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Extensor mechanism injuries after primary total knee arthroplasty

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Abstract
Background: Extensor mechanism injuries after total knee arthroplasty (TKA) continue to be a difficult complication to treat and can be associated with devastating outcomes. This study attempts to review the prevalence, treatment types, and outcomes of extensor mechanism injuries after total knee arthroplasty within a cohort of patients.
Methods: Using a clinical research database, a retrospective cohort study was performed by evaluating all patients who underwent a total knee arthroplasty over the course of 7 years from 7 hospitals within the same hospital system. These patients were then screened for subsequent operative repair of the ipsilateral extensor mechanism at a later date. Patient characteristics, implants, type of extensor mechanism injury, fixation type, subsequent surgeries were evaluated.
Results: Of the 6064 total knee arthroplasties, 104 patients with 105 (1.73%) knees went on to have extensor mechanism injuries. Quadriceps tendon injuries were the most common, followed by patellar tendon, and then patella fractures. Median time to injury was 70 days. Patients requiring additional surgery beyond initial repair of extensor mechanism injury was noted to be 47.6% (50/105). Additionally, 33% (35/105) went on to have revision of component(s) and 17.1% (18-105) received treatment for prosthetic joint infection.
Conclusions: While overall rare, extensor mechanism injuries after total knee arthroplasty can pose serious complications beyond initial repair, including need for additional surgery, infection, revision, and even amputation. Careful consideration should be taken by the treating surgeon when faced with these injuries to avoid further complications.

Keywords: Extensor mechanism, quad, quadriceps, patella, tendon, total knee arthroplasty

Introduction

Background: Primary total knee arthroplasty (TKA) continues to become a more common surgery in the orthopedic community. With projections of primary TKA estimated to continue to rise [1], understanding the technique, outcomes, complications, and the way these are treated remains imperative. Specifically, extensor mechanism injuries can be a devastating complication to primary TKA and pose as a difficult complication to manage. While extensor mechanism injuries occur in about 0.17-2.5% of primary total knees, they pose difficulty in treatment and worse patient outcomes [2, 4]. Injury to the extensor mechanism includes damage to the quadriceps tendon, patella, patellar tendon, or retinaculum that aid in extension of the knee. History has shown that outcomes after untreated extensor mechanism injuries in the setting of TKA are extremely poor, and therefore this is reserved for the low function, low demand, elderly population [3]. For the vast majority of these patients, surgical intervention is indicated. The presence of a TKA prosthesis can make surgical treatment of extensor mechanism injuries more difficult due to potential stiffness, scar tissue, and presence of a patellar component, which may limit treatment options. Additionally, studies have shown that these injuries routinely do poorly with lower functional outcomes and patient satisfaction scores when compared to uncomplicated TKA [3]. Surgical treatment varies depending on the type and severity of the injury. Soft tissue structures can undergo repair versus reconstruction, with some literature favoring reconstruction with the use of cadaveric or synthetic grafts [4]. Patellar fractures can be treated with open reduction and internal fixation, revision of the patellar component, or patellectomy. Despite the various treatment options, there is no one treatment option for each extensor mechanism injury after TKA.

With the rise of TKA procedures it is important to understand the various treatment options and their outcomes. This study aims to evaluate the rate and sequelae of extensor mechanism injuries after TKA in a cohort of patients.

Materials and Methods

Using the William Beaumont clinical research database (CRDB) (including all 7 of the system's hospitals in Michigan), all patients who underwent primary TKA from January 1, 2015, to December 31, 2022, were obtained. These patients were then evaluated for subsequent operative encounters within the Beaumont Health system for extensor mechanism injuries to the ipsilateral leg as the TKA. Extensor mechanism injury included any injury to the quadriceps tendon, patellar tendon, patellar bone, patellar polyethylene, or retinaculum. Inclusion criteria were patients who underwent primary TKA within the above time period and age 18 or older at the time of index surgery. Exclusion criteria included patients having undergone TKA prior to the time period of study, patients below the age of 18 at the time of index surgery, revision total knee arthroplasty prior to extensor mechanism injury, and patients with known ipsilateral extensor mechanism injury prior to primary total knee arthroplasty. Once patients who had subsequent extensor mechanism injuries were isolated via the CRDB (Figure 1), chart review was then used to identify baseline patient characteristics, time to extensor mechanism injury, type of extensor mechanism injury, patellar implant specifications, and extensor mechanism surgical fixation type. Baseline patient characteristics recorded included gender, age, and BMI. Additionally, it was evaluated whether patients required further surgeries to the ipsilateral knee, treatment for infection, revision (of at least 1 component) of the TKA, or if patient went on to require fusion or amputation. Lastly, comparisons were secondarily made regarding extensor mechanism injury and patellar size, gender, age, BMI, and number of additional surgeries.

