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ORIGINAL ARTICLE

Impact of diabetes mellitus and preoperative body mass index on 30-day postoperative complications and readmissions following total knee arthroplasty

Kwong Weng Loh, MS, Suraya Zulkhairi, MBBS, Khai Hsin Wong, MBBS, Khairul Anwar Ayob, MS, Veenesh Selvaratnam, FRCS, Azlina Amir Abbas, MS

Department of Orthopaedic Surgery, National Orthopaedic Centre of Excellence for Research and Learning (NOCERAL), Faculty of Medicine, Universiti Malaya, Kuala Lumpur, Malaysia

ABSTRACT

Objectives: This study aims to evaluate 30-day postoperative complications and hospital readmissions across different body mass index (BMI) categories and diabetic statuses following primary total knee arthroplasty (TKA).

Patients and methods: Between January 2013 and December 2022, a total of 502 patients (100 males, 402 females; mean age: 68.8±7.7 years; range, 45 to 91 years) who underwent primary TKA for knee osteoarthritis were retrospectively analyzed. Data collected included basic demography, BMI, diabetes mellitus (DM) status, and 30-day postoperative complications such as venous thromboembolism (VTE), infections, neurological events, cardiac events, and renal issues. Readmissions due to operative or medical complications were recorded.

Results: Of the patients, 141 (28.1%) had DM and 186 (37.1%) patients were classified as obese. The obese group experienced the highest incidence of VTE (1.6%), whereas overweight patients exhibited a higher rate of renal events (1.0%). All non-diabetic underweight patients (n=2) developed postoperative hypoglycemia. Diabetic patients had significantly increased odds of VTE compared to non-diabetics (odds ratio=6.74; p=0.009). Normal BMI diabetic patients demonstrated the highest incidence of surgical site infections (7.4%), while normal BMI non-diabetic patients were more prone to foot drop (1.1%) and cardiac events (4.5%).

Conclusion: Elevated BMI and DM independently or in combination, contribute to higher rates of postoperative complications and readmissions following TKA.

Keywords: Diabetes mellitus, obesity, postoperative complication, readmission, total knee arthroplasty.

Total knee arthroplasty (TKA) is a reliable surgical procedure for relieving pain and restoring function in end-stage knee osteoarthritis (OA).[1,2] The prevalence of diabetes mellitus (DM) in the TKA patient population has been estimated to be as high as 20%, nearly double the 11.3% reported in the general population in 2022.[3] Meanwhile, obesity/morbid obesity rates continue to rise, increasing from 31 to 36% in the general population and from 60 to 64% in primary TKA. Projection models predict that these rates would further rise to 46% in the general population and 69% in primary TKA by 2029.[4]

Obesity is a key contributor to OA, particularly in the knee joint, through increased mechanical stress,[3,5] inflammatory activation,[5,6] and metabolic

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Correspondence: Azlina Amir Abbas, MS. Department of Orthopaedic Surgery, National Orthopaedic Centre of Excellence for Research and Learning (NOCERAL), Faculty of Medicine, Universiti Malaya, 50603 Kuala Lumpur, Malaysia.

E-mail: azabbas@um.edu.my

Correspondence: Kwong Weng Loh, MS. National Orthopaedic Centre of Excellence for Research and Learning (NOCERAL), Department of Orthopaedic Surgery, Faculty of Medicine, Universiti Malaya, 50603 Kuala Lumpur, Malaysia.

E-mail: melvinloh@um.edu.my

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dysregulation.[5] It not only heightens joint load,[7] but also amplifies systemic inflammation, accelerating cartilage degradation and disease progression.[8] Diabetes mellitus adversely affects wound healing and immune responses, thereby predisposing patients to infection and venous thromboembolic (VTE) events. Together, obesity and DM are among the most frequent comorbidities encountered in patients undergoing TKA, with both conditions having been linked to an elevated risk of postoperative complications, readmission and mortality.[9-11]

Given the influence on surgical outcomes, economic implications and burden on healthcare systems, understanding how obesity and diabetes interact to influence postoperative risks is paramount. In the present study, we aimed to evaluate the impact of different body mass index (BMI) categories (underweight, normal, overweight, obese) and DM status on the incidence of 30-day postoperative complications, hospital readmissions, and mortality after primary TKA to guide surgeons and multidisciplinary care teams in optimizing patients through preoperative counselling, glycemic management, and weight reduction strategies.

