



## Routine postoperative radiographs after tibia plateau fixation have minimal impact on patient care

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### ABSTRACT

**Introduction:** Common practice in orthopedic surgery is to obtain postoperative radiographs to evaluate for healing or complications. Images obtained in the post-anesthesia care unit (PACU) have not been shown to positively impact patient care. This study plans to evaluate the clinical utility and cost-effectiveness of PACU postoperative radiographs following tibial plateau open reduction and internal fixation (ORIF).

**Methods:** Data from 211 patients who underwent a tibial plateau ORIF over a 5-year period at a single institution were retrospectively reviewed to determine if a patient received a postoperative radiograph in the PACU. Radiograph and clinical notes were reviewed to determine if postoperative radiograph resulted in management changes. Radiograph charges were calculated using CPT codes.

**Results:** A total of 142 of 211 patients (67.3%) who underwent tibial plateau ORIF received a postoperative radiograph while in the PACU. The majority of the radiographs had normal findings (88.7%). Of the 142 patients with postoperative imaging, subsequent management changes occurred for only one patient (0.7%). In this case, an incidental foot fracture was found which resulted in further CT imaging to assess the fracture. Other abnormal radiograph readings (11.3%) were generally due to incidental, chronic findings that did not require management changes. The average postoperative radiograph cost was \$433.55 per patient, totaling \$91,480 for 142 patients over a 5-year period.

**Conclusions:** Routine postoperative radiographs following tibial plateau ORIF resulted in minimal management change patients in this series. The substantial cost of postoperative radiographs yielding little clinical utility suggests the use of routine PACU imaging following tibial plateau ORIF should be discontinued. Imaging would only be indicated in situations where intraoperative complications are suspected, thus reducing unnecessary imaging and patient cost.

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### Introduction

Tibia plateau fractures constitute approximately 1% of all fractures, with an annual incidence of 10.3 per 100,000 [1,2]. These fractures tend to occur more commonly with high energy mechanisms such as motor vehicle collision before the 6th decade, while low energy impacts causing tibial plateau fractures are more common after the 6th decade. These fractures are commonly treated with open reduction and internal fixation, especially for displaced or unstable fractures [3]. Implants commonly used for tibia plateau internal fixation includes 3.5 mm and 4.5 mm proximal tibia locking compression plates (LCP), 3.5 mm medial proximal tibia LCP, tibial nails, and screw fixation without use of a plate.

Fluoroscopic and radiographic studies are highly utilized in the medical field, with roughly 293 million of these images being obtained in 2006 [4]. Within orthopedic surgery, intraoperative fluoroscopy is typically required during ORIF procedures to accomplish appropriate fracture alignment and implant placement. Subsequent postoperative radiographs are routinely obtained - both in the post-anesthesia care unit (PACU) and during outpatient follow-up. These images are acquired to assess for any surgical complications (including implant failure, fracture malalignment, or delayed bone healing) that may require subsequent management changes. These management changes may include further imaging, changes in weight-bearing status, and need for re-operation, among others.

Despite this common practice, there is little evidence to suggest that postoperative radiographs impact patient management. Several studies investigating the clinical utility of postoperative radiographs following lower extremity fracture fixation - including hip, femur, tibia, and ankle fractures - found that these images

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did not alter patient management [5–8]. Similar findings were also reported following lower extremity implant removal, total shoulder arthroplasty, and primary anterior cruciate ligament (ACL) reconstruction [8–10]. Furthermore, routine radiographs increase the patient's radiation exposure and cost of health care unnecessarily, as demonstrated in prior studies [5,7–11]. Without clear clinical utility, these images are not cost effective.

While the routine practice of postoperative radiographs in many orthopedic surgical procedures is coming under question, the role for postoperative radiographs following tibia plateau ORIF remains to be investigated. This study aims to determine if postoperative radiographs obtained in the PACU following tibial plateau ORIF has an impact on patient management. Approval for this study was granted by the Institutional Review Board (IRB).

## Patients and methods

A retrospective chart review was performed of all patients who underwent a tibial ORIF at a single level one trauma academic medical center from 2012–2016. Inclusion criteria included (1) having had a tibial plateau fracture and (2) received an ORIF to address this fracture. There were no exclusion criteria. A total of 211 patients were identified. In all patients, operative notes were reviewed to determine Schatzker fracture classification, laterality, implant type, use of bone grafting, intraoperative complications, and occurrence of and reason for re-surgery. Demographics, including age and comorbidities, were also included and are presented in Table 1.

