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ORIGINAL PAPER

The natural history of a newly developed flexion contracture following primary total knee arthroplasty

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Abstract
Purpose We investigated the incidence, natural history, and functional consequences of a newly developed flexion contracture after total knee arthroplasty (TKA).
Methods Forty patients with full knee extension preoperatively who developed a postoperative flexion contracture were match-paired 1:2 with 80 patients who had full extension. The incidence of a newly developed flexion contracture, ROM, and Knee Society scores (KSS) at six weeks, four months, and one year were analysed.
Results The incidence of a new flexion contracture at six-weeks was 14 %, but diminished to 5 % and 0.3 % at four-months and one year, respectively. One year after surgery, there was no difference in the KSS ($p=0.5$).
Conclusions This study showed that the majority of patients who developed a new flexion contracture after TKA have full knee extension one year postoperatively. Moreover, knee extension and KSS at one year are equivalent to those patients who did not developed a flexion contracture.

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Introduction

Flexion contracture is an unwanted complication of total knee arthroplasty (TKA), occurring in 1.4 to 17 % of patients [1–6]. Patients with a postoperative flexion contracture have an increased prevalence of anterior knee pain, probably secondary to an abnormal distribution of forces across the prosthetic components with an increased load in the posterior aspect of the tibial plateau and the patellofemoral joint [7]. Activities such as standing and walking on a flexed knee require increased activity of the extensor mechanism and energy expenditure, resulting in accelerated fatigue [8, 9]. In patients with a severe flexion contracture, the limb becomes functionally short, compounding the abnormal gait pattern. Due to these factors, patients with a flexion contracture have a decreased ability to walk and lower outcome scores [1].

The most recognised risk factor for the development of a flexion contracture is the presence of a preoperative flexion contracture. Ritter et al. demonstrated that in the presence of a preoperative flexion contracture of 5° or more, patients are 2.9 times more likely to develop a postoperative flexion contracture [5]. In addition, flexion contractures can be seen postoperatively in patients without a preoperative flexion contracture [5]. However, the natural history of this unanticipated postoperative feature is unknown.

Thus, the aims of this study were to determine (1) the incidence and natural history of a newly developed flexion contracture after TKA surgery and (2) if the presence of a new flexion contracture affects the clinical outcome.

Patients and methods

Three hundred fifty-five patients (380 knees, 25 bilateral) who did not have a preoperative flexion contracture and underwent primary TKA surgery between January 2006 and April 2011 by a single surgeon (AGDV) were included in the study. Patients

with a diagnosis of primary osteoarthritis, rheumatoid arthritis, or avascular necrosis were included.

Sixty patients (61 knees, one bilateral) were excluded: seven patients (seven knees) required a highly constrained, stemmed TKA due to severe angular deformity and/or bone loss; two patients (two knees) died of causes unrelated to the surgery before the first year; six patients (six knees) required reoperation (one staged reimplantation for infection, two arthroscopic debridements for patellar clunk and three for septic loosening); and 45 patients (46 knees, one bilateral) were not examined after the fourth postoperative month.

The remaining 295 patients (319 knees), representing 78 % of the original cohort, were divided into those who had a flexion contracture of 5° or more at the six-week postoperative visit (46 study patients) and those without a postoperative flexion contracture (249 control patients). Each patient in the study group was match-paired with two patients in the control group, based on four preoperative variables: age ± five years, gender, body mass index (BMI) ± 5 kg/m^2, and preoperative range of motion (ROM) ± 10°.

The Mayo matching algorithm was used. Forty of 46 patients were matched with two patients in the control group. Of the six remaining patients, three were matched with only one patient and the remaining three could not be matched. Consequently, 40 patients (40 knees) with a newly developed flexion contracture were matched with 80 control patients (80 knees) (Table 1). In addition to match-pairing, a number of preoperative and intraoperative variables were analysed to assure comparability between the two groups (Tables 2 and 3, respectively).