PATIENTS AND METHODS

This single-center, retrospective study was conducted at Universiti Malaya Medical Centre (UMMC), Kuala Lumpur between January 2013 and December 2022. Initially, patients who underwent primary TKA for knee OA were screened. Only those aged 40 years or older who had a clinical and radiographic diagnosis of primary knee OA and underwent unilateral or bilateral primary TKA were included in the study. Individuals with secondary OA due to inflammatory arthropathies or post-traumatic causes, those who had TKA for bone tumors or revision procedures, and those with incomplete medical records were excluded. Of a total of 555 patients, 53 were excluded for

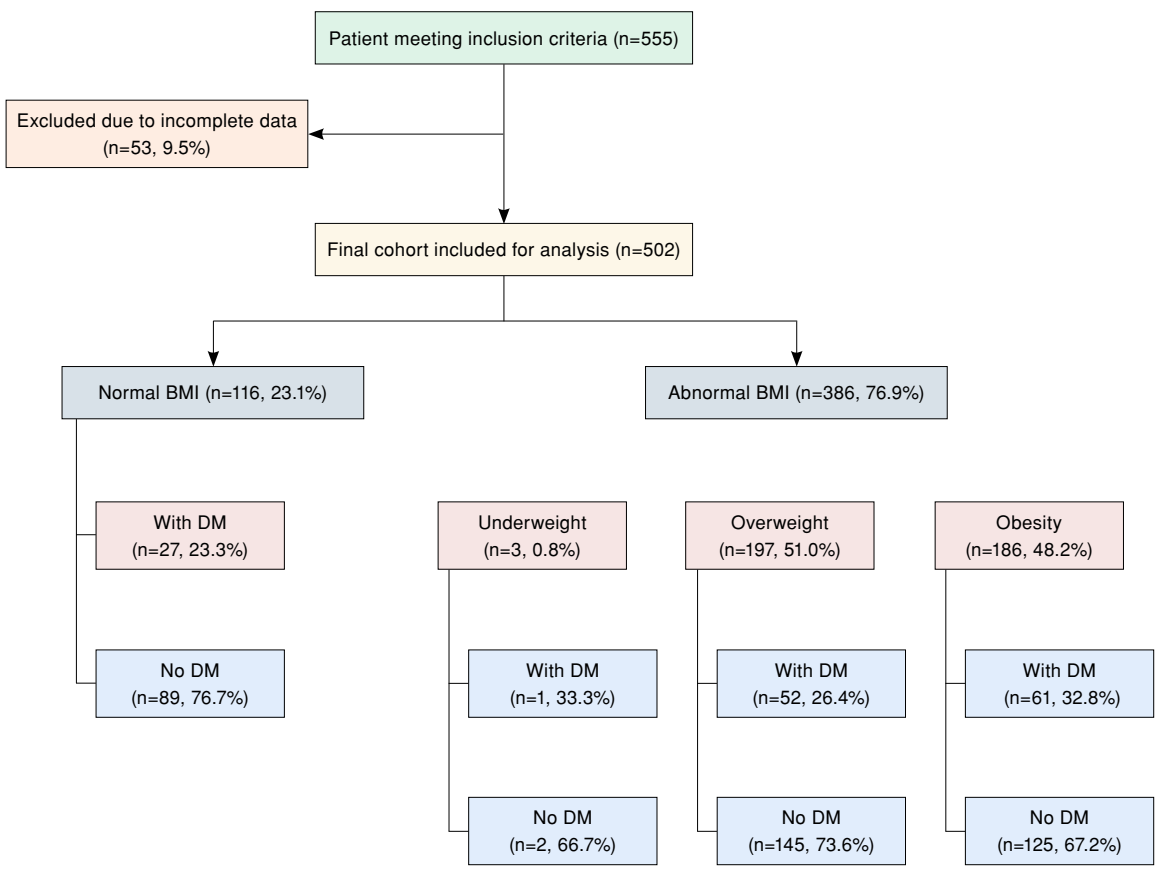


FIGURE 1. Flow diagram of patient inclusion and classification by body mass index and diabetes status.
BMI: Body mass index; DM: Diabetes mellitus.