All patient charts were reviewed to note the presence or absence of postoperative PACU imaging. In this clinical practice, postoperative imaging is ordered at the discretion of the attending physician and is obtained in the PACU. All films were reviewed by a radiologist within 24 h. Radiologists were also available on-site if there were immediate questions. Of those patients who received postoperative imaging, the radiographic notes were reviewed to assess the radiologist interpretations, the number of images, and the number of views. Clinical notes were reviewed to assess whether the radiographic findings altered management. Radiographic findings prompting management changes included, but were not limited to, mal-alignment, implant failure, and newly found fractures. Management changes include, but were not limited to, changes in weight-bearing status, re-operation due to malalignment or implant failure, and additional imaging.

Radiographic cost at this institution was determined using the Current Procedural Terminology (CPT) code for each type of radiograph obtained. Radiographic cost included the total cost, hospital charge, and radiologist charge.

To assess the long-term quality of the fracture fixation, patients were followed for at least six months postoperatively. The clinic notes and radiographs from a patient's last follow-up appointment were reviewed to determine if any implant loosening or failure had occurred.

Primary outcome included changes in management due to abnormal postoperative radiographs. Secondary outcome included total hospital charges for radiographs.

## Results

A total of 211 patients underwent tibial plateau ORIF from 2012–2016. Males represented 55.0% of the patient population and females 45.0%. The age range was 15–91 years old. Additional demographics can be found in Table 1. The implants used were categorized by laterality and type (Table 1). In general, 3.5 mm and 4.5 mm plates were used as the primary means of fixation for all Schatzker fracture classification types. Screw fixation without the use of a plate was typically only performed for Schatzker type I or

**Table 1**  
Cohort characteristics.

	n (%)
Patient demographics	
Patients	211
Age (mean ± SD)	48.3 ± 16.2
Gender (Male)	116 (55.0)
BMI (mean ± SD)	29.8 ± 7.3
Comorbidities	
Alcohol use	84 (42.2)
Chronic kidney disease	7 (3.3)
Chronic pain	28 (13.3)
Congestive heart failure	11 (5.2)
COPD	8 (3.8)
Coronary artery disease	12 (5.7)
Current smoker	72 (34.6)
Depression	27 (12.8)
Diabetes mellitus	30 (14.2)
Hypercoagulability	1 (0.5)
Hyperlipidemia	31 (14.7)
Hypertension	57 (27.0)
Parkinson disease	1 (0.5)
Peripheral vascular disease	3 (1.4)
Laterality of tibia plateau ORIF	
Right only	98 (46.4)
Left only	112 (53.1)
Both	1 (0.5)
Tibial plateau fracture classification	
Schatzker classification	
Type I	7 (3)
Type II	66 (31)
Type III	7 (3)
Type IV	20 (9)
Type V	80 (38)
Type VI	31 (15)
Posteromedial fracture fragment	3 (1)
Posterolateral fracture fragment	2 (1)
Operative details	
Type of implant for ORIF	
3.5 mm plate	143 (67.8)
4.5 mm plate	42 (19.9)
Medial proximal tibial plate	21 (10.0)
Tibial nail	0 (0)
Screw fixation without plate	4 (1.9)
Use of bone graft	
Yes	9 (4)
No	202 (96)
Intraoperative complications (of all tibia plateau ORIF's)	1 (0.5)
Patients requiring re-surgery in future (of all tibia plateau ORIF's)	46 (21.8)
Postoperative radiographs	
Number of radiographs ordered for a patient	
1	0
2	106 (74.6)
3	15 (10.6)
4	19 (13.4)
5	2 (1.4)
Radiographs read as normal	126 (88.7)
Radiograph reading documented by radiology	142 (100)
Total cost of radiographs	\$91,480.00
Average cost of radiographs per patient	\$433.55
Management change (if radiograph obtained)	1 (0.7)
Quality of implant fixation at final follow-up appointment	
Good fixation	152 (72)
Implant loosening or failure	11 (5)
No or inadequate follow-up (<6 months)	48 (23)

III fractures. Autologous or synthetic bone grafting was utilized whenever restoration of the articular congruency revealed an underlying bone defect. While bone graft was used in all fracture types, it was used more commonly for Schatzker type II fracture in this study. All patients had intraoperative fluoroscopic imaging to ensure adequate reduction and implant placement.

