

Research Article

Morbidity and Total Knee Arthroplasty as a Long-Term Sequela of Tibial Plateau Fractures

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Abstract

Background: Tibial plateau fractures comprise a heterogenic group of patients, involving several mechanisms and variability in demographic characteristics. Although short term peri-operative clinical and radiologic outcomes are well described in the literature, long-term prognosis reports are scarce.

Hypothesis: Long-term prognosis of Tibial plateau fractures may be correlated with secondary Osteoarthritis (OA) and the need for total knee arthroplasty in rates greater than reported in the current literature, which focuses on short and mid-term prognosis.

Methods: 310 patients treated for Tibial plateau fractures, with a follow up period of 10-30 years were attempted contact by mail. They were questioned about their knee function and subsequent surgeries following the index operation. Total knee arthroplasty was defined as the primary endpoint.

Results: 70 patients had responded. 61 patients were treated surgically primarily with an ORIF, and nine were treated conservatively. The median follow-up period was 211 months (range 121-368). The median Tegner-Lysholm knee function score was 74.5 (IQR 43). 25 patients underwent additional surgery in the injured knee, and 15 patients with inferior Tegner-Lysholm score had TKA. Several distinguished characteristics were found and discussed.

Conclusions: Tibial plateau fractures are a heterogenic group of injuries, with a sub-optimal functional outcome and a high prevalence of additional surgeries, in specific, knee arthroplasty.

Keywords: Tibial Plateau; Knee; Arthroplasty; Secondary Osteoarthritis; Trauma

Introduction

Tibial plateau fractures may occur due to a high-energy trauma (e.g., bumper-pedestrian injury, fall from height) or lower-energy impact such as in sports injury. These fractures may involve soft tissue, vasculature, nervous tissue, ligaments, and the integrity of the articular cartilage. The potential for late complication includes compartment syndrome, deep vein thrombosis, and severe chronic functional deficit [1]. Tibial plateau fractures are intra-articular fractures by definition. The vast majority of these fractures interfere with the congruency of the Tibial articular surface. Thus, according to the Arbeitsgemeinschaft für Osteosynthesefragen (AO Foundation) principles, intra-articular fracture mandates the restoration of this congruency with anatomical reduction, support of the disimpacted subchondral bone with bone graft and stable fixation [2]. An appropriate surgical treatment is considered the mainstay of treatment, facilitating direct bone healing adjacent to the articular surface, and preventing changes in the joint's geometry secondary to the healing process. This aims to minimize future risk for early degenerative changes. Various fixation techniques were described, as well as several surgical approaches [3]. Apart from the osseous damage, the surgical approach account for soft tissue morbidity and intra-articular structures [4,5]. In selected cases, arthroscopy may prove useful during the reduction, enabling a detailed view of the

articular surface restoration and stability [6]. The conservative treatment, hence immobilization, is reserved for selected cases with either minimal displacement or patients inappropriate for surgery.

Although short-term peri-operative clinical and radiologic outcomes for Tibial plateau fractures are well described in the literature, as peri-operative complications (e.g., peri-operative infection, chronic infection, osteomyelitis, stiffness and loss of range of motion, malunion and non-union), there is an objective difficulty in establishing long term prognosis of this injury [7,8]. Articular surface injury with limited articular cartilage regeneration potential may lead to secondary OA [9,10]. The operative solution for end-stage degenerative changes of the knee joint is often arthroplasty. Simpson, et al., have published a series of thirteen patients treated for Tibial plateau fractures using calcium phosphate cement, with two patients (15%) that eventually required knee arthroplasty [11]. A much larger cohort was published by Mehin, et al., following 311 patients, in which 3% of the operated patients had knee arthroplasty in ten years, compared to 7% of the non-operated group [12]. The recent work of Wasserstein, et al., used the health, social, and insurance registries of the Ontario state to follow up on 8,426 patients operated on for Tibial plateau fractures [13]. They were matched to a similar population (concerning age, sex, income and urban or rural inhabitation). This study demonstrated a relative risk of 5.3 for knee arthroplasty following an Open Reduction and Internal Fixation (ORIF) of a Tibial plateau fracture, comparing the general population. However, this study did not examine the cases themselves but registry codes only, neglecting laterality, for instance. As far as functional outcomes, the reports are mixed. Stevens, et al., followed 46 patients operated on for Tibial plateau fractures with a relatively good functional outcome [14]. On the contrary, van Dreumel, et al., published a follow-up of 5-10 years of 96 patients, suggesting significant reduction in the quality of life. Interestingly, no correlation between radiographic and functional outcomes was found [15].

