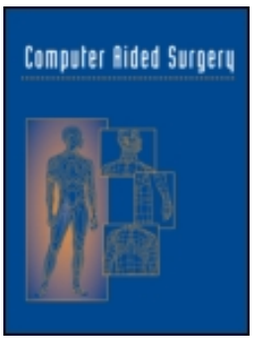

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Prediction of post-operative range of motion using intra-operative soft tissue balance in total knee arthroplasty with navigation

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ABSTRACT

This study evaluated the influence of intra-operative soft tissue balance on post-operative range of motion in patients undergoing posterior-stabilized total knee arthroplasty with navigation. After implantation of all components in 31 consecutive patients, the joint component gap was measured manually with the knee at 0°, 90°, and 120° as guided by a navigation system. We designated soft tissue balance as the absolute difference between varus stress and valgus stress (medio-lateral laxity). Changes in medio-lateral laxity were calculated from 120° to 90°, 120° to 0°, and 90° to 0°. Correlations among post-operative flexion angles and pre-operative flexion angles, intra-operative flexion angle after implantation, soft tissue balance, and the changes were analyzed. The mean pre- and post-operative knee flexion angles were 114 ± 20° and 127 ± 9°, respectively. The mean intra-operative flexion angle was 137 ± 6°. The post-operative flexion angle was positively correlated with the pre-operative flexion angle and intra-operative flexion angle after implantation. The change in soft tissue balance between 120° and 90° showed a positive correlation with the post-operative flexion angle. In conclusion, Assessment of intra-operative soft tissue balance could predict post-operative flexion angle.

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Navigation; range of motion; soft tissue balance; total knee arthroplasty

Introduction

Factors influencing range of flexion after total knee arthroplasty (TKA) can mainly be classified as intra-capsular or extra-capsular. The importance of pre-operative range of motion (ROM) for post-operative results has been well recognized.[1–3] Post-operative flexion angle is affected by several variables, including pre-operative flexion angle, surgical technique, component design, and post-operative physiotherapy.[4–6] Achieving better ROM appears to be important for increasing patient satisfaction and meeting expectations.[7]

Although soft tissue balancing has been recognized as an essential surgical intervention for improving TKA outcome, limited studies have reported the direct relationship between soft tissue balance and post-operative flexion angles.[3,8,9] Soft tissue balance in flexion and extension has been adjusted equally to achieve better flexion. Balance may be assessed intra-operatively with the use of spacer blocks, laminar spreaders, and tensioning devices as well as by placement of trial components.[8] Soft tissue balance in flexion has been adjusted at only 90°. It may be difficult to check the quantitative balance at deep flexion; however, navigation can help assess this parameter.[3,9–11]

The purpose of the present study was to evaluate the influence of intra-operative soft tissue balance on post-operative ROM in patients undergoing posterior-stabilized TKA.

Patients and methods

This prospective study included 31 consecutive patients who underwent a primary TKA between February 2009 and January 2010. Minimally invasive surgery was performed in all knees by one experienced surgeon using a mini-midvastus approach without patellar eversion.[12] Our institutional review board approved the study. Informed consent was provided by all patients. A balanced gap technique was used. The CT-free navigation system (Orthopilot 4.2, B. Braun Aesculap, Tuttlingen, Germany) was used to ensure the accuracy of implantations and measure the accurate flexion angle of

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the knee during the joint component gap measurement with a tensor.

The study included 8 men and 23 women with a mean age of 74 years (range, 58–88 years) and a mean body mass index of 27 kg/m^2 (range, 19–40 kg/m^2). The diagnoses were osteoarthritis in 29 patients and rheumatoid arthritis in 2 patients. The mean preoperative coronal alignment was 7.8 ± 5.5 in varus. The tibial osteotomy was first performed perpendicular to the tibial axis in the coronal and sagittal plane. After the tibial osteotomy, the necessary releases of the medial structures were made. The posterior cruciate ligament was sacrificed. The amount of bony cut and varus/valgus/flexion/extension alignment on the screen of the navigation system was determined based on the measurement of the extension and flexion gaps using the offset-type tensor. Posterior osteophytes in the femur were removed to avoid limitations associated with deep flexion. Following bony resections and soft tissue releases, posterior-stabilized designs were used for all cases, and all components (Colombus, B. Braun, Aesculap, Tuttlingen, Germany) were fixed with cement. All patellae were resurfaced. After implantation of all components, the arthrotomy was temporarily repaired by applying stitches, and the joint component gap (mm) was measured with the knee at 0°, 90°, and

