

## A Review of Clinical Pathway Data of 1663 Total Knee Arthroplasties in a Tertiary Institution in Singapore

GG Xu,<sup>1</sup>MBBS, MRCS (Edin), M Med (Surg), SS Sathappan,<sup>1</sup>MBChB, M Med (Ortho), FRCSEd (Ortho), J Jaipaul,<sup>2</sup>SRN, Adv Dip (Ortho), Siew Pang Chan,<sup>3</sup>PhD (Hon), CSci, CMATHMIMA, Choon Hin Lai,<sup>1</sup>MBBS, M Med (Surg), FRCS (Ortho)

### Abstract

**Introduction and Objectives:** A total knee arthroplasty (TKA) clinical pathway database has been used in our institution since the year 2000. The primary aim of this study was to review the patient epidemiology, postoperative complications and factors influencing hospital length of stay following TKA. The clinical outcomes and cost-savings between elective and same day admissions for TKA patients were also reviewed. **Materials and Methods:** The study cohort retrieved from the database comprised 1371 patients (1663 knees) who underwent total knee replacement over a 6-year time period. The following variables were reviewed: epidemiological data, admission data (elective admission [EA] versus same day admission [SDA]), hospital length of stay (LOS), and complication rates. **Results:** The mean age of patients undergoing TKA is 65.2 years (range, 22 to 90). Osteoarthritis was the main surgical indication in 96% of the study cohort. Overall, there was a gradual decline in the hospital length of stay for the study cohort for the 6-year time period. The overall complication rate was 2% and the 3 most common complications were deep vein thrombosis, pulmonary embolism and urinary tract infection. **Conclusion:** With an increasing elderly population there will be an annual increase in the number of TKAs. In our local population TKAs are performed primarily for the Chinese female in the 7th decade. The overall complication rate of TKA remains low with a mortality rate of <1%.

Ann Acad Med Singapore 2008;37:924-8

**Key words:** Complications, Epidemiology, Total knee arthroplasty

### Introduction

Total knee arthroplasty (TKA) has been established as an effective treatment modality for patients with symptomatic knee arthritis.<sup>1,2</sup> It provides predictable decrement in pain, correction of deformity and improved functional outcomes.<sup>3,4</sup> Since the geriatric population is expected to increase over the next 2 decades,<sup>5</sup> there will be an increase in the proportion of patients presenting for total knee arthroplasty.

Clinical pathways have been used in various centres to decrease the length of stay and complications of surgical patients.<sup>6-9</sup> Our institution performs a high volume of the total knee replacements in our country and a formal clinical pathway has been instituted since 2000. The TKA clinical pathway database also facilitates clinical studies and departmental audits. This study reviews the epidemiology and surgical outcomes of Asian patients undergoing total

knee replacement in a tertiary institution in Singapore.

### Materials and Methods

A retrospective study was conducted reviewing all patients who underwent primary total knee replacement in our institution between January 2000 and December 2005. Patients who had revision total knee replacement were excluded from this study. All patients in this specified time period had clinical data entered into Microsoft ACCESS database software by a dedicated case manager. All data pertaining to complications and re-admissions were also captured.

Senior orthopaedic surgeons performed all surgical procedures. All procedures were performed in laminar-flow operating rooms and patients were administered broad-spectrum antibiotics for prophylaxis. All patients had medial parapatellar approach for the TKA. Postoperative

<sup>1</sup> Department of Orthopaedic Surgery, Tan Tock Seng Hospital, Singapore

<sup>2</sup> Department of Case Mix, Tan Tock Seng Hospital, Singapore

<sup>3</sup> Clinical Research Unit, Tan Tock Seng Hospital, Singapore

Address for Correspondence: Dr SS Sathappan, Consultant & Clinician Scientist, Adult Reconstructive Surgery & Complex Trauma, Department of Orthopaedic Surgery, Tan Tock Seng Hospital, 11 Jalan Tan Tock Seng, Singapore 308433.

Email: sathappan@ttsh.com.sg; germainexu@gmail.com

rehabilitation protocol allowed all patients immediate weight bearing as tolerated on postoperative day 1. All patients received anti-thromboembolic stockings; but pharmacological agents for DVT prophylaxis were selectively used for high-risk patients. Table 1 summarises the total knee arthroplasty pathway used in our institution.

