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Original Article

Diabetes mellitus does not negatively impact outcomes and satisfaction following unicompartmental knee arthroplasty in well-controlled disease

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ABSTRACT

Background: Unicompartmental knee arthroplasty (UKA) has gained popularity in recent years in view of its minimally invasive nature and proven benefits over the traditional total knee arthroplasty (TKA) in terms of superior knee range of motion and kinametics, faster recovery, lower blood loss, shorter hospital stay and ease of revision with the preservation of bone stock.

With the increasing incidence of diabetes mellitus (DM) worldwide and an increased risk of deep infection, wound complications and early failure previously shown in diabetic patients undergoing TKA, it is prudent that we establish the impact of DM on the outcomes and complications of UKA given that there is little on the topic in the current literature.

This is especially significant in Asia as Asia is home to more than 60% of the world's population of diabetic patients with estimates of more than 200 million people having the condition. Type 2 DM in particular, is an increasing epidemic with projections to increase by more than 150% between year 2000 and 2035.

The purpose of this study is to evaluate the impact of diabetes mellitus on the outcomes and satisfaction of UKA at 2 years postoperatively. We hypothesize that diabetes mellitus does not affect the outcomes and satisfaction following UKA in Asians at 2 years postoperatively.

Methods: We conducted a retrospective review of prospectively collected registry data of 1075 UKAs performed in a multiethnic Asian population between 2006 and 2013 at our institution. Outcomes assessed included flexion range, Knee Society Score (KSS), Oxford Knee Score (OKS), Short-Form 36 (SF-36) and satisfaction scores.

All patients with DM were identified and matched with patients without DM for age, gender and body mass index. Outcomes, satisfaction, complication and revision rates were then compared between the two groups up to 2 years postoperatively. Preoperative HbA1c was used to assess the patients' blood glucose control in the DM group.

Results: A total of 104 patients (9.7%) had DM, close to the national prevalence (11.3%). At 2 years postoperatively, DM patients had better improvement in their SF-36 Mental Component Score (MCS) ($p = 0.015$) despite poorer preoperative scores (DM group $= 70 \pm 23$, non-DM group $= 77 \pm 17$, $p = 0.013$), and were in 1° more varus ($p = 0.005$) when compared to patients without DM.

There was no significant difference in the proportion of patients achieving the minimal clinically important difference for knee-specific outcomes (DM:90%, non-DM:96%) or the satisfaction rates between the groups (DM:92%, non-DM:94%). Complication rates were similar (DM:5.8%, non-DM:4.8%). There were no venous thromboembolic events, deaths or revisions during the follow-up period in both groups. The mean preoperative HbA1c in our DM group was 6.6%.

Conclusion: In this matched-pair study of diabetic versus non-diabetic patients undergoing surgery for UKA, DM does not have a clinically significant negative impact on the outcomes and satisfaction following UKA in patients with well-controlled disease.

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Introduction

This incidence of diabetes mellitus is increasing due to population growth, aging, urbanization, prevalence of obesity and physical inactivity.[1] In 2000, the prevalence of diabetes for all age groups worldwide was estimated to be 2.8%.[1] This figure is expected to increase by more than 50% by 2030 with estimates of the total number of people with diabetes projected to increase from 171 million in 2000 to 366 million in 2030.[1] Given the increasing prevalence of obesity, it is postulated that these figures are likely an underestimate of future diabetes prevalence.

Diabetes has been associated with an increased risk of deep infection, wound complications and early failure in patients undergoing total knee arthroplasty (TKA).[2–7] Asia is home to over 60% of the world's population with diabetes, with more than 200 million people estimated to have this condition.[8] With rising life expectancy throughout the world and three-quarters of the world's population living in Asia, the problem of diabetes in knee arthroplasty will become especially significant in Asia in the coming decades as knee osteoarthritis is primarily a degenerative condition.[9]

TKA has historically been the gold standard operative intervention for knee arthritis due to its predictability, durability and effectiveness in alleviating pain and restoring function.[10,11] In recent years, unicompartmental knee arthroplasty (UKA) for unicompartmental knee arthritis has gained increasing popularity in view of its minimally invasive nature and proven superior benefits over TKA in terms of knee ROM and kinematics, reduced blood loss, faster recovery, decreased length of hospital stay, ease of revision and preservation of bone stock.[12–20]

Interestingly, despite TKA having a higher survivorship compared to UKA, satisfaction rates after UKA remained similar to those after TKA.[10,21] There is however, little evidence in the literature today with regards to the impact of DM on the outcomes and complications of UKA.