In this study, we attempted to describe long-term results of patients treated for Tibial plateau fractures in our level 1 trauma center. The requirement of TKA as a marker of secondary OA and lower satisfaction with the knee function was considered as the primary outcome. Additional surgeries, including fixation revision, arthroscopy, metalware removal, and contra-lateral TKA were considered the secondary outcomes. Current knee function was also evaluated and considered as a secondary outcome.

Methods

The medical records of 310 patients, treated in the emergency department of a level 1 trauma center, for a Tibial plateau fracture, in the years 1985-2005, were selected. The minimum follow-up period was ten years (range 10.1-30.7 years). According to data from the national population records, the current address and telephone details were obtained. Patients received reported outcome forms by mail, inquiring about the treatment discipline of the fracture itself (conservative or surgical) and subsequent surgeries performed. Total knee arthroplasty was considered in this cohort as the primary outcome. Other surgical interventions were considered secondary outcomes. Knee function was assessed using the Tegner-Lysholm Score, which is a patient-reported instrument that considers limp, use of support, locking, instability, pain swelling, stair climbing, and squatting [16]. Although originally designed for evaluating patients following knee ligamentous injury, the NIH had established this rating system as valid for OA [17].

Statistical analysis: Power analysis considering the TKA rates of the general population (1.8%) and patients ten years following Tibial plateau fractures (7.3%), using the data of the study published in the Journal of Bone and Joint Surgery by Wasserstein, et al., based on Ontario province registry [13]. A power rate of 80% was found with a study group of 76 patients. Descriptive statistics were performed (by means and standard deviations). Univariate analysis comparisons were performed by Mann-Whitney test; sex variance and initial injury index treatment variance analysis was performed by chi square test. Significance level was set to $P < 0.05$. We built a logistic regression model, considering TKA surgery as the dependent variable. Variables that resulted significant in the univariate analysis determined as the independent variables. They were divided into conceptual blocks - demographics (sex, age, injury age), follow-up time and Tegner-Lysholm score. We conducted survival analysis of the native joint using Kaplan-Mayer curves defining a variable opposite of the need for TKA as the outcome. Analysis was performed using the SPSS program (vs. 20, IBM). Level of evidence: 3a, Historical cohort.

Results

Of 310 patients included in this cohort, eight patients had passed away during the follow-up period. 33 had either a false or a missing address in the records or were living at a temporary residence (tourists, pilgrims etc.) at the time of injury. 70 have

responded, 33 females and 30 males, and seven chose to do so incognito. The median follow-up period was 211 months (range 121-368 months, IQR 109.2 months).

The median Tegner-Lysholm knee function score of the study was 74.5 (IQR43).

Concerning the primary outcome of this study, 15 patients underwent total knee arthroplasty. The average interval between injury and knee replacement was 8.77 years (median was 3 years) (range 1-23 years), as seven patients underwent arthroplasty within 3 years, and three within 15 and 23 years after the index injury (Fig. 1).

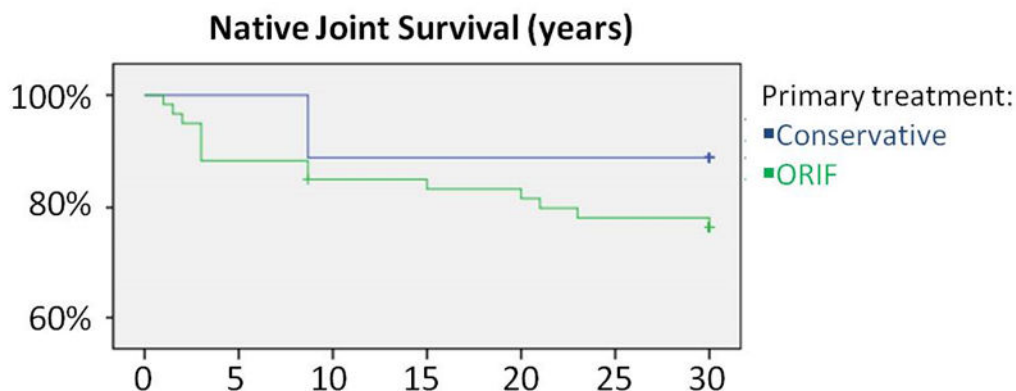


Figure 1: Kaplan-Mayer graph demonstrating survival of the native knee joints (prior to total knee arthroplasty) of the study's population.

