ORIGINAL STUDY

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Does measuring the medial gap before bone resection in total knee arthroplasty provide optimum gap adjustment and prevent bone recutting?

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This study aimed to demonstrate that measuring the medial gap before bone resection during total knee arthroplasty (TKA) provides an optimum gap adjustment in varus knees. In this study, patients were separated into two groups. Group 1 included patients whose medial joint gap was measured before bone resection and Group 2 included patients who underwent conventional technique without measuring. The medial joint gap was measured with a custom-made gap measuring device up to the point that the knee was corrected and aligned along its mechanical axis. Medial joint gap distances, distal medial femoral bone cut thicknesses, amounts of tibial resection calculated; gap internal distances measured after cutting and the thicknesses of the trial inserts were recorded. A comparison was made between the groups concerning the number of patients requiring an additional tibial bone cut and the distribution of insert thicknesses. Extra tibial bone resections were performed in two (5.7%) patients in Group 1 and 10 (28.6%) patients in Group 2. In Group 1, where the medial joint gap was measured, the need for an additional bone resection was statistically less (p=0.018). In comparing the distribution of insert size by group, the number of patients on whom an 8 mm insert had been used was significantly greater in Group 1 (p=0.024). The findings obtained in this study suggest that measuring the medial joint gap before bone resection in total knee arthroplasty may prevent repeated bone recutting and additional bone resections.

Keywords: Resection technique, total knee arthroplasty, medial joint gap.

INTRODUCTION

Total knee arthroplasty (TKA) aims to preserve the joint line, ensuring optimum balance and gap adjustment, correcting the mechanical axis, achieving optimal implant rotation and using the appropriate tibial insert thickness[1,2]. Obtaining symmetrical and balanced flexion and extension gaps are significant factors that may affect the success of treatment through total knee arthroplasty[3]. Gap adjustment is achieved using gap balancing and measured resection techniques. Both techniques have their advantages and disadvantages. In particular, because tension adjustment of the ligament is of secondary consideration in the measured resection technique, this leads to a need for recutting and soft tissue releases. In the gap balancing technique, because cuts are based on measurements, a more suitable gap and balance are attained[4]. To our knowledge, there is no study in the literature that defines the amount of bone resection needed based on a measurement of the corrected medial joint distance before cutting.

The present study aims to demonstrate that measuring the medial gap before bone resection during TKA provides an optimum gap adjustment in varus knees.

MATERIALS AND METHODS

This study was conducted by two orthopedic surgeons (UT, AF), each with a minimum of 10 years of experience, over the period March 2017-January 2018. The informed consent of the patients and ethical approval from the local ethics committee (IRB number: 13/6) were obtained for this study. The demographic data of the patients were recorded (Table I).

This research was conducted with patients undergoing total knee arthroplasty on the basis of a diagnosis of varus knee osteoarthritis. The inclusion criteria were as follows: patients undergoing total knee arthroplasty

Table I. — The demographic data of the patients

	Group 1 (n:35)	Group 2 (n:35)	P value
Mean age	68.3±6.1	67.8±6.9	P > 0.05
Mean body mass index (kg/m2)	29.1±5.2	29.4±4.9	P > 0.05
Gender (Female/Male)	11/24	13/22	P > 0.05
Mean preoperative flexion contracture	7.6±5.0	7.4±4.9	P > 0.05
Mean preoperative varus angle	13.4±5.2	12.5±5.1	P > 0.05

due to varus knee osteoarthritis, a tibiofemoral angle of ≤20°. Exclusion criteria were as follows: posttraumatic osteoarthritis, rheumatoid arthritis, hemophilic arthropathy, postseptic arthritis, tibiofemoral varus of more than 20°, flexion contracture of more than 10°, patients with extraarticular deformities, those that had undergone deformity surgery and patients with valgus gonarthrosis. Seventy patients meeting the inclusion criteria were taken into this study. Patients were separated into two groups. In Group 1, patients whose medial joint gap was measured before bone resection during surgery were included and in Group 2, patients who underwent standard surgical bone resection without measuring were included. Each group comprised 35 patients. For randomization, the first group of patients (Group 1) was selected by drawing lots, while the participants in the other group (Group 2) were recruited in order of their admittance. A posterior cruciate sacrificing implant (Scorpio® NRG PS, Stryker Howmedica Osteonics, Allendale, NJ, USA) was used on all the patients.

The technical specifications of this knee prosthesis include a femoral component thickness of 8 mm, a tibial component thickness of 6 mm and an insert of 8-16 mm. A minimum gap distance of 22 mm, 2 mm cement (1 mm for the femoral, 1 mm for the tibial component), and an allowance of 2 mm. for joint movement, comprising in total, a gap distance of 26 mm is required for this implant.