Statistical Analysis

Univariate analyses were conducted to evaluate the association between patient characteristics and the outcomes of incidence of infection (Table 4) and injury knee (Table 5). Patient characteristics were stratified by outcome and compared using Mann-Whitney U tests for continuous variables and Pearson's Chi-Squared tests for categorical variables. Spearman's rank correlation coefficient (ρ) was computed to assess the correlation between number of extra surgeries and age, BMI and patella implant size respectively. The correlation coefficients indicated negligible to weak correlations and were not statistically significant (Age: ρ) = -0.06, p = 0.543; BMI: (ρ) = 0.01, p = 0.937; Size: (ρ) = 0.13, p = 0.208).

Results

6064 primary TKA procedures were found from January 1, 2015 to December 31, 2022. Of these, 105 knees in 104 patients were found to have surgical intervention on the ipsilateral extensor mechanism (Figure 1). The average age was 67.7 years (43-85). There were 70 female knees and 35 male knees included in this study. The last patient characteristic reviewed was BMI, which averaged 34.99 (18.0-60.17). In regard to implants, the patella was resurfaced in 103/105 knees (98%). Patella size ranged from 20 mm to 41 mm. The most common patella sizes were 35 mm (27.6%), 32 mm (22.8%), and 38 mm (10.5%). These complications were seen with implants manufactured by 7 different companies (including multiple implant models from the same manufacturing company) and represented the complications of 39 different surgeons (Table 1).

Type of injury (Table 2)

When reviewing type of extensor mechanism injury, it was noted that injuries to the quadriceps tendon were the most common at 43.8% (46/105). Other soft tissue injuries included patellar tendon injuries at 20% (21/105) and retinacular tears in 8.6% (9/105). Patellar complications included patellar fracture in 13.3% (14/105) and issues involving the patellar button in 5.7% (6/105). The remaining 8.6% (9/105) knees involved two or more of the above mentioned components.

Time to extensor mechanism injury (Table 2): The average time to injury after primary TKA was 264.3 days. This ranged from one intra-operative case (0 days) to 3099 days. The median time to injury was 70 days.

Type of extensor mechanism repair (Table 2): Operative reports were reviewed for initial extensor mechanism repair/reconstruction surgery after ipsilateral TKA. Results showed the most common technique for surgical treatment was primary end to end repair with suture in 45.7% of patients (48/105). Patellar bone tunnels with suture fixation was seen in 27.6% (29/105). Less frequent methods of fixation included open reduction and internal fixation with revision of patellar button (8.6%, 9/105), open reduction and internal fixation with plate and screws (5.7%, 6/105), incorporation of allograft (3.8%, 4/105), use of suture anchors (3.8%, 4/105), or other style of procedures (4.8%, 5/105).

The final outcomes reviewed (Table 3) looked at the average number of additional surgeries the ipsilateral knee required (1 being after initial extensor mechanism repair/reconstruction attempt), the number of knees that went on to have acute or chronic periprosthetic joint infection, the number of knees that went on to revision TKA, and the number of knees that went on to fusion of amputation. The average number of additional surgeries was 0.99 (range 0-8). Furthermore, 50/105 knees (47.6%) required at least 1 additional surgery. These additional surgeries included irrigation and debridement procedures, secondary attempts at extensor mechanism repair/reconstruction, revisions, fusions, and amputations. The number of infections was noted to be 17.1% (18/105). Revisions were seen in 33% (35/105) of patients. Lastly, 1 patient went on to knee fusion and 2 patients went on to have above knee amputations. Statistical analysis showed when comparing age, gender, BMI, and patellar implant size, there was no statistical significance in the need for additional surgeries, infection, revision, fusion, or amputation (Tables 4 and 5).

Discussion

This study set out to evaluate extensor mechanism injuries after primary TKA. During the study time period, 105 knees in 104 patients were recorded at a rate of 1.73%. Vijay *et al*. reviewed this topic as well, and quoted rates from 0.17%-2.7% of extensor mechanism injuries after TKA, which correlates with the findings in this study [5].