The purpose of this study is to evaluate the effect of diabetes mellitus on the outcomes and satisfaction of UKA at 2 years postoperatively. We hypothesize that diabetes mellitus does not affect the outcomes and satisfaction following UKA in Asians at 2 years postoperatively.

Materials and methods

Study sample

We conducted a retrospective review of prospectively collected registry data of 1075 medial UKAs that were performed at a tertiary hospital between 2006 and 2013.

Outcomes assessed included flexion range, Knee Society Score (KSS), Oxford Knee Score (OKS), Short-Form 36 (SF-36) and satisfaction scores. All patients with a concomitant diagnosis of DM were identified and matched with a group of patients without DM for age, gender and body mass index. Outcomes, satisfaction, complication and revision rates were then compared between the two groups. Preoperative HbA1c was used to assess the patients' blood glucose control in the DM group.

Selection criteria for our study include patients with unilateral medial UKAs performed. These were patients that were asymptomatic in the contralateral knee at the time of surgery, inclusive of both patients with native knees and patients prior replacement surgery performed in the contralateral knee.

All medial UKAs were performed for medial non-inflammatory primary osteoarthritis of the knee. UKAs were only performed in knees with an intact contralateral compartment and patellofemoral changes not greater than grade II or III (Ahlback classification). Trochlear wear up to grade IV was accepted if the distribution of wear was central.

Exclusion criteria were as follows: (1) spastic or flaccid paralysis of one or both lower limbs regardless of cause, (2) New York Heart Association (NYHA) Class II and III cardiac failure, (3) severe pulmonary disorders limiting the patient to only home ambulation, (4) all revision arthroplasties including infected arthroplasties, and (5) lateral UKAs.

Ethical approval

Ethical approval for the study was granted by the Institutional Review Board of Singapore Health Services (SingHealth, CIRB 2017/2303). Informed consent was obtained from all patients involved in the study.

Surgical technique and perioperative management

All UKAs were performed by fellowship-trained surgeons in adult reconstruction.

Anaesthesia was either general or spinal with some patients receiving a femoral nerve block perioperatively as a single bolus. Each operation was performed with a tourniquet except in vasculopathic patients, and all patients were given a single injection of intravenous prophylactic antibiotic just before skin incision (cefazolin or vancomycin if the patient was allergic to penicillin). A midline skin incision or a medially skewed longitudinal incision was made, and the joint was exposed through a medial parapatellar arthrotomy.

An anteromedial wear pattern on the tibia was used as a surrogate for a competent anterior cruciate ligament. All implants used were of fixed-bearing design: M/G UKA from Zimmer (Warsaw, IN, USA) and PFC UKA from Depuy (Warsaw, IN, USA). Antibiotic-impregnated cement was used in all patients. Postoperatively, all patients were part of a coordinated clinical care pathway. All patients received mechanical and oral prophylaxis against venous thromboembolism. They were assessed by a physiotherapist daily and ambulation was initiated as soon as the patient was able to perform a straight-leg raise actively.

Patients were discharged when they were able to ambulate at least 20 m independently with or without a walking aid and able to climb stairs. Patients were either discharged directly to their homes or to a rehabilitative facility. They were then followed up at the specialist outpatient clinic at 1 month, 3 months, 6 months, 1 year, 2 years, and 5 years postoperatively.

Assessments

All assessments were completed independently at the Orthopaedic Diagnostic Centre of our institution. Baseline interviews were conducted preoperatively to assess sociodemographic characteristics, body mass index (BMI), knee flexion range and knee arthritis severity, using the Oxford Knee Score (OKS) for which higher scores indicate greater severity, the Short Form 36 (SF-36) questionnaire and the Knee Society Score (KSS). For the Short Form 36 (SF-36) questionnaire, we assessed only the Physical Component Score (PCS) and the Mental Component score (MCS).