This measurement is taken with a custom-designed gap measuring device that starts from a measurement of 6 mm to 16 m with 2 mm intervals in between (Fig. 1). Since knee prosthesis cutting systems are designed for 2 mm intervals, the device was manufactured in matching specifications. The medial joint gap was measured with the device positioned between the most distal medial femoral condyle and the central medial tibial plateau with the knee in extension. While applying varus stress on the knee, the device was placed in the smallest gap and using the cable technique; the size was increased until the mechanical axis of the knee was corrected. The last gap thickness measurement was recorded.

Figure 1 — Custom-designed gap measuring device.

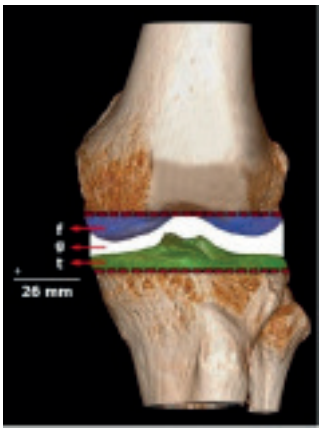

Figure 2 — Calculating the amount of tibial bone to be resected.

The distal femoral cutting block was positioned with the femoral intramedullary guide. The distal femoral bone resection was performed using the "sulcus cut" method [5,6]. The thickest part of the medial distal bone fragment removed from the femur was measured with

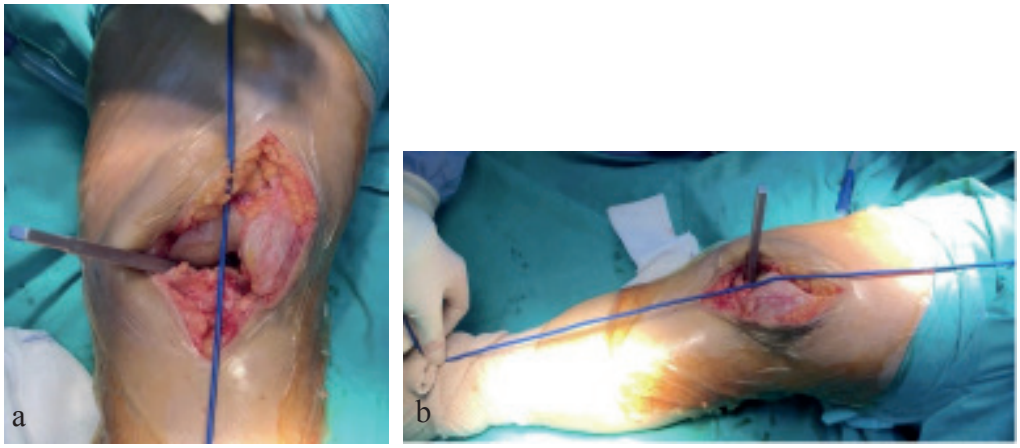

Figure 3 — Demonstration of the correction of the mechanical axis when measuring the extension gap.

the help of a compass. The following formula was used to calculate the amount of tibial bone to be resected: Tibial bone resection amount = 26 - (Measured medial joint gap + Femoral bone resection amount) (Fig. 2). Then, an amount from the medial proximal part of the tibia equal to the amount in the tibial cutting block was measured and resected.

Surgery was performed with a standard anterior longitudinal incision and a parapatellar approach. Anterior and posterior cruciate ligament excision, meniscectomy, tibial and femoral osteophyte excision and the standard medial release of the anteromedial tibial periosteum and deep medial ligament were performed. Then, the medial joint gap was measured. With the help of a guide, the distal femoral cut was first performed and the piece of medial bone excised was measured. The amount of tibial resection was calculated according to the formula. The tibial extramedullary cutting guide was placed. Then, with the tibial stylus matching the value obtained from the formula touching the medial central tibial plateau, this was fixed with a block pin and the bone resection was performed. Subsequently, using the femoral Chamfer guide, notch block guide, and tibial baseplate trial guide, the tibia was prepared. A gap block was used to measure the extension gap, which was recorded (Fig. 3a, 3b). An additional tibial cut was made for those with tight extension gaps, which was recorded. The trial implants were then placed. At this stage, flexion and extension ranges of motion (ROM), patellar tracking, the medial and lateral balance were evaluated. A suitable trial insert size was recorded. In cases that required it, extra medial soft tissue release was performed. In this group, the insert thickness determined with the gap measuring device and the trial insert were compatible in all patients. Irrigation was performed, and the implants were affixed with cement.

