

Biomechanics-based target zone following periacetabular osteotomy for hip dysplasia

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Disclosures: Kenji Kitamura (N), Masanori Fujii (N), Goro Motomura (N), Satoshi Hamai (N), Shinya Kawahara (N), Taishi Sato (N), Ryosuke Yamaguchi (N), Daisuke Hara (N), Takeshi Utsunomiya (N), Scott A Banks (N), Yasuharu Nakashima (N)

Introduction: Identifying the optimal position for the acetabular fragment during periacetabular osteotomy (PAO) that satisfies normalized joint contact pressure and required range of motion (ROM) for activities of daily living provides significant benefits to surgeons. Thus, we aimed to clarify the optimal position on the mechanical environment after PAO in dysplastic hips.

Methods: Utilizing computed tomography images of 46 subjects with dysplasia, subject-specific finite element models were created to simulate 12 patterns of virtual PAO, i.e., the lateral center-edge angle (LCEA) values of 30°, 35°, and 40° were rotated laterally and anterior rotation of 0°, 5°, 10°, and 15° were added¹. Two-dimensional to three-dimensional matching techniques were employed to assess the sagittal pelvic tilt in the weight-bearing position. Joint contact pressure on the acetabular cartilage during a single-leg stance was calculated. Hip ROM without bony impingement was simulated. The optimal acetabular fragment position to achieve normal joint contact pressure (< 4.1 MPa)¹ and required ROM for activities of daily living (flexion angle ≥ 105° and internal rotation angle at 90° of flexion ≥ 20° without bony impingement)² were investigated. A multivariate logistic regression analysis was used to identify preoperative morphologic risk factors for bony impingement in the required ROM after virtual PAO to accomplish adequate acetabular correction for the prevention of osteoarthritis progression.

Results: Among the 12 patterns of virtual PAO, the prevalence of hips with the normalized maximum contact pressure was approximately 80% at LCEA values of 30° and 35° with an additional 15° of anterior rotation, which was the highest among 12 patterns of acetabular correction (**Fig 1, Table 1**). The prevalence of patients achieving the required ROM peaked at 100% when the LCEA value was set at 30° with lateral rotation alone. As the lateral and anterior rotations increased, the rate decreased to a minimum of 47.8% at an LCEA of 40° with 15° of anterior rotation. The rate of hips in optimal position was highest at an LCEA of 30°, regardless of additional anterior rotation, i.e., all four patterns from 0° to 15°, at 65.2% (**Table 2**). In cases with LCEA values of 30° and 35° with 15° of anterior rotation, a multivariate analysis determined that the acetabular anteversion ($p = 0.046$) was an independent risk factor for the occurrence of bony impingement in required ROM; a preoperative acetabular anteversion < 22.8° predicted the possibility of compromising required ROM (sensitivity 90%, specificity 69%, area under the curve 0.82).

Discussion: Our virtual PAO study showed that the optimal position varies between individuals. Among the 12 patterns of virtual PAO, it was found that joint contact pressure was more likely to normalize at an LCEA value of 30-35° with 15° of anterior rotation. However, this position may sacrifice the required ROM in patients with a preoperative acetabular anteversion of less than 22.8°.

Significance/Clinical Relevance: Acetabular reorientation to an LCEA of 30-35° with 15° of anterior rotation may serve as a useful target for surgeons when performing PAO in the majority of patients with hip dysplasia. However, at such a position, it is imperative to note that patients with less acetabular anteversion may experience limited ROM in activities of daily living after PAO.

REFERENCES:

1. Kitamura K, Fujii M, Iwamoto M, et al. Is Anterior Rotation of the Acetabulum Necessary to Normalize Joint Contact Pressure in Periacetabular Osteotomy? A Finite-element Analysis Study. Clin Orthop Relat Res. 480 (1): 67-78, 2022
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IMAGES/TABLES

Fig.1: The distribution of joint contact pressures on the acetabular cartilage of the left hip in representative patients from the hip dysplasia group after 12 patterns of virtual PAO. The maximum contact pressure was most improved at a LCEA value of 35° with 15° of anterior rotation.

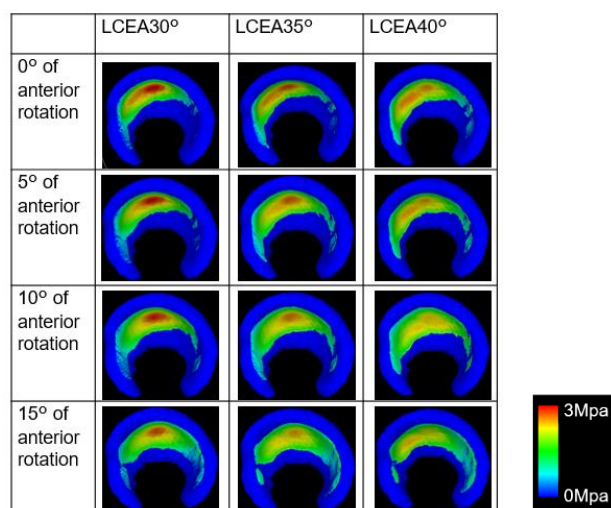


Table 1. The comparison of acetabular fragment repositions with normal joint contact pressure after periacetabular osteotomy simulation

	LCEA 30°	LCEA 35°	LCEA 40°
0° of anterior rotation	65.2 (30)	56.5 (26)	52.2 (24)
5° of anterior rotation	71.7 (33)	67.4 (31)	60.9 (28)
10° of anterior rotation	76.1 (35)	73.9 (34)	63.0 (29)
15° of anterior rotation	82.6 (38)	78.3 (36)	67.4 (31)

Values are presented as the percentage (number).

Table 2. The proportion of acetabular fragment repositions satisfying the biomechanics-based target zone after periacetabular osteotomy simulation

	LCEA 30°	LCEA 35°	LCEA 40°
0° of anterior rotation	65.2 (30)	54.3 (25)	45.7 (21)
5° of anterior rotation	65.2 (30)	56.5 (26)	41.3 (19)
10° of anterior rotation	65.2 (30)	54.3 (25)	31.3 (19)
15° of anterior rotation	65.2 (30)	52.2 (24)	32.6 (15)

Values are presented as the percentage (number).