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Surgical Duration Increases the Risk of Infection Following Total Knee Arthroplasty

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Abstract

Introduction: Risk stratification is used in total joint arthroplasty (TKA) to optimize outcomes and minimize complications. Modifiable risk factors such as surgical duration can be influenced by surgeons; however, under certain circumstances, prolonged surgery cannot be avoided. While previous studies have investigated the impact of surgical duration on post-operative complications, we felt that research was lacking in comparing both surgical duration and tourniquet time and the rate of infection following a TKA. Our learning objective was to investigate the risk of surgical site infections (SSIs) and periprosthetic joint infections (PJIs) from prolonged (1) surgical duration or (2) tourniquet time during primary TKAs.

Materials and Methods: A multicenter health-care system database consisting of 15 hospitals was queried for all patients undergoing TKA between March 2020 and December 2020. Patient demographics, comorbidities, and infection data were collected. The surgical duration and tourniquet time were calculated for each patient undergoing a TKA and compared against the rate of PJI or SSI rate. PJI was defined based on the 2018 musculoskeletal infection society (MSIS) criteria, and superficial SSI was defined as any infection that did not meet MSIS criteria.

Results: Of the 2511 patients who underwent primary TKA, 19 were found to have an infection. Average surgical duration of 126.17 min for patients with an infection compared to 103.44 min without infection (P = 0.02). There was a significantly increased infection rate with increased surgical duration after univariate analysis. Patients who developed any infection had an average tourniquet time of 78.5 min, whereas those without infections had an average of 62.14 min (P = 0.004). Infection rate began to increase once the surgical duration reached 70 min; however, the infection rate increase per 10-min increments was not statistically significant (P = 0.09). The infection rate began to increase at 50 min of tourniquet time and significantly increased as tourniquet time increased (P = 0.004).

Conclusion: Surgical duration is associated with an increased risk of infection following TKA. Our study demonstrated tourniquet time had a greater impact on infection. There are many circumstances that lead to increased surgical and tourniquet duration, including increased body mass index, and severe deformity. Surgeons should consider deflating the tourniquet as soon as the critical parts of the surgery are complete to decrease the risk of post-operative infections.

Keywords: Total knee replacement, infection, knee joint, tourniquets.

Introduction

Periprosthetic joint infection (PJI) is a serious problem that affects 1–2% of primary total knee arthroplasties (TKA) and up to 4% of revision TKAs [1]. The average annual cost of treating an infected TKA is $116,383 compared to an average of $28,249 for a routine TKA [2]. Patients with PJIs have longer hospital lengths of stay, more readmissions, more clinic visits, and more specialist consultations [2, 3]. Due to the impact of PJIs, efforts have been made by surgeons to reduce the incidence of PJIs.

Modifiable and non-modifiable risk factors have been identified as contributing to an increased rate of PJIs. Prevention of PJI is improved by

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Table 1: Univariate analysis of demographics and comorbidities

