Safe Zones for Femoral and Combined Version to Preserve Hip Range of Motion After Periacetabular Osteotomy

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INTRODUCTIONS: Restoration of impingement-free hip motion is a key goal of periacetabular osteotomy (PAO). Femoral version (FV) and combined version (CV = FV + acetabular version) are thought to influence postoperative range of motion (ROM), yet optimal thresholds that preserve function remain undefined. We aimed to: (1) identify FV and CV "safe zones" associated with satisfactory postoperative ROM, (2) quantify their relationships with ROM, (3) establish clinically useful cutoffs, and (4) determine whether FV and/or CV independently predict motion after PAO.

METHODS: In this IRB-approved retrospective cohort, we analyzed 72 hips (65 patients; mean age 28.6 years) undergoing curved PAO. One-month postoperative CT scans were processed with validated 3D software to measure FV and acetabular version, calculate CV, and simulate impingement-free ROM. "Satisfactory ROM" was defined a priori as ≥105° flexion and ≥20° internal rotation at 90° flexion. Associations were assessed with Pearson correlations, cutoffs were identified using ROC analysis with the Youden index, and independent predictors were evaluated with multivariable logistic regression. Risk strata were defined according to the derived thresholds.

RESULTS: Satisfactory ROM was achieved in 65/72 hips (90.3%). FV and CV correlated strongly with internal rotation ($r = 0.78$ and $r = 0.81$, both $P < 0.001$) and moderately with flexion ($r = 0.38$ and $r = 0.63$; $P < 0.05$ and $P < 0.001$, respectively). ROC analysis identified optimal thresholds of FV ≥21° (AUC 0.958) and CV ≥40° (AUC 0.945), each yielding 100% specificity for satisfactory ROM. In multivariable models, only FV remained an independent predictor (OR 1.21 per degree; 95% CI, 1.05–1.52; $P = 0.034$). Hips with both FV <21° and CV <40° demonstrated a markedly reduced success rate (30%)

DISCUSSION: Postoperative hip function after PAO is strongly influenced by version. Although both FV and CV associate with ROM, FV is the dominant independent determinant. Practical thresholds—FV ≥21° and CV ≥40°—define a postoperative "safe zone" that maximizes impingement-free motion. Patients with values below both thresholds are at high risk of restricted ROM and should be considered for adjunctive femoral (de)rotation procedures.

SIGNIFICANCE: This study establishes femoral version as the key independent predictor of hip motion after PAO and defines pragmatic "safe zone" thresholds (FV ≥21°, CV ≥40°) to guide surgical planning, reduce impingement risk, and improve patient-specific outcomes.

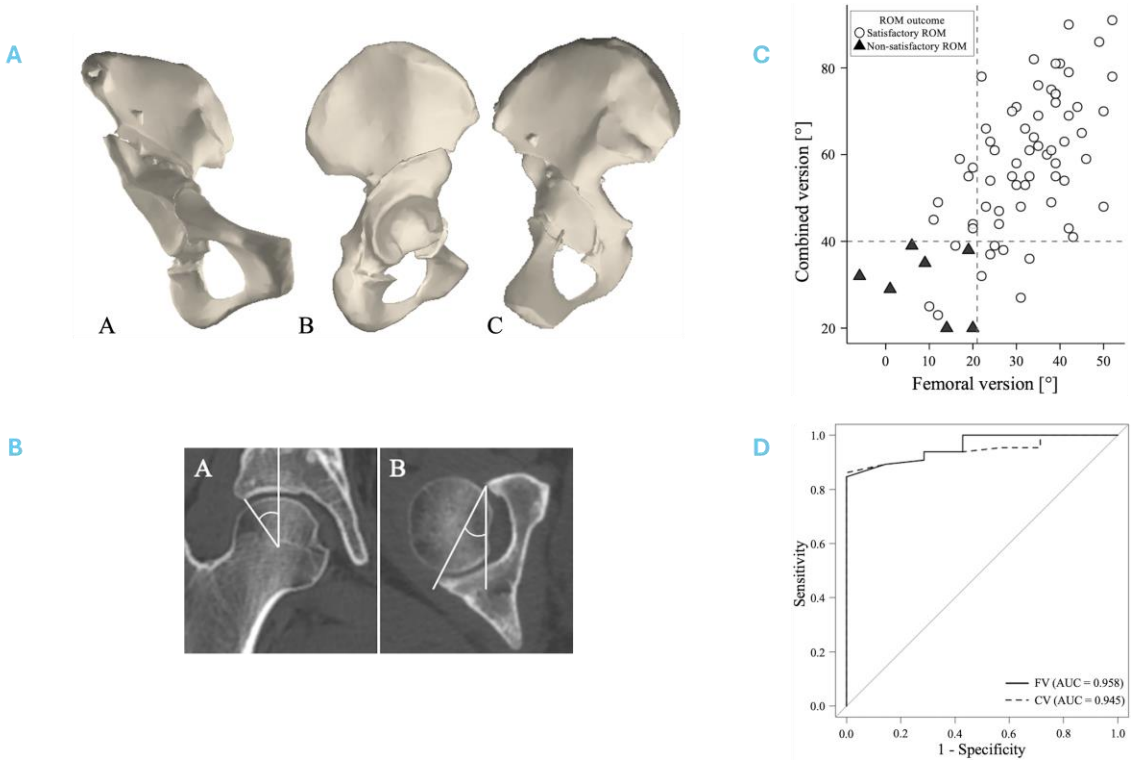

Figure 1: (A) Three-dimensional postoperative bone models of the pelvis. Anteroposterior, Lateral and Medial view of the postoperative pelvis. The acetabular fragment was laterally rotated to create a horizontal weight-bearing surface and fixed using three poly-L-lactic acid screws without iliac bone grafting. **(B)** CE and AV **(C)** Scatter plot illustrating the relationship between femoral version (FV) and combined version (CV) in patients who underwent periacetabular osteotomy (PAO). Satisfactory range of motion (ROM), defined as ≥105° of flexion and ≥20° of internal rotation at 90° of flexion, is indicated by open circles. Non-satisfactory ROM is indicated by filled triangles. The dashed lines denote threshold values of 21° for FV and 40° for CV. **(D)** ROC curves comparing the ability of femoral version (FV) and combined version (CV) to predict satisfactory ROM (defined as flexion ≥105° and internal rotation ≥20°). FV demonstrated an AUC of 0.958, with an optimal cutoff of 21° (sensitivity 0.85, specificity 1.00). CV yielded an AUC of 0.945 with a cutoff of 40° (sensitivity 0.86, specificity 1.00). There was no significant difference between the AUCs ($p = 0.73$, DeLong test).