To further assure comparability between the groups, standard radiographs in anteroposterior (AP), lateral, and axial views were evaluated by a single observer who was not involved in patient care (AA). Alignment of the knee and position of the prosthetic components were measured using the picture archiving and communication system (PACS), and the results were evaluated according to the Knee Society radiographic evaluation form [10].

Surgical technique

All operations were performed following our standard institutional perioperative care protocol. Patients underwent surgery with hypotensive epidural anaesthesia and tourniquet control. A midline incision, with a medial parapatellar arthrotomy and without patella eversion, was used in all cases [11]. The tibial cut was performed with an extramedullary guide and preceded all femoral cuts. The distal femur was then cut using an intramedullary alignment guide set at 5° of valgus with anterior referencing instrumentation. Femoral component rotation was determined using the posterior femoral condyles, the epicondylar axis, and Whiteside's line [12–14]. Flexion and extension gaps were balanced using spacer blocks, aiming at achieving rectangular and symmetric gaps. The patella was routinely resurfaced. All patients received the same posterior stabilised TKA (Genesis II Total Knee System; Smith and Nephew, Memphis, TN) and all implants were cemented.

Postoperative pain control was achieved with an epidural catheter and patient-controlled analgesia for the first 24 hours postoperatively, progressing to oral analgesics as tolerated. Drains were used in all cases and removed on the first postoperative day. Rehabilitation was initiated on the day of surgery with a continuous passive motion (CPM) machine set from 0 to 60°. All patients were weight bearing as tolerated and received multimodal thromboprophylaxis [15]. Pharmacological thromboprophylaxis for six weeks included aspirin in patients with a low risk of thromboembolic disease and Coumadin in those who were high risk [15]. Patients were discharged to home or an inpatient rehabilitation unit within three to six days after surgery.

Postoperative follow-up visits were at six weeks, four-months, and one year after surgery. In addition, eight study patients and 27 control patients returned for follow-up after the first year (mean, 2.8 years; range, 2–4 years). During each visit, the operating surgeon completed the Knee Society

Table 1 Matching variables between study (flexion contracture) and control (no postoperative flexion contracture) groups

Match paired 1:2

Variable	New FC		No FC		*P*value
	Mean ± SD	Range	Mean ± SD	Range	
Age (years)	67.6±9.4	52–83	67.9±9.2	50–84	0.8505[a]
Gender (M/F)	7/33		14/66		1.0000[b]
BMI	30.9±5.5	22.7–47.7	31±5.4	22.2–50	0.9566[a]
Preoperative ROM	117.7±8.2	100–130	118±8.4	95–135	0.8532[a]

FC flexion contracture, *BMI* body mass index, *ROM* range of motion, *SD* standard deviation

[a] *P* values were obtained using two sample *t*-test

[b] *P* values were obtained using chi-square test

Table 2 Preoperative variables between the study (flexion contracture) and control (no postoperative flexion contracture) groups

Preoperative variables			
Variable	New FC Mean ± SD	No FC Mean ± SD	*P* value
Side			0.0138[a]
Right	28 (70.0 %)	37 (46.3 %)	
Left	12 (30.0 %)	43 (53.8 %)	
Diagnosis			0.4720[a]
OA	38 (95 %)	78 (97.5 %)	
RA	2 (5.0 %)	2 (2.5 %)	
AVN	0	0	
Previous operations			0.2425[b]
1	26 (65 %)	60 (75 %)	
2	10 (25 %)	18 (22.5 %)	
3	1 (2.5 %)	0	
4	3 (7.5 %)	2 (2.5 %)	
Obese class			0.1123[a]
Normal	4 (10.0 %)	6 (7.5 %)	
Overweight	17 (42.5 %)	39 (48.8 %)	
Obese class I	9 (22.5 %)	20 (25.0 %)	
Obese class II	9 (22.5 %)	6 (7.5 %)	
Obese class III	1 (2.5 %)	9 (11.3 %)	
Patient referred KSS	47.0±11.8	44.6±18.2	0.3870[c]
Total KSS	39.7±10.0	37.2±15.2	0.2737[c]
AP limb alignment			0.2970[a]
Varus 25°	0	2 (2.5 %)	
Varus 20°	1 (2.5 %)	6 (7.5 %)	
Varus 15°	3 (7.5 %)	12 (15.0 %)	
Varus 10°	9 (22.5 %)	10 (12.5 %)	
Varus 5°	10 (25.0 %)	13 (16.3 %)	
No malalignment	8 (20.0 %)	21 (26.3 %)	
Valgus 5°	3 (7.5 %)	9 (11.3 %)	
Valgus 10°	5 (12.5 %)	3 (3.8 %)	
Valgus 25°	1 (2.5 %)	4 (5.0 %)	

