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The Final Thesis

Early Complications After Tibial Plateau Fractures

Anja Sophia Gnadl, VI Year, 2nd Group

Institute of Clinical Medicine
Clinic of Rheumatology, Orthopaedics Traumatology and Reconstructive Surgery

Supervisor — Assoc. Prof. Igoris Šatkauskas

Consultant — Dr. Raminta Martinaitytė

Head of Clinic — Prof. PhD Irena Butrimienė

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Email of the student: anja.gnadl@mf.stud.vu.lt

Summary

The objective of this study was to evaluate the association of modifiable risk variables and postoperative complications after surgical treatment of tibial plateau fractures. A case-control study was conducted in the Republican Vilnius University Hospital. Controls and cases were similar on age (> 18 years) and fracture type of IV – VI in the Schatzker classification. A total of 181 cases (30 with complications and 151 without) were collected over a period of 4 years. Statistical comparisons were evaluated using the Fisher-Test for categorical variables and Kruskal-Wallis-Test for continuous variables. Odds of surgery related complications were estimated from multivariable logistic regression, with adjustment for the three Schatzker classifications, incorporating significant variables and such with a tendency towards significancy. The use of external fixation (OR= 0.571, 95% CI: 0.051 – 3.904, p=0.601), the number of incisions (Odds Ratio = 0.372, 95% Confidence Interval: 0.063 – 2.198, p=0.272) and the length of hospital stays (Odds Ratio = 1.056, 95% Confidence Interval: 0.959 – 1.159, p=0.252) were not significantly associated with the rate of complications. The Schatzker classification type VI was associated with an increased risk of complications among the subjects. However, this variable is considered a trauma related complication and is therefore not modifiable. A statistically significant association however was observed between the modifiable variable of operation duration and the increased odds of postoperative complications (Odds Ratio = 1.013, 95% Confidence Interval: 1.001 – 1.025, p=0.035). Surgeries should therefore be conducted as quickly as possible while maintaining good quality. Surgeons should be cognisant of this risk and should create a good, well thought-out, and individual operation strategy for each patient.

Keywords: tibial plateau fracture, surgical treatment, risk factors, complications, Schatzker classification, outcomes

Introduction

Fractures of the tibial plateau are fractures that occur around the knee joint in the proximal part of the tibia bone and have significant impact on knee function (1). These types of fractures represent 1-2% of all fractures and account for around 8% of all fractures in elderly people (2)(3)(4)(5). The manner in which the fracture presents itself is determined by the cause of the injury and typically occurs as a result of either very high-velocity impact trauma, which is more common in younger men, or low-velocity impact trauma, which is more common in older women and is often classified as a fragility fracture (6).

Injuries of the tibial plateau can be difficult to manage due to the complex anatomy and biomechanics of the knee joint and therefore often requires surgical intervention. The tibial plateau is a crucial weight-bearing joint surface that articulates with the femoral condyles of the knee joint (6)(7). As a result, the primary goals of treatment include anatomical reconstruction of the proximal tibial articular surface, satisfactory limb axial alignment restoration, and secure fixation of metadiaphyseal comminution to allow early knee mobilisation (2). Unfortunately, tibial plateau fractures can be complicated and frequently coupled with soft tissue injuries, making their management challenging (6)(7).

There are several classification systems available for developing an appropriate treatment strategy. The most commonly used systems are the Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association (AO/OTA) and the Schatzker classification (8). Both are traditionally based on the two-dimension plain radiographs, but can be further enhanced by the use of two-dimensional computerised tomography (CT) scans or three-dimensional reconstructions of CT scans to classify the fracture (9)(10). However, since the Schatzker classification system is the most widely used, it will be applied in this paper (10). This system is commonly used to categorise tibial plateau fractures based on their location and severity. Included are six types of fractures, which are Type I: lateral plateau fracture without depression, Type II: lateral plateau fracture with depression, Type III: compression fracture of the lateral or central plateau, Type IV: medial plateau fracture, Type V: bicondylar plateau fracture, and Type VI: plateau fracture with diaphyseal discontinuity (11) (Fig.1) (12).

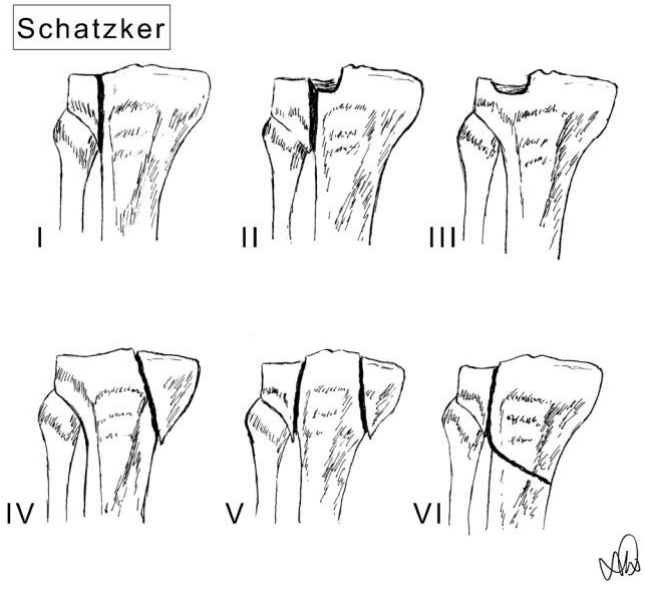

Figure 1: Schatzker classification of tibial plateau fractures

The initial three types (I, II, and III) commonly occur due to low-velocity impact trauma. IV, V and VI are usually caused by high-velocity impact trauma and considered as complex tibial plateau fractures, often associated with soft tissue injury, a high risk of wound complications and difficult reduction (2)(11). Each increasing numeric of the fracture category not only indicates an increasing severity and reflects not only an increased energy imparted to the bone at the time of injury but also an increasingly worse prognosis. The most critical parameters determining surgical management of tibial plateau fractures are fracture depression and displacement (11). Therefore, the Schatzker classification system is found to be useful in assessing the initial injury and management planning by orthopedic surgeons, and it has been found to have significant clinical relevance in predicting results and complications following surgical procedures (10)(11).

