Original article

Effect of flexion angle on coronal laxity in patients with mobile-bearing total knee arthroplasty prostheses

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Abstract Proper soft tissue tension is one of the important factors in mobile-bearing total knee arthroplasty (TKA). We evaluated varus/valgus laxities, particularly at flexion, which is a key factor in reducing the risk of subluxation and dislocation of bearings to assess the effect that the flexion angle and the presence or absence of the posterior cruciate ligament (PCL) have on laxity in patients with low-contact stress (LCS) prostheses of the PCL-retaining (24 patients, 24 knees) and PCL-sacrificing (24 patients, 24 knees) type designs during extension and flexion. Both types of prosthesis had about 4° laxity at extension and 3° at flexion. PCL-retaining prostheses had significantly less laxity at flexion than at extension (P = 0.0004 in varus, P = 0.0043 in valgus). For good clinical outcomes following TKA, 3°–4° laxity in the varus and valgus orientations is recommended. In addition, the PCL might be involved in flexion and could affect varus/valgus laxity in PCL-retaining prostheses.

Key words Coronal laxity · Total knee arthroplasty · Posterior cruciate ligament retaining · Posterior cruciate ligament sacrificing · Flexion angle

Introduction

Mobile-bearing prosthetic knee designs offer the advantage of symmetrical geometric conformation and reduced surface and subsurface stress, and the mobility of the bearings minimizes the development of interfacial bone stress. A principal feature of mobile-bearing knee designs is the promotion of load sharing through relative displacement of the tibial and femoral components. However, a drawback of mobile-bearing knee prostheses is the possibility that bearings can become dislocated. Correct ligament tension and balance, particularly during flexion, are key to reducing the risk of complications; the risk can be almost eliminated if the flexion and extension gaps are balanced, are equal, and have the proper tension.

To the best of our knowledge, the low contact stress (LCS) prosthesis (DePuy, Warsaw, IN, USA) is the only implant that has been evaluated clinically during the past 20 years to compare meniscal-bearing prostheses, in which the posterior cruciate ligament (PCL) is retained (PCLR design), with rotating-platform, mobile-bearing prostheses, in which the PCL is not retained (PCLS design).3 There are few published reports about the degree of coronal laxity that is desirable in patients with LCS-type prosthetic knees.18

Laxity in the varus and valgus orientations is an important determinant of whether total knee arthroplasty (TKA) is successful, particularly for mobile-bearing prostheses. This study was carried out to evaluate varus/valgus laxity during extension and flexion as well as retention of the PCL in PCLR and PCLS prostheses at least 1 year after TKA.

Materials and methods

A total of 48 LCS prostheses (DePuy) were analyzed. The preoperative diagnosis was osteoarthritis in all 80 patients. None of the patients (n = 35) had any clinical complications, and all could achieve passive full extension and at least 90° flexion. The PCLR and PCLS prostheses had the same coronal geometry.

Before surgery, we obtained all patients’ consent that 24 knees each were randomly assigned treatment with LCS prostheses (either PCLR or PCLS) (Table 1). In the PCLR group (24 knees from 24 patients; mean age 70 years), the average range of knee motion was 117° ± 15°, and the average Hospital for Special Surgery (HSS) score1 was 92 ± 2. Patients received follow-up treatment
for 12–56 months. In the PCLR group (24 knees from 24 patients; mean age 70 years), the average range of knee motion was $119^\circ \pm 17^\circ$ and the average HSS score was $90 \pm 4$. These patients received follow-up treatment for 12–55 months.

All the procedures were performed by a senior surgeon (Y.I.) using a standardized technique, including the release of soft tissue, which is required to obtain a proper soft tissue balance. To ensure proper tension in both compartments, spacer blocks are used during the procedure to determine the specific flexion and extension surgical gaps used for the implants. In fixed varus and fixed valgus knees, subperiosteal soft tissue sleeve release was performed to align the knee prior to bony resection. These soft tissue sleeves are stretched in full extension by use of a spacer block when an intramedullary distal femoral resection guide is used. The flexion gap is determined following sleeve release using a spacer block. Subperiosteal sleeve releases stabilize mobile bearings in the same way as fixed bearings and allow correction of fixed deformities. Proper intraoperative sagittal laxity was confirmed manually but was not evaluated quantitatively. The femoral and tibial components of all knees were fixed without cement.

Varus/valgus laxity of the knee were measured at extension (0°–20° flexion) (Fig. 1) and 75° flexion (Fig. 2). Laxity at extension was measured using a Telos arthrometer (Fa Telos, Medizinisch-Technische, Griesheim, Germany) while the patient lay in a prone position on a table (Fig. 3). Radiographs were obtained from prone patients with their knees flexed at 75° (Fig. 4). Although flexion gap laxity is normally measured at 90° of flexion, it was not possible in the present study because in this position the soft tissues of the thigh and calf would have obscured the radiograph. Because evaluation of tension in the varus and valgus orientations causes external and internal rotation of the hip, respectively, the patella was required to face forward to minimize any such rotational effects. The radiographs were obtained after force (150 N) had been applied for 1 min.

To minimize variation, all measurements were made by a single individual (Y.M.). Each measurement was done three times, and the average of these measurements was calculated. Variation in the measurements made in different patients varied by less than 1°. We used a paired and an unpaired Student’s $t$-test to compare laxity measurements at extension and 75° flexion within and between the two groups, respectively.

### Results

The mean magnitudes of the varus/valgus tension at extension and flexion for the PCLR and PCLS groups are presented in Table 2. For coronal laxity at exten-