Incidence of Early Adverse Events After Tibial Tubercle Osteotomy

Sercan Yalcin,*† MD, Karrington Seals,‡ BS, William McLaughlin,† MD, John P. Fulkerson,† MD, and Lutul D. Farrow,§ MD

Investigation performed at the Orthopaedic & Rheumatologic Institute, Cleveland Clinic, Cleveland, Ohio, USA

Background: Tibial tubercle osteotomy (TTO) is a commonly utilized surgical procedure for the treatment of patellofemoral instability. Although midterm and long-term outcomes are known, perioperative complications have not been consistently reported.

Purpose: To identify the incidence and predictors of adverse events in the first 90-day perioperative period after TTO.

Study Design: Case series; Level of evidence, 4.

Methods: Patients undergoing primary TTO between January 1, 2010, and December 31, 2019, were included. Readmissions in the first 90 days after surgery were collected, and data were collected for the following variables: age, sex, smoking status, body mass index, laterality, preoperative diagnosis, presence of trochlear dysplasia, tourniquet use, TTO procedure, tibial tubercle distalization, trochleoplasty, chondral procedure, number of screws, and use of an epidural catheter. Predictors of readmission for any reason were identified using multivariable logistic regression analysis.

Results: A total of 345 TTO procedures were included in the final analysis. The incidence of readmissions for any reason was 20.6% (71/345). The most common reason for readmission was postoperative pain (26/345 [7.5%]), followed by wound complications (19/345 [5.5%]) and epidural catheter–related complications (overall: 16/345 [4.6%]; specific: 16/167 [9.6%]. The incidence of major complications was 2.0% (7/345). The number of patients with each major complication was as follows: 1 for deep vein thrombosis, 2 for pulmonary embolism, 1 for septic arthritis, 1 for tibial tubercle fracture, and 2 for loss of fixation. Female sex and smoking were associated with readmission for pain.

Conclusion: The incidence of major complications after TTO was very low (2.0%), but 20.6% of cases required readmission, primarily for an indwelling epidural catheter (3.5%) and postoperative pain (7.5%). Concomitant soft tissue procedures and the number of screws were associated with readmission after TTO. Utilizing individualized postoperative pain management and preoperative discussions about expected pain may help to avoid readmission for pain after TTO.

Keywords: tibial tubercle osteotomy; patellofemoral instability; perioperative complication; readmission; postoperative pain

Patellofemoral instability covers a wide spectrum of disorders, from insidious anterior knee pain to recurrent frank dislocations. A number of soft tissue and bony procedures have been described for the treatment of patients with patellofemoral instability. The decision on the type of surgical treatment is made on an individual basis after a thorough assessment of the underlying abnormality. First described in 1938,[5] tibial tubercle osteotomy (TTO) is a surgical technique that allows mobilization of the tibial tubercle and thus redistributes force vectors on the patella, improving patellar tracking and offloading of patellar articular cartilage.[7,14] TTO is generally preferred for patients with patellofemoral instability due to an excessive lateral position of the tibial tubercle (tibial tubercle–trochlear groove [TT-TG] distance >20 mm) or a patellar height abnormality (Caton-Deschamps index >1.2).[11,15] For patients with patellofemoral chondral lesions or arthritis, TTO is considered in the presence of pain, swelling, and/or mechanical symptoms after undergoing a reasonable trial of nonoperative treatment. For patients with a first-time patellar dislocation, TTO is performed in the presence of an unstable osteochondral lesion.[15] TTO is one of the most commonly performed procedures to address patellofemoral instability because it can both address instability and preserve the joint from further cartilage injuries. Multiple TTO techniques have been described in the literature. The most commonly preferred techniques include anteromedialization (AMZ),[2] in which the tibial tubercle is transferred anteriorly and medially to address both instability and patellar chondral lesions, and medialization (MZ),[18] in which the tibial tubercle is transferred medially to address instability.

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Although satisfactory clinical and functional outcomes have been reported, the incidence of early postoperative complications after TTO has been reported to be as high as 46%.[8,12] These complications include, but are not limited to, postoperative pain, deep vein thrombosis (DVT), pulmonary embolism (PE), wound infection, tibial tubercle fracture, loss of fixation, delayed union, nonunion, and painful hardware.[1,3] Furthermore, concomitant soft tissue and bony procedures add additional sources of complications. Distalization at the time of TTO was recently suggested to increase the incidence of early complications.[8] Even isolated lateral retinacular release was reported to have a 7.2% complication rate.[16] However, patient- and surgery-specific risk factors for early complications after TTO have not been well-defined.