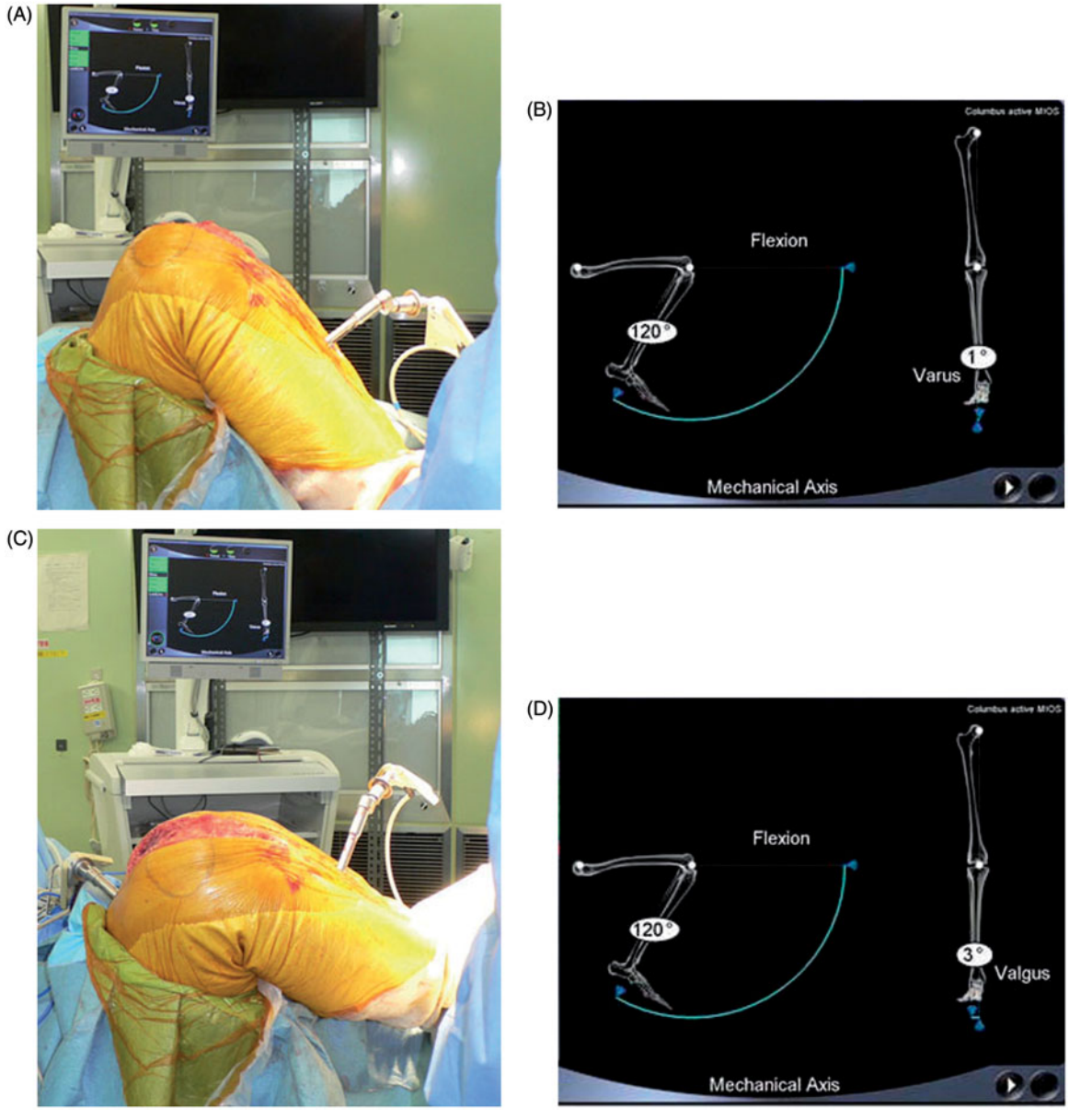

Figure 1. The joint component gap was measured manually as guided by a navigation system. Photograph (A) and screen shot (B) show varus stress at 120°. Photograph (C) and screen shot (D) show valgus stress at 120°. Screen shots show 1° varus in varus stress (B) and 3° valgus in valgus stress (D); thus medio-lateral laxity (soft tissue balance) was calculated as 4°.