When comparing the arthroplasty group to the rest of the patients, lower scores are demonstrated in all parameters, but only instability was deemed statistically significant (median score 7.5 Vs. 20, $P=0.025$). The overall mean Tegner-Lysholm score was 70.4 Vs. 53.3 (median 79 Vs. 46) in the favor of the group that hadn't required arthroplasty, $P=0.068$ (Table 1). The average age of the index injury was slightly younger for the TKA group at 42.3 years (SD13.7, median 40.5, range 19.2-71.8) comparing the group which hadn't required arthroplasty with 44.6 years (SD 15.7, median 45.9, range 15.7-69.6). The odds ratios to undergo TKA following this injury were 36.4% (12/33) for females, and 3.3% (1/30) for males ($p=0.001$).

	Range	Arthroplasty	No Arthroplasty	Total	P-value
No.		15	55	70	
Injury Age (years)	15.7-71.8	40.5 (14.3)	45.9 (27.8)	45.5 (25.2)	0.214
Current Age (years)	39-92	63.0 (18.0)	69.5 (26.0)	68.0 (25.0)	0.289
Female/Male ratio		11/1	22/29	33/30	0.002
Index treatment - ORIF		92.9%	85.5%	87.0%	0.463
Follow-up (years)	10.1-30.7	16.6 (7.5)	17.7 (9.8)	17.6 (9.1)	0.141
Limp	0-5	3 (5)	3 (2)	3 (2)	0.454
Walking aid	0-5	2 (4)	5 (0)	5 (3)	0.089
Stair climb	0-15	4 (5)	6 (4)	6 (5)	0.264
Squat	0-5	0.5 (2) ???	4 (4)	4 (4)	0.064
Instability	0-25	7.5 (20)	20 (15)	20 (16)	0.025
Swelling	0-10	4 (10)	10 (4)	10 (8)	0.240
Pain	0-25	10 (20)	20 (10)	20 (16)	0.135
Locking	0-15	6 (9)	15 (9)	15 (9)	0.052
Tegner-Lysholm score	0-100	46 (50)	79 (39)	74.5 (43)	0.068

Table 1: Primary outcome analysis (patients who required arthroplasty and those who didn't), comparing demographics and functional outcome, described using medians and IQR of Tegner-Lysholm score parameters.

A logistic regression considering demographic variables, Tegner-Lysholm score and follow-up time as associated factors with the likelihood to undergo TKA resulted in a Nagelkerke R square of 0.459, with a model significance of $P < 0.001$. However, the demographic block contributed the most (Nagelkerke R square of 0.291), specifically the female sex, followed by the Tegner-Lysholm score block (Table 2). Follow-up time hadn't resulted in a significant contribution to the primary outcome of TKA.

	B	P value	OR	95% C.I. for OR	
				Lower	Upper
Sex	-3.005	0.015	0.050	0.004	0.553
Injury Age	0.012	0.926	1.012	0.778	1.317
Age	-0.061	0.660	0.941	0.716	1.236
Tegner-Lysholm score	-0.035	0.016	0.966	0.939	0.994
Follow up	-0.145	0.430	0.865	0.604	1.239
Constant	7.288	0.051	1462.447		

Table 2: Primary outcome logistic regression parameters, demonstrating sex and Tegner-Lysholm scores associated with TKA surgery.

Of the study's population, 25 patients underwent additional surgery in the injured knee - knee arthroplasty, arthroscopy (five), revision of ORIF (two), and metalware extraction [14,15]. The average Tegner-Lysholm score was significantly higher (73.3, median 83) in the group which hadn't required additional surgery comparing the group which had (55.0, median 59), suggesting a significantly inferior function for the group of patients requiring subsequent surgeries. The significantly different elements were instability (median score 20 Vs. 15, $P=0.004$), pain (average score 18.4 Vs. 12.8, $P=0.015$, median 20 for both), and locking (median score 15 Vs. 10, $P=0.044$) (Table 3). The average age at injury was younger for the group which had required additional surgery (39.6, median 40.5) than the group which hadn't (46.7, median 48.4), but the difference was statistically insignificant ($P=0.077$). Again, the odds ratios to undergo additional surgery following this injury were 52% (17/33) for females, and 16.7% (5/30) for males ($P=0.007$).