The primary objective of this study was to identify the incidence of adverse events in the first 90-day perioperative period after TTO. The secondary objective was to identify predictors of perioperative complications, and the tertiary objective was to identify the predictors of readmission for postoperative pain. It was hypothesized that major complications after TTO would be rare.

METHODS

After obtaining institutional review board approval, a retrospective chart review was performed on patients undergoing TTO at a single institution between January 1, 2010, and December 31, 2019, to identify the incidence of early adverse events in the first 90-day perioperative period. Patients undergoing primary TTO were included. The indications for TTO were persistent patellofemoral pain due to osteoarthritis, recurrent instability, or a first-time dislocation with a chondral defect with a TT-TG distance >20 mm. TTO with the AMZ technique was performed in the presence of patellar chondral lesions, and distalization was performed if the Caton-Deschamps index was >1.4. Exclusion criteria were patients with missing follow-up data and 90-day follow-up radiographs, revision TTO, TTO after total knee arthroplasty, concomitant anterior cruciate ligament reconstruction, previous rotational and coronal alignment correction osteotomy, a history of soft tissue procedures for patellar instability, and congenital patellar dislocations or patellar instability secondary to a congenital disorder/syndrome.

Data Collection

Data were collected for the following variables: age, sex, smoking status (never vs ever), body mass index (BMI), laterality (unilateral vs bilateral), preoperative diagnosis (first-time dislocation vs recurrent dislocation vs recurrent subluxation/pain/osteoarthritis), presence of trochlear dysplasia (yes/no), tourniquet use (yes/no), TTO procedure (TTO vs TTO + soft tissue procedures), tibial tubercle distalization (yes/no), trochleoplasty (yes/no), chondral procedure (yes/no), number of screws (1 vs ≥2), and use of an epidural catheter (yes/no).

When utilized, the epidural catheter was used for postoperative pain control for 2 weeks based on surgeon preference and was limited to the period between 2010 and 2016, after which it was replaced by regional blocks. DVT prophylaxis was also based on the surgeon's preference, and there was not a single uniform prophylaxis regimen. Also, the number of screws to fix the tibial tubercle was based on surgeon preference. Surgery was recorded as bilateral only if the patient underwent simultaneous bilateral knee surgery. Patients who underwent knee surgical procedures at 2 different time points were recorded as unilateral for the respective knee surgery. Preoperative diagnosis was classified based on the patient's history of a first-time dislocation, a recurrent dislocation, and recurrent subluxation/pain/osteoarthritis. Trochlear dysplasia was graded using preoperative knee radiographs. All soft tissue procedures, including medial patellofemoral ligament (MPFL) reconstruction, were classified as soft tissue procedures. All chondral procedures were included in the final analysis except for loose body excision, which was not considered a cartilage procedure. Smoking status was reported separately for each knee for patients undergoing bilateral knee surgery at 2 different time points. Delayed union was defined as incomplete bony healing on 3-month postoperative radiographs. The TTO techniques used in this cohort were AMZ and MZ.

Complications limited to the 90-day perioperative period were collected using REDCap.[4] REDCap is a validated cloud-based data management system that allows users (both physicians and patients) to enter and analyze data. Among the complications observed in this cohort, major complications were defined as DVT, PE, septic arthritis, tibial tubercle fracture, and loss of fixation.

Statistical Analysis

Data were analyzed separately for readmission for all causes and readmission for pain in particular. TTO techniques (AMZ vs MZ) were also compared for readmission rates. Data for continuous variables such as age and BMI were reported as medians and interquartile ranges.

*Address correspondence to Sercan Yalcin, MD, Yale New Haven Hospital, 20 York Street, New Haven, CT 06510, USA (email: seralple@gmail.com) (Twitter: @seralple).
†Department of Orthopaedics & Rehabilitation, Yale School of Medicine, New Haven, Connecticut, USA.
‡School of Medicine, Case Western Reserve University, Cleveland, Ohio, USA.
§Orthopaedic & Rheumatologic Institute, Cleveland Clinic, Cleveland, Ohio, USA.
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Ethical approval for this study was obtained from Cleveland Clinic (No. 20-1274).