120° guided by a navigation system. We measured manually in the position of no stress, varus stress, and valgus stress up to palpable endpoints (Figure 1). We designated soft tissue balance as the absolute difference between varus stress and valgus stress (medio-lateral laxity). Various changes in medio-lateral laxity were calculated, including from 120° to 90°, 120° to 0°, and 90° to 0°. Intra-operative maximum flexion and extension angles were recorded. Before and 6 months after surgery, knee flexion and extension angles were also evaluated.

Statistical analysis

Friedman test and Wilcoxon signed rank test were used to compare values between pre-operative and post-operative flexion angles as well as soft tissue balance among different flexion angles. Correlations among post-operative flexion angles and pre-operative flexion angles, intra-operative flexion angle after implantation, soft tissue balance, and the changes were analyzed using Spearman's rank correlation test. Correlation between post-operative extension angle and pre-operative extension angles and medio-lateral laxity at 0° was also analyzed. Statistical significance was set at $p < 0.05$.

Results

The mean pre- and post-operative knee flexion angles were 114 ± 20° and 127 ± 9°, respectively. The post-operative flexion angle significantly increased compared with the pre-operative flexion angle ($p < 0.001$). The mean intra-operative flexion angle was 137 ± 6°. The post-operative flexion angle was positively correlated with the pre-operative flexion angle (Figure 2A) and intra-operative flexion angle after implantation (Figure 2B).

The mean medio-lateral laxity was 2.7 ± 1.7°, 3.0 ± 2.9°, 4.8 ± 3.0°, and 5.2 ± 3.3° at 0°, 90°, 120°, and maximum (mean 137 ± 6°) of flexion, respectively (Figure 3). A significant increase was found between 90° and 120° of knee flexion ($p = 0.002$). Mean changes in medio-lateral laxity were 1.8 ± 2.7°, 2.2 ± 2.6°, 0.4 ± 2.3° at each ROM from 120° to 90°, 120° to 0°, and 90° to 0° knee flexion, respectively. The change in the soft tissue balance (medio-lateral laxity) between 120° and 90° showed a positive correlation with the post-operative flexion angle (Figure 4). No other parameters showed a correlation with post-operative flexion angles.

The post-operative extension angle (mean −1 ± 3°) showed no correlation with pre-operative (mean −8 ± 8°) and intra-operative extension angles (mean −1 ± 2°).

Discussion

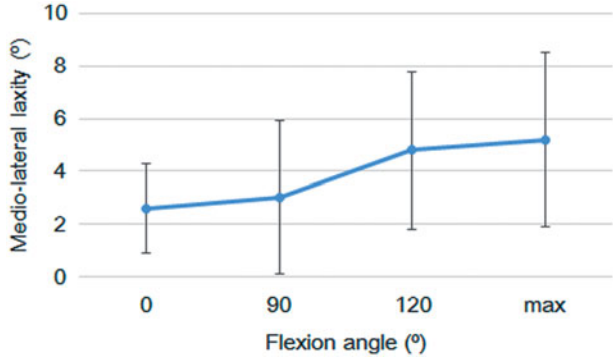

Figure 3. Intra-operative medio-lateral laxity in posterior-stabilized TKA at 0°, 90°, 120°, and maximum of flexion. All results are expressed as the mean ± standard deviation.