Regarding the type of injury patients sustained, quadriceps tendon injuries were the most common. This included 43.8% of patients from the pool of extensor mechanism injuries and only 0.76% of all primary TKA patients in the study time period. Comparatively, patellar tendon injuries made up 0.35% and patellar fractures/patellar button issues made up 0.33% of primary total knee complications. While there were

no identifiable individual studies comparing the rates of the various extensor mechanism components and their rate of failure, individual studies have looked at the rate of each of their failures. Heer *et al*. quoted quadriceps tendon injuries after TKA at a rate of 0.1-1.1% of all total knees, fitting with these results (9). Additionally, Heer *et al*. performed a similar, but separate, study looking at patellar tendon injuries after TKA and referenced a rate of 0.17-1.0% [10]. While our study showed over twice as many quadriceps tendon tears compared to patellar tendon tears, the overall rate of each continues to fit with previously recorded data. Lastly, Sheth *et al*. looked at the rate of periprosthetic patellar fractures after TKA and showed a wider rate of 0.5-3% [11]. Our study showed a rate of 0.23% periprosthetic patellar fractures, which is slightly lower than previously reported rates. When including the 6 additional cases for patellar complications (patellar button loosening, maltracking, patellar button recall etc.), the rate becomes 0.33%, which is still lower than the quoted rate. However, this study only looked at patients who underwent surgical intervention for their extensor mechanism injury after primary TKA. Those who underwent non-operative management were not included. Additionally, this study only looked at patients who received their surgical treatment at one of the seven facilities within the one hospital system. Therefore, those who ended up in the care of other hospital systems or were lost to follow-up were unable to be tracked or included. The inability to track patients who underwent non-operative treatment, treatment at a facility not included in the hospital system (I.e., unaffiliated surgery centers), or treatment by another surgeon outside of the included hospital system could only lead to underestimations in the quoted rates this study found regarding each type of extensor mechanism injury.

The time to injury in our study was a mean of 264 days, which is comparative to previous studies showing a mean of 7 months or about 221 days [6]. There was one intra-operative patellar tendon injury included in our study. Including this injury as time 0, the range for the time to injury was 0-3099. With a large range of values, the median was noted to be 70 days, which may be more representative.

Extensor mechanism repairs have historically been shown to be difficult to treat. Primary end to end repair has shown poor outcomes including increased extensor lag and increased rates of re-rupture [3].

Additionally, there has been evidence to show the use of allografts and/or mesh have more reliable outcomes with decreased rates of extensor lag and re-rupture [6]. Despite this evidence, our study showed the most common form of repair for soft tissue extensor mechanism injuries was direct end to end repair with suture (45.7%). This was quite high when comparing it to the use of adjunct fixation, such as allograft, mesh, or suture anchors. When combining all adjunct methods of fixation, their combined rate of 14.8% was 3 times less likely to be used on initial repair/reconstruction. While not specifically recorded, it was seen that repeat attempts for extensor mechanism repair/reconstruction was more likely to use adjunct methods.

This study showed a high percentage of patients (47.6%) who required additional surgery after initial attempt to repair/reconstruct the peri-prosthetic extensor mechanism injury. Dobbs *et al*. in their study showed a rate of 23% of patients having failure of extensor mechanism repair in the setting of TKA. Furthermore, they specifically reported a re-tear rate amongst quadricep tendon repairs to be 40% [7]. While our study showed a higher rate of patients requiring at least one additional surgery (range 1-8 additional surgeries), this included all cause return to surgery for the ipsilateral knee, not only for re-injury to the extensor mechanism. As mentioned, patients returned to the operating room not only for re-tears, but also for irrigation and debridement, revision of implants, fusion, and above knee amputation. In our study, the high proportional rate of direct end to end repair with suture may have led to increased failures and therefore increased number of cases returning for additional surgery. Additionally, another confounding variable may be the low rate of un-resurfaced patellas. Our study population showed 103/105 knees (98%) had resurfaced patellas, which over this time period appears to be consistent with this region's trend. While studies have shown leaving the patella un-resurfaced leads to higher rates of revision surgeries [12], there has yet to be a high-powered study discussing if this step impacts extensor mechanism injuries. One study showed patella fractures after TKA with un-resurfaced patella occurred at a rate of 0.05% [8]. Our study showed 0.23% of total knees had an eventual patella fracture that required surgical intervention.

