CLINICAL ARTICLE

Total Knee Arthroplasty in Asian Subjects: Preoperative Range of Motion Determines Postoperative Range of Motion?

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Objective: To evaluate whether preoperative range of motion is a key determinant of postoperative range of motion in Asian patients undergoing conventional total knee arthroplasty.

Methods: A retrospective review of 302 patients who underwent primary total knee arthroplasty performed by a single surgeon was conducted. Patients who had a fixed flexion deformity of $\geq 15^\circ$ were excluded. Postoperative range of motion (ROM) was measured prospectively. Patients were stratified into two groups: preoperative ROM $< 110^\circ$ and preoperative ROM $\geq 110^\circ$. Postoperative ROM and mean change in ROM at 6 months and 2 years of follow-up were then compared using Student's *t*-test.

Results: Group of ROM $< 110^\circ$ had a poorer postoperative range of motion at both 6-months and 2-years of follow-up than Group of ROM $\geq 110^\circ$ ($P < 0.001$). Postoperatively, Group of ROM $< 110^\circ$ had gained range of motion whereas Group of ROM $\geq 110^\circ$ had lost range of motion ($P < 0.001$).

Conclusions: Similar to the Western population, preoperative range of motion is a key determinant of postoperative range of motion in Asian patients. This should be taken into consideration by surgeons during preoperative planning and in managing patients' expectations.

Key words: Outcomes; Preoperative; Range of motion; Total knee arthroplasty

Introduction

Osteoarthritis (OA) of the hips and knees is estimated to be the fourth leading cause of functional disability worldwide. OA is strongly associated with ageing and aging is indeed occurring rapidly in the Asian region. The morbidity burden of OA is increasing significantly in Asia¹, where there is a greater demand for a good, pain-free range of knee joint motion for cultural, religious or simply lifestyle reasons. Asians are more likely than Westerners to squat and kneel for prolonged periods of time. Researchers have concluded that prolonged squatting accounts for the significant difference in prevalence of knee OA between Chinese subjects from Beijing, China and

white Western subjects participating in the Framingham OA study². Total knee arthroplasty (TKA) is considered the definitive solution to chronic knee pain secondary to OA. According to the national registry in Seoul, Korea, the number of TKAs performed has been increasing steadily over the years³. However, patients' expectations of TKA outcomes seem to differ from the actual measured outcomes of this procedure⁴. The most frequent outcomes expected by patients are improvement in pain, restoration of function and elimination of need for assistive devices. There is a significant difference between actual and expected activities after TKA for OA. Patients who attend preoperative education classes report

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Disclosure: The authors of this study declare no conflicts of interest, including specific financial interests and relationships and affiliations relevant to the subject of this manuscript.

Received 5 June 2013; accepted 22 October 2013

feeling better prepared for their surgery and are better able to control their postoperative pain⁵. Many factors affect postoperative range of motion (ROM) and function. Numerous studies have been conducted on Western populations to elucidate the impact of various factors that affect TKA outcomes⁶⁻⁸.

The impact of preoperative ROM on post-TKA ROM is of particular interest in Asian subjects. Khatri *et al.* conducted a prospective study in India in which 52 knees with a preoperative ROM of $>50^\circ$ were compared to 50 age- and sex-matched knees with a preoperative ROM of $>90^\circ$. They reported inferior outcomes in knees with a preoperative ROM of $<50^\circ$. However, in a study of Western subjects, Russell *et al.* concluded that the preoperative ROM was not predictive of the postoperative ROM¹⁰. Conversely, Farahini *et al.* followed 95 knees up for 1 year and concluded that preoperative ROM had a significant impact on postoperative ROM¹¹. With current published reports rather divided, there have been relatively few studies specifically investigating the impact of preoperative ROM on postoperative ROM following conventional TKA in Asian subjects.

In this study, we investigated whether Asian patients with a poorer preoperative ROM end up with poorer postoperative ROM following conventional TKA. We also asked if these patients gained more ROM postoperatively than their counterparts with better preoperative ROM.

Materials and Methods

This study is a retrospective review of data that was collected prospectively on 320 patients who had undergone elective TKAs from January 2006 to May 2009. All had the same surgical technique and postoperative care. Eighteen patients were excluded for one of following three reasons: (i) symptomatic OA in the contralateral knee (defined as self-reported knee pain greater than 4 on a 10-point, verbal analog scale); (ii) other lower extremity orthopedic conditions or neurologic impairments that limited function; or (iii) a fixed flexion deformity of $>15^\circ$. These exclusions left 302 patients (94%) for review. Our institutional review board waived approval for this study.