Comorbidities and hospital length of stay were assessed via the electronic health records at our institution. Alignment was measured on the lower limb long leg radiographs obtained pre- and postoperatively.

Definition of good outcome

In the absence of universally accepted criteria, our primary analysis defined a good UKA outcome as an overall improvement in

the outcome scores greater than or equal to the minimal clinically important difference (MCID). This was the same definition used by Hawker et al. in their study of predictors in patients undergoing total joint arthroplasty.[22] The MCID represented one-half of the standard deviation of the difference between the pre and post-operative outcome scores.[23] The calculated MCID for our cohort of patients was 5 for the OKS and 10 for the PCS.

Statistical analysis

The *t*-test was used for parametric analyses and the Mann-Whitney *U* test was used for nonparametric analyses. The odds ratios for a good outcome (MCID criterion) for OKS and PCS respectively were determined using log Poisson regression. All p-values less than 0.05 were considered significant. All statistical analyses were performed using SAS ver. 9.3 (SAS Inc., Cary, NC, USA).

Results

A total of 104 patients (9.7%) had a concomitant diagnosis of DM, close to the national prevalence (11.3%).[24] Clinical details of the patients can be seen in Table 1.

Although matching was only performed for age, gender and BMI, the comparative arms of the non-DM group and the DM group were fairly similar in other aspects such as demographic variables, osteoarthritis variables, number of co-morbidities, peri-operative details and health services utilization as well.

The number of patients having concomitant diagnosis of ischemic heart disease were 14 in the DM group and 13 in the non-DM group respectively. None of these patients had limitations in ordinary physical activity (NYHA Class 1). We excluded 2 patients with NYHA Class 2 heart failure and 1 patient with NYHA Class 3 heart failure as part of our exclusion criteria in our DM group. There were no patients identified with NYHA Class 2 or 3 heart failure in our non-DM group.

There were only 3 differences that reached statistical significance amongst the variables assessed between the two groups. Firstly, more Indians were found in the DM group (DM group = 10, non-DM group = 3, p = 0.044). Secondly, patients with DM had a poorer preoperative SF-36 MCS (DM group = 70 ± 23, non-DM group = 77 ± 17, p = 0.013). Thirdly, patients with DM started ambulating slightly later (Days to ambulation for DM group = 1.2 ± 1.3, non-DM group = 1.8 ± 1.4, p = 0.002).

The follow-up timeframe was the same for both groups at 2.8 years. (Table 1). Complication rates were similar for both groups (Non-DM:4.8%, DM:5.8%). In the non-DM group, there were 5 patients (5/104) that had complications, 4 patients had superficial infection (3 treated with oral antibiotics, 1 required intravenous antibiotics) and 1 patient had wound dehiscence. In the DM group, there were 6 patients (6/104) that had complications, 5 patients had superficial infection (all treated with oral antibiotics), 1 patient had wound dehiscence and 1 patient had a stitch abscess. There were no venous thromboembolic events (pulmonary embolism or deep vein thrombosis), no deaths or revisions in both groups during the follow-up period.

There was excellent control of blood glucose levels preoperatively in the DM group as evidenced by their preoperative HbA1c taken within 1 month prior to the operation. The mean preoperative HbA1c was 6.6% with no patients having HbA1c levels more than 7.7%. 28.8% of patients were on oral hypoglycaemic agents (OHGA) and 2.9% required insulin. The average duration of DM from

Table 1
Clinical details of patients undergoing unicompartmental knee arthroplasty.