Regardless of its significance, early complications following surgery for tibial plateau fractures can arise in any type of fracture. Wound infection, deep vein thrombosis, pulmonary embolism, compartment syndrome, and nerve damage are among the most common complications. Early detection and management of these problems are crucial for avoiding further morbidity and improving patient outcomes (3)(6)(7)(13).

There is no single risk factor for complications, however a multitude of risk factors have been identified as being potential predictors of early complications following tibial plateau fracture surgery. These include patient related factors like age, gender, as well as trauma related factors such as fracture type and severity (3)(13). All these factors can also be called non-modifiable variables. However, special attention should be paid to modifiable variables, which can also be called surgery related factors, such as timing of procedure, length of surgery, implant used, and surgical methods, which, according to literature, have the most influence on the likelihood of complications developing (14)(15)(16). Therefore, it is critical to obtain a comprehensive understanding of the extent of soft tissue injury around the knee to identify the optimal timing of surgical intervention. By far the most preferred treatment option currently is open reduction and internal fixation (ORIF) (17). While a prompt surgical intervention (within 48 hours) allows for easier reduction and earlier patient mobilisation, range of motion, and recovery, temporising external fixation followed by delayed ORIF, have dramatically lowered previously high rates of postoperative complications (18)(19).

Even though current treatments, such as deferring definitive surgery, utilising temporary external fixation, and paying attention to the number of incisions, have reduced infection rates, 2-14% of other postoperative complications remain, with rates increasing with a higher Schatzker type (19)(20). Other studies report postoperative infection rates ranging from 3 to

45% (21). A proximal tibial fracture was even established as an independent risk factor for postoperative complications in a recent study (20). As a result, it is critical to select the right approach and surgical method for each case individually to ensure proper restoration and to keep the patient safe from serious complications (8). Obviously, it is impossible to eliminate the probability of developing complications entirely because most risk factors, such as fracture severity and surrounding tissue damage, were spontaneously added at the time of trauma occurrence and are frequently used as prognostic variables (22). However, the association between all these factors and the development of complications remains largely unknown (13). The primary objective of this case control study was to estimate the complication rate resulting from a tibial plateau fracture and its association to non-modifiable risk factors such as age, gender, fracture type, and trauma mechanism. Our secondary objective was to look at the association between modifiable surgery risk variables and postoperative complication rates. The findings will provide insight into the risk factors for early complications following tibial plateau fracture surgery, particularly in patients with Schatzker type IV-VI fractures.

Patients and Methods

Patients

This study is an analytic observational study with a case-control approach, which aims to investigate the early complications after tibial plateau fractures. It was conducted among 407 people over the age of 18, who were treated surgically in the Republican Vilnius University Hospital over the period of 4 years who experienced a tibial plateau fracture. 52 Patients were excluded, who had intervention done in different hospitals, received conservative treatment and if the fracture was pathological of nature. Another exclusion criteria was the absence of preoperative X-rays or/and CTs. Of all the 355 included patients the study was focused on subjects with the presence of complex tibial plateau fractures (IV, V, VI according to Schatzker classification). Which left a total sample group of 181 people. Cases and control groups were determent based on the occurrence of early complications within 6 months. The focused case group therefore composed of a total of 30 subjects and were opposed to a control group of 151. The medical records of these patients will be analysed to evaluate the early complications following tibial plateau fractures and to identify potentially modifiable risk factors associated with early complications.

Methods

Data analysis was conducted using R Statistic Program Version 4.2.3 (R Foundation for Statistical Computing, Vienna, Austria; www.R-project.org). In the overall sample description,

each person counts only once. In other words, one observation was removed for these studies, since a single person is represented twice in the data set. However, in the categorical and continuous descriptive level the two cases that belong to the same person were both considered in the following representations. For categorical variables, the absolute and relative (= %) frequencies are shown. For continuous variables, the mean / standard deviation (SD) and the range is given. This is the range from the minimum to the maximum. For the statistical comparisons, only the no complication and surgery related groups cases are examined. This is because the surgery related factors are modifiable and can therefore be influenced and reduced with certain guidelines. They were evaluated using the Fisher-Test for categorical variables and Kruskal-Wallis-Test for continuous variables. In addition, the Shapiro-Test was used to check whether one cannot assume a normal distribution for the continuous data and in such cases, non-parametric tests like the Kruskal-Wallis-Test is the right choice. The value $p < 0.05$ was used to determine statistical significance for all statistical tests. Odd ratios (OR) and 95% confidence intervals (95% CI) were obtained from multivariable logistic regression to account for the matching variables. A coefficient of determination for association according to Nagelkerke R^2 was also specified (23).