incomplete data. Finally, a total of 502 patients (100 males, 402 females; mean age: 68.8±7.7 years; range, 45 to 91 years) were included. The study flowchart is shown in Figure 1. Written informed consent was obtained from each patient. The study protocol was approved by the Universiti Malaya Medical Centre, Medical Research Ethics Committee (date: 21.10.2023, no: 202294-11518). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Data collection and definitions

Medical data of the patients were retrieved from the hospital database. Data were collected on demographics such as age and sex, BMI, the presence of DM, and other comorbidities including ischemic heart disease, hypertension, and renal disease. The status of DM and glycemic control was confirmed using the medical records and laboratory results. The BMI was categorized as underweight (<18.5 kg/m^2), normal (18.5-24.9 kg/m^2), overweight (25-29.9 kg/m^2), or obese (≥30 kg/m^2). The type of surgery, whether unilateral or simultaneous bilateral TKA, was recorded from operative notes. Patients were considered for bilateral TKA if both knees demonstrated advanced OA with functionally limiting pain.

The primary outcome measures included 30-day postoperative complications and hospital readmissions. Postoperative complications encompassed VTE events such as deep vein thrombosis (DVT) or pulmonary embolism (PE), infectious complications (superficial or deep surgical site infection (SSI), pneumonia, and urinary tract infection), neurological events such as foot drop or stroke, cardiac events including myocardial infarction or arrhythmias, renal complications such as acute kidney injury or electrolyte imbalance, and glycemic imbalances (e.g., hyperglycemia or hypoglycemia) requiring active management. Data on perioperative blood transfusion requirements were recorded.

Readmission was defined as any unplanned hospitalization within 30 days after surgery, and the main cause was documented as infection, VTE, or another relevant etiology. In-hospital mortality was defined as death from any cause during 30-day hospitalization.

Statistical analysis

Statistical analysis was performed using the IBM SPSS version 23.0 software (IBM Corp., Armonk, NY, USA). Continuous data were expressed in mean ± standard deviation (SD) or median (min-max),

TABLE I
Baseline characteristics of patients

Variables	n	%	Mean±SD
Age (year)			68.8±7.7
Sex			
Male	100	19.9	
Female	402	80.1	
Height (cm)			153.2±13.1
Weight (kg)			70.9±17.6
BMI (kg/m^2)			29.0±5.3
BMI subtypes			
Underweight	3	0.6	
Normal	116	23.1	
Overweight	197	39.2	
Obese	186	37.1	
Diabetes mellitus			
Yes	141	28.1	
No	361	71.9	
Type of surgery			
Unilateral TKA	344	68.5	
Bilateral TKA	158	31.5	

SD: Standard deviation; BMI: Body mass index; TKA: Total knee arthroplasty.

TABLE II
Body mass index distribution of patients undergoing unilateral and bilateral TKA

	Type of surgery			
	Unilateral TKA (n=344)		Bilateral TKA (n=158)	
BMI subtypes	n	%	n	%
Underweight	3	0.9	0	0
Normal	76	22.1	40	25.3
Overweight	131	38.1	66	41.8
Obese	134	39.0	52	32.9

TKA: Total knee arthroplasty; BMI: Body mass index.

while categorical data were expressed in number and frequency. Correlations between categorical variables were evaluated using chi-square test or Fisher exact tests. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated to quantify relative risks. A p value of <0.05 was considered statistically significant.

RESULTS

The mean BMI was 29.0±5.3 kg/m^2. Diabetes mellitus was diagnosed in 141 patients (28.1%). Of the entire cohort, 344 (68.5%) underwent unilateral TKA, and 158 (31.5%) had simultaneous bilateral TKA (Table I). Among the unilateral TKA group, 94 (27.3%) were diabetic; among the bilateral group, 47 (29.7%) had DM. Overweight and obese BMI categories accounted for 77.0% (n=265) of unilateral TKA cases and 74.7% (n=118) of bilateral TKA cases (Table II).

Fifty-seven patients (11.4%) required blood transfusions to manage perioperative blood loss. The most common complications within 30 days included VTE, SSIs, cardiac events, neurological events, renal issues, glycemic imbalances, and allergic reactions (Table III).

Five patients experienced VTE, including four from the diabetic group and four with a BMI ≥25 kg/m^2 (overweight or obese). Surgical site infections, comprising superficial or deep infections, were observed in 19 patients. Cardiac events were documented in 14 patients, while neurological complications included one case each of stroke and foot drop, and two cases of postoperative delirium. Renal complications occurred in three patients, and 13 patients with DM experienced significant episodes of either hyperglycemia or hypoglycemia requiring medical attention.