FC flexion contracture, *OA* osteoarthritis, *RA* rheumatoid arthritis, *AVN* avascular necrosis

[a] *P* values were obtained using chi-square test

[b] *P* values were obtained using Fisher exact test

[c] *P* values were obtained using two sample *t*-test

score (KSS). Gravity-assisted, passive range of motion (ROM) was assessed with a goniometer preoperatively and at each subsequent postoperative visit, with the patient in a supine position. All postoperative assessments were done by the operating surgeon.

There were no statistically significant differences between the study and control groups in any of the matching variables (Table 1), or in the additional preoperative and postoperative comparative variables, with the exception of laterality (Tables 2 and 3). There was an over representation of right knees in the study group. The postoperative radiographic analysis revealed no differences in the radiographic alignment of the knees in the frontal plane (4.7±1.8° in the study group and 5.3±2.0° in the control group; p=0.1033) or in regard to tibial slope angle (5.1±1.9° and 5.0±1.8°, respectively; p=0.653). The flexion angle for the femoral component was 5.1±2.6° in the study group and 4.0±2.6° in the control group (p=0.0248).

Statistical analysis

Outcome variables in the study included ROM, passive extension, passive flexion, number of patients with a flexion contracture of 5° or more at each follow-up visit, and individual and combined categories of the KSS. Categorical variables were analysed and matched using the Mayo matching algorithm form. For comparison between paired groups, p-values were obtained using the two sample *t*-test, chi square test and Fisher's exact test. A p-value of <0.05 was considered significant. Continuous variables were expressed as a mean ± standard deviation.

Results

Forty-six (46 knees) out of 295 patients (319 knees) (14.4 %) developed a new flexion contracture of 5° or more at the first

Table 3 Intraoperative variables between study (flexion contracture) and control (no postoperative flexion contracture) groups

Intraoperative variables					
Variable	New FC		No FC		*P* value
	Mean ± SD	Range	Mean ± SD	Range	
Tourniquet time (minutes)	51.9±8.0	(30–68)	53.7±12.0	(35–103)	0.3495[a]
Insert type					0.0712[b]
PS	36 (90.0 %)		61 (76.3 %)		
CCK	4 (10.0 %)		19 (23.8 %)		
Insert size (mm)					0.8105[b]
9	17 (42.5 %)		35 (43.8 %)		
11	18 (45 %)		38 (47.5 %)		
13	5 (12.5 %)		7 (8.8 %)		
Lateral release					0.6103[b]
No	34 (85.0 %)		65 (81.3 %)		
Yes	6 (15.0 %)		15 (18.8 %)		

FC flexion contracture, *PS* posterior-stabilized, *CCK* constrained liner

[a] *P* values were obtained using two sample *t*-test

[b] *P* values were obtained using chi-square test

follow-up visit (six weeks). There were three patients with a flexion contracture over 15°, 20 patients with a flexion contracture between 10 and 15°, and 23 patients with a flexion contracture of over 10°.

The number of patients with a residual flexion contracture diminished over time. A residual flexion contracture was detected in 14 of 46 patients at four months (30 %) and seven patients at one year (15 %). None of these seven patients had a residual flexion contracture greater than 5°. The initial postoperative flexion contracture in these seven patients was 10° in three and 5° in the remaining five. None of the 11 patients available for follow-up after the first year had a residual flexion contracture.