Of all 211 patients, 142 (67.3%) received postoperative radiographs while in the PACU. The majority of the radiographs had normal findings (88.7%). Other abnormal radiograph readings (11.3%) were due to incidental chronic findings that did not require management changes. Examples of chronic findings included degenerative changes of the knee, osteopenia, and chronic fibular deformities related to prior trauma. Abnormal findings unrelated to chronic processes included lipohemarthrosis, concurrent fibular fracture, and ghost tracks from prior fixation. Of the 142 patients with postoperative radiograph, only one patient (0.7%) received a subsequent management change. In this case, the patient had a tibia-fibula imaging series due to clinical concern for more extensive injuries after a high-energy trauma. Incidental distal fibular and calcaneal fractures were found. This resulted in further CT imaging to assess the fracture, without further changes in management.

Intraoperative complications and re-surgeries were uncommon but did occur. There was one case with intraoperative complications. The patient had acute oxygen desaturation intraoperatively and recovered without intervention. Postoperative Computed Tomography Pulmonary Angiography showed acute segmental and subsegmental pulmonary emboli. There were no other intraoperative complications. Re-operations occurred for 46 patients (21.8%), commonly due to infection, implant failure, or pain relating to the implant (Table 1).

Patients must have had at least a six-month follow-up appointment, as this was generally the final scheduled appointment for a patient being followed for a tibial plateau fracture at this institution. The quality of the fracture fixations can be seen in Table 1. The majority of patients (72%) had good fixation at the last follow-up appointment, without any evidence of hardware failure or loosening. A considerable amount of patients (23%) did not have adequate follow-up to assess the implant fixation quality. A representative intraoperative fluoroscopic image, post-operative

PACU radiograph, and a clinic radiograph at one-year follow-up is shown in Fig. 1.

The total cost for postoperative radiographs was \$91,480, which is an average of \$433.55 per patient.

## Discussion

Rising healthcare costs and increased public awareness of healthcare spending has prompted more investigation into cost-conscious patient management. In 2012, medical imaging within the United States accounted for 17% of the \$2.8 trillion annual health care spending [12,13]. In addition to cost, the increasing use of medical imaging exposes the patient and healthcare team to substantial doses of ionizing radiation. Therefore, healthcare quality standards should seek to minimize radiography without adversely affecting patient management, in order to lower healthcare cost and radiation exposure.

This study assessed the clinical utility of postoperative PACU radiographs on patient management following tibial plateau ORIF by a fellowship-trained orthopaedic trauma surgeon. The data presented here showed that postoperative radiographs provide minimal impact on subsequent patient management. Although the expertise and experience of the surgeons is likely related to the surgical outcome, most of these images showed normal postoperative changes. In only one circumstance did a postoperative radiograph change management in the form of additional imaging for a calcaneal and fibular fracture; however, additional injuries in this patient were suspected prior to this radiograph given the patient's clinical exam and mechanism of injury. Thus, the imaging of the distal tibia and foot would have been obtained independent of the postoperative radiograph.

The results from this study reinforce and advance previous studies investigating the use of postoperative radiographs

