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Residual posterior femoral condyle osteophyte affects the flexion range after total knee replacement

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Abstract We followed up 92 patients with total knee replacement and a pre-operative knee flexion of at least 90°. The patients were followed up regularly at 3 months, 6 months and 1 year. The outcome measured was the amount of maximum passive knee flexion at the end of 1 year after replacement. The potential factors affecting the final flexion range were investigated. After regression analysis, apart from pre-operative knee flexion ($p < 0.001$), the most significant independent surgical factors that predict the amount of post-operative flexion were presence of residual posterior femoral condyle osteophyte ($p = 0.046$) and overstuffing the patella by more than 2 mm during resurfacing of the patella ($p < 0.001$).

Résumé Nous avons suivi 92 malades après une arthroplastie totale du genou qui avait en pré-opératoire une flexion d'au moins 90°. Les malades ont été suivis à 3 mois, 6 mois et 1 an régulièrement. Le résultat mesuré était l'angle de flexion passive maximale du genou une année après la prothèse. Les facteurs potentiels qui affectent la flexion obtenue ont été étudiés. Après analyse de régression, à côté de la flexion pré-opératoire du genou ($p < 0.001$), les facteurs significativement les plus importants pour prédire la flexion post-opératoire étaient la présence d'ostéophytes résiduels du condyle fémoral postérieur ($p = 0.046$) et l'épaississement de plus de 2 mm de la rotule par le resurfaçage ($p < 0.001$).

Introduction

Range of motion is an important outcome in total knee replacement (TKR). Adequate knee flexion is crucial for

most daily activities (e.g. average knee flexion required in level ground walking = 67°, walking upstairs = 83°, walking downstairs = 90°, rising from a chair without support = 93°) [4, 6–8].

It is well known that the most critical factor predicting post-operative knee flexion is pre-operative flexion range [4, 9–11, 13, 14]. The importance of other potential factors (such as adequacy of removal of osteophyte over posterior femoral condyle, change in joint line, patella thickness, and soft tissue balance) are less well documented.

It seems logical to assume that residual osteophyte on the femoral condyle will affect the range of flexion after TKR, as the posterior part of the polyethylene insert will probably impinge on the osteophyte when the flexion exceeds 90° (Fig. 1). We assumed the null hypothesis of absence of a relationship between the presence of posterior femoral condyle osteophyte and the degree of knee flexion after TKR in this study to test the hypothesis. In addition, we also attempted to investigate the relative importance of various surgical techniques on the final flexion 1 year after the index surgery in a group of patients with good pre-operative flexion range.

Materials and methods

From July 2000 to June 2001, a total of 107 low contact stress (LCS) rotating platform primary TKRs (Low Contact Stress, Depuy, NJ, USA) were carried out in our institution. The surgical technique was standardised (midline incision, Insall approach, scarification of the posterior cruciate ligament, femoral cut with intramedullary alignment referencing, tibial cut with extramedullary alignment referencing). The post-operative rehabilitation protocol was also standardised. Early active mobilisation of the knee was encouraged on the second day after surgery. The deep drain was removed 48 h after the operation. A continuous passive movement (CPM) machine was not employed. Ninety-two patients with pre-operative flexion of the knee of at least 90° were included in this prospective study.

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Fig. 1 Residual posterior femoral condyle osteophyte after total knee replacement

All patients were followed up regularly at intervals of 3 months, 6 months and 1 year after the index operation. Patients were excluded from this review if they failed to return for follow-up at 1 year or if significant complications occurred before the 1-year assessment.

The range of motion was documented clinically by using a goniometer. The amount of maximum passive flexion at the end of 1 year was used as the outcome assessed in this study. Standing long X-ray films of the operated lower limbs (from hip joint to ankle joint) were taken before the index surgery and 6 weeks after the surgery. Standing short films of the operated knee were taken at each follow-up. The Knee Society Knee Score and Knee Society Function Score were recorded.

Intra-operative findings were documented on a standard form, which included the thickness of the patella (and the change in patella thickness if patella resurfacing was performed) and the ability to achieve a balanced flexion gap. The flexion gap was considered to be balanced if there was a difference of less than 5° laxity between the medial and lateral collateral ligament at 90° of flexion at the end of the operation.

