

Knee Osteotomies Can Be Performed Safely In An Ambulatory Setting



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Purpose: The purpose of this study was to assess the rate of hospital admissions, inpatient conversions, reoperations, and complications associated with tibial tubercle osteotomies (TTO), high tibial osteotomies (HTO), and distal femoral osteotomies (DFO) performed at our ambulatory surgery center compared with our inpatient hospital facility. **Methods:** A retrospective review of patients receiving a TTO, HTO or DFO at our institution between June 2011 and October 2019 was performed. Inclusion criteria consisted of patients undergoing the aforementioned procedures for malalignment, and a minimum of 90-days follow-up. Revision osteotomies, those undergoing an osteotomy for an acute fracture, and those with rule-out criteria for outpatient surgery (ASA > 3, and body mass index >40) were excluded. Complications, including readmission and reoperation, were compared between the two groups using either the Fisher's exact test and independent samples *t*-test, where applicable, and a *P* value of <0.05 was considered to be statistically significant. **Results:** The study included 531 patients undergoing osteotomies (222 ambulatory surgical center [ASC] and 309 hospital) with no patients lost to follow-up in the 90-day postoperative period. No patients operated on at an ASC required transfer to inpatient setting. There were no differences in complication rates, readmission, or reoperation rates among the two groups (4.1% vs 4.9%; *P* = .8328; 3.1% vs 4.5%, *P* = .5026; 3.1% vs 4.5%; *P* = .5026; respectively). Complications, including surgical site infection and arthrofibrosis were not significantly different in the two cohorts, (1.4% vs. 2.6%, *P* = .341 and 1.4% vs 1%; *P* = .698, respectively). **Conclusions:** Osteotomies about the knee performed in an ambulatory setting were safe, with no difference in readmission, reoperation, or postoperative complications compared to those performed at an inpatient hospital. Additionally, no patient required conversion from an outpatient to an inpatient setting. **Level of Evidence:** Level III, retrospective comparative study.

Introduction

Osteotomies about the knee are used to correct malalignment in active patients. Tibial tubercle osteotomies (TTO) are commonly performed to offload patellofemoral chondral lesions or correct an elevated tibial tubercle-trochlear groove measurement in

patients with patellar instability.¹⁻³ High tibial osteotomies (HTO) are usually used to treat varus deformity about the knee, and genu valgum is frequently treated with a distal femur osteotomy (DFO).⁴⁻⁷ The literature has shown good results for TTO, HTO, and DFO procedures to correct malalignment and restore patient function.^{2,4,6} However, there is concern over the potential of neurovascular complications, pain control, and potential compartment syndrome in the immediate postoperative setting, and thus these patients are often admitted overnight for observation.⁸

In the current American health care environment, there has been an increasing demand for safe, high-quality care with an emphasis on value.⁹ This has led to an increased interest in the feasibility and safety of performing procedures in an outpatient setting. There are multiple studies in the literature demonstrating the feasibility and safety of outpatient total knee arthroplasty, unicompartmental knee arthroplasty, total hip arthroplasty, and shoulder arthroplasty.¹⁰⁻¹⁴ Given the

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emphasis on value and improvements with pain control, our institution has routinely been performing osteotomies in an outpatient setting at an ambulatory surgical center.

There is a paucity of data surrounding the safety of performing osteotomies about the knee in an ambulatory surgical center setting with regard to whether this leads to an increase in short-term complications such as neurovascular compromise or whether patients require readmission or transfer to an inpatient facility for pain control. The purpose of this study was to assess the rate of hospital admissions, inpatient conversions, reoperations, and complications associated with tibial tubercle osteotomies (TTO), high tibial osteotomies (HTO), and distal femoral osteotomies (DFO) performed at our ambulatory surgery center compared with our inpatient hospital facility. Our hypothesis is that there will be no differences in readmission, reoperation, and postoperative complications between the two cohorts. Additionally, we hypothesize that the number of transfers to an inpatient setting from an outpatient surgical facility will be negligible.