Variable	Infection (*n*=19)	No infection (*n*=2,502)	*P*-value
Age (years)	63.0±7.2	66.8±9.0	0.07
BMI (kg/m^2)	31.8±6.3	32.2±6.4	0.78
Sex			
Male	11 (58%)	924 (37.1%)	0.06
Female	8 (42%)	1,568 (62.9%)	
Laterality			
Right	13 (68.4%)	1,237 (49.6%)	0.28
Left	6 (31.6%)	1,199 (48.1%)	
Bilateral	0 (0.0%)	23 (0.9%)	
Anemia	6 (31.5%)	332 (13.2%)	**0.02**
Renal Failure	1 (5.3%)	183 (7.3%)	0.59
MRSA (nasal swab)	7 (36.8%)	519 (20.8%)	0.09
Malnutrition	1 (5.3%)	6 (0.2%)	**0.05**
Diabetes	2 (10.6%)	462 (18.5%)	0.29
MI	0 (0.0%)	23 (0.9%)	0.67
PVD	0 (0.0%)	28 (1.1%)	0.64
CVA	0 (0.0%)	32 (1.3%)	0.62
CKD	0 (0.0%)	20 (0.8%)	0.7
COPD	0 (0.0%)	57 (2.3%)	0.51
Peptic Ulcer Disease	0 (0.0%)	18 (0.7%)	0.71
Rheumatoid Arthritis	0 (0.0%)	56 (2.2%)	0.51
Smoking	8 (42.1)	787 (31.6%)	0.33
Anxiety	6 (31.6%)	293 (11.8%)	**0.01**
Depression	5 (26.3%)	252 (10.1%)	**0.02**
ESRD	0 (0.0%)	3 (0.1%)	0.88
Hypertension	12 (63.2%)	1,104 (44.3%)	0.1
Hyperlipidemia	10 (52.6%)	796 (31.9%)	**0.05**
Preoperative COVID	0 (0.0%)	29 (0.9%)	0.64
Post-operative COVID	0 (0.0%)	10 (0.3%)	0.78
Anesthesia			
General	4 (21.1%)	917 (31.2%)	0.22
Spinal	15 (78.9%)	2,025 (68.8%)	
Use of cement	15 (78.9%)	2,048 (82.2%)	0.39
Antibiotic Cement	14 (73.7%)	1,464 (58.8%)	**0.05**
Antibiotic Cement Type			
Gentamicin	11 (78.6%)	1,307 (89.2%)	0.42
Tobramycin	3 (21.4%)	157 (10.7%)	

identifying and optimizing modifiable pre-operative patient risk factors such as morbid obesity, malnutrition, uncontrolled diabetes mellitus (DM), anemia, cardiovascular disorders, renal failure, nicotine abuse, alcohol abuse, and depression [4, 5]. While patient-related factors have been shown to increase the risk of post-operative infection, operative factors including surgical duration have inconclusive data. Some studies have shown that surgical duration alone does not correlate with PJI [6, 7]. On the other hand, previous studies have also shown that surgical duration >120 min is associated with an increased risk of PJI [8-12]. Similar inconclusive data have been seen regarding tourniquet timing and the association with TKA PJI [13-16].

It is essential to minimize the risk factors for PJI; surgical duration and tourniquet time need further investigation to analyze whether both are associated with increased risk of SSI and PJI. The objective of this study is to determine if prolonged surgical duration or tourniquet time is associated with post-operative complications, such as SSIs and PJIs in primary TKAs.

Materials and Methods

Study population

This was an institutional review board-approved investigation. A retrospective collected institutional database was queried consisting of TKA patients who were identified by ICD-10 diagnosis codes across 15 hospitals in our health-care system. There were 2732 patients from 25 different surgeons who underwent primary TKA between March 1, 2020, and December 31, 2020. Of these patients, there were 211 patients excluded from the study due to revision TKAs, bilateral simultaneous TKAs, prior surgery for anterior cruciate ligament reconstruction, open reduction internal fixation, Charcot joints, rheumatoid arthritis, or concomitant procedures to their primary TKA. While tourniquets were utilized in all TKA cases, tourniquet data (e.g., tourniquet time, pressure) was not recorded during 191 procedures. There was one infection following primary TKA that had incomplete data for surgical duration and tourniquet timing and was excluded from

Table 2: Univariate analysis of surgery duration, tourniquet time, tourniquet pressure, and any infection

Variable	Infection (n=19)	No infection (n=2,502)	P-value
Operative Time (min)	126.17±34.58	103.44±31.37	0.02
Tourniquet Time (min)	78.50±18.44	62.14±24.32	0.004
Tourniquet Pressure (mmHg)	291.67±24.25	292.02±35.59	0.97

Table 3: Multivariate analysis of surgery duration, tourniquet time, and any infection

Variable	OR	95% CI	P-value
Operative Time (min)	1.01	(0.99, 1.02)	0.33
Tourniquet Time (min)	1.02	(1.00, 1.04)	**0.05**

the study.