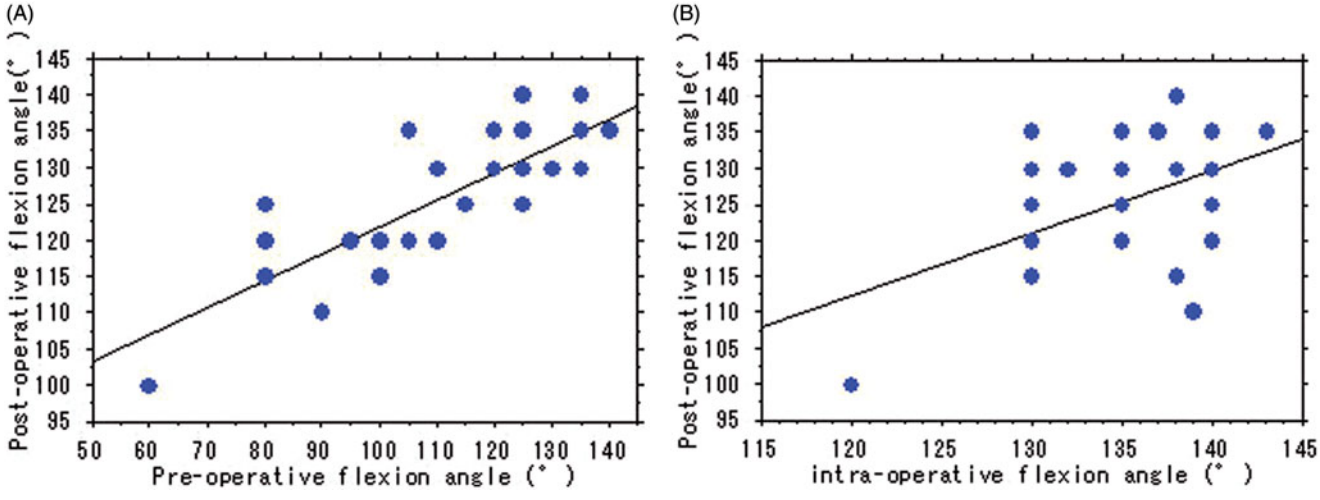

Figure 2. Correlation between post-operative knee flexion angle and (A) pre-operative flexion angle ($R = 0.794$, $p < 0.001$), and (B) intra-operative flexion angle ($R = 0.424$, $p = 0.020$).

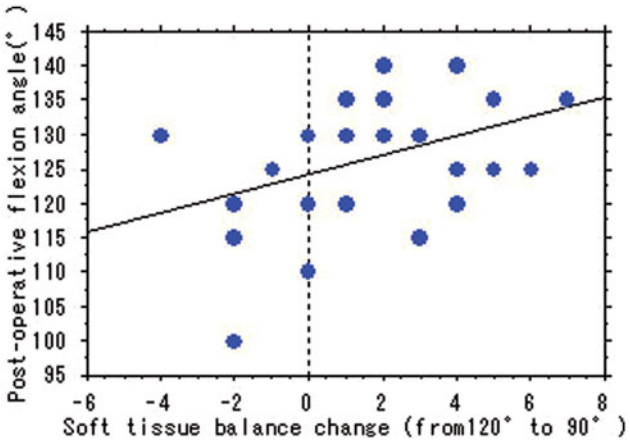

Figure 4. Correlation between post-operative knee flexion angle and change in soft tissue balance (medio-lateral laxity, from 120° to 90°, $R = 0.414$, $p = 0.023$).

The most important finding of the present study was that values of the change in medio-lateral laxity between 120° and 90° showed a positive correlation with post-operative flexion angles. Loose soft tissue balance at 120° might be required to achieve more than 120° of flexion.

Soft tissue balance assessment with the patella reduced may have the potential to help predict post-operative outcome.[10] In a previous study using posterior-stabilized TKA, changes in the joint component gap from 135° to 90° showed a positive correlation with post-operative knee flexion angle.[3] The mean post-operative flexion angle was 119° in their study, and many patients could not reach 135° of flexion. Our results that 120° to 90° showed a positive correlation with post-operative flexion angle could help predict postoperative flexion angle, because our mean post-operative flexion angle was 126°, indicating many patients could reach 120° of flexion. The changes in soft tissue balance from 90° to 0° showed no correlation with post-operative knee flexion angle in our study. Previous study [3] demonstrated that changes in the joint component gap of 90° to 0° showed an inverse correlation with post-operative knee flexion angle in posterior-stabilized TKA. One of the reasons for this discrepancy might be the difference in post-operative flexion angle. In addition, soft tissue balance assessed in the present study is quite different from the previous paper [3] in which soft tissue balance was quantitatively assessed with the use of tensioning device with distraction force. In contrast, other report [13] demonstrated that changes in the joint component gap from 90° to 0° showed a positive correlation with post-operative flexion angles in cruciate-retaining TKA. Another reason for this discrepancy might be the different patterns of soft tissue balance between posterior-stabilized and cruciate-retaining TKA.[13]

Femoral component design factors that influence postoperative flexion include restoring posterior femoral condylar offset.[14] A high-flex design might provide improved flexion compared with a standard design. However, controversy exists whether improved flexion was achieved using a high-flex design.[15,16] Our results might provide useful information for prosthetic design. It might be better that the medial and lateral condyles have a lesser radius posteriorly than distally.

Limitations of this study include a small sample size, measuring soft tissue balance manually, no assessment of midflexion laxity, and short follow-up. A previous study demonstrated that the ROM 24 months after TKA could be predicted from the ROM after 6 months [17] and the ROM collected at 6 months was sufficient for an analysis.

In conclusion, the assessment of intra-operative soft tissue balance could predict the post-operative flexion angle.

Declaration of interest

The authors report no conflicts of interest.

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