Obese group reported the highest VTE rates (1.6%), whereas overweight patients exhibited more renal events (1.0%) than other subgroups. Normal BMI diabetic patients had the highest incidence (7.4%) of SSIs, while normal BMI non-diabetic patients showed increased cardiac events (4.5%). Normal BMI group reported highest incidences of respiratory tract infection (2.6%) and neurological event (0.9%) (Table III).

Diabetic patients had notably higher odds of VTE (OR=6.74; p=0.009), implying a significant correlation between DM and VTE risk (Table IV). Although SSIs appeared more frequent among diabetic patients (OR=3.02) and obese patients (OR=1.88), neither of these elevations achieved statistical significance (p=0.082 and p=0.17, respectively).

Of 23 readmissions (4.6%) recorded, six involved patients who were either obese or overweight and returned with superficial or deep SSIs (Table V). One such readmission pertained to a VTE event, and five were due to complications such as allergic reactions or persistent pain. In the diabetic cohort, one patient was readmitted for prosthetic joint infection and another for a superficial infection (Table VI).

Within 30-day postoperative period, only one patient (0.2%) died. This patient, who had diabetes and a normal BMI, underwent a unilateral TKA. Postoperatively, the patient developed hospital-acquired pneumonia leading to sepsis and ultimately multiorgan failure.

DISCUSSION

The present study highlights the interaction of obesity, DM, and postoperative complications within 30 days following TKA, with findings largely consistent with existing literature highlighting elevated BMI and suboptimal glycemic control as critical risk factors for complications, including

TABLE III

Thirty-day perioperative complications following total knee arthroplasty, stratified by body mass index and diabetes status.

	Body mass index														
	Underweight (n=3)			Normal (n=116)				Overweight (n=197)				Obesity (n=186)			
	DM (n=1)	No DM (n=2)		DM (n=27)		No DM (n=89)		DM (n=52)		No DM (n=145)		DM (n=61)		No DM (n=125)	
Perioperative complication	n	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Postoperative blood transfusion (n=57)	0	1	50	6	22.2	11	12.4	3	5.8	18	12.4	7	11.5	11	8.8
Venous thromboembolic event (n=5)															
Pulmonary embolism	0	0	0	0	0	0	0	1	1.9	0	0	0	0	0	0
Deep vein thrombosis	0	0	0	1	3.7	0	0	0	0	0	0	2	3.3	1	0.8
Surgical site infection (n=19)	0	0	0	2	7.4	5	5.6	0	0	6	4.1	0	0	6	4.8
Cardiac event (n=14)															
Angina	0	0	0	0	0	1	1.1	0	0	0	0	0	0	1	0.8
Asystole	0	0	0	0	0	1	1.1	0	0	0	0	0	0	0	0
Hypotensive	0	0	0	1	3.7	2	2.2	0	0	2	1.4	0	0	1	0.8
Sinus bradycardia	0	0	0	0	0	0	0	0	0	1	0.7	0	0	0	0
Sinus tachycardia	0	0	0	0	0	0	0	0	0	1	0.7	1	1.6	0	0
Syncope	0	0	0	0	0	0	0	0	0	0	0	1	1.6	0	0
Atrial fibrillation	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.8
Respiratory tract infection (n=4)															
Pneumonia	0	0	0	1	3.7	1	1.1	0	0	0	0	0	0	0	0
URTI	0	0	0	0	0	1	1.1	0	0	0	0	0	0	1	0.8
Neurological deficit (foot drop) (n=1)	0	0	0	0	0	1	1.1	0	0	0	0	0	0	0	0
Neurology event (n=3)															
Stroke	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.8
Delirium	0	0	0	0	0	1	1.1	0	0	1	0.7	0	0	0	0
Glycemic imbalance (n=13)															
Hypoglycemia	0	2	100	0	0	0	0	0	0	0	0	0	0	0	0
Hyperglycemia	0	0	0	1	3.7	0	0	0	0	0	0	10	16.4	0	0
Renal event (n=3)															
UTI	0	0	0	0	0	0	0	0	0	0	0	1	1.6	0	0
Electrolyte imbalance	0	0	0	0	0	0	0	1	1.9	1	0.7	0	0	0	0
Allergic reaction (includes blood transfusion, antibiotic, dressing) (n=4)	0	0	0	0	0	1	1.1	0	0	1	0.7	1	1.6	1	0.8

DM: Diabetes mellitus; URTI: Upper respiratory tract infection; UTI: Urinary tract infection.