Variables

The following data on demographics and comorbidity variables were prospectively collected: age, sex, body mass index (BMI), past medical history of anemia, malnutrition, DM, myocardial infarction, peripheral vascular disease, cerebrovascular accident, chronic kidney disease, end-stage renal disease, chronic obstructive pulmonary disease, peptic ulcer disease, rheumatoid arthritis, anxiety, depression, hypertension, hyperlipidemia, pre-operative coronavirus 2019 (COVID-19), and post-operative COVID-19 (Table 1).

The primary variable of interest was surgical time, in minutes, between surgical incision and surgical closure. This data were collected from the anesthesia record. Other variables that were investigated were tourniquet time and tourniquet pressure. Tourniquet time was defined as the duration of time, in minutes, between tourniquet inflation and release. Tourniquet pressure was determined and set by the operating surgeon and maintained by the electric tourniquet system as appropriate. This data were collected from the surgical operative report. The primary outcome of interest was the incidence of post-operative infection following primary TKA. Post-operative infections were defined as either superficial surgical site infection (SSI) (i.e., skin or subcutaneous tissue) or PJI, as defined by the 2018 MSIS criteria [17]. SSIs were defined by a clinical diagnosis of infection (presence of any combination of redness at the surgical site, constitutional symptoms, elevated white blood cell count) that was treated with a course of oral antibiotics and local wound care without return to the operating room. All post-operative infections were documented throughout the 90-day follow-up period.

Data analysis

All data were analyzed using the Statistical Package for the Social Sciences Version 26.0. The criterion for statistical significance was set at $\alpha = 0.05$. A two-proportion z-test was used to compare the incidence of post-operative infection to that of prior studies. Independent samples t-tests were used to identify continuous variables that were predictive

Table 4: Analysis of surgical duration in 10-min increments and the rate of any infection

Operative Time (min)	Number of patients	Number of Infections	Percentage increased risk of infection
0–9	0	0	0%
10–19	3	0	0%
20–29	3	0	0%
30–39	3	0	0%
40–49	5	0	0%
50–59	18	0	0%
60–69	111	0	0%
70–79	352	1	0.20%
80–89	405	1	0.20%
90–99	365	1	0.20%
100–109	257	2	0.30%
110–119	215	2	0.30%
120–129	183	3	0.40%
130–139	140	2	0.60%
140–149	99	4	0.70%
150–159	59	0	0.70%
160–169	41	0	0.70%
170–179	23	0	0.70%
180–189	17	0	0.70%
190–199	7	0	0.70%
>200	24	2	0.80%
	P-value	**0.09**	

Table 5: Analysis of tourniquet time in 10-min increments and the rate of any infection

Tourniquet time (min)	Number of patients	Number of infections	Percentage increased risk of infection
0–9	29	0	0
10–19	21	0	0
20–29	75	0	0
30–39	156	0	0
40–49	414	0	0
50–59	460	3	0.3
60–69	399	6	0.6
70–79	257	1	0.6
80–89	158	1	0.6
90–99	131	3	0.7
100–109	48	3	0.8
110–119	50	1	0.8
120–129	40	0	0.8
>130	21	0	0.8
	***P*-value**	**0.004**	

of post-operative infection in univariate analysis. Predictor variables found to be statistically significantly associated with post-operative infection were subsequently included in multivariate logistic regression modeling. The Chi-square test was used to measure the statistical significance of the relationship between tourniquet time in 10-min increments and surgical duration in 10-min increments.

Results

The incidence of post-operative infection was 0.76% (19 patients) of the 2,511 patients who underwent a primary TKA. There were 7 SSIs (0.28%) and 12 PJIs (0.48%). Patient demographics and comorbidities were compared between patients with post-operative SSIs and those without infections (Table 1). There is a significant increase in infection incidence among patients with anemia (P = 0.02), malnutrition (P = 0.05), anxiety (P = 0.01), depression (P = 0.02), and hyperlipidemia (P = 0.05) (Table 1).