Our study also looked at the rate of infection, revision implant procedures, and the rates of amputation and fusion. According to national registry data, the rate of prosthetic joint infection after TKA is estimated to be 1.03% [13]. While there is limited literature to compare rates of prosthetic joint infection in the setting of extensor mechanism injury, our study showed a rate of 17.1%. While there are many variables that may contribute to this elevated rate, it highlights the increased risk for infection these patients may be predisposed to. Similarly, the rate of revision procedures performed was found in 33% of patients. Bloch *et al*. showed one of the most important factors associated with extensor mechanism injuries was malpositioning of the implants [3]. Critical evaluation in patients with these injuries should be performed including obtaining a thorough history regarding mechanism of injury and possible evaluation of component alignment, as these patients may be at higher risk for revision surgery. One patient went on to knee fusion and 2 went on to above-knee amputation, which highlights the most morbid endpoints in this setting.

Of note, when comparing age, gender, BMI, and patellar implant size, there was no significant difference in the incidence of infection, need for revision of one or more implants components, nor need for additional surgeries. This may show that all patients are at increased risk for further complications, however further data would be required to support this.

The strengths of this study include looking at a multi-center study, which was vastly inclusive to all orthopedic surgeons performing TKA, despite varying levels of training. There were few exclusion criteria in an effort to evaluate the wide variety of patients an arthroplasty surgeon may encounter. Furthermore, this study was able to perform an in-depth review of this cohort, comparing the different types of extensor mechanism injuries and their various treatment options with one study. This was something that previously was covered more broadly and required comparisons of patient populations from different studies. Finally, this study reviewed the general peri-prosthetic extensor mechanism repair/reconstruction techniques of this region.

In regard to limitations, this study was performed as a retrospective chart review. Additionally, as mentioned prior, the results may be an underestimate due to patients being treated at facilities not sharing electronic medical records with the center included. There was no standardization of surgeon

level of expertise, surgical technique, or extensor mechanism repair technique. Additionally, there was no record for review regarding post-operative protocols, limitations, satisfaction, or range of motion results.

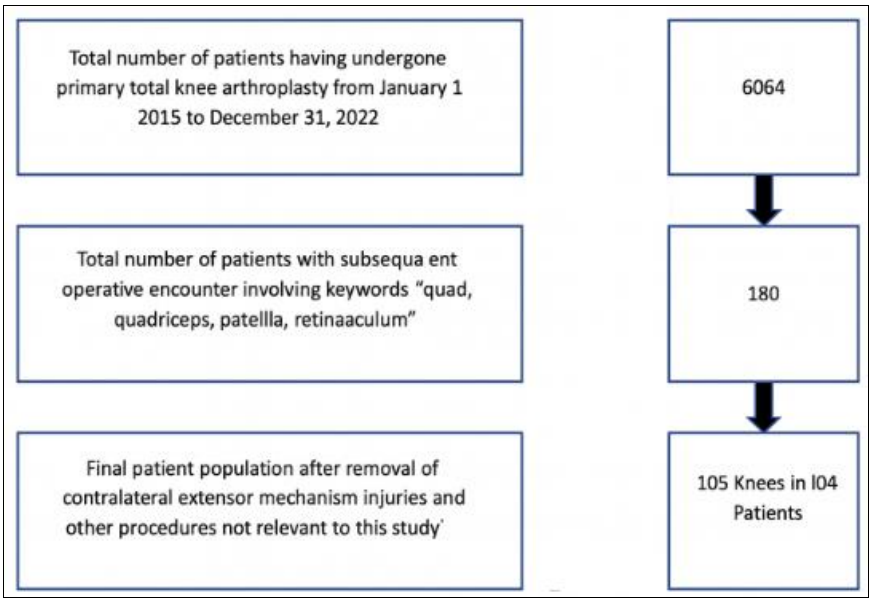

Fig 1: Demonstrates the patient selection process. Initial patient selection began with all total knee arthroplasty procedures within the study time period. This was then filtered down to the relevant patient population.

Table 1: Reviews patient characteristics included in this study.