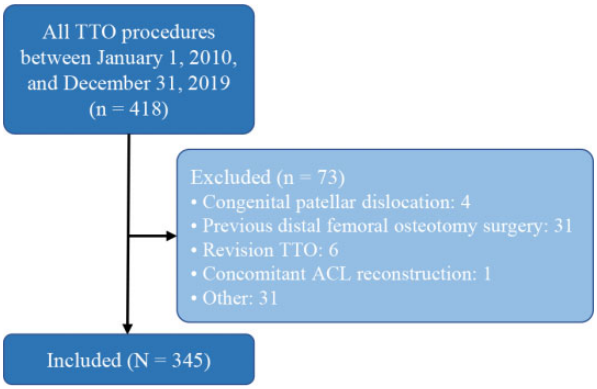

Figure 1. STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) diagram of patient enrollment in the study. ACL, anterior cruciate ligament; TTO, tibial tubercle osteotomy.

Categorical variables such as sex, smoking status, laterality, and TTO procedure were summarized as counts and percentages.

Multivariable logistic regression was used to model readmissions. The predictors included age, sex, BMI, laterality, TTO procedure, TTO technique, number of screws, and distalization. For acute pain, because of the small event number, a series of univariate logistic regression models were built instead, using the same set of predictors, but only 1 predictor was present in the model at a single time. It should be noted that the number of screws was not chosen as a predictor in univariate logistic regression because of perfect separation. Because all patients with acute pain had $\geq$2 screws, perfect separation would generate some estimation problems in model fitting. As a result, the number of screws was not included. Results were summarized using odds ratios (ORs), 95% CIs, and *P* values.

The predictive ability of the multivariable model for readmission was measured by the bootstrapped bias-corrected C index. The C index ranges from 0.5 to 1, with higher values indicating better performance. Variables were ranked based on their relative contribution to the models, as assessed by the increase in the Akaike information criterion (AIC) upon removing the variable from the full model. An AIC $\geq$2 indicates a statistically better model. A nomogram to aid the risk calculation is shown in Appendix Figure A1. Predictors with missing data were singly imputed using multiple imputation by chained equations (*mice* package in R software). Data management and analysis were performed using R software (Version 4.0, R-Foundation, Austria). All tests were 2-sided, with an alpha level of .05.

RESULTS

Of 418 TTO procedures performed between January 1, 2010, and December 31, 2019, there were 73 cases excluded, leaving 323 patients (345 knees) operated on by 14 fellowship-trained orthopaedic sports medicine surgeons and therefore included in the final analysis (Figure 1). The demographic and surgical characteristics of the study participants are shown in Table 1. The number of simultaneous bilateral knee surgical procedures was 18. Preoperative radiographs were available in 323 knees (93.6%) to classify trochlear dysplasia. Of these, trochlear dysplasia was present in 86 knees (26.6%). The numbers of first-time dislocations, recurrent dislocations, and recurrent subluxation/pain/osteoarthritis were 20, 202, and 123, respectively (Table 1).

An epidural catheter was used after 167 surgical procedures (48.4%), and a tourniquet was used in 297 surgical procedures (86.1%) (Table 1). Isolated TTO was performed in 64 knees, isolated MPFL reconstruction only was added in 11 knees, soft tissue procedures without MPFL reconstruction (medial reefing, lateral retinacular lengthening, vastus medialis obliquus advancement) were added in 245 knees, and any combination of MPFL reconstruction and other soft tissue procedures was added in 25 knees. The tibial tubercle was distalized in 128 knees (37.1%). Trochleoplasty was performed in only 6 knees (1.7%). The only treatment for meniscal lesions was partial meniscectomy, which was performed in 8 knees.

Based on the intraoperative Outerbridge classification, 110 knees (31.9%) had no cartilage lesion, 80 knees (23.2%) had grade 1 to 2 lesions, and 155 knees (44.9%) had grade 3 to 4 lesions. A type of chondral procedure was performed in 178 knees (51.6%). The AMZ technique was performed in 294 knees, and the MZ technique was performed in 51 knees. One screw was used in 40 knees, 2 screws in 304 knees, and 3 screws in 1 knee.