TABLE IV
Bivariate analyses of total knee arthroplasty patients with comorbidities and thirty-day postoperative complications

	No comorbid			With DM			Overweight & obesity		
Complication	n	OR	*p*	n	OR	*p*	n	OR	*p*
DVT/PE	0	1.118	0.290	4	6.738	0.009	4	0.038	0.845
SSI	5	0.892	0.345	2	3.015	0.082	12	1.884	0.170
Foot drop	1	4.525	0.033	0	0.391	0.532	0	3.225	0.073

DM: Diabetes mellitus; OR: Odds ratio DVT: Deep vein thrombosis; PE: Pulmonary embolism; SSI: Surgical site infection.

TABLE V
Thirty-day readmissions of total knee arthroplasty patients by body mass index and diabetes status

	Normal BMI-Non DM		With DM		Overweight & obesity	
	Unilateral TKA	Bilateral TKA	Unilateral TKA	Bilateral TKA	Unilateral TKA	Bilateral TKA
SSI	1	0	1	0	5	1
PJI	0	0	1	0	0	0
DVT/PE	0	0	0	0	0	1
Other causes: Allergic, pain	0	0	0	0	4	1

BMI: Body mass index; DM: Diabetes mellitus; TKA: Total knee arthroplasty; SSI: Surgical site infection; PJI: Prosthetic joint infection; DVT: Deep vein thrombosis; PE: Pulmonary embolism.

TABLE VI
Bivariate analyses of total knee arthroplasty patients needing readmission within 30 days after operation

	No DM and normal BMI			With DM			Overweight & obesity		
Reason for readmission	n	OR	*p*	n	OR	*p*	n	OR	*p*
SSI	1	0.071	0.790	1	0.670	0.413	6	0.348	0.555
PJI	0	0.222	0.638	1	2.565	0.109	0	3.225	0.073
DVT/PE	0	0.222	0.638	0	0.391	0.532	1	0.311	0.577
Others	0	1.118	0.290	0	1.973	0.160	5	1.569	0.210

DM: Diabetes mellitus; BMI: Body mass index; OR: Odds ratio; SSI: Surgical site infection; PJI: Prosthetic joint infection; DVT: Deep vein thrombosis; PE: Pulmonary embolism.

infection and VTE. One of the main findings was the significantly elevated risk of VTE among diabetic patients, as demonstrated by an OR of 6.74. A fixed-effects meta-analysis with moderate heterogeneity among the studies (p=0.10) indicated that pre-existing diabetes significantly increased the risk of DVT following total knee replacement (OR=1.36; 95% CI: 1.07-1.72; p=0.01).[12] Wang and Zhao,[13] in a retrospective analysis of 245 patients undergoing TKA, found that DM significantly increased the risk of DVT, with diabetic patients having a 2.76-fold greater likelihood compared to non-diabetic patients (OR=2.76; p=0.003).

In a study by Zhao et al.[14] involving 358 patients, DVT occurred within 14 days after surgery in 198 patients, with a significantly higher incidence observed in the diabetic group (74.3%, 52/70) compared to the non-diabetic group (50.7%, 146/288; p=0.012). Logistic regression analysis demonstrated that DM independently increased the risk of postoperative DVT by 2.71-fold (95% CI: 1.183-6.212, p=0.018). Hyperglycemia plays a significant role in developing a prothrombotic condition, characterized by elevated coagulation factors and impaired fibrinolysis, which can predispose individuals to thrombotic events.[15]

The overall incidence of DVT in our cohort was lower than rates commonly reported in the literature.[12,16,17] Several institutional practices may contribute to this finding. Firstly, all patients receive mechanical thromboprophylaxis and are mobilized early, which has been shown to significantly reduce VTE risk.[18] Pharmacological prophylaxis, such as acetylsalicylic acid, is

prescribed based on individual risk factors. The diagnosis of DVT in this study was based on clinical suspicion corroborated by imaging, when indicated. As routine postoperative screening with Doppler ultrasound is not performed, it is possible that asymptomatic or subclinical DVT cases were underdiagnosed.