All patients had undergone unilateral posterior-stabilized TKAs performed by a single surgeon, the senior author of this study (THC). Tourniquets had been applied to the surgically treated limbs throughout the course of the surgeries. TKAs had been performed in a standard fashion for all patients. A medial parapatellar approach had been used for patients with varus OA and a lateral parapatellar approach for patients with valgus knees with OA. All patients in this study had received standard tibial implants. All components had been fixed with cement. Patellar resurfacing had not been performed in all patients. Drains had been inserted in all patients and removed on either the second postoperative day or when the drainage was <70 mL, whichever occurred earlier. All patients had received standardized postoperative care, which included appropriate oral and parenteral analgesia, mechanical calf pumps, continuous passive motion from the first postoperative day, and daily inpatient physiotherapy assessments. All

patients had begun ambulation on the second postoperative day. Patients had been discharged when they were able to ambulate independently with or without a walking aid. None of the patients had received oral chemoprophylaxis for deep vein thrombosis and pulmonary embolus because our previous study on Asian patients undergoing conventional TKAs without chemoprophylaxis but with mechanical prophylaxis showed a low incidence of venous thromboembolic events¹².

On discharge, patients were followed up at the specialist outpatient clinic at 1 month, 6 months, 1 year, and 2 years. At each visit, the patients reported their pain scores and any other concerns to the surgeon. The surgeon also examined the knee for any signs of wound or joint infection. Radiographs of the knee were also obtained in the immediate postoperative period and at the 1-year follow-up. Patients' heights and weights on hospital admission were extracted from the standardized medical case notes. Health service utilization data collected during the 6 months after discharge were extracted from the local healthcare databases. These data included length of stay and readmission to hospitals. Detailed reviews were conducted by physiotherapists 6 months and 2 years after TKA. Preoperatively and at 6-month and 2-year follow-ups, ROM of the surgically treated knee was determined consecutively by two experienced physiotherapists using a standardized plastic hand goniometer with 18 cm plastic movable limbs to measure ROM with 1° increments in flexion and extension measurements. The patient was supine with the contralateral knee fully extended. The operated knee was then passively placed in full passive flexion by the physiotherapist and measurements obtained while the patients held their knees in that position. The physiotherapists were blind to the measurements of their colleagues. The mean value correct to the nearest 1° was used as the final ROM. Preoperative Knee Society¹³, SF-36 (Medical Outcomes Trust, Hanover, NH, USA)¹⁴ and Oxford knee scores¹⁵ were also collected for baseline comparison. There were no missing data with respect to the relevant clinical details and the ROMs of all patients in the study who returned for the required follow-ups.

Patients were then stratified according to their preoperative ROM. Group 1 consisted of patients with a ROM of $<110^\circ$, whereas Group 2 consisted of patients with a ROM $\geq 110^\circ$. A cut-off of 110° was chosen because it allowed for the most balanced comparison. This stratification resulted in two groups with comparable clinical characteristics and preoperative outcome scores. Regression analysis did not show any confounding bias. Of the 302 patients, 81 had a preoperative ROM of $<110^\circ$ (Group 1), whereas 221 had a preoperative ROM $\geq 110^\circ$ (Group 2). Patients in Group 1 had longer postoperative hospital stays. Otherwise, no differences in mean ages, proportions of men and women, body mass indices, medical statuses, discharge location and duration of surgery were identified between the two groups (Table 1). Preoperatively, patients in Group 1 and Group 2 had comparable Knee Society, SF-36 and Oxford knee scores, with no significant differences (Table 2).