At the first postoperative visit (six weeks after surgery), the mean knee flexion contracture was 8±3.9° in the study group and 0±0° in the control group ($p<0.0001$). The flexion angle was 98.9±15.6° in the study group and 107.3±14.8° in the control group ($p=0.0046$). The individual categories and the total functional section of the KSS were similar between the study and the control groups ($p=0.0658$). The individual categories in the knee section of the KSS were similar between the study and the control groups, with the exception of flexion contractures ($p<0.0001$) and the arc of motion ($p<0.0001$). The total knee section of the KSS was lower in the study group than in the control group (74.4±14.8° vs. 81.2±15.4°, respectively; $p=0.02$) (Table 4).

At the second postoperative visit (four months after surgery), the mean flexion contracture in the study group was 2±3° versus 0.1±0.6° in the control group ($p=0.0004$). The individual categories and the total functional section of the KSS were similar between the study and the control groups ($p=0.4896$). The individual categories in the knee section of the KSS were similar between the study and the control groups, with the exception of extension ($p<0.0004$) (Table 4). The total knee section of the KSS showed no significant differences between the groups ($p>0.1206$) (Table 4).

At the third postoperative visit (one year after surgery), the mean flexion contracture in the study group was 0.8±1.8° vs. 0.3±1.6° in the control group ($p=0.13$). The individual categories and the total functional section of the KSS were similar between the study and the control groups ($p=0.192$). The individual categories and the total knee section of the KSS were similar between the study and the control groups (Table 4).

At the final follow-up visit (mean, 36.9±16.1 months after surgery), the mean flexion contracture in the study group was 0.6±1.8°, representing one patient with a residual flexion contracture of 5°. The individual categories and the total function section of the KSS were similar between the study and the control groups ($p=0.1733$). The individual categories and total knee section of the KSS were similar between both groups ($p=0.3638$).

Discussion

The incidence of fixed flexion deformity after TKA ranges from 1.4 to 17 % [1–6, 16]. While some studies have reported that the condition does not improve postoperatively [17–20], other investigators have shown gradual recovery with conservative management [19, 21–24]. It has been well established that the presence of a preoperative flexion contracture increases the risk of developing a postoperative flexion contracture [5]. However, the incidence and natural history of a newly developed flexion contracture in patients after total knee arthroplasty has not been extensively studied [4, 21].

In this study, the incidence of a newly developed flexion contracture after TKA diminished from 14.4 % at six weeks

Table 4 Postoperative variables between study (flexion contracture) and control (no postoperative flexion contracture) groups

Postoperative results									
Outcome	Postoperative visit								
	Six weeks			Four months			One year		
	Group		*P* value	Group		*P* value	Group		*P* value
	New FC Mean ± SD	No FC Mean ± SD		New FC Mean ± SD	No FC Mean ± SD		New FC Mean ± SD	No FC Mean ± SD	
Extension	−8°±3.9°	0°	<0.0001	−2°±3.0°	−0.1°±0.6°	0.0004	−0.8°±1.8°	−0.3°±1.6°	0.1306
Referred KSS	65.2±13.8	70.1±13.5	<0.0658	85.7±12.6	87.4±11.8	0.4896	87.4±15.6	91.0±10.1	0.1920
Total KSS	74.3±14.8	81.2±15.4	<0.0200	85.4±21.3	77.5±34.2	0.1206	89.5±13.8	91.7±17.7	0.4838

FC flexion contracture

P values were obtained using two sample *t*-test

postoperatively to 0.3 % at one year. All newly develop flexion contractures resolved to 5° or less at one year postoperatively with conservative management. In addition, we found that pain and function as determined by the KSS at one year were equivalent to those patients without a postoperative flexion contracture. This suggests that patients who develop a new flexion contracture detected six weeks postoperatively are not likely to have different KSS and function one year after surgery than patients without a preoperative and postoperative flexion contracture.