The amount of residual posterior femoral condyle osteophyte was assessed according to whether it would cause impingement of the tibial insert during flexion of the knee over 90°. A circle best describing the shape of the posterior condyle was drawn. It represented the pathway of the insert on flexion beyond 90°. The point at which the arc of the circle was interrupted by the osteophyte was then defined as the point where potential impingement might occur. The angle of the arc was named as the “residual posterior fem-

Fig. 2 Residual posterior femoral condyle osteophyte angle

oral condyle osteophyte angle” (Fig. 2). Impingement of the tibial insert on the residual osteophyte when flexion exceeded 90° was defined to be present when the posterior femoral condyle osteophyte angle was equal to 0°.

The position of the patella of the replaced joint was documented by measuring the Insall–Salvati ratio on the standing post-operative X-ray (Fig. 3). Patella baja was assumed to be present if the Insall ratio was equal to or less than 0.85. The amount of posterior slope of the implanted tibial tray was measured with reference to the mechanical axis of the tibia in the post-operative standing long films of the lower limb (Fig. 4).

Fig. 3 Insall–Salvati ratio. *I* implant, *T* tibia

Fig. 4 Posterior slope of implanted tibial tray

The maximum passive flexion of the replaced knee at 1-year follow-up was used as the final outcome measured. The null hypothesis was assessed by using the independent *t* test. Statistical significance was assumed if *p* was <0.05 . The significance of other factors (i.e. age, sex, pre-operative knee flexion, ability to create a balanced flexion gap, thickness of the patella, presence of patellar baja and the posterior slope of the implanted tibial tray) were tested by examining their association with maximum passive knee flexion at 1-year follow-up. Bivariate correlation, paired *t*-test and independent *t* test were used whenever appropriate. Statistical significance was assumed if *p* was <0.05 . A backward linear regression test was carried out to find out the independent significant factors in predicting the flexion range 1 year after the index surgery.

Results

No patients were excluded. The Knee Society Knee score increased from 41 pre-operatively to 88 at 1-year follow-up. The Knee Society Function Score increased from 42 pre-operatively to 73 at 1-year follow-up.

The average pre-operative knee flexion was 107.5° (SD 15.5°) and the average knee flexion 1-year post-operation was 99.6° (SD 13.3°). The flexion 1-year post-operation

was found to be significantly related to the pre-operative knee flexion ($p<0.001$, paired *t* test).

There were a total of 61 patients (12 men; 47 women). The mean age at the time of operation was 65.7 years (SD 9.9 years). Eight patients (nine knees) suffered from rheumatoid arthritis. One patient (two knees) suffered from ankylosing spondylitis. The rest (52 patients) suffered from primary osteoarthritis. A previous operation had been carried out in ten of the knees studied.

The male patients had better flexion at the end of 1 year (men: $105.5\pm10.2^\circ$; women: $97.9\pm13.7^\circ$; $p=0.021$, independent *t* test). The age at the time of TKR, the diagnosis leading to joint replacement and a history of previous knee operation were not found to be significantly related to the amount of knee flexion 1 year post-operation.

Seven knees were found to have significant residual posterior femoral condyle osteophyte, which was thought to cause potential impingement on the insert when knee flexion exceeded 90° . The knee flexion at the end of 1 year in this group of patients was found to be significantly less compared with those without significant residual posterior femoral condyle osteophyte ($p=0.032$, independent *t* test; Table 1).

The flexion gap was considered to be satisfactorily balanced in 78 knees. The knees with a satisfactorily balanced flexion gap showed a better knee flexion 1 year post-operation ($100.6\pm14.0^\circ$, $p=0.013$, independent *t* test; Table 1).

The patella was replaced in 23 knees. The average thickness of the patella at the end of the operation was 21.9 ± 1.5 mm (range 18–25 mm). The average increase in patella thickness in the resurfacing group was 0.58 ± 1.45 mm (range 0–7 mm). There was an increase in patella thickness of more than 2 mm in ten knees. The knee flexion at the end of 1 year was found to be significantly less in those knees with an increase in patella thickness of more than 2 mm ($89.9\pm13.3^\circ$; $p=0.014$, independent *t* test; Table 1).