All patient bio-data (e.g. age, sex, diagnosis, co-morbidities) and complications were retrieved from the database. The admission type (same-day versus elective admission) and length of stay were also analysed. A statistician performed all statistical analysis. Fisher exact test and biserial correlation were applied to ascertain the association amongst the variables. The analysis was performed with Stata 9.0 (Stata Corp, Texas, USA), and tests were conducted at a 5% level of significance.

**Results**

The study cohort comprised 1663 knees in 1371 patients who underwent total knee replacement in the 6-year time period. The male to female ratio was 1:4. Mean age at the time of operation was 65.2 years (range, 22 to 90). Majority of patients undergoing TKA in this institution were in the 7<sup>th</sup> decade (range, 61 to 70) and made up approximately 40.2% (Table 2). Patients either more than 80 years or below 50 years of age comprised of only 7.5% of the cohort. Racial distribution of our study cohort was nearly similar to our country’s demographics: 1178 Chinese (86.0%), 88 Malays (6.4%), 77 Indians (5.6%), 6 Eurasians (0.7%), and 22 Others (1.6%).

Almost half of the cohort (50.6%) had no co-morbidities. In the remaining patients, one third had 1 co-morbidity. The 3 most common co-morbidities were hypertension (45.9%), dyslipidaemia (16.9%) and diabetes mellitus (13.0%). Right-sided TKR (55.1%) slightly exceeded left TKR (44.9%).

In 96% of patients, the pre-dominant diagnosis was osteoarthritis; 4% of patients had rheumatoid arthritis (RA). Due to disease severity, more than half the patients in our cohort (56.6%) were dependent on a quad-stick.

About 44.5% of patients were able to ambulate independently. Previously all patients were electively admitted a day before surgery for preoperative evaluation. Over the 6-year period an increasing number of patients were evaluated and optimised at the preoperative clinic and admitted only on the day of surgery (Fig. 1).

Overall, over the 6-year period, the average length of stay (LOS) for the entire cohort showed a decreasing trend (Fig. 2). This is attributed to an increasing number of patients being optimised prior to the TKA and are only admitted on the day of surgery. Furthermore, the shift from elective admission to same day admission is not associated with an increase in complications (no difference in complication rates between the 2 cohorts, *P* value = 0.99).

The overall complication rate and 30-day cumulative complication rate was 2% and 3.72%, respectively for the 6-year time period (Table 3). The 30-day cumulative complication rate was calculated based on in-hospital complication rates as well as complications requiring further admission within a month from initial surgery. There was no co-relation between number of comorbidities and number of complications developed during hospitalisation or at 30 days (*P* value 0.44). We calculated the *P* value using the Spearman Correlation (Co-efficient 0/02).

Deep vein thrombosis (DVT) occurred in 11 patients. DVT and pulmonary embolism (PE) are only diagnosed when they have been shown to be scan positive, as all clinical probable DVT/ PE are further sent for a Duplex study or a spiral CT thorax, respectively and all cases were treated with appropriate anti-coagulation as per the advice of the vascular clinic physicians.

Patients who demised following index surgical procedure in hospital were defined as in-patient mortalities. One patient died following the operative procedure and cause of death was attributable to sepsis from a chest infection (rate 0.06%). One patient died at 30 days following the index

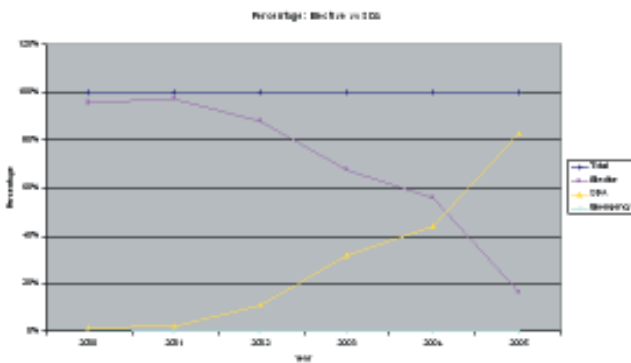


Fig. 1. Percentage of elective admissions compared to same day admissions.