Surgery was performed using the same approach that was implemented in the case of Group 1 patients. Femoral bone resection was performed using the technique of the sulcus cut. Then, an 8 mm tibial stylus was placed at the highest point of the lateral tibial central plateau and the tibial bone was cut. The other stages of the surgery were performed as in Group 1. Again, for patients for whom an additional bone cutting was performed, their gap intervals and insert thicknesses were recorded.

Medial joint gap distances, distal medial femoral bone cut thicknesses, amounts of tibial resection calculated; gap internal distances measured after cutting, and the thicknesses of the trial inserts were recorded. A comparison was made between the groups concerning the number of patients requiring an additional tibial bone cut and the distribution of insert thicknesses.

SPSS v.16.0 software (SPSS Inc., Chicago, USA) was used in the statistical analysis. The analyses were performed at a confidence interval (CI) of 95% and two-tailed testing determined that $P<0.05$ could be accepted as statistically significant. The Shapiro-Wilk test was used to evaluate the numerical data to determine whether they were parametric. The Wilcoxon signed-rank test was performed to conduct a statistical evaluation of differences in each of the groups.

RESULTS

The mean age of the patients in Group 1 was 68.3 ± 6.1; 24 were female, and 11 were male. Mean BMI was 29.1±5.2, preoperative extension limitation was 7.6 ± 2.2 and the preoperative varus angle was 16.4±3.2. In Group 2, the mean age was 67.8 ± 6.9; 22 were female and 13 were male. Mean BMI was measured as 29.4±4.9, preoperative extension limitation was 7.0 ± 2.9 and the preoperative varus angle was 14.5±3.1.

Table II. — Comparison of results

	Group 1	Group 2	P value
Extra tibial bone resection(%)	n:2 (5.7%) (2 mm)	n:10 (28.6%) (2-6mm)	**0.018**
Insert size (8, 10, 12,14,16)	8 (n:29) (82.9%) 10 (n:6) (17.1%)	8 (n:22) (62.9%) 10 (n:9) (25.7%) 12 (n:4) (11.4%)	**0.024**
Mean resection of the medial femoral bone	10.5±1.2 (8-14mm)	10.5±1.1 (8-12mm)	0.841
Mean resection of the medial tibial bone	4.0±1.8 (2-8mm)	3.6±1.8 (2-8mm)	0.298

No demographic differences were detected between the groups.

In Group 1, two (5.7%) and in Group 2, 10 (28.6%) patients had extra tibial bone resections. In Group 1, where the medial joint gap was measured, the need for an additional bone resection was statistically less (p=0.018).

Concerning insert size, an 8 mm insert was used in 29 patients in Group 1 (82.9%), while a 10 mm insert was used in six patients (17.1%) in the same group. In Group 2, an 8 mm insert was used in 22 (62.9%) patients, while an insert of 10 mm was used in another nine (25.7%), and an insert of 12 mm was used in four (11.4%) patients in the same group. In comparing the distribution of insert size by group, the number of patients on whom an 8 mm insert had been used was significantly greater in Group 1 (p=0.024). (Table II)

BMI, age, gender, preoperative joint extension limitation did not affect additional bone resection and insert size.

DISCUSSION

The outcome of this investigation was that taking measurements of the medial joint distance in the measured resection technique helped us determine the thickness of bone to be resected more accurately. Besides providing us with the amounts of femoral and tibial bone resection that would yield an optimum gap, measuring the joint gap will make it possible to achieve a more accurate gap.

While in the measured resection technique, distal femoral bone resection and proximal tibial bone resection are the most significant determinants in achieving a suitable extension gap, the medial joint gap of the knee is usually ignored. At the same time, adjusting the extension gap and measurements are generally carried out after bone resection. Finally, the effects of medial soft tissue and the medial collateral ligament on the gap are assessed after bone resection. If the amount of bone resection is inadequate, the gap becomes tight, calling for another bone resection. If the amount of bone resection is excessive, the gap distance is compensated by the use of a thicker PE insert. However, this is one of the factors that can adversely affect the success of arthroplasty[7-10].

In the case of gap balancing, bone cutting is attempted after ligaments are released. Bone cuts using measured resection do not take soft tissue tension into account. Instead, markers, such as the trance epicondylar, anterior-posterior, or posterior condylar axes, provide appropriate femoral component rotation and gap balance. In the gap balancing technique, however, the femoral component is positioned parallel to the resected proximal tibia, with each collateral ligament equally tensioned to obtain a rectangular flexion gap[4].