Table 1 Significant factors affecting knee flexion 1 year post-operation

Factor	Measurement	Significance
Pre-operative knee flexion	107.5 ± 15.5 degrees	$p<0.001^*$
Sex		
Male	$105.5\pm10.2^\circ$	$p=0.021^{**}$
Women	$97.9\pm13.7^\circ$	
Balanced flexion gap		
Yes	$100.6\pm14.0^\circ$	$p=0.015^{**}$
No	$94.4\pm5.3^\circ$	
Increase in patella thickness		
Yes	$89.0\pm13.3^\circ$	$p=0.014^{**}$
No	$100.4\pm13.4^\circ$	
Presence of significant residual posterior femoral condyle osteophyte		
Yes	$89.3\pm11.3^\circ$	$p=0.032^{**}$
No	$100.5\pm13.2^\circ$	

*Paired *t* test

**Independent *t* test

The average Insall-Salvati ratios in the pre-operative and post-operative standing X-ray were 1.25 ± 0.24 and 1.23 ± 0.24 . Five knees were found to have patella baja as the post-operative Insall ratio was less than 0.85. There was no relation between the final flexion range and the presence of post-operative low-lying patella.

The average posterior slope of the implanted tibial tray was $12.5 \pm 2.9^\circ$. There was no relationship between the amount of posterior tibial slope of the implanted tibial tray and the final flexion range.

Backward linear regression was carried out to determine the relative importance of the factors identified. Ability to achieve balanced flexion gap and being male were excluded after the regression analysis. The independent significant factors predicting the flexion range of TKR 1 year after the index surgery were pre-operative knee flexion ($p < 0.001$), presence of residual osteophyte in posterior femoral condyle ($p = 0.046$) and increase in patella thickness of more than 2 mm ($p < 0.001$).

Discussion

There is a rising expectation regarding the outcomes of TKR in our patients. It is no longer surgery for the old and disabled. Many patients receiving TKRs are relatively young and expect a relatively normal lifestyle after surgery. Patients demand better knee flexion after TKR in order to enjoy their life. This is particularly important for some people who require extreme knee flexion in their daily activities (e.g. sitting in the Japanese style, kneeling for the Buddhist and squatting in the southern Chinese). In order to address this demand, increasing numbers of new prostheses are on the market. Their manufacturers claim that the design is improved and that the patient will have better knee flexion after surgery. On the other hand, many surgeons nowadays advocate routine removal of the posterior femoral condyle osteophyte to maximise the amount of flexion after TKR. However, there is only a limited evidence in the literature concerning the importance of residual osteophyte for knee flexion [10].

The most important factor predicting the final flexion range is pre-operative knee flexion [4, 9–11, 13, 14]. The effect of pre-operative flexion is so dominant that it is not easy to prove the importance of other potential factors affecting flexion after TKR. We attempted to minimise the effect of pre-operative flexion by studying a pre-selected group of patients with satisfactory pre-operative knee flexion (equal to or more than 90°). After regression analysis, we were able to demonstrate that, other than pre-operative knee flexion ($p < 0.001$), the presence of residual posterior femoral condyle osteophyte ($p = 0.046$) and overstuffing of the patella of more than 2 mm ($p < 0.001$) were also significant independent factors affecting flexion 1 year after operation in a group of patients with satisfactory pre-operative knee flexion.

We found that the presence of residual posterior femoral condyle osteophyte is critical in determining post-operation flexion after TKR ($p = 0.032$, independent t test). It re-

mained a significant independent factor after regression analysis ($p = 0.046$). Removal of the osteophyte avoids impingement of the polyethylene insert on deep flexion of the replaced knee and allows more flexion to occur. The procedure is not difficult. It is usually done after the femoral bone cut is completed. The femur can be raised with an intra-medullary rod to allow better exposure and visualisation of the posterior femoral condyle. A broad chisel is used to remove the osteophyte in one piece. Care should be taken to avoid supracondylar fracture of the femur if the chisel is inserted too deeply. However, with caution, the chance of having this complication is minimal. We believed that routine removal of posterior femoral condyle osteophyte should be advocated to improve the final flexion of the replaced knee joint.

Overstuffing of the patella is common, especially when resurfacing of the patella is performed in patients with thin patellas. In our institution, the usual patella thickness is around 21–22 mm. In this study, the mean pre-operative patella thickness was 21.2 ± 1.6 mm (range 15.5–24 mm). Overstuffing of the patella is not uncommon if resurfacing is attempted and this will have an adverse effect on knee flexion. Patellar resurfacing is controversial [1–3, 5, 12, 15], and it is the practice in our institution that the patella will not be routinely resurfaced except in cases of inflammatory arthritis.

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