In the current study, we found an OR of 3.02 for SSIs among diabetic patients, which, although not statistically significant, aligns with trends reported by Qin et al.[19] (OR=4.7 for superficial infections) and Hong et al.[20] (OR=1.71 for periprosthetic joint infections). Patients undergoing elective TKA must achieve adequate glycemic control before surgery. To minimize postoperative complications, our institution uses glycated hemoglobin (HbA1c) threshold of less than 8% as a criterion for elective primary TKA. Effective glycemic control in diabetic patients undergoing TKA may lower their complication risk to levels comparable to non-diabetic patients.[21]

The role of obesity in TKA complications was also evident, although not all findings reached significance. The OR of 1.88 for SSIs in obese patients did not achieve statistical significance, but aligns with prior reports identifying elevated BMI as a risk factor for wound complications. Amin et al.[22] reported no complications in the control group, whereas 32% of morbidly obese patients experienced complications, including superficial infections (17%) and prosthetic joint infections (5%). Belmont et al.[23] identified BMI of ≥40 kg/m² as an independent predictor of the development of postoperative complication following TKA (OR=1.47; 95% CI: 1.09-1.98).[23] This higher complication rate may result from the increased surgical complexity and longer operative time required in morbidly obese patients.[24,25]

By 2029, projections estimate that up to 69% of patients undergoing primary elective TKA are be classified as overweight or obese.[4] Consequently, surgeons would need to carefully weigh the benefits of TKA, including pain relief and enhanced physical function, against the elevated risk of postoperative complications in high-risk populations, particularly among obese patients.[26] Although these patients have an increased risk of postoperative complications, effective management of such complications may still allow them to achieve favorable functional outcomes following TKA.[27]

Our study reported a single case of 30-day mortality in a diabetic patient who developed pneumonia, subsequently complicated by sepsis and multiorgan failure. Belmont et al.[23] identified diabetes as an independent predictor of thirty-day mortality (OR=2.99; 95% CI: 1.35-6.62) among a national sample of 15,321 unilateral TKA patients in the United States. Diabetes mellitus was associated with a three-fold increase in the overall risk of mortality.[23] On the contrary, Choi et al.[28] found that DM had no effect on the risk of mortality.

Implementing comprehensive preoperative optimization strategies, including glycemic control,[29] weight management,[30] nutritional counselling,[29] and exercise interventions,[31] is essential for reducing perioperative complications in patients undergoing TKA. Preoperative education and exercise, or prehabilitation, have been shown to enhance physical function both before and after TKA.[31] These programs focus on strengthening the muscles around the knee, improving range of motion, and enhancing overall physical fitness, thereby facilitating recovery and reducing the length of hospital stay.[31] Optimizing glycemic control with the aim of HbA1c below 7.5% is crucial to mitigate infection risk.[29] Tailoring these strategies to individual patient's modifiable risk factors ensures optimal surgical outcomes, reduced hospital length of stay and fewer postoperative emergency department visits in patients undergoing TKA.[32]

Nonetheless, this study has several limitations. First, its retrospective design and single-center setting may limit the generalizability of the findings. Second, small sample sizes in certain subgroups, such as the underweight patients, reduced the statistical power to detect significant differences in complication rates. The low incidence of some complications further limited robust subgroup analyses. Finally, by focusing solely on 30-day postoperative complications, the study does not capture long-term complications or functional results following TKA. Future work may focus on the cost-effectiveness of multifaceted interventions, such as weight reduction, diabetes education, and intensive perioperative glucose control aimed at minimizing complications and readmissions. By integrating these strategies, clinicians can better optimize care for the growing and increasingly complex population of patients undergoing TKA.

In conclusion, elevated BMI and DM independently or in combination, contribute to higher rates of postoperative complications and readmissions following TKA. These results underscore the importance of preoperative

counselling, weight reduction, and meticulous perioperative glycemic control, particularly in patients with these high-risk profiles.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Designed and wrote the initial draft: L.K.W., S.Z.; Participated in data collection: S.Z., W.K.H., K.A.A., V.S.; Conducted data analysis: S.Z., W.K.H., A.A.A.; Conducted manuscript review and editing: K.A.A., V.S., A.A.A. All authors were involved in writing and reviewing the manuscript. All authors read and approved the final manuscript.

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