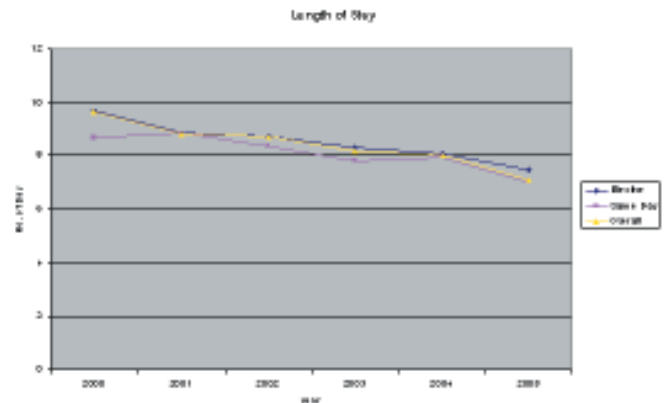


Fig. 2. Length of stay for elective admissions, same day admissions and overall length of stay.

Table 1. Total Knee Replacement Pathway

Op day	Clamp drain if >300 ml Continuous passive motion Sufficient analgesia Catheterise if NPU > 6 hours TEDS Antibiotics x 3 days IV hydrocortisone if rheumatoid patient
POD1	Check haemoglobin Chest physiotherapy Partial weight bearing started CPM if not started
POD2	Off drain if drainage minimal Partial weight bearing Review antibiotics Discharge planning
POD3	Review intravenous patient controlled analgesia and convert to oral analgesia AmulationStart stair climbing Wound inspection
POD4	Review all medications
POD 5	Off CPM if flexion >/=90 degrees Home if ambulating well

Table 4. Distribution of Males and Females With Age in the Singapore Population (6<sup>th</sup> to 9<sup>th</sup> Decade)<sup>10</sup>

Percentages	Male percentage (%)	Female percentage (%)
6 <sup>th</sup> decade (51-60)	6.55	6.49
7 <sup>th</sup> decade (61-70)	3.23	3.26
8 <sup>th</sup> decade (71-80)	2.09	2.09
9 <sup>th</sup> decade (81-90)	0.64	0.96
Total	12.51	12.80

procedure due to sepsis secondary to urinary tract infection, making the mortality rate 0.11% at 30 days. Though both patients' mortality was not directly related to the TKA, it is probable that it may be related to physiological complications that occur after a major surgical procedure.

Re-admission rates were about 0.4% to 1% per year between 2003 and 2005. There were a total of 8 re-admissions between 2003 and 2005. Four patients were re-admitted for a clinical diagnosis of deep vein thrombosis. One patient was admitted for revision surgery for a periprosthetic fracture following a fall. Four patients were readmitted for wound infection. Three patients had superficial wound infection and were successfully treated with intravenous antibiotics. One patient was admitted for deep wound infection. During pre-operative medical optimisation for removal of implants, he succumbed to severe urinary sepsis.

Table 2. Distribution of Males and Females Undergoing TKR in Terms of Number of Knees (Over Denominator of 1654)

Percentages	Male (No.) / Percentage (%)	Female (No./#)/ Percentage (%)
3 <sup>rd</sup> decade (21-30)	3/0.2	0/0
4 <sup>th</sup> decade (31-40)	3/0.2	6/0.4
5 <sup>th</sup> decade (41-50)	15/0.9	51/3.1
6 <sup>th</sup> decade (51-60)	69/4.2	337/20.4
7 <sup>th</sup> decade (61-70)	125/7.6	538/32.5
8 <sup>th</sup> decade (71-80)	98/5.9	352/21.3
9 <sup>th</sup> decade (81-90)	11/0.7	46/2.8
Total of 6 <sup>th</sup> to 9 <sup>th</sup> decade	1330/80.4	324/19.6

Table 3. Inpatient and 30-day Complication Rates

	In hospital complication rate (%)	30 day cumulative complication rate (%)
Deep venous thrombosis	0.66	1.13
Urinary tract infection	0.30	0.30
Wound infection	0.24	0.79
Pulmonary embolism	0.18	0.17
Pressure sore	0.12	-
Acute myocardial infarction	0.12	0.23
Pneumonia	0.12	0.12
Cerebral vascular accident	0	0
Congestive heart failure	0.06	0.06
Cellulitis of leg	0.06	0.06
Dislocation of knee prosthesis	0.06	0.06
Popliteal artery damage	0.06	0.06%