Methods

Patients

In this Institutional Review Board-approved, retrospective comparative study, all patients from June 2011 to October 2019 treated with a knee osteotomy either at our ambulatory surgical center or inpatient hospital were identified and chart reviewed for eligibility. Inclusion criteria consisted of patients undergoing a TTO, HTO, or DFO for malalignment, and a minimum of 90-days follow-up. Revision osteotomies, those undergoing an osteotomy for an acute fracture, and those with rule-out criteria for outpatient surgery (ASA > 3, and body mass index [BMI] >40) were excluded. Those patients undergoing concomitant procedures, such as ligamentous stabilization, meniscus transplant, or cartilage restoration procedures were included. In our infancy of performing these complex peri-articular procedures, we tended to perform these surgeries at the inpatient setting due to concerns over possible complications. With time, we recognized this as unnecessary and transitioned these procedures to an ambulatory surgical center or inpatient setting secondary to surgical block time of the operating surgeon.

Surgical Technique

General indications for surgery included the following: for TTO, recurrent patellar instability, patellofemoral chondral lesions, and/or arthritis non-amenable to conservative management, and concomitant radiographic measurements (e.g., tibial tubercle to trochlear groove length); for HTO, primary or secondary medial compartment arthritis; and for

DFO, primary or secondary lateral compartment arthritis. Additionally, HTOs and DFOs were performed for meniscal insufficiency, revision anterior cruciate ligament (ACL) reconstruction, or chondral defects undergoing restoration in the setting of malalignment. However, the ultimate decision to perform osteotomies about the knee were performed at the discretion of the attending surgeon. The vast majority of cases used a combination of general and regional anesthesia, while a smaller percentage used either general anesthesia alone or a combination of spinal and regional anesthesia. In general, the majority of TTOs and HTOs got an adductor canal block in addition to general anesthesia. In the extremely rare setting, patients received spinal anesthesia, and almost all DFOs were performed under general anesthesia alone. The surgical approaches were not standardized for this study. TTOs were done either freehand or with a jig centered about the tibial tubercle. HTOs and DFOs were performed via an opening wedge approach. The appropriate correction of the TTO, HTO, and DFO was done at the discretion of the attending surgeon. Drains were sparsely used by one of our surgeons (MJA) earlier during the study when he was in the first two years of practice, and then the surgeon switched to without drains. No other surgeons in the cohort used drains. There was no difference in implant/equipment availability, postoperative rehabilitation protocols, or cohort of surgeons between facilities. Furthermore, there was no difference in magnitude of selection for determining where the procedure was performed. Postoperative pain management for patients regardless of location or type of surgery included 10 to 20 oxycodone-acetaminophen (5-325 mg) tablets depending upon surgeon preference. Patients who stayed overnight were managed with acetaminophen and oxycodone (administered separately due to hospital formulation).

Data Collection

Data on patient characteristics and preoperative demographics was collected, including age, gender, laterality, body mass index, and ASA grade. Intraoperative and postoperative complications, including arthrofibrosis, hardware complications, neurovascular complications, and wound complications were also assessed. Additionally, it was recorded whether a patient required conversion to an inpatient admission, readmission for complications, or a subsequent procedure within 90 days.

Statistical Analysis

Statistical analysis was performed using SPSS (IBM Corp. Released 2013. IBM SPSS Statistics for Macintosh, version 22.0. Armonk, NY: IBM Corp.). Descriptive statistics were calculated for all continuous and categorical variables. Continuous variables were

Table 1. Patient Demographics

	ASC	Hospital	<i>P</i> Value
<i>N</i>	222	309	
Age	32.9 ± 11.2	32.1 ± 12.1	.4387
Gender M/F	100/122	129/180	.4492
BMI	26.3 ± 5.2	27.1 ± 5.2	.0809
ASA grades 1/2/3	116/103/3	138/167/4	.218
DFO/HTO/TTO	16/48/158	34/79/196	.1368
GA/Regional/Both	5.6%/1.1%/93.3%	5.1%/8.4%/86.5%	.0037

ASA, American Society of Anesthesiologist Physical Status; ASC, ambulatory surgical center; BMI, body mass index; DFO, distal femoral osteotomy; GA; general anesthesia; HTO, high tibial osteotomy; M/F, male/female; *N*, number; TTO; tibial tubercle osteotomy.

reported as weighted mean and estimated standard deviation, whereas categorical variables were reported as frequencies with percentages. Fisher's exact or chi-squared test was used to analyze categorical variables. The independent or paired *t*-test for normally distributed variables, or the nonparametric Mann-Whitney *U*-test or Wilcoxon signed-rank test was performed to compare continuous variables. A value of $P < .05$ was considered statistically significant.