Results

Of the 181 eligible cases, 30 had complications and 151 had none. Descriptive statistics for the cases and controls are shown in Table 1. A 16.6% complication rate is evident, of which 36.6% were trauma related and 70% were surgery related. However, there is some overlap as 2 patients had both complication types. The average age of cases and controls was 54 years old, 51.1% were female and 48.9% were male. Regarding gender, there are clear differences in the proportions. Women predominate in the no complications group with a small majority of 53%, while men predominate in the complication group with 58.6%. The youngest group with a mean age of 53.5 had no complications compared to the complications group being somewhat older with a mean of 56 years of age. 76.7% of patients with complications had a Schatzker type VI fracture, however also half (53.6%) of the subjects without complications. Further analyses of the Schatzker classification including the subdivision of the type of complication are presented in the following (Fig. 3). Most patients did not have an open fracture (97.2%) and did not use external fixation (85.6%). Therefore, it is not surprising that also the majorities with absent complications or present complications had no open fracture (“No Complication”: 98.0%; “Complication”: 93.3%) or external fixation (“No Complication”: 88.1%; “Complication”: 73.3%).

Table 1: Description of samples

	No Complication (N=151)	Complication (N=30)	Total (N=181)
Gender			
F	80 (53.0%)	12 (41.4%)	92 (51.1%)
M	71 (47.0%)	17 (58.6%)	88 (48.9%)
Age			
Mean (SD)	53.497 (16.108)	56.100 (16.697)	53.928 (16.188)
Range	19.000 - 87.000	26.000 - 84.000	19.000 - 87.000
Schatzker			
IV	45 (29.8%)	4 (13.3%)	49 (27.1%)
V	25 (16.6%)	3 (10.0%)	28 (15.5%)
VI	81 (53.6%)	23 (76.7%)	104 (57.5%)
Open Fracture			
-	148 (98.0%)	28 (93.3%)	176 (97.2%)
+	3 (2.0%)	2 (6.7%)	5 (2.8%)
External Fixation			
-	133 (88.1%)	22 (73.3%)	155 (85.6%)
+	18 (11.9%)	8 (26.7%)	26 (14.4%)

Abbreviations: F – female, M – male; - = no, + = yes; SD = standard deviation

The reasons for the complications were either trauma related, or surgery related (Table 2). There were 11 trauma related and 21 surgery related complications, with 2 patients having both. Also, two different trauma and surgery related complications occurred in 2 patients each. 72.7% of trauma related complications were due to neurovascular reasons. The same number of 18.2% (2 times each) had the complications of compartment syndrome and pulmonary embolism, the latter also being fatal in both cases. The majority of surgery related complications were infections with 85.7%. The second most frequent complication were implant failures with 14.3% and with only one occurrence pseudoarthrosis was the rarest complication with 4.8%.

Table 2: Description of complication types

	Trauma related (N=11)	Surgery related (N=21)
Neurovascular Complication	8 (72.7%)	
Compartment Syndrome	2 (18.2%)	
Pulmonary Embolism	2 (18.2%)	
Infection		18 (85.7%)
Implant Failure		3 (14.3%)
Pseudoarthrosis		1 (4.8%)

Most patients had a fall from standing height (31%) as a trauma circumstance, followed by falls from heights greater than 1.5 meters (20%), were falls from ladders and stairs were incorporated. Falls from moving objects, like bicycles or other moving vehicles, was the second to last with 10% and the rarest reason, at 7% was impact (Fig. 2).

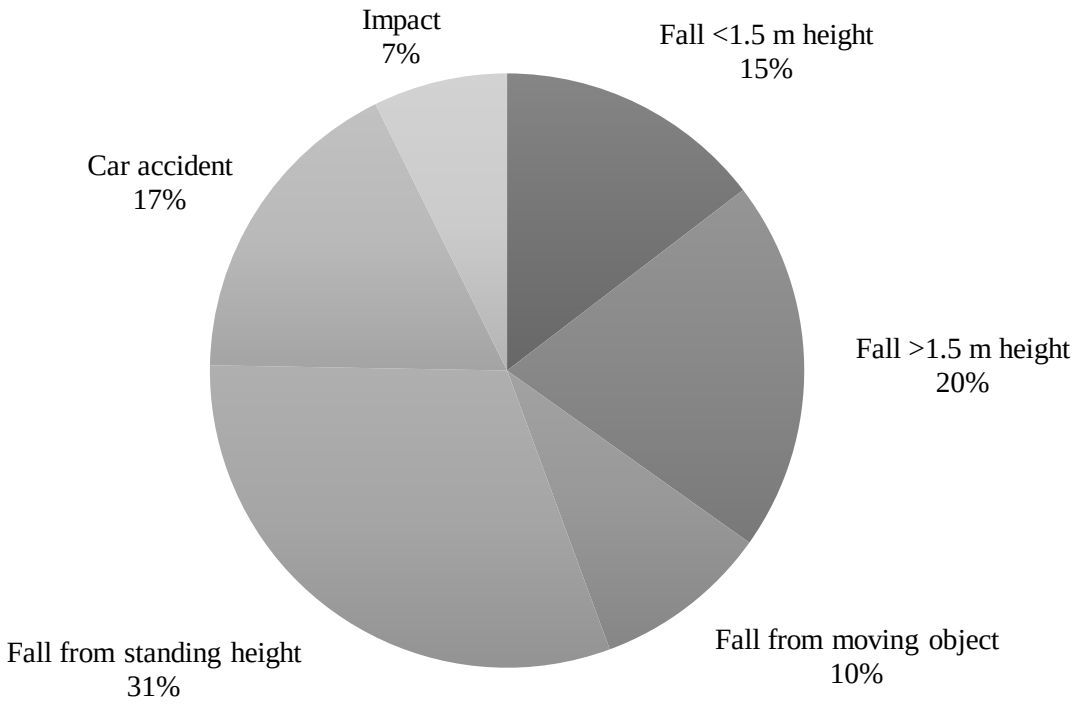

Figure 2: Pie chart for visualisation of percentage of trauma circumstances

Also tabulated is the tendency that the higher the Schatzker classification, the smaller the proportion of no complications. 91.8% with Schatzker classification type IV were free of complications, 89.3% with classification type V, and 78.8% with classification type VI. Thus, the data suggest that higher classifications of fractures are more likely to be associated with complications. However, Schatzker type VI was in general the most represented group with a total of 104, making 57.5% of the total patient pool, compared to a total of 77 of Schatzker type IV and V. The stacked bar chart also further visualises the distribution of complication or no complication groups in the respective Schatzker classifications (Fig. 3). The percentage share is shown in each bar. From left to right the proportion of no complications decreases further and further.