Age	**Mean**	**67.7 years**
	Range	43-85 years
Gender	Male	35
	Female	70
BMI	Mean	34.99
Polyethylene Size	20 (mm)	1 (Number of patients)
	24	1
	25	4
	26	1
	27	6
	28	2
	29	8
	30	2
	31	3
	32	24
	33	1
	34	3
	35	29
	37	2
	38	11
	40	3
	41	1
	Unknown	1
	Unresurfaced	2
Company	Stryker	50 (Number of patients)
	Not Reported	22
	Zimmer Biomet	18
	Smith and Nephew	9
	Depuy	4
	Microport	1
	Exactech	1

Table 2: Reviews the various extensor mechanism injuries, the time to injury, and the selected surgical fixation reported.

Type of Extensor Mechanism Injury	**Quadriceps Tendon**	**46**
	Patellar Tendon	21
	Retinacular Tears	9
	Patella Fracture	14
	Patellar Button Complications	6
	2 or more components	9
Time to Extensor Mechanism Injury	Mean	264.5 (days)
	Median	70
	Range	0-3099
Type of Extensor Mechanism Fixation	All Suture. Tendon to Tendon	48
	Patellar Bone Tunnels and Suture	29
	ORIF with Revision of Patella	9
	ORIF with plate and screws	6
	Suture Anchors	4
	Allograft incorporation	4
	Combination/Miscellaneous	5

Table 3: Reviews the outcomes of patients with extensor mechanism injuries after TKA.

Extra Surgeries Required	**Number of patients requiring extra surgery**	**50 (47.6%)**
	Average number of extra surgeries	**0.99 surgeries/patient**
Number of Infections	18	17.1%
Number of Revision Arthroplasty Surgeries	35	33.3%
Number of Knee Fusions	1	
Number of Above Knee Amputations	2	

Table 4: Shows statistical analysis comparing Age, Gender, BMI, and patellar implant size in regards to risk of infection. There was no statistical significance among these characteristics and the risk of infection.

Infection Y/N			
	N	**Y**	**P**
n	86	19	
Age (mean [SD])	67.44 (9.11)	68.84 (5.78)	0.523
Gender - M (%)	28 (32.6)	6 (31.6)	1.000
BMI (mean [SD])	35.52 (8.67)	32.65 (7.53)	0.186
BMI_CAT (%)			0.505
<25	7 (8.2)	3 (15.8)	
25-29.99	17 (20.0)	4 (21.1)	
30+	52 (71.8)	12 (63.2)	
Patella implant size (mm) (median [IQR])	32.00 [31.00, 35.00]	35.00 [29.00, 35.00]	0.597
IMPLANT_SIZE_CAT (%)			0.138
<32	19 (22.6)	6 (33.3)	
32-34	29 (34.5)	2 (11.1)	
35+	36 (42.9)	10 (55.6)	

Table 5: Shows statistical analysis comparing Age, Gender, BMI, and patellar implant size in regards to risk of revision arthroplasty surgery. There was no statistical significance among these characteristics and the risk of revision.

Revision Knee Y/N			
	N	**Y**	**P**
n	70	35	
Age (mean [SD])	67.09 (9.06)	68.91 (7.55)	0.306
Gender - M (%)	18 (25.7)	16 (45.7)	0.065
BMI (mean [SD])	35.43 (9.06)	34.13 (7.35)	0.465
BMI_CAT (%)			0.450
<25	6 (8.7)	4 (11.4)	
25-29.99	12 (17.4)	9 (25.7)	
30+	51 (73.9)	22 (62.9)	
Patella implant size (mm) (median [IQR])	32.00 [30.00, 35.00]	32.00 [32.00, 35.00]	0.398
IMPLANT_SIZE_CAT (%)			0.837
<32	18 (26.1)	7 (21.2)	
32-34	20 (29.0)	11 (33.3)	
35+	31 (44.9)	15 (45.5)	

Conclusion

In conclusion, this study continues to reinforce the poor outcomes associated with extensor mechanism injury after TKA. Patients undergoing TKA should be made aware of the potential risk and consequences of extensor mechanism injury. Additionally, those who unfortunately experience this complication should continue to have their expectations managed and stress the importance of the

repair/reconstruction post-operative time period including weight bearing or motion restrictions and signs/symptoms of infection. From a clinical standpoint, this study exemplifies the high rate of complications with treatment of these injuries. Treating surgeons should use this information when deciding how to approach treating these injuries and possibly consider using augmentation, such as suture anchors, allograft, or mesh. Overall, this topic includes a wide range of topics that would benefit from further investigation and further research is required to evaluate the various treatment options and their role in definitive patient outcomes and satisfaction.

Abbreviations

TKA - Total knee arthroplasty

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