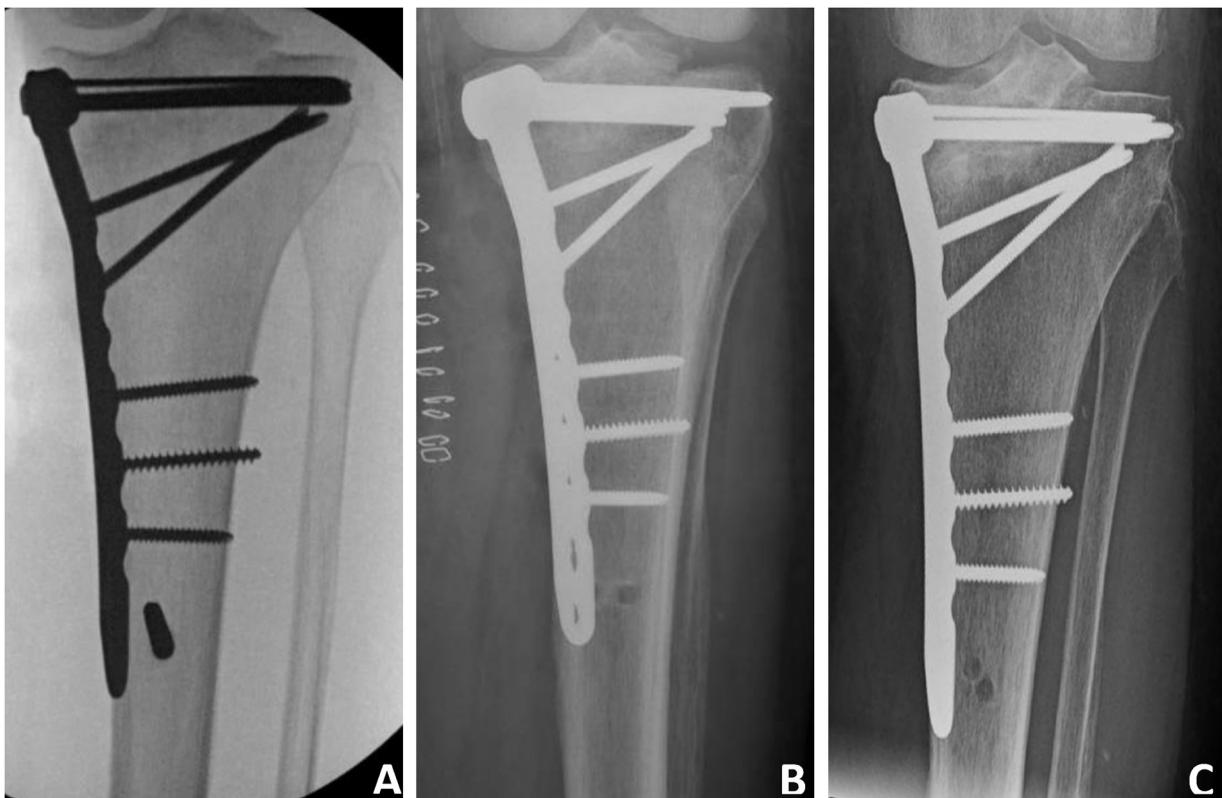


Fig. 1. Representative intraoperative fluoroscopic image (A), post-operative PACU radiograph (B), and one-year follow-up radiograph (C) from a single patient.

following routine orthopedic procedures. In the absence of clinically concerning patient symptoms or exam findings, few studies have demonstrated the utility in obtaining postoperative radiographs to alter patient management without a specific indication. Phelps et al. found that immediate imaging following lower extremity fracture fixation may be useful if intraoperative fluoroscopic images did not adequately show proper reduction and alignment or if the fixation was obscured on imaging, such as from overlying splints or casts [8]. Additionally, this study recommended outpatient radiographs at appropriate clinic visits, beginning with a patient's advancement to full weight bearing until fracture union. Unless a patient's history and physical was concerning, imaging at other times in the inpatient and outpatient recovery process was not helpful for patient management, and increased patient healthcare cost unnecessarily.

Cooney et al. found that postoperative radiographs following internal fixation for femoral neck fractures did not change patient management [5]. Additionally, Harish et al. compared intraoperative fluoroscopic images to postoperative flat plate radiographs following ankle fracture fixation [6]. In 25 of 30 patient charts reviewed in that study, there was no difference in the information provided between the fluoroscopic images and flat plate radiographs. Furthermore, postoperative radiographs did not alter patient management in any case. As such, the authors concluded that postoperative radiographs were unnecessary, as they did not provide any additional information compared to fluoroscopic images, and they did not affect patient management. These findings have been echoed in other orthopedic specialties where postoperative radiography did not provide a clinical benefit following total shoulder arthroplasty and primary ACL reconstruction [9,10].

Currently, radiographic imaging is an essential element within orthopedic surgery. Intraoperative fluoroscopic imaging is used in every fracture fixation procedure and is critical in order to guide surgical procedures, ensure correct reduction and alignment, and check implant placement. Postoperative radiographs - especially while the patient is in the PACU - are also considered routine practice, even following multiple intraoperative fluoroscopic images. One proposed reason for these additional flat plate radiographs is to better evaluate overall limb alignment. However, improvements in fluoroscopy, such as flat panel detectors and wider field of view, likely decreases the concern for unrecognized malalignment. This advancement in fluoroscopic technology minimizes clinical benefit for subsequent flat plate radiographs, especially while the patient is in PACU, and are sufficient imaging to ensure appropriate fixation. Therefore, flat plate radiographs may be more useful regarding patient management if intraoperative fluoroscopic images are not obtained. Additionally, postoperative radiographs may be more useful following the use of a particular type of implant used (e.g. screw fixation vs. plate fixation). In this study, there were no differences in complication rates or management changes depending on the type of implant used. Therefore, investigating this specific question is not possible in this study.