Both resection and gap balancing techniques are presently used in standard TKA to attain tissue balancing and implant stability, but there has been no agreement as to which method may be considered superior to the other so far. There are mixed reports in the literature supporting each technique based on kinematic data. Increased femoral condylar liftoff is an outcome that is associated with the measured resection technique in some research, but assertions in other studies point to the shortcoming that gap balancing techniques digress from anatomical alignments[4,11].

It was reported in a study conducted by Kawano T. et al. that additional tibial resection had to be implemented in three out of 30 patients due to a tight extension gap[12]. Wernecke GC. et al. noted in their study, in which they used patient-specific cutting guides, that they were required to perform additional bone resection for 37% of their patients and of these additional cuts, 16% was implemented on the tibial side[13]. In the study of Pietsch M. et al., in which cutting guides were used, the rate of additional resection was 62% in the distal femur and 34% in the proximal tibia[14]. In the present study, additional proximal tibial bone resection was

Table III. — Data of the articles related with parameters of bone spesific recuts in TKA

Author/s	Patients	Additional tibial bone resection	Additional femoral bone resection	Procedure
Kawano T. et al. (14)	n:30	n:3(10%)	-	Conventional measured resection technique
Gregory C. et al. (20)	n:116	n:18(16%)	n:20(21%)	Patient-specific cutting guides
Pietsch M. et al. (21)	n:50	n:17(34%)	n:31(62%)	Patient-specific cutting guides
Seong et al. (22)	n:59	-	n:16(27%)	Navigated total knee arthroplasy
Group 1 Current study	n:35	n:2 (5.7%)	-	Measuring the medial gap with measured resection technique
Group 2	n:35	n:10(28.6%)	-	Conventional measured resection technique

performed on 10 knees in Group 2 and on two knees in Group 1. An extra bone resection was not necessary for the group in which the medial joint distance was measured (Table III).

In a study conducted by Seong et al.[15], a soft tissue release was implemented in 43 out of 59 cases, but in 16, an additional 2 mm femoral bone resection was required. Some authors recommend reduction osteotomy and using a small size component in cases of patients with a tight extension gap[16,17]. Measuring the joint distance and calculating the amount of tibial resection above all prevented an extra bone resection. It was also quite helpful to us in adjusting the extension gap.

It is crucial to determine the level of distal femoral resection to be implemented in total knee arthroplasty. This cut is what achieves the original alignment of the joint and preserves the balance in the soft tissue of the knee[18,19]. It has been proven in studies that using the "sulcus cut" technique in distal femoral resection is an excellent landmark in attaining joint alignment[5,6,9]. The surgical practice involves performing an 8-10 mm resection from the healthy lateral proximal tibia condyle or a 2 mm resection from the degenerated medial section[20,21]. This surgical technique may not provide some patients with an appropriate gap. If the gap is tight after bone resection, this may require repeated bone resections[12]. If the gap is too wide after bone resection, a thicker polyethylene insert (PE) may need to be used[22-24]. Since taking measurements of soft tissue tension is challenging before surgery, it may not be possible to determine how much of a bone resection is needed[25]. Cross MB et al. have demonstrated that extra bone resections in the distal femur cause coronal plane laxity and mid-flexion instability[26]. A significant reference for us in our study was the sulcus cut technique in distal femoral resection. The thickness of the bone tissue resected from the medial condyle of femur in this study varied between 8-12 mm. Instability was not observed in any of the patients.

A tight gap because of the insufficient bone section may lead to extension contracture in the joint and excessive erosion of the PE[27,28]. Again, excessive bone resection may cause an elevated joint line, mid-flexion instability, anterior pain in the knee and patellar crepitus[29]. In Group 1 patients, where we measured the medial joint distance, an 8-10 mm insert was used and there were only two patients with inadequate bone resections. In Group 2, inserts of 8-10 mm were used in 32 patients, while 12 mm inserts were used in four others. In this group, bone resection was inadequate in 10 patients and there was excessive bone resection in four others. The more accurate use of the insert was observed in Group 1.

In this study, the first limitation was that the bone resection blocks used in this study were the products of only one manufacturer. Cutting blocks and bone resection systems belonging to other manufacturers may yield different results. The second limitation was that cutting blocks may lead to faulty bone resection. Our third limitation was that comparison was not made by measuring the medial joint gap using navigation-aided systems that have been reported to be more accurate in bone resection in recent years.

CONCLUSION

The outcome of our study led us to the conclusion that it is not only femoral-tibial bone resections that are significant but that the medial joint gap is also a significant factor in achieving an optimum extension gap. Measuring the medial joint gap before bone resection in total knee arthroplasty may prevent repeated bone recutting and additional bone resections. Furthermore, we can use this method to avoid the disadvantages of the measured resection technique.

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