Surgical duration

Operative duration was found to have a significant increase in postoperative infection with univariate analysis (Table 2). Patients who underwent a TKA over 126.17 min had an increased rate of infection compared to patients who underwent a TKA within 103.44 min (P = 0.02). However, the multivariate analysis did not show a significant increase in infection due to surgical duration (Odds Radio [OR] 1.01 [95% Confidence interval [CI] 0.99–1.02], P = 0.33, Table 3). Yet, the infection rate increased as the surgical duration increased, and all the infections occurred after 70 min of surgical duration (Table 4). The highest number of infections (4) occurred during the 140–149-min time period. The infection rate was 0.2% at 70 min and increased to 0.8% by 200 min, however, there was no statistical significance in the infection rate throughout the 10-min surgical duration time periods (P = 0.09, (Table 4).

Tourniquet time

Tourniquet time was shown to be associated with a significantly increased rate of postoperative infection with univariate analysis (P = 0.004, Table 2). There was an increased rate of infection when a tourniquet was used for over 78.5 min compared to patients who only had a tourniquet time of 62.14 min (P = 0.004). There was no difference in tourniquet pressure between TKA patients with infections (291.67 mmHg) and TKA patients without infections (292.02 mmHg, P = 0.97, Table 2). A multivariate analysis showed tourniquet time as opposed to surgical duration alone was associated with an increased rate of postoperative infection after total knee arthroplasty (OR 1.02 [95% CI 1.00–1.04]; P = 0.05, Table 3). The infection rate also significantly increased as the tourniquet time increased over the course of 10-min increments (P = 0.004, Table 5). The infection rate started increasing at 50 min of tourniquet time with no infections before the 50-min tourniquet time period (Table 5). The highest number of infections (6) occurred during the 60-min time period. The risk of infection reached a rate of 0.8% once the tourniquet time reached 100 min (Table 5).

Discussion

Surgical duration and tourniquet time are measurable objective data points that surgeons can follow intraoperatively to guide them in mitigating the risk of postoperative PJI. The goal is to be efficient in the operating room; however, surgical duration and tourniquet time can be increased when performing TKA in patients with multiple comorbidities or complex TKAs. By investigating how incremental increases in surgical duration and tourniquet time impact the risk of infection, surgeons can use the data to intraoperatively manage and mitigate infection risks especially when performing challenging TKAs. Studies have shown that younger patients and patients with higher BMIs undergo longer surgical durations [8, 10]. Duchman et al. discovered multiple risk factors for increased operative times such as age ≤65 years of age, male sex, BMI ≥30 kg/m2, and American Society of Anesthesiologists classification of 3 or 4 [11]. There are also factors outside patient comorbidities that impact surgical duration such as new operating room staff. While surgery at a teaching hospital with residents and fellows can increase the surgical duration and tourniquet time, previous studies have shown that the increase in surgical duration from trainee involvement does not increase the risk of PJI [18]. These are some of the many factors that can contribute to longer surgical durations and tourniquet times. Our data shows that the risk of infection significantly increases when tourniquet time increases, particularly once a tourniquet has been inflated for at least 50 min.

There are some limitations to this study. First, there was only a 0.8% rate of postoperative infections among all the patients who received a TKA. This low rate of postoperative infection shows that our surgeons are making appropriate efforts to decrease PJIs. The infection rate of 0.8% is lower than the literature rate of 1% to 2% PJI rate among primary TKA, which might also be due to the low patient sample size [1]. Secondly, another limitation was the sample size. Only 2,511 patients were included in the study who underwent primary total knee arthroplasties. While larger sample sizes of patients can help to identify and analyze relatively rare post-operative complications such as SSIs and PJIs, a power analysis was performed before the initiation of this study to obtain an appropriate sample size. Thirdly, the patient data were pulled via ICD-10 codes, thus there was some missing data in the medical records including exact surgical time, tourniquet time, and some outpatient post-operative records. To maintain a more complete data collection, patients without surgical and tourniquet times were excluded from the study.

