Image-less versus Image-Based Robotic Total Knee Arthroplasty- A Radiological Comparison of Accuracy

Aim

This study aimed to evaluate the accuracy of imageless and image-based robotic systems in total knee arthroplasty (TKA). The primary objective was to compare intra-operative planning and final component positioning with corresponding post-operative measurements obtained from scanograms and computed tomography (CT), thereby assessing the ability of each system to reproduce planned alignment parameters.

Methods

A prospective radiological evaluation was conducted in 160 patients undergoing primary robotic-assisted TKA, comprising 80 imageless procedures performed with the VELYS system and 80 with the STRYKER Mako system. Intra-operative data were recorded from final executed robotic plans, and all patients underwent post-operative CT and scanogram evaluation. Six alignment parameters were analyzed: femoral flexion, femoral rotation relative to the posterior condylar axis (PCA), femoral and tibial component coronal angles, tibial slope, and mechanical hip–knee–ankle angle (mHKA). Absolute deviations from intra-operative targets were calculated. Between-group comparisons were performed using Welch's t-tests or Mann–Whitney U tests. Bland–Altman analyses assessed systematic bias. Inter-observer reliability was high (ICC = 0.85, 95% CI 0.78–0.91).

Results

Both systems demonstrated high accuracy in reproducing intra-operative plans, with errors (AE) typically within 1–3°. Femoral flexion showed absolute errors (AE) of 2.73° in the imageless group and 3.15° in the image-based group ($p = 0.26$). Femoral rotation to PCA showed modest variability (1.95° vs 2.05°, $p = 0.92$). Coronal alignment was most consistent: absolute errors (AE) in femoral and tibial component coronal angles averaged 1.27° and 0.73° in the imageless cohort compared with 0.90° and 0.88° in the image-based cohort; the difference was not significant ($p = 0.065$ and $p = 0.40$). Tibial slope showed the greatest dispersion, with absolute errors (AE) of 3.56° and 4.19° ($p = 0.11$), and both systems demonstrated systematic post-operative reduction in slope compared to planned values. Importantly, post-operative weight-bearing mHKA was consistently higher than final alignment achieved in both groups, with absolute errors (AE) of +4.57° for imageless and +4.50° for image-based systems ($p = 0.89$).

Conclusions

Imageless and image-based robotic-assisted TKA systems provided comparable accuracy in translating intra-operative planning to post-operative alignment. Coronal component parameters were highly reproducible, while tibial slope showed consistent post-operative reduction. Although the image-based system showed a trend toward improved femoral coronal accuracy and the imageless system showed numerically smaller tibial slope deviations, neither reached statistical significance. Both robotic platforms deliver precise component placement.