	Range	Subsequent Surgery	No Subsequent Surgery	Total	P-value
No.		25	45	70	
Injury Age (years)	15.7-71.8	40.5 (17.2)	48.4 (26.4)	45.5 (25.2)	0.077
Current Age (years)	39-92	64.0 (18.0)	73.5 (24)	68.0 (25.0)	0.078
Female/Male ratio		17/5	16/25	33/30	0.004
Index treatment - ORIF		95.8%	82.2%	87.0%	0.110
Follow-up (years)	10.1-30.7	17.6 (8.1)	17.4 (10.4)	17.6 (9.1)	0.948
Limp	0-5	3 (5)	3 (2)	3 (2)	0.361
Walking aid	0-5	5 (3)	5 (0)	5 (3)	0.122
Stair climb	0-15	6 (10)	6 (4)	6 (5)	0.252
Squat	0-5	1 (5)	4 (4)	4 (4)	0.055
Instability	0-25	15 (15)	20 (15)	20 (16)	0.004
Swelling	0-10	6 (8)	10 (4)	10 (8)	0.096
Pain	0-25	20 (15)	20 (10)	20 (16)	0.015
Locking	0-15	10 (9)	15 (9)	15 (9)	0.044
Tegner-Lysholm score	0-100	59 (63)	83 (41)	74.5 (43)	0.026

Table 3: Comparison of demographics and functional outcome, described using medians and IQR of Tegner-Lysholm score parameters, between the patients who had required subsequent surgeries and the ones which hadn't.

When tracking back and analyzing the treatment for the initial injury, of the 70 patients, 61 were treated with open reduction and internal fixation of the Tibial plateau fracture, and nine were treated conservatively. Of the nine patients that were treated conservatively, only one was treated with subsequent total knee arthroplasty. Of the 61 patients that were surgically fixated primarily, 14 underwent total knee arthroplasty. The average function score of the operated group was 67.9 (SD 29.5, median 77, IQR 46) compared to 64.0 (SD 21.5, median 58, IQR 44) of the conservatively treated group. No statistically significant difference was demonstrated, comparing the various Tegner Lysholm score's separate elements and combined, as for the patient's age at the index injury (Table 4).

	Range	Conservative	ORIF	Total	P Value
No.		9	61	70	
Injury Age (years)	15.7-71.8	31.2 (29.3)	46.2 (23.7)	45.5 (25.2)	0.286
Current Age (years)	39-92	70.0 (35.0)	68.0 (23.0)	68.0 (25.0)	0.945
Follow-up (years)	10.1-30.7	19.0 (6.7)	16.9 (9.1)	17.6 (9.1)	0.053
Limp	0-5	3 (0)	3 (2)	3 (2)	0.106
Walking aid	0-5	5 (3)	5 (3)	5 (3)	0.674
Stair climb	0-15	6 (4)	6 (4)	6 (5)	0.459
Squat	0-5	4 (3)	4 (4)	4 (4)	0.224
Instability	0-25	20 (20)	20 (15)	20 (16)	0.657
Swelling	0-10	10 (10)	10 (7)	10 (8)	0.838
Pain	0-25	20 (3)	20 (20)	20 (16)	0.963
Locking	0-15	10 (13)	15 (9)	15 (9)	0.264
Tegner-Lysholm score	0-100	58 (44)	77 (46)	74.5 (43)	0.335
Additional Surgery		1 (11.1%)	24 (39.3%)	25 (35.7%)	0.147
TKA		1 (11.1%)	14 (23.0)	15 (21.4%)	0.672

Table 4: Index treatment - conservative Vs. surgical (ORIF) functional outcome, described using medians and IQR of demographics, index treatment and Tegner-Lysholm score parameters.

Our institute's digital radiographic records enabled us to restore only 19 records of the study population. The Schatzker classification rank distribution was three with type I (one patient underwent TKA after 3 years), six with type II, one with type III, one with type IV, six with type V (two patients underwent TKA after 1 and 3 years), and two type VI (both underwent TKA at 1.5 and 21 years).

Noted is the fact that three of the fifteen patients who underwent arthroplasty, did so in the contra-lateral knee as well. Two patients were operated on for contralateral arthroplasty two years following the index injury; the third did so 21 years after the injury, with injury to ipsilateral TKA interval of 20 years. Of the 55 patients that hadn't gone through TKA in the injured knee, none was operated for TKA in the contralateral knee.

Discussion

This study was designed in purpose to demonstrate the long-term follow-up results of patients treated for Tibial plateau fractures, primarily their likelihood to undergo TKA of the injured knee. Data for other subsequent surgeries and functional outcomes was also collected and analyzed.

