

ORIGINAL RESEARCH

# Evaluation of Intraoperative Ligamentous Injury During Total Knee Arthroplasty Involving Resident Training

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## ABSTRACT

**Introduction:** Although residency training and its relationship to patient safety has long been a topic of discussion in forums on graduate medical education, intraoperative errors by orthopaedic residents has not been well studied. Furthermore, an association between resident training level and intraoperative errors is unknown. The focus of this study was to evaluate and compare intraoperative ligament injuries that occurred during total knee arthroplasties (TKAs) performed by junior residents versus senior residents. A retrospective analysis was performed on a consecutive series of TKAs over a 4-year period.

**Methods:** A total of 32 residents were involved in the 346 cases identified, with 142 surgeries performed by a junior resident and 205 performed by a senior resident. An evaluation of the frequency of ligament damage with regards to when the rotation took place and the month within the specific rotation was also performed. Finally, the last factor analyzed was whether there was a correlation between a patient's body mass index (BMI) and ligament injury to be sure that this did not affect the results.

**Results:** There was no significant difference in the occurrence of ligament injury in cases which were performed by the junior residents in comparison with surgeries performed by the senior residents ( $p=0.58$ ). There was no relationship between ligament damage and the month of the rotation or when the rotation took place in the year.

**Discussion:** This analysis suggests that junior residents can play the same role as operative surgeons, with supervision, as the senior residents, without compromising patient safety.

**Keywords:** Knee injury; Knee examination; Knee arthroplasty.

## INTRODUCTION

There has been much interest concerning

residency training and how it relates to patient safety, clinical outcomes, and the increasing costs associated with teaching hospitals. Training residents requires a balance of patient safety while also providing educational opportunities for the doctors in training, and little research has been

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done to assess at which level orthopaedic residents should be involved in surgery. A study on resident participation in laparoscopic cholecystectomies demonstrated a longer operative time and a higher rate of operative complications in junior versus senior resident cases (1). A study of arthroscopic anterior cruciate ligament (ACL) reconstruction showed significantly longer surgical times, thus leading to higher cost for procedures performed by a teaching service (2). Furthermore, it was shown that teaching residents to perform total knee arthroplasty (TKA) resulted in increased operating room time and resource consumption when compared to a TKA performed on a private service (3). Although previous studies have shown an increased operative time (1-4), a comparison of total hip and knee arthroplasties performed on a teaching service versus a private practice service did not show a difference in any clinical outcome between the groups (4). Another study evaluated whether the training level of a resident was related to the rate of pediatric prescription errors in an academic emergency department and found that error rates were no higher for the lower-level residents. This study also found no difference in error rates between the beginning and end of the academic year (5).

In the present study, our goal was to measure patient safety in regards to junior vs senior resident involvement in the operating room. Ligament injuries were chosen as the measure of patient safety because they are directly related to the operative skill level of the surgeon, their avoidance is important, and they may be readily determined. Post-operative alignment was not used because all decisions regarding placement of cutting jigs were reviewed and possibly adjusted by the attending surgeon before bone cuts were made. Operative time was not used because

it was consistently less for both junior and senior residents than the upper limit of 2 hours of tourniquet time. Estimated blood loss could be considered as another measure of safety, but a tourniquet was used in all cases and intraoperative blood loss was minimal.

In addition, previous authors have noted a higher level of ligament injury in patients with increased body mass index (BMI) (6,7). Therefore, the patients' BMI was also recorded to determine if junior- or senior-level residents had a higher proportion of patients with a higher BMI.

Although one might expect the complication rate to be higher with junior residents, after training residents since 1996 the senior author felt that the incidence of complications was not higher for junior residents with appropriate supervision. We hypothesized that there would be no difference in intraoperative ligament injuries between TKA performed by junior or senior residents and no difference in ligament injuries between TKA performed in the months at the beginning or end of the rotation or in rotations at the beginning or the end of the postgraduate year.

## **MATERIALS & METHODS**

After institutional review board approval, the operative reports of all TKAs performed by a single surgeon in a teaching hospital between January 1, 2008 to December 31, 2012, were reviewed to determine the incidence of ligament injury occurring during the operation. Only cases in which the same attending surgeon was directly supervising were included in order to eliminate any variability in supervising attending physicians' styles or level of experience. Demographic and hospital data, including patient BMI,

were collected prospectively for all patients. Using the operative reports, the postgraduate level of the primary surgeon, the occurrence of ligament injury, and the date of the operation were recorded. Patients with preoperative ligament injuries were excluded from the study.

Postgraduate year (PGY) 1, 2, and 3 were defined as junior residents and PGY 4 and 5 were defined as senior residents. The rotation duration of the arthroplasty service is 3 months. All residents rotated as both a junior and as a senior on the arthroplasty service for a total of 6 months. In all surgeries, the resident was the primary surgeon with the attending surgeon directly supervising and assisting. Typically, the junior resident had seen the senior resident or attending surgeon perform several TKAs and understood the technique, surgical approach, and preparation. The senior residents had previous experience during their junior years of training as the primary surgeon in performing a TKA, but the total number of knee replacements that the junior residents had observed prior to the start of the arthroplasty rotation was variable and depended on their rotations in medical school. The experience level of the senior residents prior to beginning the arthroplasty rotation was generally 30-50 TKAs that they had performed as a junior resident.

The attending surgeon was present for the critical portion of the operation in all patients, from incision until subcutaneous closure. The posterior cruciate ligament was retained, if it appeared functional, in all patients. An attempt was made to protect the ligaments with retractors and to avoid avulsing ligaments. A ligament was classified as injured during the operation if there was no evidence of preoperative ligament damage and the ligament was torn, stretched, cut by

the saw, avulsed from its insertion, or in any way appeared compromised during surgery.