Surgical duration

Our data showed that surgical duration over 126.17 min significantly increased the risk of infection. However, the critical point of surgical timing that increases the incidence of infection for TKAs varies among published manuscripts. Bohl et al. showed that a 15-min increase in surgical duration from the mean operative time of 91 min increased the risk of SSI by 9% [10]. Wang et al. also showed an increase in total joint arthroplasty (TKA) infection when surgical duration is >90 min [12]. The incidence of SSI was found to be 2.1% and PJI was 1.4% when the operative time increased over 90 min [12]. Similar to our study, previous research has shown that surgical duration >110 min is associated with a higher risk of deep infection following a TKA [9]. Anis et al. discovered that there was a 3 times higher risk of PJI and 1.5 times risk of SSI when surgical duration was over 121 min [8]. While there is no agreed-upon time cut-off for the appropriate surgical duration, the data show that the risk of infection increases as the surgical duration increases.

Tourniquet time

Surgical duration has been studied showing an increased rate of infection, however, little is documented regarding tourniquet timing and the risk of infection. Tourniquet use has been cited as a method for decreasing surgical time, allowing better cementation penetration, and reducing radiolucent lines through bloodless surgery [19]. Ahmed et al. showed that the use of a tourniquet only decreased the duration of surgery by 3.7 min [20]. Our results demonstrate that increased tourniquet time significantly increased the rate of post-operative infection. Like our findings, Abdel-Salam and Eyers performed a randomized control trial that showed that patients who underwent a TKA without the use of a tourniquet had fewer superficial skin infections, deep-vein thrombosis, earlier straight leg raises, and earlier knee flexion compared to patients who underwent a TKA with a tourniquet [13]. Magan et al. also found that there was a 4% incidence of infection with tourniquet use compared to a 2% rate of infection when tourniquets were not used during TKAs [21]. While our results showed no difference between tourniquet pressure and the rate of post-operative infection, some studies have found an association between surgical site pain, muscle damage, and wound complications when tourniquet pressure is 150 mmHG greater than the patient's systolic blood pressure [22]. While the reason for why tourniquet use increases infection rate has not been fully understood, one explanation is that tourniquet use causes reactive hyperemia following deflation that causes a 10% increase in limb size [13, 23].

Conclusion

Surgical duration and tourniquet timing are modifiable risk factors that can be improved by optimizing pre-operative planning, operating room efficiency, and surgical education. While longer surgical duration is associated with a greater risk of infection following TKA, our study demonstrated that time under a tourniquet had a significant impact on post-operative infection. Surgeons should strive to maximize efficiency to decrease both surgical duration and tourniquet time, thus minimizing post-operative SSIs. Furthermore, surgeons should consider deflating the tourniquet as soon as the critical parts of the surgery are complete to decrease the risk of post-operative infections.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given his consent for his images and other clinical information to be reported in the Journal. The patient understands that his name and initials will not be published, and due efforts will be made to conceal his identity, but anonymity cannot be guaranteed.