Adverse Events

A total of 71 readmissions (20.6%) were recorded in the first 90-day perioperative period (Table 2). The most common reason for readmission was postoperative pain (26/345 [7.5%]), followed by wound complications (19/345 [5.5%]) and epidural catheter–related complications (12/345 [3.5%]). Among patients having epidural catheter, the complication rate was 7.1% (12/167). The number of arthrofibrosis cases requiring manipulation under anesthesia was 2 (0.6%). The incidence of major complications was 2.0% (7/345). The number of patients with each major complication was as follows: 1 for DVT, 2 for PE, 1 for septic arthritis, 1 for tibial tubercle fracture, and 2 for loss of fixation.

Results of Multivariable Analysis

Multivariable analysis for overall readmissions demonstrated that any concomitant soft tissue procedure (OR, 2.40; $P = .040$) and the use of $\geq$2 screws (OR, 3.04; $P = .046$) were associated with readmission after TTO (Table 3).

Univariate logistic regression analysis for readmission for pain demonstrated that female sex (OR, 10.13; $P = .024$) and smoking (OR, 2.49; $P = .037$) were associated with readmission for pain (Table 4). Multivariable analysis on TTO technique demonstrated that the technique was not associated with readmission (Table 5). Overall, the number of screws and TTO procedure ranked the highest according

TABLE 1
Patient and Surgical Characteristics[a]

	Total (N = 345)	No Readmission (n = 274)	Readmission (n = 71)	No Acute Pain (n = 319)	With Acute Pain (n = 26)
Age, y	20.0 (16.0-28.0)	20.0 (16.0-28.0)	20.0 (16.0-29.5)	20.0 (16.0-28.0)	25.0 (16.0-32.0)
Sex					
Male	93 (27.0)	77 (28.1)	16 (22.5)	92 (28.8)	1 (3.8)
Female	252 (73.0)	197 (71.9)	55 (77.5)	227 (71.2)	25 (96.2)
Smoking					
Never	280 (81.2)	228 (83.2)	52 (73.2)	263 (82.4)	17 (65.4)
Ever	65 (18.8)	46 (16.8)	19 (26.8)	56 (17.6)	9 (34.6)
BMI, kg/m^2	26.2 (22.8-30.4)	26.2 (22.6-30.4)	26.1 (23.0-30.9)	26.2 (22.8-30.4)	26.3 (22.0-31.2)
Laterality					
Unilateral	327 (94.8)	261 (95.3)	66 (93.0)	303 (95.0)	24 (92.3)
Bilateral	18 (5.2)	13 (4.7)	5 (7.0)	16 (5.0)	2 (7.7)
Diagnosis					
First-time patellar dislocation	20 (5.8)	14 (5.1)	6 (8.5)	17 (5.3)	3 (11.5)
Recurrent dislocation	202 (58.6)	162 (59.1)	40 (56.3)	191 (59.9)	11 (42.3)
Recurrent subluxation/pain/ osteoarthritis	123 (35.7)	98 (35.8)	25 (35.2)	111 (34.8)	12 (46.2)
Tourniquet use					
No	48 (13.9)	41 (15.0)	7 (9.9)	47 (14.7)	1 (3.8)
Yes	297 (86.1)	233 (85.0)	64 (90.1)	272 (85.3)	25 (96.2)
Trochlear dysplasia[b]					
No	237 (73.4)	180 (70.0)	57 (86.4)	216 (72.2)	21 (87.5)
Yes	86 (26.6)	77 (30.0)	9 (13.6)	83 (27.8)	3 (12.5)
TTO procedure					
TTO	64 (18.6)	56 (20.4)	8 (11.3)	61 (19.1)	3 (11.5)
TTO + soft tissue procedures	281 (81.4)	218 (79.6)	63 (88.7)	258 (80.9)	23 (88.5)
TTO technique					
AMZ	294 (85.2)	228 (83.2)	66 (93.0)	268 (84.0)	26 (100.0)
MZ	51 (14.8)	46 (16.8)	5 (7.0)	51 (16.0)	0 (0.0)
Trochleoplasty					
No	339 (98.3)	269 (98.2)	70 (98.6)	313 (98.1)	26 (100.0)
Yes	6 (1.7)	5 (1.8)	1 (1.4)	6 (1.9)	0 (0.0)
Cartilage procedure					
No	167 (48.4)	131 (47.8)	36 (50.7)	153 (48.0)	14 (53.8)
Yes	178 (51.6)	143 (52.2)	35 (49.3)	166 (52.0)	12 (46.2)
No. of screws					
1	40 (11.6)	36 (13.1)	4 (5.6)	40 (12.5)	0 (0.0)
≥2	305 (88.4)	238 (86.9)	67 (94.4)	279 (87.5)	26 (100.0)
Use of epidural catheter					
No	178 (51.6)	147 (53.6)	31 (43.7)	168 (52.7)	10 (38.5)
Yes	167 (48.4)	127 (46.4)	40 (56.3)	151 (47.3)	16 (61.5)
Distalization					
No	217 (62.9)	173 (63.1)	44 (62.0)	201 (63.0)	16 (61.5)
Yes	128 (37.1)	101 (36.9)	27 (38.0)	118 (37.0)	10 (38.5)