Student's *t*-test was used to compare means and the *Z* test to compare proportions between the two groups. Linear

TABLE 1 Patient characteristics

Characteristics	Group 1 (n = 81)	Group 2 (n = 221)	P
Clinical characteristics			
Mean age (range, yrs)	65.7 (52.3–83.0)	66.4 (50.7–82.7)	0.282
Sex: female (%)	78	76	0.718
Mean body mass index (range, kg/m ²)	29.2 (19.5–42.4)	27.4 (17.9–40.1)	0.119
Medical status			
Primary diagnosis OA (%)	99	98	0.555
Primary diagnosis inflammatory arthritis (%)	1	2	0.555
Cardiovascular disease (%)	26	24	0.719
Diabetes mellitus (%)	18	16	0.682
Mean number of co-morbidities ± SD	2.1 ± 1.7	2.3 ± 1.4	0.301
Health services utilization			
Hospital LOS (SD) (days)	5.8 ± 2.6	5.1 ± 2.3	0.025
Discharged directly home (%)	78	84	0.226
Surgical			
Operative time (SD) (min)	58 ± 15	54 ± 18	0.075

Note: Group 1, Pre-operative range of motion < 110°; Group 2, Pre-operative range of motion ≥ 110°; LOS, length of stay; OA, osteoarthritis; bold font indicates significant value.

aggression analysis was performed to rule out the effects of possible confounders. All statistical analyses were performed using Statistical Package for the Social Sciences (SPSS) Version 17 (IBM SPSS Statistics, Armonk, NY, USA).

Results

At the 6-month follow-up, Group 1 had a lower ($P < 0.001$) mean ROM than Group 2 (Table 3). Similarly at the 2-year follow-up, Group 1 had a lower ($P < 0.001$) mean ROM than

TABLE 2 Pre-operative mean range of motion and outcome scores

Index	Group 1 (n = 81)	Group 2 (n = 221)	P
Mean range of motion ± SD (°)	99 ± 6	128 ± 10	<0.001
Mean knee score ± SD	31 ± 16	34 ± 17	0.197
Mean function score ± SD	47 ± 21	51 ± 18	0.093
Mean Oxford knee questionnaire score ± SD	39 ± 9	37 ± 7	0.106
Mean SF-36 physical component score ± SD	31 ± 11	32 ± 11	0.485
Mean SF-36 mental component score ± SD	50 ± 10	50 ± 10	1.000

Note: Group 1, Pre-operative range of motion < 110°; Group 2, Pre-operative range of motion ≥ 110°; bold font indicates significant value.

TABLE 3 Postoperative range of motion(°)

Range of motion	Group 1 (n = 81)	Group 2 (n = 221)	P
6 months			
Mean postoperative flexion ± SD	105 ± 14	117 ± 13	<0.001
Mean change in flexion ± SD	+6 ± 2	–11 ± 4	<0.001
2 years			
Mean postoperative flexion ± SD	109 ± 13	122 ± 13	<0.001
Mean change in flexion ± SD	+10 ± 3	–6 ± 2	<0.001

Note: Group 1, Pre-operative range of motion < 110°; Group 2, Pre-operative range of motion ≥ 110°; bold font indicates significant value.

Group 2. Group 1 had gained ROM, whereas Group 2 had lost ROM compared with their respective mean preoperative ROM.

Discussion

Total knee arthroplasty is the standard treatment for severe knee osteoarthritis; the main goals being are to make the surgically treated knee pain-free and to stabilize it with an appropriate ROM. Progress in knee implant design and surgical techniques resulted in this procedure achieving alleviation of pain and restoration of stability to the knee joint. However, enhancing the postoperative ROM has always been challenging¹¹. Restoration of ROM is one of the major criteria for patient satisfaction, especially in Asian patients who require deep flexion of the knee for many daily activities.

In answer to our first question, we found that Asian patients with poorer preoperative ROM end up with poorer postoperative ROM following conventional TKA, suggesting that preoperative ROM may be a key determinant of postoperative ROM. This is in concordance with many studies that have found preoperative ROM to be the strongest predictor of postoperative ROM following TKA^{16–18}. Ritter *et al.* evaluated 4727 knees on which cruciate-retaining TKA had been performed over a period of 15 years¹⁸. His team used statistical clustering analysis paired with log-linear regression to determine which variables had the most significant impact on postoperative ROM. They found that preoperative ROM was the strongest determinant of postoperative ROM. Conversely, Russell *et al.* assessed 152 consecutive knees on which a single surgeon had performed cruciate-substituting TKAs¹⁰. Patients were stratified into two groups based on their preoperative ROM (Group 1 < 95°, Group 2 > 95°). This team found no significant difference between these groups in ROM 12 months after surgery (mean, 120° and 123°, respectively). The fact that a single surgeon performed cruciate-substituting TKAs on all knees makes this study similar to ours. However, the ROM was only measured by one physiotherapist in Russell *et al.*'s study. We also feel that the small number of patients in their Group 1 ($n = 32$) and a follow-up of only 1 year weaken their findings. It is known that long-standing poor preoperative ROM leads to stiffening of the extensor mechanism, severe destruction of the body structure and periarticular fibrotic changes in the soft tissue¹⁹. These are usually irreversible changes that cannot be corrected fully during TKA. This is the probable reason for poorer preoperative ROM leading to poorer postoperative ROM, as seen in our study.