Tibial plateau fractures are highly prevalent, with a bimodal distribution (young males and elderly females), the prognosis remains elusive. A selected group of patients with minimally displaced fractures could successfully be treated conservatively. Many authors advocate satisfactory results with an ORIF procedure for Tibial plateau fractures but long-term follow-up results are inconsistent [7,10,14,15,19,20]. In our study we validate some of the previous literature, suggesting an increased likelihood of knee arthroplasty in the population of patients who suffered Tibial plateau fractures. Although this injury is considered to carry a relatively fair prognosis, the high prevalence of additional surgeries (25 patients out of 70), and specifically TKA (15

patients), suggests a higher incidence of end-stage secondary OA. Functional outcomes differences focus mainly on pain and instability parameters. An interesting finding was the obvious trend for females to undergo additional surgeries, especially TKA, suggesting either a higher rate of failure, discontent, or higher compliance with our study (reporting bias). Noted is the fact that although secondary OA evolves over time, follow-up time for itself hadn't resulted as a significant parameter correlating with eventual TKA.

The lack of intermediate follow-up results in this study, and the fact that the functional scores were collected after some of the patients were operated on for TKA could be considered as a drawback, since one might assume TKA should have improved functional scores. Indeed, it was impossible to regain the Tegner-Lysholm score before TKA for analysis. On the other hand, since it resulted in a significantly lower score in the arthroplasty group, it may be interpreted either the function prior to TKA was even worse in this group, or that TKA following several years of recovery from a Tibial plateau injury has, regrettably, a limited prognosis.

Other studies address TKA performed on the previously injured and repeatedly operated knee. The significantly lower functional score of the TKA group in our study should be addressed through several aspects. Secondary post-traumatic OA requiring arthroplasty is the exception, following the common treatment of ORIF [21]. It is also fair to presume these patients were deemed with a poorer prognosis according to their habitus, initial injury characteristics, and rehabilitation quality. Some studies discuss the option of TKA as the primary operative solution, especially in the elderly and osteoporotic population [22-25]. The main advocates are poor bone stock quality, enhancing early ambulation and reduce revision rates. The high prevalence of additional surgeries in our cohort supports the later argument to some degree. Time to surgery of an average of 8.77 years from the injury to arthroplasty, may have a substantial effect on the functional starting point prior to arthroplasty, and presumably a negative effect on rehabilitation and outcome. The patient selection process, involving a systematic evaluation in these cases of secondary OA should be addressed thoroughly, as major complications might occur [26]. Novel technology, e.g. Computer-Assisted Surgery (CAS), navigation, robotic arms, and Patient-Specific Instrumentation (PSI) is more and more available and may improve surgical outcomes.

The difficulty to establish a reliable prognosis in real time may have several explanations. One possibility is the regaining understanding of the three-column concept in the last decade and its importance for the surgical outcome, which might not be reflected in previous clinical studies [27-29]. Another possibility of the lack of correlation of clinical outcome with radiological findings could be the soft tissue injury characteristics, which are not currently defined by a consensual classification system with respect to Tibial plateau fractures [15,30,31].

Conclusion

Our study supports a trend in the literature, arguing that Tibial plateau fractures are a heterogenic group of injuries, with a sub-optimal functional outcome and a relatively high prevalence of the need for additional surgeries, in specific, knee arthroplasty. The requirement for arthroplasty is, indeed, a predictive value for a significantly inferior function and satisfaction, both prior to and following this procedure.

Limitations

We used patient-reported outcome forms delivered by mail to the study's population. 70 responses from 310 patients represent 23% compliance rate, which is consistent with previous literature for this methodology. Due to the prolonged follow-up period, the quality of data, in specific the absence of some of objective imaging and documentation, may lead to a selection bias, favoring the patients with the less successful outcome. The relatively higher need of females for additional surgeries, in specific TKA, might be explained by a different compliance rate to this study, although the overall group of patients complying with our questionnaire is quite balanced in this perspective.

No demographic or radiologic data could be collected and analyzed regarding the seven patients who chose to respond to our petition incognito. The absence of some of the digital radiograph records, due to the long follow-up period, of a substantial part of the study's population, prevents us from determining the correlation between the fracture's type and the primary outcome.

Ethics Approval

Any aspect of the work covered in this manuscript that has involved either experimental animals or human patients has been conducted with the ethical approval of all relevant bodies and that such approvals are acknowledged within the manuscript.

Conflict of Interest

The authors have no conflict of interest to declare.

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