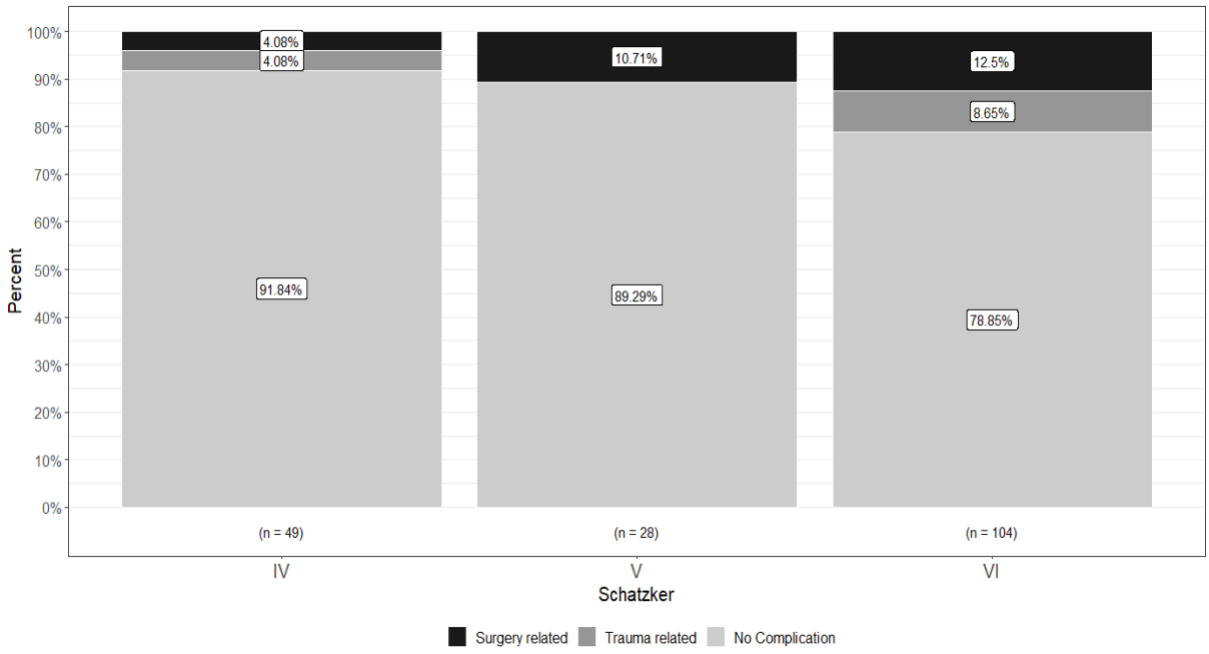

Figure 3: Bar chart for visualisation of percentage of complication and no complication type

When comparing categorial variables (Table 3), 76.5% of surgery related complications had 2 incisions made and 2 plates used. 21.1% who experienced complications had an external fixation, but also 11.8% of those who did not have any complications. Comparable figures of 36.8% for complications and 19.7% for no complications are observed in the use of skeletal traction. A Tourniquet was used in 63.2% for all experiencing complications and 74.8% in the group of no complications. However, all categorical variables were shown to be non-significant at the $p < 0.05$ significance level. The value "1" is the highest possible value visible in patients with additional trauma and open fracture, however this is a non-significant effect. Also, with consideration of the different Schatzker classifications, no significant correlations are found.

Table 3: Comparison of categorical variables

	No Complication (N=152)	Surgery related (N=19)	Total (N=171)	p-value
Gender				0.620
F	80 (52.6%)	8 (44.4%)	88 (51.8%)	
M	72 (47.4%)	10 (55.6%)	82 (48.2%)	
Schatzker				0.189
IV	45 (29.6%)	2 (10.5%)	47 (27.5%)	
V	25 (16.4%)	3 (15.8%)	28 (16.4%)	
VI	82 (53.9%)	14 (73.7%)	96 (56.1%)	

Drain				0.799
-	58 (38.9%)	8 (44.4%)	66 (39.5%)	
+	91 (61.1%)	10 (55.6%)	101 (60.5%)	
Tourniquet				0.280
-	38 (25.2%)	7 (36.8%)	45 (26.5%)	
+	113 (74.8%)	12 (63.2%)	125 (73.5%)	
Side				0.092
L	81 (53.3%)	9 (47.4%)	90 (52.6%)	
R	71 (46.7%)	10 (52.6%)	81 (47.4%)	
Trauma Mechanism				0.149
High-velocity impact	84 (55.3%)	7 (36.8%)	91 (53.2%)	
Low-velocity impact	68 (44.7%)	12 (63.2%)	80 (46.8%)	
Additional Trauma				1
-	130 (85.5%)	16 (84.2%)	146 (85.4%)	
+	22 (14.5%)	3 (15.8%)	25 (14.6%)	
No. of Incisions				0.354
1	60 (40.3%)	4 (23.5%)	64 (38.6%)	
2	87 (58.4%)	13 (76.5%)	100 (60.2%)	
3	2 (1.3%)	0 (0.0%)	2 (1.2%)	
No. of Plates				0.095
1	55 (37.4%)	3 (17.6%)	58 (35.4%)	
2	90 (61.2%)	13 (76.5%)	103 (62.8%)	
3	2 (1.4%)	1 (5.9%)	3 (1.8%)	
Skeletal Traction				0.134
-	122 (80.3%)	12 (63.2%)	134 (78.4%)	
+	30 (19.7%)	7 (36.8%)	37 (21.6%)	
External Fixation				0.275
-	134 (88.2%)	15 (78.9%)	149 (87.1%)	
+	18 (11.8%)	4 (21.1%)	22 (12.9%)	
Open Fracture				1
-	149 (98.0%)	19 (100.0%)	168 (98.2%)	
+	3 (2.0%)	0 (0.0%)	3 (1.8%)	