	Non-DM Group (n = 104)	DM Group (n = 104)	*P*-value
Demographic variables			
Age, mean ± SD	63.1 ± 8.0	63.4 ± 8.1	0.788
Gender, no. (%) female	67 (64)	67 (64)	1.000
Chinese, no. (%)	92 (88)	85 (82)	0.174
Malay, no. (%)	7 (7)	7 (7)	1.000
Indian, no. (%)	3 (3)	10 (10)	**0.044**
Others, no. (%)	2 (2)	2 (2)	1.000
Completed high school, no. (%)	41 (39)	43 (41)	0.780
English-literate, no. (%)	50 (48)	46 (44)	0.401
Osteoarthritis-related variables			
Flexion range (degrees), mean ± SD	128 ± 13	124 ± 18	0.068
Alignment (degrees), mean ± SD	6 ± 4 Varus	6 ± 4 Varus	1.000
Knee Society Knee Score, mean ± SD	44 ± 15	46 ± 20	0.416
Knee Society Function Score, mean ± SD	61 ± 18	59 ± 16	0.398
Oxford Knee Score, mean ± SD	32 ± 8	34 ± 9	0.092
SF-36 Physical Component Score, mean ± SD	51 ± 20	52 ± 21	0.726
SF-36 Mental Component Score, mean ± SD	77 ± 17	70 ± 23	**0.013**
Number of co-morbidities, no. (%)			
0	35 (34)	33 (32)	0.764
1-2	52 (50)	48 (46)	0.490
3 or more	17 (16)	23 (22)	0.289
Perioperative details			
Regional anaesthesia, no. (%)	72 (69)	74 (71)	0.764
Operated side, no. of right knees (%)	62 (60)	58 (56)	0.575
Days to ambulation (days), mean ± SD	1.2 ± 1.3	1.8 ± 1.4	**0.002**
Follow-up (years), mean ± SD	2.8 ± 1.3	2.8 ± 1.3	1.000
Pre-operative HbA_1C value (%)	N.A.	6.6 ± 0.8	N.A.
Anthropometric measurements			
Body mass index (kg/m^2), mean ± SD	27.1 ± 4.3	27.7 ± 4.1	0.304
Health services utilization			
Hospital LOS (days), mean ± SD	4.3 ± 3.1	4.3 ± 1.9	1.000
Discharge directly home, no. (%)	93 (89)	88 (85)	0.303

DM = Diabetes mellitus, SD = Standard deviation, LOS = Length of stay.

onset to time of operation is 14.4 ± 8.1 years.

The 2-year outcomes and comparisons can be seen in Table 2. At 2 years postoperatively, patients with DM were in 1° more varus (DM group = 4 ± 3° varus, non-DM group 5 ± 2° varus, p = 0.005), had slightly poorer knee-specific outcomes (Postoperative Knee Society Knee Score for DM group = 90 ± 10, non-DM group = 86 ± 14, p = 0.019) and a slightly lesser improvement in knee-specific scores (Change in Knee Society Knee Score for DM group = 46 ± 21, non-DM group = 39 ± 25). There was no difference in terms of preoperative knee-specific scores preoperatively (Preoperative Knee Society Knee Score for DM group = 44 ± 15, non-DM group = 46 ± 20, p = 0.416). The slightly poorer Knee Society Knee Scores in the DM group compared to the non-DM group were consistent with the OKS (non-DM group = 17 ± 5, DM group = 19 ± 7, p = 0.019) where higher scores indicate greater severity.

Patients with DM however, had better improvement in their MCS when compared to patients without DM postoperatively (MCS for DM group = 14 ± 22, non-DM group = 7 ± 19, p = 0.015).

There was no significant difference in terms of flexion range and functional scores (Knee Society Function Score, PCS) between the groups both preoperatively and at 2 years postoperatively. There was also no significant difference in the 2-year satisfaction rates between the groups (Non-DM:94%; DM:92%).

In the non-DM group, 72% and 96% of the patients achieved the MCID for the PCS and OKS respectively. In the DM group, 72% and 90% of the patients achieved the MCID for the PCS and OKS respectively. The difference in the proportions achieving the respective MCID between the two groups was not statistically significant.