Results

Patient Demographics

A total of 531 osteotomies were performed during the study period, with 222 patients receiving surgery at an ambulatory surgical center (ASC) and 309 patients receiving surgery at an inpatient hospital. No patients were lost to follow-up within the 90-day postoperative period. There were no significant differences in patient demographics regarding age, gender, BMI, or ASA ($P > .05$). Additionally, there was no significant difference in the rate of DFOs, HTOs, or TTOs being performed in the ASC or hospital facility (7.2%/21.6%/71.2% vs 11%/25.6%/63.4%; $P = .1368$). There was also no significant difference in the type of anesthesia used between operative settings ($P = .0037$). The patient demographics are reported in Table 1.

90-Day Complications

No patients who had surgery at the ASC required an immediate inpatient conversion. Of those done in the hospital, 128 were discharged on the day of surgery (41.4%), and the average length of stay was 1.91 days.

The readmission and reoperation rates between the two cohorts were not statistically significant (ASC: 4.1% vs hospital: 4.9%, $P = .5026$). Additionally, there were no significant differences in complication rates between those who had surgery in the ASC or hospital ($P = .8328$). The most common complication requiring readmission was wound infection. The incidence of wound infection was not significantly different among the two groups (ASC: 1.4% vs Hospital: 2.5%;

$P = .3735$). Furthermore 1 patient in the ASC group and 3 patients in the hospital group required manipulation under anesthesia for arthrofibrosis (ASC: 1.4% vs Hospital: 1%; $P = .698$). One patient in the hospital group had a postoperative deep venous thrombosis (DVT) requiring readmission and thrombectomy. Only 1 patient in the hospital group had an intraoperative complication with compartment swelling requiring prophylactic fasciotomies, and that patient was discharged on postoperative day 3. The 90-day complications between the cohorts are compared in Table 2, and the individual complications are illustrated in Table 3.

Discussion

The most important finding in our study was that osteotomies about the knee performed in an ambulatory surgical center were safe, with no difference in readmission, reoperation, and postoperative complications compared to those performed at an inpatient hospital. Overall, there was a low rate of complications, with no patients whose surgery was performed at the ambulatory center having an acute neurovascular complication, such as compartment syndrome, that required a return to the operating room or conversion to an inpatient stay. No patients having surgery at the ambulatory center required an overnight admission for pain control. However, surgeons still need to be vigilant about individual risk factors that may predispose patients to the need for hospitalization after these procedures.

In recent years, there has been a push for improved quality care in all of medicine.⁹ This is a challenge as we attempt to increase value of health care while decreasing costs. Many strategies focusing on improving these two aspects of patient treatment have been implemented across the country, and one of the most successful methods of increasing value has been the transition of procedures traditionally requiring an inpatient stay to the outpatient setting. Most notably in orthopaedic surgery, this transition has been adapted by arthroplasty surgeons.¹⁰⁻¹⁴ Multiple studies have demonstrated that outpatient arthroplasty can be done safely and efficiently in the outpatient setting.¹⁰⁻¹⁴

Table 2. 90-Day Complications

	ASC	Hospital	<i>P</i> Value
Complications within 90 Days	9 (4.1%)	15 (4.9%)	.8328
Readmission within 90 Days	7 (3.1%)	14 (4.5%)	.5026
Reoperations within 90 Days	7 (3.1%)	14 (4.5%)	.5026
Arthrofibrosis	3 (1.4%)	3 (1%)	.698
Compartment Syndrome	0 (0%)	1 (0.3%)	>.99
Deep venous thrombosis	0 (0%)	1 (0.3%)	>.99
Granuloma	0 (0%)	1 (0.3%)	>.99
Infection	3 (1.4%)	8 (2.6%)	.3735
Painful Hardware	2 (0.9%)	1 (0.3%)	.5742
Pulmonary Embolus	1 (0.5%)	0 (0%)	.4181