Abbreviations: F = female, M = male; L = left, R = right; - = no, + = yes; No. = number

However, the statistical comparison of continuous variables shows a significant effect regarding the duration of surgery with a p-value of p=0.002 (Table 4). In the group of individuals with surgery related complications, the mean value for duration of surgery is significantly longer (169 minutes / 2h 49min) than for patients with no complications (130

minutes / 2h 10min). Due to the significant p-value of operation duration, the additional specification of effect sizes is useful to estimate the strength of the effect. With a result of a value of 0.0501, this effect can be described as small. Another observation could be made regarding the length of the hospital stay. Patients who had a surgery related complication (21 days) stayed in the hospital about twice as long as patients who did not have a complication (11 days). With a p-value of p=0.058 however, this variable just misses the $p < 0.05$ cut off limit, which could mean a possible risk but is not statistically significant.

Table 4: Comparison of continuous variables

	No Complication (N=152)	Surgery related (N=19)	Total (N=171)	p-value
Age				0.436
Mean (SD)	53.520 (16.057)	56.947 (17.424)	53.901 (16.196)	
Range	19.000 - 87.000	26.000 - 82.000	19.000 - 87.000	
Hospital Stay				0.058
Mean (SD)	11.928 (10.772)	21.105 (21.323)	12.947 (12.632)	
Range	1.000 - 88.000	2.000 - 83.000	1.000 - 88.000	
Time to Op				0.582
Mean (SD)	7.434 (9.328)	8.316 (7.550)	7.532 (9.133)	
Range	0.000 - 84.000	0.000 - 25.000	0.000 - 84.000	
Time to Hospitalisation				0.765
Mean (SD)	1.257 (3.356)	1.105 (3.635)	1.240 (3.377)	
Range	0.000 - 18.000	0.000 - 16.000	0.000 - 18.000	
Op Duration (min)				0.002
Mean (SD)	129.872 (53.135)	168.529 (45.715)	133.855 (53.605)	
Range	25.000 - 335.000	90.000 - 250.000	25.000 - 335.000	

Abbreviations: Op = operation; SD = standard deviation

When presented separately by Schatzker classifications, significant differences are also seen per group (Fig. 4). Because even divided into the 3 types, the operating time for surgery related complications is longer than those with no complications, especially in Schatzker type VI. Also visible are some outliers, which are visible as a “*“ outside of the boxes.

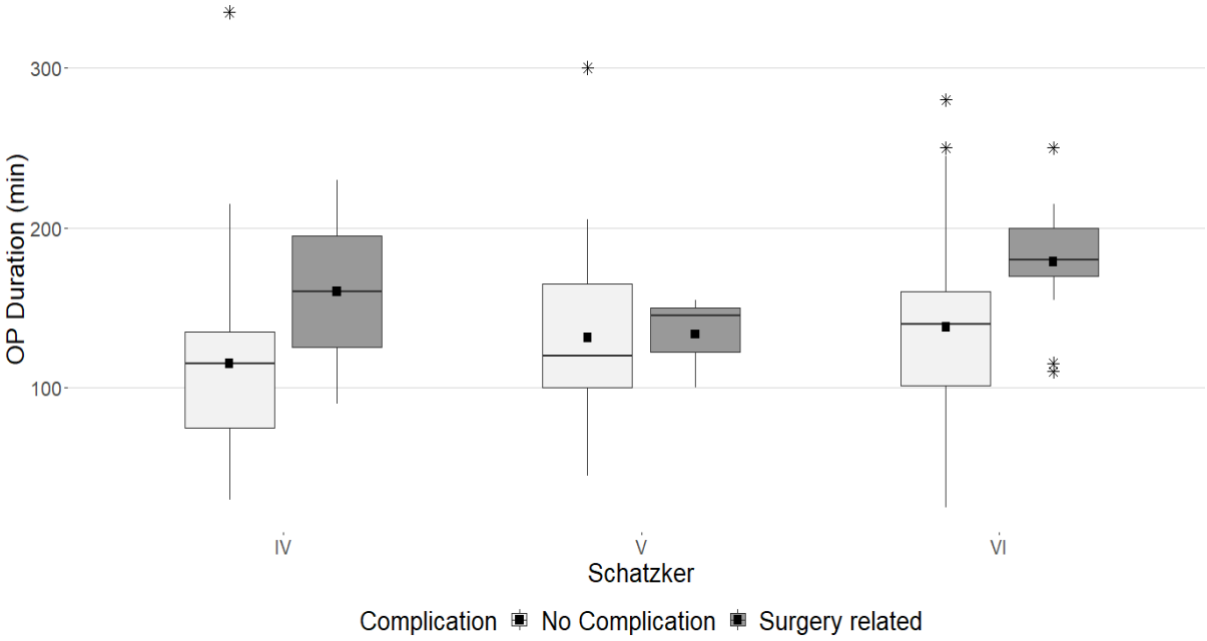

Figure 4: Boxplot representing operation duration separately according to Schatzker classifications comparing complication vs. no complication group

Therefore, comparisons were made with continuous variables for each Schatzker classification group individually. There were no significant effects in Type IV (p=0.460) and V (p=0.766). On the other hand, the length of surgery with Schatzker type VI was found to be significant, with a p-value of p=0.003 (Table 5). Patients with surgery related complications had a significantly longer operation time. The effect size is 0.0833, indicating that this effect is moderate. Again, the length of the hospital stay had a smaller p-value with p=0.264 compared to the other continuous variables with p-values of approximately 0.7 but did not meet the requirements of $p < 0.05$.

