

Prediction of the 'grand-piano sign' during total knee replacement during total knee replacement: a computer-simulation study

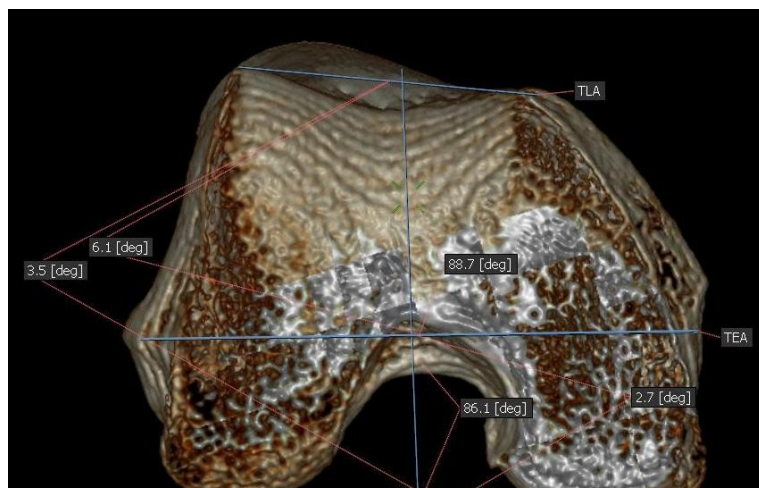
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Purpose: To measure relative position of the various anatomical landmarks for rotational alignment of the femoral component during total knee arthroplasty by computer-simulation. To compare morphology of cut surface after anterior femoral resection by various landmarks for external rotation and to decide which landmark can better predict the morphology of the cut surface by surgical transepicondylar axis (TEA).

Materials & Methods: A total of 73 distal femora with varus osteoarthritis in 73 females were scanned using computerized tomography. Computer image software was used to compare relative position of surgical TEA, posterior condylar axis (PCA), anteroposterior (AP) axis of the distal femur, and anterior trochlear line (TLA). We simulated the anterior femoral resection parallel to surgical



The morphology of the resected surface of the femur is quantified in a CT scan (A, the most proximal point of the anterior bone cut on the medial condyle; B, the most proximal part of the anterior bone cut on the lateral condyle; C, the most distal point on the anterior bone cut on the medial condyle; D, the most distal point on the anterior bone cut on the lateral condyle; F, the intersection of B to C-D; E, the intersection of A to C-D

transepicondylar axis (TEA), at an external rotation of 3° relative to PCA and perpendicular to AP axis. The varying types of morphology obtained on the anterior resected surface of the femur were then classified. The vertical distance (A-E) between the most proximal point (A) of the anterior bone cut on the medial condyle and the line (C-D) connecting two most distal points (C and D) of anterior bone cut on both the lateral and medial condyles was measured. Another vertical distance (B-F) was measured between the most proximal point (B) of the anterior bone cut on the lateral condyle and the line (C-D) (Fig. 1). The ratio of A-E to B-F (A-E:B-F) was calculated for each simulated resection. The morphological patterns on the resected surface were quantified and classified as the 'grand-piano sign', 'the boot sign' and the 'butterfly sign'. The 'grand-

piano sign was assigned when the A-E to B-F ratio was between 0.585 and 0.79, the 'butterfly sign' for bigger ratio than 0.79 and 'the boot sign' for smaller ratio than 0.585. The morphology by AP axis and PCA was compared with the surface by surgical TEA respectively.

Results: Surgical TEA was $2.7 \pm 1.2^\circ$ externally rotated relative to PCA. The line perpendicular to AP axis was externally rotated by an average of $1.3 \pm 3.8^\circ$ relative to surgical TEA and $3.9 \pm 3.9^\circ$ to PCA. TLA was $6.1 \pm 2.6^\circ$ externally rotated to TEA, and $3.5 \pm 2.6^\circ$ to TEA. The intra-observer reproducibility assessed by one observer with intraclass correlation coefficient and was 0.942, 0.902, 0.915, 0.937, and 0.927 respectively.

When anterior resection by TEA was simulated, 'grand-piano sign' was appeared in 59 cases(76.6%). If the resection by PCA was simulated, the morphology was same as that by TEA in 66 cases (85.7%). In 7 cases (9.1%) only resection by AP axis resulted in the morphology by TEA.

When anterior resection was simulated with 3°external rotation relative to PCA, the morphology was similar to the pattern of the resected surface by surgical TEA in 57 cases (73.6%). When the knees were resected perpendicular to AP axis, the morphology of TEA appeared only in 44 cases (56.7%) and the difference was significant ($P = 0.0413$). Pearson's correlation coefficient for between A-E:B-F ratio by TEA and that by PCA was 0.822 and between the ratio by TEA and that by AP axis was 0.537. Cohen's kappa coefficient for correlation between the morphologic pattern expressed as the ratio of A-E:B-F was measured. The value was 0.442 for between TEA and PCA and 0.241 for between TEA and AP axis.

Conclusion: When anterior resection was simulated in Korean femoral patients, resection at 3° external rotation to PCA can better predict the morphologic pattern of cut surface by surgical TEA than the one by AP axis.