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References

1. Izakovicova P, Borens O, Trampuz A. Periprosthetic joint infection: Current concepts and outlook. EFORT Open Rev 2019;4:482-94.
2. Kapadia BH, McElroy MJ, Issa K, Johnson AJ, Bozic KJ, Mont MA. The economic impact of periprosthetic infections following total knee arthroplasty at a specialized tertiary-care center. J Arthroplasty 2014;29:929-32.
3. Colston J, Atkins B. Bone and joint infection. Clin Med (Lond) 2018;18:150-4.
4. Eka A, Chen AF. Patient-related medical risk factors for periprosthetic joint infection of the hip and knee. Ann Transl Med 2015;3:233.
5. Gold PA, Garbarino LJ, Anis HK, Neufeld EV, Sodhi N, Danoff JR, et al. The cumulative effect of substance abuse disorders and depression on postoperative complications after primary total knee arthroplasty. J Arthroplasty 2020;35:S151-7.
6. Naranje S, Lendway L, Mehle S, Gioe TJ. Does operative time affect infection rate in primary total knee arthroplasty? Clin Orthop Relat Res 2015;473:64-9.
7. Scigliano NM, Carender CN, Glass NA, Deberg J, Bedard NA. Operative time and risk of surgical site infection and periprosthetic joint infection: A systematic review and meta-analysis. Iowa Orthop J 2022;42:155-61.
8. Anis HK, Sodhi N, Klika AK, Mont MA, Barsoum WK, Higuera CA, et al. Is operative time a predictor for post-operative infection in primary total knee arthroplasty? J Arthroplasty 2019;34:S331-6.
9. Badawy M, Espehaug B, Fenstad AM, Indrekvam K, Dale H, Havelin LI, et al. Patient and surgical factors affecting procedure duration and revision risk due to deep infection in primary total knee arthroplasty. BMC Musculoskelet Disord 2017;18:544.
10. Bohl DD, Ondeck NT, Darrith B, Hannon CP, Fillingham YA, della Valle CJ. Impact of operative time on adverse events following primary total joint arthroplasty. J Arthroplasty 2018;33:2256-62.e4.
11. Duchman KR, Pugely AJ, Martin CT, Gao Y, Bedard NA, Callaghan JJ. Operative time affects short-term complications in total joint arthroplasty. J Arthroplasty 2017;32:1285-91.
12. Wang Q, Goswami K, Shohat N, Aalirezaie A, Manrique J, Parvizi J. Longer operative time results in a higher rate of subsequent periprosthetic joint infection in patients undergoing primary joint arthroplasty. J Arthroplasty 2019;34:947-53.
13. Abdel-Salam A, Eyres KS. Effects of tourniquet during total knee arthroplasty. A prospective randomised study. J Bone Joint Surg Br 1995;77:250-3.
14. Arthur JR, Spangehl MJ. Tourniquet use in total knee arthroplasty. J Knee Surg 2019;32:719-29.
15. Li X, Yin L, Chen ZY, Zhu L, Wang HL, Chen W, et al. The effect of tourniquet use in total knee arthroplasty: Grading the evidence through an updated meta-analysis of randomized, controlled trials. Eur J Orthop Surg Traumatol 2014;24:973-86.
16. Zak SG, Yeroushalmi D, Long WJ, Meftah M, Schnaser E, Schwarzkopf R. Does the use of a tourniquet influence outcomes in total knee arthroplasty: A randomized controlled trial. J Arthroplasty 2021;36:2492-6.
17. Parvizi J, Tan TL, Goswami K, Higuera C, della Valle C, Chen AF, et al. The 2018 definition of periprosthetic hip and knee infection: An evidence-based and validated criteria. J Arthroplasty 2018;33:1309-14.e2.
18. Anis HK, Rothfusz CA, Eskildsen SM, Klika AK, Piuzzi NS, Higuera CA, et al. Does surgical trainee participation affect infection outcomes in primary total knee arthroplasty? J Surg Educ 2022;79:993-9.
19. Hegde V, Bracey DN, Johnson RM, Dennis DA, Jennings JM. Tourniquet use improves cement penetration and reduces radiolucent line progression at 5 years after total knee arthroplasty. J Arthroplasty 2021;36:S209-14.
20. Ahmed I, Chawla A, Underwood M, Price AJ, Metcalfe A, Hutchinson CE, et al. Time to reconsider the routine use of tourniquets in total knee arthroplasty surgery. Bone Joint J 2021;103-B:830-9.
21. Magan AA, Dunseath O, Armonis P, Fontalis A, Kayani B, Haddad FS. Tourniquet use in total knee arthroplasty and the risk of infection: A meta-analysis of randomised controlled trials. J Exp Orthop 2022;9:62.
22. Pinsornsak P, Pinitchanon P, Boontanapibul K. Effect of different tourniquet pressure on postoperative pain and complications after total knee arthroplasty: A prospective, randomized controlled trial. J Arthroplasty 2021;36:1638-44.
23. Silver R, de la Garza J, Rang M, Koreska J. Limb swelling after release of a tourniquet. Clin Orthop Relat Res 1986;206:86-9.

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