Table 5: Comparison of continuous variables of Schatzker classification type VI

	No Complication (N=82)	Surgery related (N=14)	Total (N=96)	p-value
Age				0.747
Mean (SD)	54.927 (14.383)	56.643 (17.491)	55.177 (14.786)	
Range	22.000 - 83.000	26.000 - 82.000	22.000 - 83.000	
Hospital Stay				0.264
Mean (SD)	15.390 (12.347)	24.357 (23.441)	16.698 (14.673)	
Range	2.000 - 88.000	2.000 - 83.000	2.000 - 88.000	

Time to Op				0.775
Mean (SD)	9.939 (11.137)	8.714 (7.660)	9.760 (10.676)	
Range	0.000 - 84.000	0.000 - 25.000	0.000 - 84.000	
Time to Hospitalisation				0.756
Mean (SD)	0.951 (2.964)	0.286 (0.469)	0.854 (2.753)	
Range	0.000 - 17.000	0.000 - 1.000	0.000 - 17.000	
Op Duration (min)				0.003
Mean (SD)	137.846 (49.735)	178.750 (39.088)	143.300 (50.243)	
Range	25.000 - 280.000	110.000 - 250.000	25.000 - 280.000	

Abbreviations: Op = operation; SD = standard deviation

This result of the significance of the operation duration in Schatzker type VI was visualised with another boxplot (Fig. 5). Again, some outliers are visible as "*" outside the boxes. In this diagram, you can also clearly see that the operation time in the surgery related group is always longer, except for the outliers. Surgery times in the no complication group averaged 138 min (2h 18 min), whereas the surgery related group had an average time of 179 min (2h 59min) coming close to 3 hours. This results in a difference of almost three quarters of an hour with 41min.

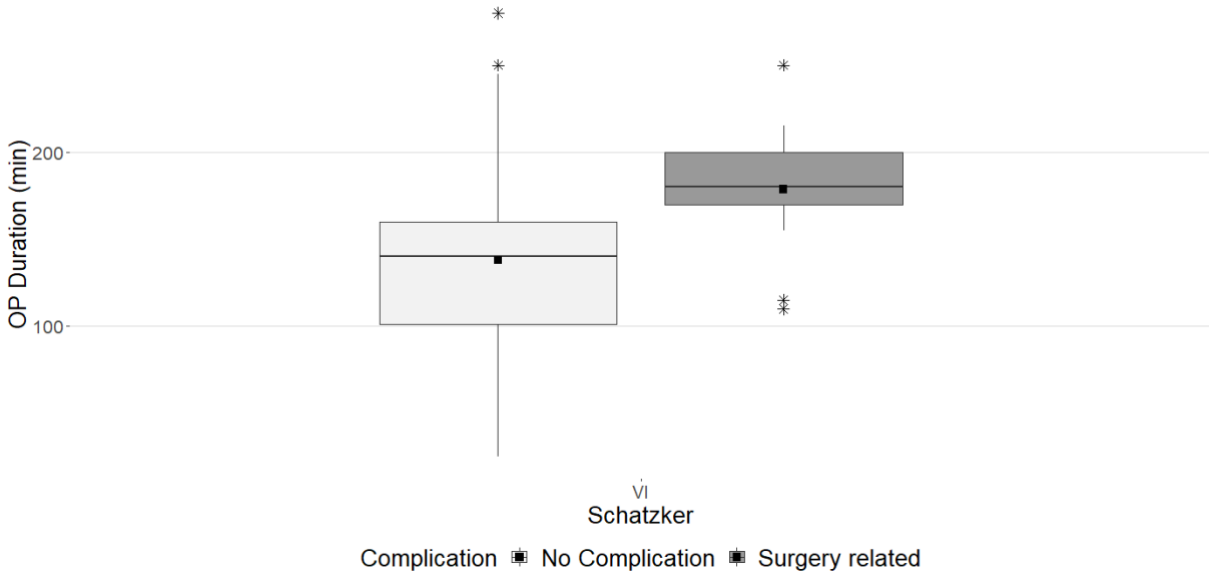

Figure 5: Boxplot representing operation duration according to Schatzker type VI comparing complication vs. no complication groups

Not only are there outliers in the boxplot (Fig. 5) and the number of cases in the surgery related group is small to very small in each case, but the Shapiro Tests also shows significant p-values several times (Normal distribution - "No Complication" p= <0.001; Distribution Schatzker type VI - "No Complication" p=0.03), which indicates a violation of the normal distribution (Table 6).