Discussion

DM is a chronic systemic disease that may give rise to complications that affect the outcomes following UKA. With the incidence of DM as well as UKA utilization rates expected to increase, orthopaedic surgeon must be aware of the impact of DM on the outcomes, satisfaction and complications of UKA. This is especially significant in Asia as Asia is home to the majority of the world's diabetic population and will be facing issues of an aging population in the next few decades with rising life expectancy worldwide.[8,9]

The prevalence of diabetes in Singapore increased from 8.2% in 2004 to 11.3% in 2010, and is projected to continue to increase to 15% in 2050.[25,26] 32% of known diabetics had poor blood sugar control (HbA1c > 8), and Indians consistently had the highest prevalence of diabetes compared to Malays and Chinese across the years.[25] We observed that there were more Indians in the DM group (DM group = 10, non-DM group = 3, p = 0.044). This may be a reflection of the higher prevalence of diabetes in Indians in Singapore compared to the other races.

Patients with DM also had a poorer preoperative SF-36 MCS in our study (DM group = 70 ± 23, non-DM group = 77 ± 17, p = 0.013). Similar to other chronic illnesses, DM has been shown to have a relationship with poor mental wellness, in particular, its relationship to depression.[27–30] Kamarul et al. reported lower mean SF-36 scores in mental health, general health, social functioning, and physical functioning in Type 2 DM patients compared to the general population, especially if they had poor glycaemic control (HbA1c > 7.5).[31] The improvement in MCS postoperatively however, was significantly better in the group with DM (p = 0.015), suggesting that UKA may be beneficial in improving their health-related quality of life.

The slightly longer time to ambulation in our DM group (Days to ambulation for DM group = 1.2 ± 1.3, non-DM group = 1.8 ± 1.4, p = 0.002) of 0.6 days could be potentially be explained by (i) poorer motivation given the poorer preoperative MCS score, or (ii) higher levels of postoperative pain due to the increased likelihood of contraindication to non-steroidal anti-inflammatory drugs in patients with DM. DM is the most common cause of chronic kidney disease and a major risk factor for cardiovascular disease.[32,33] We adopted a multimodal analgesia regime as part of perioperative care, starting intraoperatively with a combination of an opioid, a steroid, a long acting local anaesthetic and an anti-inflammatory drug, given as an intraarticular injection, and continuing postoperatively with paracetamol, an oral non-steroidal anti-inflammatory drug and intravenous opioid delivered via a patient-controlled analgesia pump. This was a similar regime given to both groups and omitted only in cases where there were contraindications.

Historically, the goal of total knee arthroplasty has been to return the patients joint alignment to be within 3° of mechanical axis. This theory has been challenged in recent years with the development of the kinematical alignment concept.[34] Interestingly, in the evaluation of the outcomes of 214 kinematically aligned TKAs, Howell et al. found no significant difference in terms of OKS and WOMAC scores across patients in all 3 groups differentiated by alignment (i) in range between −2.5° and −7.4° valgus, (ii) varus (>− 2.5°), and valgus (<−7.4°).[35] Our finding of a 1° more varus in

Table 2
2-year outcomes following unicompartmental knee arthroplasty.

Outcome	Non-DM Group		DM Group		MCID	*P*-value[b]	*P*-value[c]
	Absolute	Change[a]	Absolute	Change[a]			
Flexion range (degrees), mean ± SD	129 ± 10	0 ± 20	128 ± 11	4 ± 16	*N.A.*	0.494	0.113
Alignment (degrees), mean ± SD	4 ± 3 Varus	*N.A.*	5 ± 2 Varus	*N.A.*		**0.005**	*N.A.*
Knee Society Knee Score, mean ± SD	90 ± 10	46 ± 21	86 ± 14	39 ± 25		**0.019**	**0.030**
Knee Society Function Score, mean ± SD	80 ± 16	18 ± 21	76 ± 20	17 ± 19		0.113	0.719
Oxford Knee Score (OKS), mean ± SD	17 ± 5	15 ± 8	19 ± 7	15 ± 8	5	**0.019**	1.000
SF-36 Physical Component Score (PCS), mean ± SD	75 ± 20	24 ± 24	71 ± 21	19 ± 21	10	0.161	0.111
SF-36 Mental Component Score, mean ± SD	84 ± 15	7 ± 19	84 ± 17	14 ± 22	*N.A.*	1.000	**0.015**

N.A. = not applicable, MCID = minimal clinically important difference, DM = Diabetes mellitus, SD = Standard deviation.
[a] Compared to preoperative values.
[b] *P*-value for comparison of absolute values.
[c] *P*-value for comparison of change from preoperative values.

the DM group in postoperative alignment is likely not clinically relevant although p values reached statistical significance (DM group = 4 ± 3° varus, non-DM group 5 ± 2° varus, p = 0.005).