[a]Data are reported as median (interquartile range) or n (%). AMZ, anteromedialization; BMI, body mass index; MZ, medialization; TTO, tibial tubercle osteotomy.
[b]Unknown/missing for 22 knees.

to the relative contribution to the model for readmission (increase in AIC) (Appendix Figure A1).

DISCUSSION

The overall readmission rate in the first 90 days after surgery was found to be 20.6%, of which 3.5% was related to the use of an epidural catheter and 7.5% was related to acute postoperative pain. The incidence of major complications was low at 2.0% in our cohort. Utilizing multivariable analysis, this study demonstrated that concomitant soft tissue procedures and the number of screws were predictors of readmission after TTO, while the TTO technique was not found to be a predictor. In addition, female sex and smoking were predictors for readmission for pain after TTO.

Johnson et al[8] reported the incidence of early adverse events after TTO as 46% in a cohort of 153 patients. In their cohort, the incidence of delayed union was 23%, and the

TABLE 2
Reasons for Readmission[a]

	Value (n = 71)
Minor complications	69/345 (20.0)
Arthrofibrosis	2
Atelectasis	1
Wound complication	19
Bleeding from incision	1
Cellulitis	7
Delayed wound healing	1
Eschar formation	1
Wound dehiscence	6
Wound infection	3
Knee effusion	1
Acute postoperative pain	26
Transient extensor hallucis longus neuropathy (not epidural related)	1
Epidural catheter–related complications	16/167 (9.6)
Back pain	1
Bowel incontinence	1
Cellulitis around epidural catheter entry site	3
Extensor hallucis longus weakness	2
Transient lower extremity sensory deficit	3
Orthostatic syncope	1
Urinary retention	1
Opioid-related complication	2
Constipation	1
Vomiting	1
Major complications	7/345 (2.0)
DVT	1
PE	2
Septic arthritis	1
Tibial tubercle fracture	1
Loss of fixation	2

[a]Data are reported as Number or number (%). DVT, deep vein thrombosis; PE, pulmonary embolism.

TABLE 3
Multivariable Model for Overall Readmissions[a]

	Odds Ratio (95% CI)	*P*
Age (IQR increase)	0.98 (0.68-1.42)	.916
Sex (female vs male)	1.31 (0.70-2.45)	.406
BMI (IQR increase)	1.02 (0.71-1.46)	.916
Laterality (bilateral vs unilateral)	1.58 (0.52-4.81)	.420
TTO procedure (TTO + soft tissue procedures vs TTO)	2.40 (1.04-5.53)	**.040**
No. of screws (≥2 vs 1)	3.04 (1.02-9.08)	**.046**
Distalization (yes vs no)	0.78 (0.44-1.39)	.394

[a]Boldface *P* values indicate statistical significance ($P < .05$). BMI, body mass index; IQR, interquartile range; TTO, tibial tubercle osteotomy.

incidence of painful hardware was 21%. Of the 35 patients with delayed union, only 1 patient required revision TTO. In our study, no patient was diagnosed with delayed union. Painful hardware was also reported to be a major concern in earlier studies, with an incidence as high as 70%.[13] Pain

TABLE 4
Univariate Logistic Regression for Readmission for Pain[a]

	Odds Ratio (95% CI)	*P*
Sex (female vs male)	10.13 (1.35-75.88)	**.024**
Smoking (ever vs never)	2.49 (1.05-5.86)	**.037**
Laterality (bilateral vs unilateral)	1.58 (0.34-7.27)	.560
TTO procedure (TTO + soft tissue procedures vs TTO)	1.81 (0.53-6.23)	.350
Epidural catheter (yes vs no)	1.78 (0.78-4.04)	.170
Distalization (yes vs no)	1.06 (0.47-2.42)	.880
Age (IQR increase)	1.16 (0.69-1.95)	.570
BMI (IQR increase)	1.02 (0.60-1.73)	.940

[a]Boldface *P* values indicate statistical significance ($P < .05$). BMI, body mass index; IQR, interquartile range; TTO, tibial tubercle osteotomy.

