3D Acetabular Coverage Can be Used to Indicate Borderline Dysplastic Hips for Hip Arthroscopy or Periacetabular Osteotomy

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INTRODUCTION: Borderline hip dysplasia (BHD) is an intermediate configuration of the hip where acetabular coverage of the femoral head lies between that of frank dysplasia and normal coverage. Although varying definitions exist for BHD, many consider a lateral center edge angle between 18° to 25° as borderline [1]. When treating patients with femoroacetabular impingement syndrome (FAIS), those with frank dysplasia and normal coverage have well-established treatment algorithms, including management via periacetabular osteotomy (PAO) and hip arthroscopy (HA), respectively. There remains uncertainty on whether to treat FAIS in the setting of BHD with a PAO or HA. Although HA provides a less invasive surgical option, PAO has long been considered the gold standard treatment. Notably, those who fail treatment with HA are subsequently indicated for PAO. Many surgeons assess the potential efficacy of HA based on the degree of dysplasia, as measured by LCEA on 2-dimensional (2D) radiographs. However, 2D measurements provide limited information on the 3-dimensional (3D) morphology of the hip joint. The purpose of our study was to explore if 3D coverage patterns can be used in lieu of 2D metrics to improve HA indications in patients with BHD.

METHODS: Fifteen patients (14F/1M, age range 15 – 58, mean 31 y.o.) with BHD, as defined by 18° < LCEA ≤ 25° who underwent HA for FAIS between 12/2018 – 1/2022 were identified within a prospectively maintained repository that is IRB approved. In all cases, the same attending surgeon performed the operation. 3D models of the femur and pelvis were generated from preoperative 1.5T Flash-Dixon sequence magnetic resonance imaging scans (Materialise Mimics v. 25.0, Leuven, Belgium) using previously described methodology [2]. Acetabular coverage was measured by projecting the acetabular rim onto the superior surface of the femoral head. The superior surface of the femoral head was divided into lateral and medial halves as well as quadrants based on bony landmarks. Percent coverage was collected globally, laterally, and by quadrant using a commercially available CAD program (Materialise 3-matic v. 17.0, Leuven, Belgium) [3]. Patients who required subsequent PAO were deemed non-survivors (NS), as opposed to those who were successfully treated with a single operation (survivors, S). Coverage patterns are presented as means with standard deviations and were compared between survivors and non-survivors using two-tailed paired student's *t*-test.

RESULTS SECTION: Among the 15 included hips, there were no differences in age, sex, BMI, or follow-up time ($p \geq 0.427$, for all). Radiographically, between survivors and non-survivors, there were no differences in LCEA (S: 21.3 ± 2.1, NS: 20.7 ± 2.8, $p = 0.634$), Tönnis angle (S: 10.4 ± 2.7, NS: 11.7 ± 1.2, $p = 0.422$), or anterior center edge angle (ACEA) (S: 24.4 ± 6.0, NS: 23.1 ± 2.0, $p = 0.718$). 3D coverage patterns are illustrated visually in **Figure 1** and numerically in **Table 1**. Notably, there was significant difference in lateral ($p = 0.012$) and anterolateral ($p = 0.049$) coverage when measured on a 3D model. There was no difference in global, posterolateral, and anteromedial coverage between groups ($p \geq 0.059$, for all).

DISCUSSION: Hip dysplasia is a pathology that predominantly affects female patients, as represented in our cohort. Much uncertainty remains in determining the optimal treatment modality for borderline dysplastic hips. Through patient counseling and shared decision making, patients and surgeons choose whether to pursue HA or PAO for intervention. However, further understanding on surgical indications can provide practitioners with the means to avoid subsequent PAO due to failed HA. Identifying such preoperative markers can aid in reducing prolonged patient pain, incidence of secondary surgery, and additional healthcare costs. In our study, preoperative 2D radiographic measurements did not discern differences across survivors and non-survivors undergoing HA. However, 3D acetabular coverage of the femoral head was different between those that required subsequent PAO and those who did not. The results of our study demonstrate that hips with decreased anterolateral and lateral 3D femoral head coverage are more likely to fail HA and should be preferentially indicated for a PAO.
This study is not without limitations, as the results of our study are predicated on a small cohort of non-survivors. Further studies that update these parameters with greater certainty are warranted.

SIGNIFICANCE/CLINICAL RELEVANCE: Traditional measurements of dysplasia including LCEA, Tönnis angle, and ACEA demonstrate limitations in adequately characterizing the degree of dysplasia within a hip. 3D models provide a more robust method to assess hips preoperatively and properly indicate patients for HA or PAO.

REFERENCES: [1] Zhang et al. Orthop Surg. 2023 Oct. 15(10):2665-2673. [2] Malloy P, *et al*. J Orthop Res. 2020 Sep. 38(9): 2050-2056. [3] Larson JH *et al*., Proceedings ORS Annual Meeting vol. 48:1580

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Figure 1. Visual comparison of 3D coverage by quadrant between survivors and non-survivors.

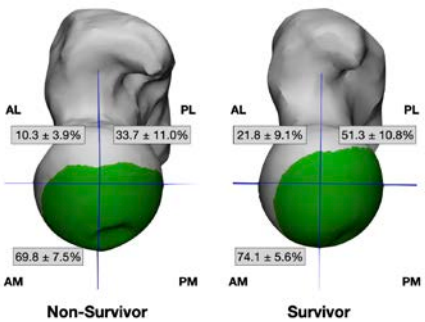

Table 1. Statistical comparison in 3D coverage between survivors and non-survivors.

	Survivor	Non-Survivor	P-Value
Global	63.0 ± 5.2 %	58.3 ± 4.0%	0.307
Lateral	36.5 ± 7.7%	21.7 ± 3.2 %	0.012
AL	21.8 ± 9.1%	10.3 ± 3.9 %	0.049
PL	51.3 ± 10.8%	33.7 ± 11.0%	0.059
AM	74.1 ± 5.6%	69.8 ± 7.5%	0.560