We found poorer knee-specific outcomes in the DM group, in both the Knee Society Knee Score and the OKS. This is likely not clinically relevant as (i) the absolute difference in scores between the two groups was very small (less than 5) in Knee Society Knee Score (Postoperative Knee Society Knee Score for DM group = 90 ± 10, non-DM group = 86 ± 14, p = 0.019), (ii) scores of 17 and 19 are both considered excellent in the grading for OKS (OKS scores for DM group = 19 ± 7, non-DM group = 17 ± 5, p = 0.019), and (iii) the difference in the proportion of patients achieving MCID with the OKS did not reach statistical significance (DM group = 90%, non-DM group = 96%). There is no available data in the current literature evaluating knee-specific outcomes of UKA in DM versus non-DM groups. Postoperative Knee Society Knee Score and OKS are reportedly not influenced by DM in TKA.[36,37]

Restricted range of motion with significantly lower knee flexion and poorer functional recovery has been reported in DM patients after TKA.[38] Postoperative function scores have also been shown to be lower in patients with diabetes and even lower if they are insulin dependent.[2]

Earlier UKA studies have shown superior knee ROM and kinematics, decreased length of hospital stay, faster recovery and reduced blood loss over the traditional TKA.[12–20] The postoperative functional scores (Knee Society Function Score, PCS) and flexion range in our matched-pair study of UKA in patients with and without DM showed no significant difference (Knee Society Function Score p = 0.113, PCS p = 0.161, flexion range p = 0.494). There is also no difference in the proportion of patients achieving MCID with the PCS (DM group = 72%, non-DM group = 72%). This may be due the minimally invasive nature of the UKA with less tissue involvement in terms of both soft tissue disruption and bone loss.

Wound healing has long been recognised to be a problem in patients with diabetes.[39] In patients undergoing TKA, DM has been associated with an increased risk of deep infection, wound complications and early failure.[2–7] Patients with DM have been reported to be at increased risk for revision within 10 years of the index TKA.[40] The complication rates of UKA were similar in both DM and non-DM groups in our study (DM group = 5.8%, non-DM group = 4.8%). The profiles of the complications were also similar in that the complications in both DM and non-DM groups were all minor and did not necessitate returning to the operating theatre. Superficial infections were the commonest complication in both arms, most of which were treated adequately with oral antibiotics alone with only 1 patient (non-DM group) requiring intravenous antibiotics.

There were no early failures or revision surgeries required in both DM and non-DM groups up to 2-year postoperatively. There was excellent control of blood glucose levels preoperatively in the majority of patients in the DM group as evidenced by their preoperative HbA1c. The mean preoperative HbA1c in our DM group was 6.6% with no patients having HbA1c levels more than 7.7%.

The strengths of our study are as follows: (i) this is the first study evaluating the effect of DM on the outcomes and satisfaction of UKA at 2 years postoperatively, (ii) using a matched-pair analysis reduces confounding bias during comparison of the two groups, and (iii) prospectively collected data reduces recall bias during data collection. However, there were also some limitations. First, while our data was collected prospectively, the study analyses was done in retrospective fashion which introduces bias. Secondly, while the study originates from an Asian nation, its results cannot be applied to all Asian countries due to the unique population demographics as well as the fact our cohort were predominantly female. Thirdly, our study evaluated short-term outcomes at 2-years as our registry is relatively new for UKA patients.

Conclusion

In this matched-pair study of diabetic versus non-diabetic patients undergoing surgery for UKA, DM does not have a clinically significant negative impact on the outcomes and satisfaction following UKA in patients with well-controlled disease.

Conflicts of interest statement

Dr. Seng Jin Yeo has a consultancy with DePuy Synthes. All other authors have no conflicts of interest relevant to this article.

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