Table 6: Shapiro-Test to determine normal distribution

Shapiro-Test for normal distribution total		
	W	p-value
No Complication	0.96	<0.001
Surgery related	0.97	0.77

Shapiro-Test for normal distribution Schatzker V		
	W	p-value
No Complication	0.92	0.05
Surgery related	0.88	0.33

Shapiro-Test for normal distribution Schatzker VI		
	W	p-value
No Complication	0.97	0.03
Surgery related	0.94	0.52

Variables that had at least a weak significant effect in the previous comparative tables were used to determine their association to complication rates in the regression analysis. Unfortunately, no statistically significant association was found among the majority of modifiable risk factors. The length of the surgery alone was significantly associated with a higher risk of complication due to $p < 0.05$, as shown in Table 7. The OR for the operation duration was 1.013, with a 95% CI of 1.001 - 1.025 and a p-value of p=0.035. This suggests a significant risks of this variable impacting complication rates and effectively states that for every additional 10 minutes of surgery length, the chance of surgery related complications increases by 1.3%. The remaining variables with an OR greater than 1.0 do not have a 95% CI where both values are >1.0 and hence have a possible risk but are not statistically significant. The coefficient of determination reaches a high quality with a Nagelkerkes $R^2 = 0.301$. A calculated Cook's distance of a maximum of 0.30 is not >1 and therefore, there are no distorting observations. The variance inflation factor (VIF) has a maximum value of 3.202 and

consequently never surpasses 5. As a result, it is safe to assume that there is no multicollinearity.

Table 7: Demonstration of association

	b	SE	z	p-value	OR	95% CI	VIF
Gender M	0.449	0.691	0.65	0.516	1.567	0.403 – 6.265	1.566
Age	0.039	0.025	1.561	0.119	1.039	0.992 – 1.094	1.767
Op Duration (min)	0.013	0.006	2.11	0.035	1.013	1.001 – 1.025	1.454
No. of Incisions	-0.989	0.9	-1.099	0.272	0.372	0.063 – 2.198	2.412
No. of Plates	0.946	0.872	1.085	0.278	2.576	0.461 – 14.715	2.279
Hospital Stay	0.054	0.047	1.145	0.252	1.056	0.959 – 1.159	3.202
External Fixation	-0.561	1.071	-0.523	0.601	0.571	0.051 – 3.904	1.528
Time to Op	-0.057	0.065	-0.872	0.383	0.945	0.821 – 1.062	2.753
Schatzker V	0.921	1.047	0.88	0.379	2.512	0.328 – 23.881	1.373
Schatzker VI	0.834	0.895	0.932	0.351	2.304	0.456 – 17.723	1

Abbreviations: Gender M = male; Op = operation; No. = number
b = unstandardised beta coefficient; SE = standard error of "b"; z = significance of regression coefficient; OR = odds ratio; 95% CI = confidence interval; VIF = variance inflation factor

Nagelkerkes $R^2 = 0.301$

The results of Table 7 were further visualised in Figure 6. The operation duration variable lies entirely to the right of the 95% CI (95% CI: 1.001 – 1.025) and therefore indicated an influence on the occurrence of complication rates. Some variables, such as the length of hospital stays (95% CI: 0.959 – 1.159) and age (95% CI: 0.992 – 1.094) are close, but even if they are practically on one side, they have a modest proportion on the opposite side, albeit slightly.

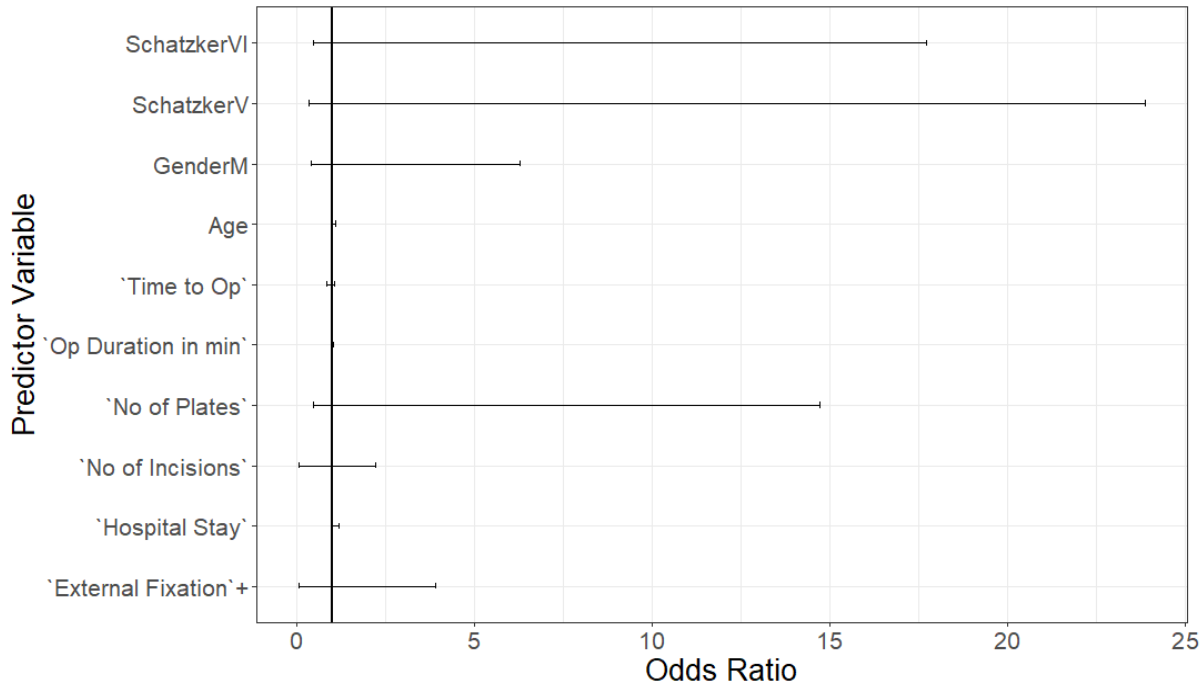

Figure 6: Graphical representation of the odds ratios and the associated confidence intervals

In this analysis, only one modifiable variable could be presented that showed a high significant association with the complication rate. The longer the surgery duration, the higher the risk of suffering a postoperative complication. Therefore, the duration of surgery (OR= 1.013, 95% CI: 1.001 – 1.025, p=0.035) was found to be an independent predicator of complications. The use of external fixation (OR= 0.571, 95% CI: 0.051 – 3.904, p=0.601), the number of incisions (OR= 0.372, 95% CI: 0.063 – 2.193, p=0.272) and the length of hospital stays (OR = 1.056, 95% CI: 0.959 – 1.159, p=0.252) had no significant association.