## Discussion

A review of world population statistics revealed that in 1950, the proportion of people aged  $\geq 60$  was 8% and in 2000 it rose to 10%; this figure is expected to be 21% in 2050.<sup>5</sup> Similarly in Singapore, the proportion of the geriatric patient population has been speculated to increase over the next 2 decades. The proportion of persons more than 65 years was 4.9% in 1980; this has nearly doubled to about 8.3% in the year 2005.<sup>10</sup> Life expectancy has also risen with each individual likely to live to an average of 79.9 years in 2005. The annual rate of total knee replacement will be expected to increase over the next few decades.

A significant proportion of patients in this study were in the 7<sup>th</sup> decade (61 to 70 years). For many of the socio-cultural activities (e.g. kneeling, squatting and sitting cross-legged), optimal knee range of motion is important.<sup>11</sup> This leads to probable progressive knee arthritis leading to

Table 5. Comparison of In-hospital and 30-day Complication Rates

	Department of Orthopedic Surgery, UCLA <sup>22</sup> (n = 222,684)		Department of Orthopedic Surgery, Mayo Clinic, Minnesota <sup>21</sup> (n= 10,244)		Our Institution (Department of Orthopaedic Surgery)	
	In hospital %	30 day %	In hospital %	30 day %	In hospital n = 1660 (%)	30 day n = 886 (2003-2005) (%)
Mortality	0.18	0.49	–	0.5	0.06	0.11
Infection	0.34	0.86	–	–	0.24	0.79
Pulmonary embolism	1.79	2.09	–	0.7	0.18	0.17
DVT	–	–	–	1.5	0.66	1.13
MI	–	–	–	0.4	0.12	0.23
Overall	–	–	–	2.2	1.99	3.72

relatively younger patients presenting to the orthopaedic surgeon in the local context.

Singapore's demographics based on recent population statistics is as follows: 75.6% Chinese, 13.6% Malay, 8.7% Indian and 2.1% Others.<sup>10</sup> Both the Chinese and Indian patient population in this study is very similar to the local demographics. In contrast, the percentage of Malay patients in this study is significantly lower than the general population. The authors and senior surgeons in our institution have observed that elderly Malay patients are often not in favour of surgical intervention despite severe symptomatic knee arthritis; and this may possibly explain the smaller sample size amongst this group.

This study reveals that females are approximately 4 times more likely than their male counterparts to undergo TKA. It may be postulated that the proportion of females is higher than males for the individual age groups. However, the percentage of males in the whole population in the 6<sup>th</sup>, 7<sup>th</sup> and 8<sup>th</sup> decades is comparable to the female counterparts; only in the 9<sup>th</sup> decade does the proportion bias move towards the female gender (Table 4). Thus, the more plausible explanation is that in the Asian population, females are more likely to have varus knees deformity and this may predispose them to a relatively higher preponderance of symptomatic knee arthritis at an earlier age when compared to males.<sup>12</sup>

RA as an indication for TKR is low (4%). RA has a low incidence in Asians.<sup>13</sup> This is so, compared to the Caucasian population.<sup>14-18</sup> The Swedish registry had a 11% to 17.4% incidence of RA as an indication for TKA.<sup>17,19</sup> In a large TKA series from North America, the incidence of RA comprised nearly a third of the patient population (31.2% RA vs. 68.1% OA).<sup>1</sup> In the Norwegian registry, the OA and RA proportion undergoing TKA is 76% and 15%, respectively.<sup>18</sup> Thus, in the Asian population the main indication for total knee arthroplasty remains as

osteoarthritis.<sup>13,20</sup>

Generally the complication rates such as deep venous thrombosis and pulmonary embolism appear to be smaller than those reported in European and North American studies.<sup>1</sup> This may be due to an intrinsic difference in disease susceptibility. Protocol for DVT prophylaxis is clinically based rather than consensus driven. All patients are prescribed anti-thromboembolic stockings and are mobilized by the first post operative day. Only patients with multiple risk factors for DVT are administered low-molecular-weight-heparin (LMWH) postoperatively. In this study, patients did not receive a routine duplex and was based on clinical assessment. Currently, a study has been conducted in our institution to assess the overall risk of DVT in our local patient population.