Table 3. Individual 90-Day Complications

Age	Gender	ASA	Procedure	Complication	Readmission	Intervention
Ambulatory Surgical Center						
38	Female	1	HTO	PE	No	Anti-coagulant
19	Female	1	TTO	Painful hardware	Yes	Removal of hardware
22	Female	2	TTO	Arthrofibrosis	Yes	Manipulation under anesthesia
29	Male	2	TTO	Painful hardware	Yes	Removal of hardware
16	Male	1	TTO	Infection	Yes	Irrigation and debridement
28	Male	1	TTO	Infection	Yes	Irrigation and debridement
17	Female	1	TTO	Arthrofibrosis	Yes	Manipulation under anesthesia
29	Male	1	HTO	Arthrofibrosis	Yes	Manipulation under anesthesia
38	Female	2	TTO	Superficial infection	No	Antibiotics
Hospital						
37	Male	2	HTO	Intraoperative compartment syndrome	No	Prophylactic fasciotomy
42	Female	1	TTO	Infection	Yes	Irrigation and debridement
21	Female	1	TTO	Arthrofibrosis	Yes	Manipulation under anesthesia
18	Female	2	TTO	Infection	Yes	Irrigation and debridement
48	Female	2	DFO	Infection	Yes	Irrigation and debridement
44	Female	1	TTO	Infection	Yes	Irrigation and debridement
30	Female	1	TTO	Infection	Yes	Irrigation and debridement
21	Male	1	HTO	Infection	Yes	Irrigation and debridement
19	Female	1	TTO	Infection	Yes	Irrigation and debridement
41	Female	1	HTO	Infection	Yes	Irrigation and debridement
36	Female	1	TTO	Painful hardware	Yes	Removal of hardware
46	Female	1	DFO	Granuloma	Yes	Granuloma excision
17	Male	2	TTO	DVT	Yes	Thrombectomy
28	Female	1	TTO	Arthrofibrosis	Yes	Manipulation under anesthesia
27	Male	1	TTO	Arthrofibrosis	Yes	Manipulation under anesthesia

ASC, ambulatory surgical center; ASA, American Society of Anesthesiologist Physical Status; DFO, distal femoral osteotomy; DVT, deep venous thrombosis, HTO, high tibial osteotomy; TTO, tibial tubercle osteotomy.

Osteotomies around the knee have, and continue to be, procedures that surgeons advocate for an inpatient stay due to fears of neurovascular compromise, compartment syndrome, and poor post-operative pain control.⁸ However, the results from our study demonstrate that osteotomies about the knee can safely be performed in an outpatient setting at an ambulatory surgical center with no patient requiring a conversion to an inpatient stay due to lack of pain control. It is worth noting that typically in our institution that patients are discharged with acetaminophen-oxycodone and NSAIDs.

In our study, the most common complication requiring a return to the operating room was infection or wound complications that required irrigation and debridement. A recent, systematic review of 19 studies looking at TTOs showed an overall complication rate of 0% to 11%, with a 3% major complication rate.¹⁵ Early complication rates, including fracture, infection, and DVT, were all reported to occur in less than 1%.¹⁵ In those undergoing HTO, there is a concern of potential neurovascular injury and compartment syndrome, which may cause surgeons to be hesitant about performing these in an ambulatory setting.⁸ Song performed a comparative study of those undergoing closing-wedge and opening-wedge HTO in 194 patients undergoing HTO.¹⁶ They found that neurovascular injuries and compartment syndrome occurred in those with a lateral closing wedge osteotomy, which

has been shown to increase the risk of acute neurovascular injury due to the lateral side approach. In our series, we performed a medial opening wedge approach, which may explain our lower complication rate. DFOs have a similar complication profile, and Wylie et al. performed a systematic review of 16 studies and reported an overall complication rate of 9.1%, with the incidence of early complications, such as fracture, DVT/PE, and infection, reported to be 1.6%, 0.5% and 1%, respectively.⁷

