<0.001$). In FAI, the maximum internal rotation without acetabular labrum was 26.4 degrees, which decreased to 17.0 degrees with reconstructed labrum. In BDDH, it was 44.3 degrees without labrum and 24.1 degrees with reconstructed labrum. There was a significant difference of maximum internal rotation angle before and after the acetabular labrum reconstruction. The discrepancy between bony and acetabular labrum impingement angle was significantly larger in BDDH than FAI ($p<0.05$).
<DISCUSSION>
In CT based dynamic simulation, it is impossible to reflect the soft tissue influences particularly by labrum. One of the superiority in our study is that labrum was reconstructed based on patient specific data from 3D-MRI. Because

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labrum was significantly thickened in BDDH comparing with FAI, the discrepancy of maximum internal rotation angle was also significantly larger in BDDH than FAI in the virtual acetabular labrum model. In this regard, the influence of labrum should be considered particularly in BDDH cases.