The mortality rates in this study (<1%) are comparatively lower than in other case series. UCLA and Mayo studies<sup>21,22</sup> reported that with careful selection of patients, the mortality rates are generally <2%. Table 5 shows a comparison of complication rates in-hospital and at 30 days between our local data and overseas centres in Mayo and UCLA.<sup>21,22</sup> The differences in mortality rate can be explained by 2 factors that are inter-related: younger patient group and more than 70% of the patients have 1 or no co-morbidities. Furthermore, with an increase in the number of same-day admissions, patients were well optimised prior to surgery and the use of clinical pathway probably also associated with overall improvement in morbidity and mortality compared to results from other centres.

For our patient cohort, wound infection was not shown to be associated with diabetes mellitus. All the patients who experienced wound infection were non-diabetics. However, all patients with urinary infection had diabetes mellitus. Common co-morbidities such as hypertension and diabetes mellitus were not co-related with the occurrence of deep venous thrombosis or pulmonary embolism ( $P < 0.05$ ).

Previously, patients were admitted electively a day prior to surgery (elective admissions) for administrative reasons, preoperative anesthetic reviews and for blood cross matching. Over the 6 years, there has been a steady increase in same day admission (SDA) with patient optimisation and preparation for surgery done at the out-patient setting (Fig. 1). There are no differences in immediate post-surgical outcomes. Overall the mean length of stay between same day and elective admissions is approximately 1 day. On a daily basis, the costs involved for a typical knee replacement patient are ward charges and daily treatment fees, which cost 300 Singapore dollars (S\$300) daily, not including surgical fees. In our institution approximately 400 patients undergo total knee arthroplasty every year. The total cost savings is S\$300 x 400 = \$120,000/year. With a shift towards same day admissions, tertiary institutions can expect to economise on bed availability for acute care as well as monetary savings of more than \$100,000 dollars on an annual basis.<sup>23</sup>

We expect the rates of TKA to increase over the next 20 years as surgery becomes more acceptable to the population as a way of improving the quality of life. With a more rigorous rehabilitation protocol and dedicated pathway, it is likely that future complication rates will decrease together with the length of stay. This paper serves as a basis for comparison of future database of epidemiological information on TKA in Singapore since it allows tracking of outcomes and serves as a platform to conduct further analysis and studies.

## Conclusion

The use of the knee pathway has led to a significant decrease in the length of stay among patients undergoing TKR in our institution mainly due to same day admission. It has also been instrumental in keeping the complication rates low as well as establishing early rehabilitation as part of the postoperative protocol. Moreover, the transition from elective admission to same day admission of TKA patients resulted in significant cost savings to our institution.

## Acknowledgements

*The authors would like to convey their special thanks to Professor Low Yin Peng, Mr Li Yung Hua, Mr Wong Ho Poh, Mr Winston Chew, Mr Yu Chun Sing, Mr Sarbjit Singh, Mr Jeffrey Chew, Mr Yegappan and Mr Lim Lian Arn for contributing cases in the study and to Ms Mariah Sulaiman for secretarial support.*