There are limitations to the study. First, range of motion was obtained with a goniometer. Though it can be argued that measurements obtained with other methods, such as gait analysis or fluoroscopy, can be more precise, Gogia et al. found that goniometric measurements of the knee are both reliable and valid [25]. The second limitation is the lack of long-term follow-up. However, it has been established that ROM after TKA does not substantially improve after the first postoperative year [26–29]. Consequently, the lack of long-term follow-up is unlikely to have clinical consequences. In our study, only one of eight study patients who were seen after the first year (mean follow-up of 36 months) had a mild flexion contracture of 5°. The third limitation is our retrospective analysis. In order to account for confounding variables that may be different between the study and control groups, we match-paired each study patient with two control patients for four variables known to affect postoperative ROM: age, gender, BMI, and preoperative ROM [5, 16]. In order to avoid bias introduced by the study of patients with diagnoses that predispose to the development of a flexion contracture, patients with post-traumatic or post-infectious arthritis were excluded. Rather, we focused on patients with a diagnosis of osteoarthritis, rheumatoid arthritis, or avascular necrosis. Patients with these diagnoses have shown no differences in their outcomes after TKA surgery [20, 30, 31]. In addition to strict-pairing, a number of preoperative, intraoperative, and radiographic variables were compared. Of all variables analysed to assure comparability between the study and the control groups, only laterality and flexion angle of the femoral component showed a statistically significant difference. Mehta et al. found that right TKA patients may have better outcomes from surgery than left TKA patients when operated on by a right-handed surgeon [32]. Contrary to Mehta's observation, in our analysis of a right-handed arthroplasty surgeon, right knees were over-represented in the study (flexion contracture) group and not in the control group. Faris et al. demonstrated that postoperative ROM is not affected when the flexion angle of the femoral component is less than 20° [33]. Consequently, the small radiographic angular difference (1.1°) we observed between the study and the control patients is unlikely to be clinically relevant.

The incidence of a new flexion contracture detected six-weeks after surgery was 14.4 %. This is slightly higher than that reported in the literature due to the fact that we considered any loss of extension greater than 5° to be a flexion contracture. We selected this value given that many authors have found that quadriceps muscle fatigue, anterior knee pain, altered gait mechanics, lower knee outcome scores, and patient dissatisfaction occur with a flexion contracture over 5° [1, 5, 8, 9, 19, 30, 34, 35]. If we had defined flexion contracture as a lack of extension of 10° or more, our flexion contracture incidence at six weeks and one year would have been 5.96 % and 0 %, respectively.

While the majority of flexion contractures detected immediately after TKA may be attributed to the presence of pain and joint effusion [4, 34, 36], less information is available on newly developed flexion contractures noted at six-weeks. Aderinto et al. observed that the presence of a preoperative fixed flexion deformity was a good predictor for

the development of post-operative fixed flexion deformity [21]. Moreover, they showed that postoperative flexion contractures improve with conservative management during the first three years. Other investigators have demonstrated similar flexion contracture improvement with rehabilitation and physiotherapy after intraoperative correction [4, 7, 24].

The second aim of this study was to compare the evolution over time of this newly developed flexion contracture with those patients who did not develop a contracture postoperatively. We found significant differences in the total KSS and ROM, but not in the referred KSS at the six-week follow-up visit. At the one year visit, however, there were no significant differences between the study and control groups with regard to extension, ROM, total KSS, and referred KSS. In addition, patients with a flexion contracture showed an excellent recovery between the six-week and four-month follow-up visits. Goudie et al. reported significantly decreased Oxford knee scores and patient satisfaction in patients with a fixed flexion contracture postoperatively [1]. However, these were not patients with a newly developed flexion contracture postoperatively.

In summary, our study showed that the majority of patients who developed a new flexion contracture (over 5°) after TKA surgery (incidence 14.4 % at six weeks) had full knee extension one year postoperatively (incidence 0.3 %). Moreover, knee extension, KSS pain, and KSS function at one year were equivalent to those patients who had not developed a postoperative flexion contracture.

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Conflict of interest The authors declare that they have no conflict of interest.

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