TABLE 5
Multivariable Model for Readmission Using TTO Technique[a]

	Odds Ratio (95% CI)	*P*
Age (IQR increase)	1.00 (0.70-1.45)	.986
Sex (female vs male)	1.32 (0.71-2.48)	.380
BMI (IQR increase)	1.02 (0.71-1.46)	.920
Laterality (bilateral vs unilateral)	1.55 (0.51-4.72)	.438
TTO technique (MZ vs AMZ)	0.46 (0.16-1.34)	.158
No. of screws (≥2 vs 1)	1.78 (0.55-5.77)	.340
Distalization (yes vs no)	0.90 (0.52-1.58)	.722

[a]AMZ, anteromedialization; BMI, body mass index; IQR, interquartile range; MZ, medialization; TTO, tibial tubercle osteotomy.

related to hardware may be caused by the size and number of screws and the fixation method. Johnson et al[8] reported that patients were 10 times more likely to have symptomatic screws if the osteotomy site was fixed with 4.5-mm screws than 3.5-mm screws. In our study, although data regarding the screw diameter were collected, only the number of screws was included in the multivariable analysis, which found that ≥2 screws increased both the overall readmission rate and not the readmission rate for pain. All patients admitted for pain had ≥2 screws, and the TTO technique was AMZ in all those patients. No patient required screw removal in the first 90-day period.

Distalization of the tibial tubercle was proposed to be a major cause of complications. Johnson et al[8] reported a 42% complication rate after TTO with tibial tubercle distalization and an 18% complication rate after isolated TTO in a univariate analysis. In our study, the tibial tubercle was distalized in 37.1% of knees, which allowed distalization to be included in the multivariable analysis. However, statistical analysis did not reveal tibial tubercle distalization as a risk factor for readmission. The overall incidence of tibial tubercle distalization in patients who were readmitted for any reason was 38.0% (27/71). With regard to readmission for postoperative pain, tibial tubercle distalization was performed in 38.5% (10/26) of knees.

The incidence of wound-related problems was 5.5% (19/345). Mayer et al[10] reported 1 superficial wound

infection and 1 deep infection that required surgical debridement in a series of 25 patients, and Karataglis et al[9] reported 2 cases with a superficial wound infection in a series of 57 patients. In our cohort, 1 case each had bleeding from the incision, delayed wound healing, and eschar formation; 7 cases for cellulitis requiring antibiotic use; 6 cases for wound dehiscence requiring resuturing some portion of the incision; and 3 cases for a wound infection requiring wound debridement. All but 2 wound-related problems occurred after AMZ of the tibial tubercle.

Unlike the high early readmission rate, the incidence of major complications was low at 2.0%. Tanaka et al[17] reported the incidence of DVT as 3.8% after TTO in their case series. Similarly, Johnson et al[8] reported the incidence of DVT as 3.0% in the first 90 days after TTO. In our cohort, there was only 1 case (0.3%) of DVT and 2 cases (0.6%) had PE. Earlier studies noted that patients >20 years of age had a significantly higher risk compared with younger patients for DVT.[6,17] In our study, the mean age of our patients was 20.0 years, consistent with the existing data. Only 1 case (0.3%) with a BMI of 36.7 kg/m^2 had a tibial tubercle fracture after a fall. This is less than the 1% rate reported by Payne et al[12] in a systematic review on 787 patients.

Unique to our study, epidural catheter–related complications were reported. A total of 167 cases were sent home with an epidural catheter for 2 weeks for postoperative pain control. It contributed to 3.5% of all readmissions. Specifically, in cases with an epidural catheter, the complication rate was 9.6% (16/167). An epidural catheter was used by 1 surgeon only, and all complications were temporary and were resolved uneventfully. The efficacy of using a postoperative epidural catheter for pain control is controversial. As some readmissions were related to epidural catheter problems, this type of management may be less desirable. Also, it was utilized in the first years of the study period and was replaced by regional blocks during the majority of this period. The same trend was followed across the country.