In answer to our second question, we found that Asian patients with poorer preoperative ROM gained more flexion than their counterparts with better preoperative ROM, who lost flexion following TKA. Similar findings have been reported by several Western studies^{20–22}. In a landmark study conducted by Parsley *et al.*, 313 posterior-cruciate-retaining TKAs were assessed to determine the influence of preoperative ROM on postoperative ROM²². It was found that patients with limited flexion preoperatively demonstrated improvement in flexion postoperatively. In contrast, patients with >105° of

flexion preoperatively demonstrated a decrease in flexion postoperatively. Their study indicated movement towards the mean range of motion. There was a similar trend in our study.

There was one interesting secondary finding in our study. It can be seen from Table 1 that patients with poorer preoperative ROM had longer hospital stays. Several studies to evaluate the factors determining length of stay after TKA have been performed^{23,24}. All these studies cite only patient factors as being significant: surgical factors appear not to have a significant effect on length of stay. In our study, the difference in mean length of stay was less than 1 day. It is possible that patient factors that were not evaluated in this study could have been responsible for longer stay of patients with poorer preoperative ROM.

The findings of this study have implications for preoperative counselling and managing patients' expectations, especially in Asian patients. Scott *et al.* concluded that patient expectations correlate strongly with satisfaction following TKA²⁵. They assessed 1217 consecutive patients both prior to TKA and 6 months after, using the SF-12 health questionnaire and Oxford knee score. They assessed satisfaction at 1 year, then performed multivariate regression analysis to identify independent predictors of dissatisfaction. Based on their findings, Scott *et al.* suggested that managing patient expectations prior to surgery may reduce dissatisfaction. Managing the expectations of Asian patients with regards to ROM is particularly important because Asians have a greater demand for pain-free knee joints with good ROM for cultural, religious or simply lifestyle reasons. The findings of our study can be used to counsel patients preoperatively so that their expectations are realistic. Identifying patients who are likely to have poorer postoperative ROM would facilitate implementation of specific prehabilitation in a bid to improve their postoperative ROM. Matassi *et al.* conducted a prospective study on 122 patients with knee OA, randomly allocating them to control or treatment groups²⁶. The 61 subjects in the treatment group underwent a 6-week home-based exercise program before undergoing TKA. His study suggested that home-based prehabilitation improved knee motion. The patients in the treatment group achieved 90° of range of motion faster and had shorter hospital stays.

Some strengths of our study are that all TKAs were performed by one surgeon and all patients underwent the same rehabilitation protocol. The two groups had similar preoperative outcome scores, making the comparison meaningful. Postoperative ROM was also measured prospectively. Although this was a retrospective review, our data were all collected prospectively. However, the results of this study must be interpreted in context of its limitations. Because it was an observational study, cause and effect cannot be implied. Other limitations of our study were the short-term follow up and relatively few patients in the group with poorer preoperative ROM. Although our patients were drawn from a multi-ethnic Asian society, the results cannot be generalized to populations in all Asian countries. However, our findings will be useful to Western surgeons operating on Asian immigrant patients. We also studied only one particular subset of TKA, the

posterior-stabilized fixed-bearing implant. However, we were still able to answer our primary research question and our findings were concordant with previous studies on the same topic^{16–18}. Many of the limitations inherent to this study could be addressed by a well-designed cohort study.

The findings of our study suggest that preoperative ROM is a key determinant of postoperative ROM in Asian

patients undergoing conventional TKA. Similar to studies on Western populations, Asian patients with poorer preoperative ROM gained flexion, whereas those with better preoperative ROM lost flexion postoperatively. These findings should be taken into consideration by surgeons, including those in the West operating on Asian patients, during preoperative planning and in managing patients' expectations.

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