As stated earlier, cost and radiation exposure are concerns associated with the use of radiographs. This study found a total of \$91,480 was billed to 142 patients who received postoperative radiographs, equating to \$433.55 per patient. In light of minimal clinical benefit for postoperative radiographs, these imaging costs and associated radiation exposure are not justified. This point is supported by similar studies. Werner et al. demonstrated that postoperative radiographs following primary ACL reconstruction added an extra \$562 per patient, which they concluded was not acceptable given that the radiographs did not provide a clinical benefit [10]. Similarly, Dempsey et al. found that radiographs obtained during standard outpatient follow-up intervals (2 weeks, 6 weeks, 4 months, and 1 year) following TSA did not change patient management, but the additional imaging costs were over \$1700 per patient [9].

There are several limitations to this study. Similar to others investigating this subject, this study used a retrospective chart review strategy relying on accurate hospital notes to determine if and why management plans changed. While the population size was modest with 211 patients included in the study, management changes are more likely to occur if there is an intraoperative complication. In this study, there was only one intraoperative complication that was unrelated to the tibial plateau fixation. Due to a small population size with intraoperative complications, these results may be difficult to extrapolate to patients who have a complication. For this reason, we do not discourage surgeons from obtaining intraoperative and postoperative imaging to adequately evaluate cases where there is higher risk or specific concern for complication.

## Conclusion

Routine postoperative radiographs following tibial plateau ORIF resulted in minimal management change for our patients, as has been demonstrated in other orthopedic specialties. Postoperative radiographs resulted in significant costs while yielding little clinical utility. This suggests that routine PACU radiographs following tibial plateau ORIF should only be used in situations where the surgeon desires to document a lack of intraoperative complications, especially if intraoperative fluoroscopic images were not obtained. This approach will reduce unnecessary imaging and patient cost.

## Conflict of interest

The authors of this study do not have any conflicts of interest to report.

## References

- [1] Albuquerque RP, Hara R, Prado J, Schiavo L, Giordano V, et al. Epidemiological study on tibial plateau fractures at a level I trauma center. *Acta Ortop Bras* 2013;21:109–15.
- [2] Elsoe R, Larsen P, Nielsen NPH, Swenne J, Rasmussen S, Ostgaard SE. Population-based epidemiology of tibial plateau fractures. *Orthopedics* 2015;38:780–6.
- [3] Prat-Fabregat S, Camacho-Carrasco P. Treatment strategy for tibial plateau fractures: an update. *EFORT Open Rev* 2016;1:225–32.
- [4] National Council on Radiation Protection and Measurements. Ionizing radiation exposure of the population of the United States: 2006. NCRP report no. 160. Bethesda, MD: National Council on Radiation Protection and Measurements; 2009. <https://ncrponline.org/publications/reports/ncrp-report-160/>.
- [5] Cooney AD, Campbell AC. Do check X-rays influence the management of patients who have undergone hip fracture fixation using image intensifier guidance? *Injury Int J Care Injured* 2006;37:763–7.
- [6] Harish S, Vince AD, Patel AD. Routine radiography following ankle fracture fixation: a case for limiting its use. *Injury Int J Care Injured* 1999;30:699–701.
- [7] Haddad FS, Williams RL, Prendergast CM. The check X-ray: an unnecessary investigation after hip fixation? *Injury Int J Care Injured* 1996;27:351–2.
- [8] Phelps K, Coleman M, Seymour R, Bosse M. Utility of routine postoperative radiographs after fixation of lower extremity fractures. *J Am Acad Orthop Surg* 2018;26:799–808.
- [9] Dempsey IJ, Kew ME, Cancienne JM, Werner BC, Brockmeier SF. Utility of postoperative radiography in routine primary total shoulder arthroplasty. *J Shoulder Elbow Surg* 2017;26:e222–36.
- [10] Werner BC, Burrell MT, Kew ME, Dempsey IJ, Gwathmey FW, Miller MD, et al. Limited utility of routine early postoperative radiography after primary ACL reconstruction. *Knee* 2016;23:237–40.
- [11] Bajraliu M, Walley KC, Loesch E, Kwon JY. Postoperative x-rays after routine orthopedic hardware removal following lower extremity trauma: are they really necessary? *Orthop J Harv Med Sch* 2016;17:39–42.
- [12] Medicare Payment Advisory Commission. Report to the congress: medicare payment policy. <http://www.medpac.gov/docs/default-source/reports/march-2012-report-to-the-congress-medicare-payment-policy.pdf>.
- [13] Martin AB, Hartman M, Whittle L, Catlin A. The National Health Expenditure Accounts Team. National Health Spending in 2012: rate of health spending growth remained low for the fourth consecutive year. *Health Aff* 2014;33:67–77.