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Risk factors for a post-operative neutrally aligned total knee arthroplasty in the sagittal plane developing fixed flexion deformity at 2 years follow up study

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ABSTRACT

Background: The incidence of fixed flexion deformity (FFD) following total knee arthroplasty (TKA) has been reported to be as high as 17%, increasing demand on the quadriceps and hindering mobility. The aim of this study is then to identify these predictors for the development of FFD.
Methods: In this retrospective study, all patients who underwent primary TKA from January 2008 to June 2009 at a single institution were identified. All patients with neutral alignment in the sagittal place of the knee intra-operatively were identified and followed up. The knee motion was measured in both operated and contralateral knees and followed-up for a minimum of 24 months post-operatively.
Results: Multivariate analysis demonstrated pre-operative FFD of the non-operated knee (p-value 0.03), pre-operative range of motion of the operated knee (p-value 0.01) and non-operated (p-value 0.01) knee and pre-operative maximum flexion of the operated knee (p-value 0.001) to be independent risk factors for development of FFD at 24 months.
Conclusions: Independent risk factors for the development of post-operative FFD in TKA are pre-operative FFD of the operated knee, FFD of the non-operated knee and the maximum flexion of the operated knee. The relative risk of a male developing FFD is also as high as 1.34.

Keywords: Knee arthroplasty, Fixed flexion deformity, Risk factor

INTRODUCTION

The primary goals of total knee arthroplasty (TKA) are to improve pain and produce satisfactory range of motion. However, many factors can work against these, leading to a result that is short of ideal.[1-3] One of the main factors includes that of being able to achieve neutral alignment in the sagittal place of the knee in full extension. Yet, operated knees can end up in either genu recurvatum (GR) or with a fixed flexion deformity (FFD), both of which lead to a poor functional outcome and reduced patient satisfaction.

The incidence of FFD following TKA has been reported to be as high as 17%, compromising on pain relief and the achievable range of motion.[1,4] With a FFD of the knee, the quadriceps have to be continually contracted to avoid buckling of the knee, leading to a greater energy expenditure and resultant fatigue, such that patients experience muscle weariness when standing, walking or climbing stairs due to the increased demand on their quadriceps.[5-7] Similarly, the walking velocity has also been found to decrease in a linear fashion with the degree

of FFD.[5,8] Gait studies of patients with flexion contractures have also shown that the limb length discrepancy and shortened stride length have led to abnormal forces on the contralateral knee, including increased extension and adduction moments, which theoretically can lead to greater wear of the cartilage in the contralateral knee, potentially accelerating the arthritic process.[5,9,10] Additionally, trunk alignment may also be adversely affected by the FFD, altering the kinematics of the spine, potentiating future pathologies.[5,8] Taken in totality, the presence of a FFD of the knee yielded significantly higher Knee society scores (KSS) in previous studies.[4,11]

While some flexion contractures after TKA eventually resolve, a percentage of this persist.[1,4,5] The identification of pre-operative predictive factors of a persistent post-operative FFD could then highlight patients at risk of a poor functional outcome. However, to date, there are no studies available in the literature that have been conducted to determine the causative factors for the development of FFD in a post-operative neutrally aligned TKA in the sagittal plane. The aim of this study is then to identify these predictors for the development of persistent FFD at the 24-month time point despite an intra-operative neutral alignment in the sagittal plane of the knee.

METHODS

This study was conducted at a tertiary care hospital (Singapore general hospital) in Singapore. In this retrospective review of prospectively collected data, all patients who underwent primary TKA from January 2008 to June 2011 at a single institution were identified. Revisions, previous unicondylar knee arthroplasty and previous osteotomies were excluded.

All patients with neutral alignment in the sagittal plane of the knee intra-operatively were included in the study. These patients were followed-up for a minimum of 24 months post-operatively. Neutral alignment in the sagittal plane was defined as the angle between the femoral axis and the tibial axis on the sagittal plane. All the patients were diagnosed with osteoarthritis. Rheumatoid arthritis was excluded both clinically and by laboratory testing.

The demographics and clinical variables of these patients were assessed and recorded by an examiner different from the operating surgeon pre-operatively and intra-operatively. The demographic variables recorded included the gender, age, height and body mass index (BMI) of the patient, while the clinical variables recorded included the pre-operative FFD of bilateral knees, pre-operative range of motion of bilateral knees, pre-operative maximum flexion of bilateral knees, pre-operative alignment of the operated knee in the coronal plane, pre-operative laxity of the operated knee in the transverse plane and intra-operative range of motion of the operated knee. These demographic and clinical factors were then analyzed against the post-operative findings of full extension or FFD at the 24-month time point.

Sagittal alignment was mainly measured with a goniometer. Additionally antero-posterior, and lateral weight bearing X-rays were done pre-operatively, post-operative day 2, post-operative 3, 12 and 24 months.