Discussion

The tibial plateau is an important load-bearing element of the human body. Complex tibial plateau fractures are difficult to treat (24) and had a complication rate of 16.6% in the Republican Vilnius University Hospital, which is in the range of infection rates commonly reported in literature (15). Temporary external fixation prior for acute stabilisation (25) followed by the anatomical reduction with ORIF remains the best treatment option for tibial plateau fractures, especially in high-velocity trauma fractures (17). Prevention of complications is more important than secondary treatment after its occurrence (24). An ideal analysis of the cause of postoperative complications would have to take into consideration an infinite number of variables. For example, factors such as patient characteristics, operational site preparation and draping, antibiotic administration, surgical technique, and postoperative

care could all contribute to a postoperative infection (20). While it is impossible to examine every variable that may influence the rate of postoperative complications, this study focuses on a wide range of patient and injury related variables, with a particular emphasis on treatment variables over which the surgeon has reasonable control. Longer operational periods have been proven to be a major predictor of postoperative complications related to tibial plateau fractures (20). The OR presented in this study effectively states that for every additional 10 min of surgery duration, the chance of surgery related complications rises by 1.3%. Some studies however indicated that every extra 30 minutes of operation time raised the probability by 2.5% (26)(27), while others observed that every extra hour of operative time increased the risk of complication by 78% (15). In this study, the difference in absolute operating times for all procedures between the surgery related complication group and the no complication group was 39 minutes (169 minutes for surgery related complication vs. 130 minutes for no complication). We hypothesise that prolonged operational time is an indication of technical difficulty, including preoperative planning, surgeon experience, surgeon exhaustion, equipment availability, additional traumas, patient compliance, and fracture difficulty, which are associated with greater incidence of complications following surgery (20). Another mentionable modifiable variable was the length of hospital stays. Patients who had a surgery related complication stayed in the hospital about twice as long as patients who did not have a complication. This was not a statistically significant finding, but it was close to the cut-off value at p=0,058. The lengthy hospitalisation could be the source of the surgery related infection, but it could also be attributable to complications that occurred while patients were still in the hospital. Other modifiable variables had no associations that were remotely close to a p <0.05. However, there are interesting results for the variables that are not modifiable. One of the non-modifiable variables is the Schatzker classification type, which was identified in this analysis as an independent predictor of postoperative complication (p=0.002). The association of Schatzker classification type VI with the prevalence of complications is particularly significant (p=0.003). The current literature reports postoperative complication rates ranging from 2% to 13%, with rates increasing with Schatzker type (19).

Because of more extensive soft tissue injury and open contamination of the site with microbial organisms, open fractures are a well accepted risk factor for complications (20). It is therefore surprising, that in our study this variable was found to be not significant and thus no independent predictor of postoperative complications. Nevertheless, we continue to believe that the presence of an open fracture, does indeed play an important role in the development of complications after surgery. Other variables were also found to have no influence on the rate

of postoperative complications, like number of incisions and plates used. However, the number of incisions and plates have been identified as significant risk factors for surgery related complications following tibial plateau fracture in numerous other studies (15).

In short, operating times that are approaching 3 hours (20) and the fracture type VI of the Schatzker classification are independent predictors of complications. Treatment of complex tibial plateau fractures should prioritise immediate reconstruction of the mechanical axis and articular surface with precise soft tissue management (20). Reducing operating times through hasty handling or poor fracture reduction is not acceptable. However, using a staged approach to avoid prolonged wound exposure, cooperating with an experienced support staff, and focusing on other operating room improvements may be beneficial in reducing operative times.

Despite dealing with a highly relevant topic in trauma surgery, our study has some limitations that must be acknowledged. First, patients were operated on by several orthopaedic surgeons. The probability that outcomes were influenced by the expertise of specific surgeons is not possible to rule out entirely. However, all the surgeons had extensive experience managing tibial plateau fractures. Second, the sample size on the subject was rather small, limiting the ability of offering definitive guidance on tibial plateau fracture management.

Conclusions and Recommendations

Conclusions

Although trauma related complications, such as fracture type, trauma mechanism, patient age, and comorbidities, cannot be influenced, good management can reduce or preferably avoid surgery related complications. 36.6% of complications in this study are trauma related and cannot be prevented. Among these variables, only the Schatzker classification is statistically significant. All other variables showed no association of any magnitude. About 70% of complications are surgery related and therefore preventable. Among those, only a significant association was found for the duration of surgery, but not for the time between trauma and surgery, number of incisions, use of external fixation or any other factors. However, the length of hospital stay could be interpreted as a risk, but has no statistical importance.

In conclusion, the current study found that Schatzker type VI and surgical time were significant risk factors for developing complications after surgical treatment of tibial plateau fractures.

Recommendations

Identification of variables associated to postoperative complications will assist surgeons in optimising the surgical process and regulating each patient's state prior to surgery, potentially reducing the occurrence of complications. During this study one modifiable variable showed

significant correlation with the rate of surgery related complications which was the duration of surgery. Surgeries should therefore be conducted as quickly as possible while maintaining good quality. In order to shorten the duration of the procedure while maintaining high quality, a thorough pre-operative assessment and a well thought-out surgical strategy should be provided, taking into account the individual factors of each patient.

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