Evaluation of amount of bony cut using a novel image-matching software after total knee arthroplasty

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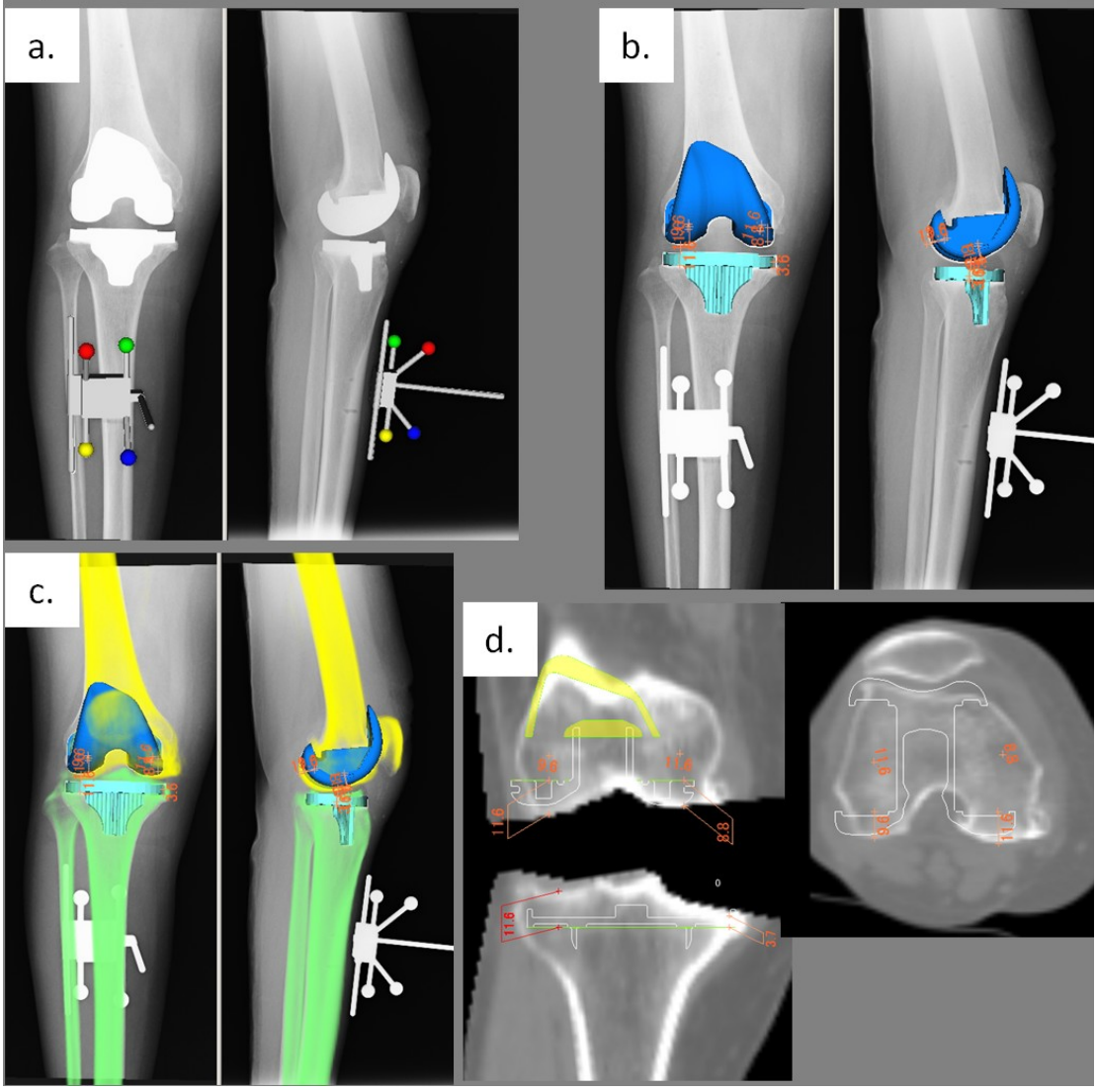
Introduction: Implant position with reference to bone and postoperative lower extremity alignment are commonly considered critical factors affecting the long-term survival of total knee arthroplasty (TKA) [1, 2]. An automated image-matching technique using a Computer-Aided Design (CAD) program is presented to assess alignment of the entire lower extremity for normal and implanted knees and the positioning of implants with respect to bone [3]. However, the accuracy of its software is not still clarified. The purpose in this study is to clarify the hypothesis that novel three-dimensional (3D) image-matching software could assess the positioning of implants accurately and would be a useful tool for post-operative evaluation after TKA.

Figure 1



Methods: 30 consecutive patients who had knees of osteoarthritis with varus deformity were investigated in this study. All TKAs (Triathron, posterior-stabilized) were performed using computer navigation system (Stryker, New Jersey, USA). During the surgery, we measured actual thickness of each cutting bone as follows; medial (MDF) and lateral (LDF) condyles of the distal femur, medial (MPF) and lateral (LPF) condyles of posterior femur, and medial (MPT) and lateral (LPT) proximal tibia. The thickness of bone saw, 1.27mm was added to each value. Three weeks after TKA, radiographs of antero-posterior and lateral views were undertaken and post-operative evaluations were performed using a three-dimensional image-matching software, "ATHENA KNEE" (SoftCube Co., Ltd., Osaka, Japan). Briefly, a 3D marker was attached on the surface of the patient's lower leg and the silhouettes of the marker in the images were used to couple the two radiographic images three dimensionally (Figure 1a). Next, implanted components were matched to the images using CAD program (Figure 1b). In addition, images of computed tomography (thickness; 2.5mm) were matched to the coupled radiographic images (Figure 1c). In the matched image, we also measured the thicknesses of cutting bone of each part as follows; medial (A-MDF) and lateral (A-LDF) condyles of the distal femur, medial (A-MPF) and lateral (A-LPF) condyles of posterior femur, and medial (A-MPT) and lateral (A-LPT) proximal tibia (Figure 1d). We compared the data to the actual amounts of bony cut and investigated whether the post-operative evaluation were well correlated to the intra-operative condition. For descriptive analysis, all values were evaluated by calculating the mean and standard deviation. The paired Student's t-test was used for the within group analyses. The Pearson product moment correlation coefficient and a linear regression analysis were used to evaluate the contribution of quantitative parameters.

Results: There were no significances between MDF (8.77±1.63mm) and A-MDF (8.56±1.58mm) ($p=0.06$), MPF (12.62±2.56mm) and A-MPF (12.47±2.65mm) ($p=0.36$), and MPT (3.10±1.82mm) and A-MPT (3.01±1.81mm) ($p=0.23$). There were significance between LDF (9.44±1.92mm) and A-LDF (8.87±1.91mm), LPF (10.20±2.55mm) and A-LPF (9.38±2.32mm), and LPT (11.34±2.08mm) and A-LPT (10.40±2.02mm) ($p<0.01$). Linear regression analysis revealed excellent correlation between all part of cutting bone ($p<0.001$).

Discussion: In this study, there were excellent correlations between every amounts of bony cut. However, regarding amounts of cutting bone of lateral side, there were approximately 1mm significant differences between the actual measurement and the measured on software. The difference is possibly considered to be remained cartilage. 3D image-matching software in this study is considered to be accurate enough to assess the positioning of implants with respect to bone after TKA.

References

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