*Sources of grants/ equipment: Nil*

## REFERENCES

- Rand JA, Ilstrup DM. Survivorship analysis of total knee arthroplasty. Cumulative rates of survival of 9200 total knee arthroplasties. *J Bone Joint Surg Am* 1991;73:397-409.
- Li PL, Zamora J, Bentley G. The results at ten years of the Insall-Burstein II total knee replacement. Clinical, radiological and survivorship studies. *J Bone Joint Surg Br* 1999;81:647-53.
- Mullaji AB, Padmanabhan V, Jindal G. Total knee arthroplasty for profound varus deformity: technique and radiological results in 173 knees with varus of more than 20 degrees. *J Arthroplasty* 2005;20:550-61.
- Ritter MA, Faris GW, Faris PM, Davis KE. Total knee arthroplasty in patients with angular varus or valgus deformities of > or = 20 degrees. *J Arthroplasty* 2004;19:862-6.
- United Nations Executive Summary on World Population Ageing. Available at: [http://www.un.org/esa/population/publications/worldageing19502050/pdf/62executivesummary\\_english.pdf](http://www.un.org/esa/population/publications/worldageing19502050/pdf/62executivesummary_english.pdf). Accessed 23 Jul 2007.
- Pearson SD, Kleefield SF, Soukop JR, Cook EF, Lee TH. Critical pathways intervention to reduce length of hospital stay. *Am J Med* 2001;110:175-80.
- Macario A, Horne M, Goodman S, Vitez T, Dexter F, Heinen R, et al. The effects of a perioperative clinical pathway for knee replacement surgery on hospital costs. *Anesth Analg* 1998;86:978-84.
- Mabrey JD, Toohey JS, Armstrong DA, Lavery L, Wammack LA. Clinical pathway management of total knee arthroplasty. *Clin Orthop Relat Res* 1997;345:125-33.
- Pearson S, Moraw I, Maddern GJ. Clinical pathway management of total knee arthroplasty: a retrospective comparative study. *Aust N Z J Surg* 2000;70:351-4.
- Singapore Population Statistics. Available at: <http://www.singstat.gov.sg>. Accessed 23 July 2007.
- Zhang Y, Hunter DJ, Nevitt MC, Xu L, Niu J, Lui LY, et al. Association of squatting with increased prevalence of radiographic tibiofemoral knee osteoarthritis: the Beijing Osteoarthritis study. *Arthritis Rheum* 2004;50:1187-92.
- Tang WM, Zhu YH, Chiu KY. Axial alignment of the lower extremity in Chinese adults. *J Bone Joint Surg Am* 2000;82-A:1603-8.
- Dai SM, Han XH, Zhao DB, Shi YQ, Liu Y, Meng JM. Prevalence of rheumatic symptoms, rheumatoid arthritis, ankylosing spondylitis, and gout in Shanghai, China: a COPCORD study. *J Rheumatol* 2003;30:2245-51.
- New Zealand National Joint Registry. Available at: <http://www.cdhb.govt.nz/NJR>. Accessed 3 July 2008.
- United Kingdom National Joint Registry. Available at: <http://www.njrcentre.org.uk/StatsOnline/allSummaryMap.php>. Accessed 3 July 2008.
- Canadian Joint Replacement Registry. Available at: [http://secure.cihi.ca/cihiweb/dispPage.jsp?cw\\_page=AR\\_30\\_E](http://secure.cihi.ca/cihiweb/dispPage.jsp?cw_page=AR_30_E). Accessed 3 July 2008.
- Robertsson O, Knutson K, Lewold S, Lidgren L. The Swedish Knee Arthroplasty Register 1975-1997: an update with special emphasis on 41,223 knees operated on in 1988-1997. *Acta Orthop Scand* 2001;72:503-13.
- Furnes O, Espehaug B, Lie SA, Vollset SE, Engesaeter LB, Havelin LI. Early failures among 7,174 primary total knee replacements: a follow-up study from the Norwegian Arthroplasty Register 1994-2000. *Acta Orthop Scand* 2002;73:117-29.
- Robertsson O, Dunbar MJ, Knutson K, Lidgren L. Past incidences and future demand for knee arthroplasty in Sweden: a report from the Swedish Knee Arthroplasty Register regarding the effects of past and present population changes on the number of knee arthroplasties performed. *Acta Orthop Scand* 2000;71:376-80.
- Zeng QY, Zang CH, Li XF, Dong HY, Zhang AL, Lin L. Associated risk factors of knee osteoarthritis: a population survey in Taiyuan, China. *Chin Med J (Engl)* 2006;119:1522-7.
- Mantilla CB, Horlocker TT, Schroeder DR, Berry DJ, Brown DL. Frequency of myocardial infarction, pulmonary embolism, deep venous thrombosis, and death following primary hip or knee arthroplasty. *Anesthesiology* 2002;96:1140-6.
- Healy WL, Iorio R, Ko J, Appleby D, Lemos DW. Impact of cost reduction programs on short-term patient outcome and hospital cost of arthroplasty. *J Bone Joint Surg Am* 2002;84-A:348-53.
- SooHoo NF, Zingmond DS, Lieberman JR, Ko CY. Optimal timeframe for reporting short-term complication rates after total knee arthroplasty. *J Arthroplasty* 2006;21:705-11.