105 knees (21%) were done with the aid of full navigation, these data were recorded intra-operatively and we recognized a pattern between the intra-operative sagittal alignment and the sagittal alignment at 6 months are similar. From that we postulated that the type of deformity at 6 months is reflective of intra-operative deformity (post-replacement), most likely due to the subsiding of pain and swelling of the immediate post-operative phase. Thus we have done our comparison analysis based on the deformity at 6 months.

SPSS 17.0 was used with univariate and multivariate analysis was done using linear regression for statistical analysis.

RESULTS

Within the 18-month study period, 489 knees underwent primary TKA and those that were neutrally aligned in the sagittal plane intra-operatively were identified. Out of these, 344 patients had full extension at the 24-month time point (group A) whereas 145 patients had FFD at the 24-month (group B) time point.

In group A there were 45 males (17%) and 221 females (83%), and the mean age of the patient's was 66.4 years (range 41.9–83.7 years) when they were recruited. The mean height of the patient's was 154.2 cm (range 138–180 cm) and the mean body-mass index (BMI) was 28 (range 17–49) pre-operatively. In group B there were 52 (39%) males and 80 (61%) females. The mean height of the patients was 154.8 cm (range 133–184 cm) and the mean body-mass index (BMI) was 29.1 (range 17.4–49.8) (Table 1). Of these demographic variables, only male gender showed a statistically significant predisposition for FFD, with $p<0.001$, while age, height and body mass index did not demonstrate any statistical significance.

Table 1: Demographics.

Demographic Variables	Group A	Group B
Gender	Male: 45 (17%) Female: 221 (83%)	Male: 52 (39%) Female: 80 (61%)
Mean Height	154.2 cm (range 138–180 cm)	154.8 cm (range 133–184 cm)
Body mass index (BMI)	28 (range 17–49)	29.1 (range 17.4–49.8)

With regards to clinical variables pre-operatively and intra-operatively (Table 2), firstly using univariate analysis we identified the factors of the non-operated knee causing statistically significant post-operative FFD of the operated knee. They were pre-operative FFD (mean difference 4.53) with p=0.037 and pre-operative range of motion (mean difference 4.53 degrees) with p<0.01.

Table 2: Risk factors for developing FFD at 24 months in post TKA patients.

Risk factors for developing FFD (univariate analysis)	Mean difference	Significance
Operated Knee		
Pre-operative range of motion	4.14	0.01
Pre-operative maximum flexion	5.71	0.01
Intra-operative range of motion	3.67	0.04
Pre-operative FFD	5.52	0.01
Alignment in the coronal plane	1.56	0.62
Laxity in the transverse plane	2.20	0.53
Non-operated Knee		
Pre-operative FFD	4.53	0.037
Pre-operative range of motion	4.53	0.01
Risk factors for developing FFD (multi-variate analysis)		
Pre-operative fixed flexion deformity of the non-operated knee		0.03
Pre-operative fixed flexion deformity of the operated knee		0.001
Pre-operative maximum flexion of the operated knee		0.01

Factors of the operated knee causing statistically significant post-operative FFD of the operated knee were pre-operative range of motion (mean difference 4.14 degrees) with p<0.01 and pre-operative maximum flexion (mean difference 5.71 degrees) with p=0.01 and intra-operative range of motion of the operated knee (mean difference of 3.67 degrees) with p<0.04 and intra-operative range of motion of the operated knee (mean difference of 3.67 degrees) with p<0.04.

Multivariate analysis also demonstrated pre-operative FFD of the non-operated knee (p value 0.03), pre-operative FFD of the operated knee (p value 0.01) and pre-operative maximum flexion of the operated knee (p value 0.001) to be independent risk factors for development of FFD at the 24-month time point.

Pre-operative range of motion of the operated knee, maximum flexion of the non-operated knee, alignment in the coronal plane and laxity in the transverse plane, however, did not demonstrate a statistical significance for the development of FFD.

Notably, 78 patients of the full extension group and 13 patients of the FFD group had undergone bilateral TKA within the 24 months, being statistically significant with p value of 0.004 for patients with a FFD to require a TKA of the contralateral knee within 2 years.

There was no statistical significance between intra-operatively neutrally aligned cruciate retaining knees or cruciate sacrificing knees, acquiring FFD at 24 months.

DISCUSSION

Post-operative FFD has a detrimental effect on the functional outcome and patient satisfaction following TKA. Although TKA procedures have a high success rate, it is undeniably true that full extension of the operated knee is not consistently achieved.[4] In 1987, Tew et al reported the incidence of FFD following TKA to be as high as 17%, and in this study, FFD occurred in 29.7% of the patients at the 24-month time point.[1] This high incidence then prompts an investigation on the possible pre-operative predictive factors of poor functional outcome and dissatisfaction post-operatively, which could possibly influence the management of these patients.