To compare the differences between age, gender, and BMI for the patients treated by junior and senior residents, an analysis of variance (ANOVA) with Bonferroni correction was used.

To determine if there was a difference between junior and senior residents performing the surgery with regards to intraoperative ligament injury a multinomial logistic regression model was applied. A Chi-square test was used to compare junior and senior residents and their relationship to the rate of PCL and MCL injuries since these were the two most common ligament injuries. All statistical analysis was performed using SPSS 20 and  $p < 0.05$  was considered a statistically significant difference.

The rate of ligament injury was not determined in cases without resident involvement. A previous study (4) noted a complication rate of 3% of TKAs performed by a private practice service, but the literature regarding the rate of ligament damage in TKAs performed without resident involvement is scarce.

## RESULTS

This study identified 346 consecutive TKA operations. There was no statistically significant difference in age ( $p=0.10$ ), gender ( $p=0.10$ ), or BMI ( $p=0.46$ ) for the group of patients treated by junior residents versus senior residents. The most common preoperative diagnosis was osteoarthritis. Among the patients, 289 were female, 57 were male, and the average age was 57. The average BMI was 35.4 and the average BMI for junior and senior residents was 32.7 and 32.0, respectively. 143 (41%) of the operations were performed by a junior resident and

203 (59%) were performed by a senior resident. With regard to the junior residents, 140 operations were performed by second-year residents and 3 operations were performed by third-year residents. As for the senior residents, 196 were in their fourth year of training and 7 were in their fifth year.

The overall incidence of ligament injury was 7.4% (26 of 346 surgeries). There was no significant difference ( $p=0.58$ ) in the occurrence of injury in cases performed by junior residents, 9 of 143 (6.3%), when compared to cases performed by senior residents, 17 of 203 (8.4%). However, there were more PCL injuries in TKAs performed by junior residents when compared to senior

residents ( $p=0.76$ ) and there were more MCL injuries in TKAs performed by senior residents than junior residents ( $p=0.05$ ). These were the two most common ligaments damaged by the junior and senior residents, respectively. There was also no difference in ligament damage with regards to the specific month within a rotation ( $p=0.69$ ) or when the rotation took place ( $p=0.65$ ) (Table 1). The overall rate of specific ligament damage can be seen in Table 2.

There was a significant difference ( $p=0.03$ ) in ligament injuries between all BMI categories greater than 30 when compared to patients with a BMI of less than 30. A patient with BMI of 30-40 was ten times more likely to be at risk for an injury, a BMI of 40-50 conferred eight times the risk, and a patients with a BMI of greater than 50 was nine times more likely to be at risk than someone with a BMI of less than 30.

**Table 1. Frequency of ligament damage in relation to specific month and rotation.**

	Frequency	P Value
Month		
1	9	0.887
2	12	0.354
3	5	0.930
Rotation		
1	5	0.373
2	9	0.210
3	6	0.953
4	6	0.646

**Table 2. Overall ligament damage.**

Ligament	Frequency	%	P Value
IT band & LCL	1	0.3	<0.01
MCL	10	2.9	0.02
Patellar	3	0.9	<0.01
PCL	10	2.9	0.71
Popliteus	2	0.6	<0.01
No tear or cut	319	92.2	0.44

## DISCUSSION

In this study, we found no difference in intraoperative ligament injuries between TKAs performed by junior or senior residents and no difference in ligament injuries between TKAs performed in the months at the beginning or end of the rotation or in rotations at the beginning or the end of the postgraduate year. This is in contrast to the findings of a previous study that looked at the complication rate of laparoscopic cholecystectomies and found a higher rate of operative complications for junior-level residents compared to senior-level residents (1). However, it is possible that this difference was due to the nature of the procedure being performed or the amount of supervision.

The PCL was lacerated in 2.9% of patients and it was more frequently done

by junior residents than senior residents. We are not sure why this is the case. A cruciate retractor was placed behind the tibia and may have partially protected the PCL, but currently we have resumed the practice of placing a ¼-inch osteotome into the tibia anterior to the PCL to reduce the rate of injury. This step may make removal of the resected tibial fragment more tedious, but better protects the PCL, particularly when an inexperienced surgeon is making the tibial cut.

The MCL was lacerated in 2.9% of patients and it was more frequently done by senior residents than junior residents. We are also not sure why this is the case. Careful retractor placement with adequate, but not excessive, force is required to protect the MCL, and it is possible that the senior author was more involved in the retractor placement for junior residents than for senior residents.

One weakness of the study is that the degree of difficulty was not differentiated and it is probable that the senior-level residents chose the more difficult cases, although the BMI of the patients between the two resident groups was similar. Comparison of the preoperative radiographs may have helped to differentiate the degree of difficulty. Another weakness is that all ligament injuries were recorded as an injury regardless of whether the injury was clearly iatrogenic or were the result of a previously degenerated structure, which may have caused us to overestimate the actual iatrogenic injury rate. Also, the authors did not control for the amount of involvement or direction that was given by the supervising attending physician and it very well may have been more intense for the junior residents. In addition, the present study was performed by a single surgeon at a single institution and may not be generalizable to other surgeons or other institutions. Lastly, a power calculation was

not performed prior to our study, thus limiting the applicability of the results.

The BMI was similar for cases performed by junior and senior residents, which is important because other authors have noted an increased incidence of ligament injury in obese patients (6,7). This finding is possibly due to the fact that obese patients may have more preoperative ligament damage and visibility may be compromised leading to greater force applied to the retractors.

This study shows that junior residents are able to perform the average TKA without a higher incidence of ligament damage, when supervised. This is similar to the results of previous studies on pediatric prescription writing in the emergency department, which showed that lower-level residents are not more prone to errors compared with senior-level residents (5).

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