Our study found no differences in complication rates between those performed at an ambulatory surgical center and an inpatient hospital. Only one patient who underwent a combined HTO and ACL reconstruction had a neurovascular complication in the form of a potential compartment syndrome. This was identified at the time of surgery after the ACL graft was passed, and the patient underwent a prophylactic four-compartment fasciotomy before exiting the operating room for fear of an impending compartment syndrome; subsequently, this patient had an uncomplicated stay. However, no patient had a clinical compartment syndrome post-operatively. No patient that had surgery at an ambulatory surgical center had to be transferred to the hospital for conversion to inpatient stay, whereas 7% in the hospital group required inpatient stays of 3 days or greater. However, the majority of these cases were performed very early in the study period, during which our

surgeons would routinely admit patients overnight for pain control. This underscores the importance of these data; as our surgeons realized that patients could be safely discharged on postoperative day 0, they began converting these procedures to the outpatient surgery center. The potential cost difference is an important consideration as well, especially in light of our ever increasingly cost-conscious health care system. Ferrari et al. performed a cost-effectiveness analysis of inpatient versus outpatient ACL reconstruction and found that the mean cost savings varied from \$1,371 to \$7,390 per procedure for outpatient ACLs.¹⁷ Additionally, these data can have important medicolegal implications, as our data show similar complication rates regardless of where the procedure was performed.

Overall advancements in anesthesia and local pain control have added to the ability to discharge patient on the day of surgery. In our institution, an increasing utilization of local blocks combined with sedation has improved the immediate postoperative recovery. Additionally, institutionalized implementation of multimodal pain control, including nonopioid and opioid medications has led to decreased postoperative pain.^{18,19} As corrective osteotomies are typically done in a younger, more active, and healthier patient population, these patients tend to have an increased physiological reserve, allowing for a more rapid recovery from surgery. Thus, our study has shown that these may be successfully performed as an outpatient procedure at an outpatient facility without significant concern for readmission for pain or increased complication rates. One must remember, however, that these data are not attempting to show superiority of one location over another; that is not truly possible with the retrospective nature of this study. However, the results of this study do show, in our opinion, the excellent safety profile of osteotomies performed in an outpatient setting.

Limitations

One of the limitations to this study is that it is retrospective in nature, and the patients were not randomized to where they were to have their procedure and introduces the potential for selection bias. However, the relative lack of differences between the two cohorts potentially mitigates this limitation. Early in the study period, cases were more frequently performed at the inpatient facility for planned overnight stays secondary to lack of surgeon familiarity with typical post-operative pain in these patients. Hospital stays can then increase in time, for example, if the patient fails a physical therapy evaluation and requires further inpatient training. Additionally, this study includes multiple surgeons who use different techniques and have varied levels of experience with these procedures, leading to the possibility that more experienced surgeons may

have better outcomes and fewer complications. However, the fact that there were no major neurovascular complications or issues requiring conversion to inpatient regardless of level of experience corroborates the conclusion that these procedures can be safely performed in an outpatient setting. Additionally, our group has the benefit of practicing at a tertiary medical center, where intraoperative complications can be readily identified and treated regardless of the location of the procedure. Also, as there were multiple concomitant procedures performed with each technique, we feel this makes it truly representative of a real-world cohort. Finally, a post hoc power analysis was performed based on the results, with a power of 80%, and an alpha of .05, 9,602 patients, would be needed to determine a statistically significant difference in complications, which is not feasible, as these procedures are not common. Thus, our results are at risk of a type II error.

Conclusion

Osteotomies about the knee performed in an ambulatory setting were safe, with no difference in readmission, reoperation, and postoperative complications compared to those performed at an inpatient hospital. Additionally, no patient required conversion from an outpatient to an inpatient setting.

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