Limitations

There are several limitations to this study. A multivariable analysis relies on the number of adverse events, and therefore, more adverse events would allow us to include more variables in the analysis. The number of knees for each variable is also important. In this study, only 6 knees underwent trochleoplasty, and 8 knees underwent partial meniscectomy. Therefore, these cases could not be included as variables in the multivariable analysis. Concomitant soft tissue procedures were decided based on patients' intraoperative findings, and thus, there were different combinations that did not allow us to add each as a variable. As a result, all soft tissue procedures were included as a single variable. Similarly, the screw size was not added because the inclusion of 1 screw fixation procedure would double screw size groups.

CONCLUSION

The incidence of major complications after TTO was very low (2.0%), but 20.6% of cases required readmission primarily for an indwelling epidural catheter (3.5%) and postoperative pain (7.5%). Concomitant soft tissue procedures and the number of screws were associated with readmission after TTO. In addition, female sex and smoking were associated with readmission for pain. Utilizing individualized postoperative pain management and preoperative discussions about expected pain might help to avoid readmission for pain after TTO. Additionally, this study may lead to the exploration of alternative approaches for postoperative multimodal pain control.

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APPENDIX

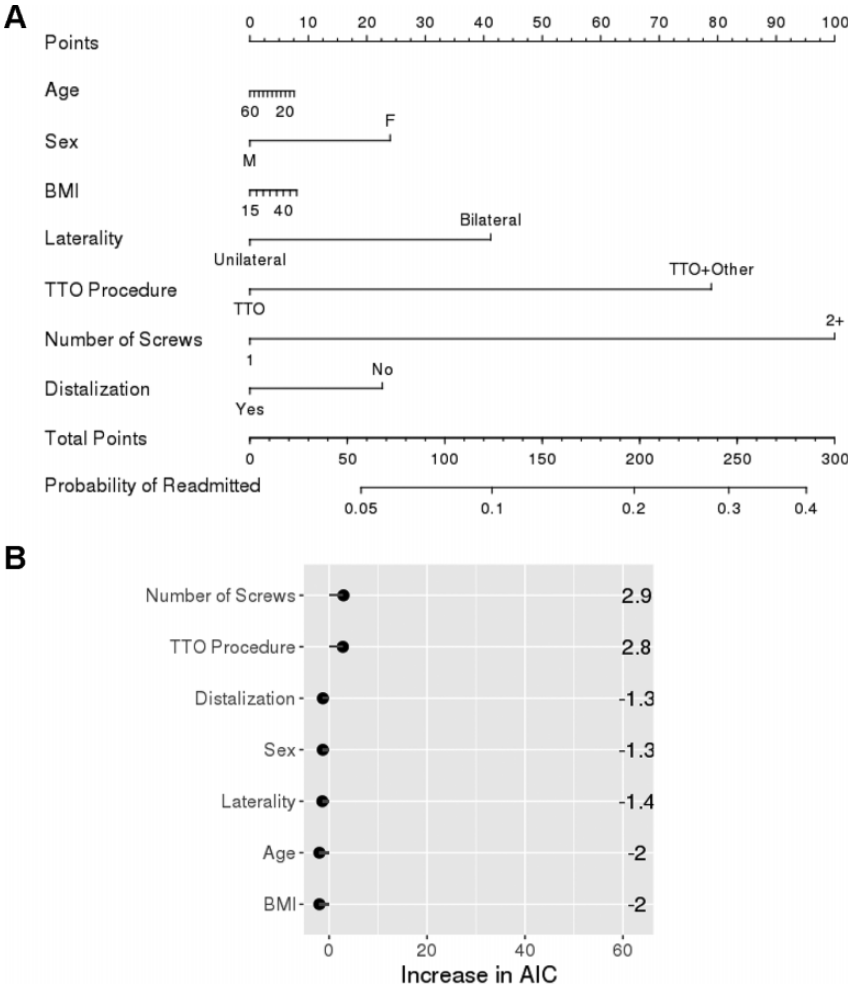

Figure A1. (A) A nomogram for the readmission model. We can calculate the predicted probability of readmission given a specific patient profile. The idea is to map the patient's profile to the point system (pick the number of points associated with each predictor value, add all the points up, locate the sum on the total points axis, and then trace down to the predicted probabilities axis). (B) A variable importance plot using the Akaike information criterion (AIC). Overall, the number of screws and tibial tubercle osteotomy (TTO) procedure ranked the highest according to the relative contribution to the model (increase in AIC). BMI, body mass index; F, female; M, male.