Flexion contractures immediate post-operatively are most commonly caused by pain and effusion, with the natural history of these contractures being that of its resolution with time.[2] Studies on the natural history of FFD post-operatively revealed a tendency for majority of the FFD to increase in the early post-operative period and then decrease, followed by a gradual improvement in knee movement with time.[4,10-16] However, there still exist a proportion of these patients with persistent FFD that might require surgical correction, and arthrofibrosis involving excessive post-operative scarring is regarded as the most unresponsive cause of FFD.[2] Here, we then analysed the predictive factors of these persistent FFD at the 24-month post-operative time point.

Demographic predictive factors for FFD

In our study, the only demographic risk factor that showed a predilection for the development of FFD following TKA is that of male gender, with the relative risk of a male developing FFD being 1.34. This finding is similar to previous studies that have been published, with the development of FFD being associated with male gender at the 1-week and 3-year time points, though gender was not found to be a significant predictor at the

6-week and 6-month timepoints.[2,4,5,19] This could possibly be explained by the natural history of the development of FFD, with majority of the deformities resolving over time, such that male gender is a predictive factor for persistence of FFD. In fact, in a long-term study by Ritter et al, male gender was concluded to have more than 2.3 times the likelihood of development of a FFD greater than 10 degrees post-operatively.[19] Follow-up studies at regular intervals post-operatively could then be performed to better understand the association between gender and the natural history of FFD.

In the same study by Ritter et al, however, age was found to be a significant predictor in the development of FFD, with every decade of life increasing the chance of post-operative flexion contracture by 35%. This association, however, was not reflected in our study, as well as multiple previous studies, possibly due to the narrow age range in our patients since only patients who underwent TKA secondary to primary osteoarthritis were included in our study, as opposed to the varied indications of osteoarthritis, rheumatoid arthritis, osteonecrosis and others in the study by Ritter et al, yielding an age range of 21 years to 91 years.[2,4,19] The results of our study is then reflective of the specific population of patients who underwent TKA secondary to primary osteoarthritis of the knees, with no association between the age of the patients and the development of FFD of the knee.

Other notable risk factors novel to this study includes that of height and body mass index of the patients pre-operatively. While these factors could possibly alter the forces exerted on the knee post-operatively, there is no demonstrable statistical relationship between these factors and the development of FFD following TKA in our study.

Clinical predictive factors for FFD

Pre-operative FFD of the operated knee and its association with FFD post-operatively has been intensively researched upon. While pre-operative FFD could understandably result in an eventual FFD as proven in multiple studies, this relationship only holds true for the immediate post-operative period, and long-term studies have demonstrated continued and sustained improvement in FFD up to ten years post-operatively, such that FFD was uncommon even in knees with severe pre-operative flexion deformity as soon as six months post-operatively.[2,4,5,16-18] This finding is then corroborated in our study with no statistically significant correlation between pre-operative and post-operative FFD of the operated knee at the 24-month time point. In fact, our study has found that FFD of more than 10 degrees or genu recurvatum of more than 5 degrees in the non-operated knee is more predictive of the development of persistent FFD of the operated knee at the 24-month time point, possibly due to the abnormal forces exerted on the operated knee when there is a contralateral knee with FFD secondary to limb length discrepancy and shortened stride length.[5,9,10]

Unique to our study, pre-operative range of motion of less than 90 degrees in the operated knee and less than 105 degrees in the non-operated knee as well as pre-operative maximum flexion of less than 100 degrees are found to be related to the development of FFD of the knee following TKA. These predictors are novel factors that have been minimally studied in previous publications, though these factors could understandably lead to the development of FFD post-operatively due to the alteration of the forces exerted on the operated knee as a result of these variables.

Recommendations

With the identification of these novel predictors for the development of FFD of the knee following TKA, the next step would be to identify measures that could possibly prevent or minimize the poor functional outcomes in these patients identified pre-operatively. Surgical techniques, for example, inevitably plays a role in the potential for residual flexion contracture and sufficient gap must be created for the operated knee to reach full extension, since the extension gap will be tighter in knees with FFD. Implant malpositioning will also influence the post-operative range of motion, limiting the arc of motion due to constraints of the articulation, and these should be avoided particularly in patients who are at higher risk of developing FFD as identified by these risk factors.[20] Post-operative rehabilitation regime should also be undertaken more rigorously by these patients with placement of bolster under the ankle, suspension of the knee and the use of knee immobilisers to ensure the achievement of full extension.[5] Eventually, studies showing the efficacy of these regimes could also elucidate patients with the need for bilateral interval TKA as a result of this complication following TKA.

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