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Iatrogenic Peroneal Nerve Palsy Rates Secondary to Open Reduction Internal Fixation for Tibial Plateau Fractures Using an Intraoperative Distractor

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Abstract

Objective: To report the rate of peroneal nerve palsy after routine use of intraoperative distraction during open reduction internal fixation (ORIF) for lateral unicondylar and bicondylar tibial plateau fracture (TPF) repairs.

Design: Retrospective chart review

Setting: Level I trauma center

Patients: Patients with traumatic TPF treated with ORIF between 2007 and 2017

Intervention: ORIF for lateral unicondylar and bicondylar TPF.

Main Outcome Measurement: Presence and resolution of neurovascular injury

Results: There were a total of 21 lateral unicondylar and 40 bicondylar TPFs repaired via ORIF in 60 patients identified during the study period with one year follow up and complete records for review. Thirty-six patients had staged external fixation prior to ORIF while 24 were treated with ORIF initially. Of the staged patients, 9 of 36 (25%) developed nerve palsy while those undergoing initial ORIF (not staged) developed palsy in only one case (1 of 24, or 4%). Of the patients who developed nerve palsy 9 of 10 (90%) were staged with an initial external fixator prior to ORIF. The incidence of iatrogenic peroneal nerve palsy secondary to intraoperative distraction was 16.4% (10 of 61). Only 60% (6 of 10) of peroneal nerve palsies recovered clinically with a mean recovery time of approximately 14 weeks. Comparison of demographics in patients with peroneal nerve palsy versus those without yielded no significant difference by sex (p = 0.08), age (p =0.27), fracture type (p = 0.29), tobacco use (p = 0.44) or alcohol use (p = 0.78).

Conclusions: Peroneal nerve palsy is a common sequela of ORIF for TPFs involving the lateral compartment utilizing an intraoperative distractor. Staged external fixation followed by definitive ORIF using intra-operative distraction, was associated with significant risk for developing nerve palsy (9/10). Many patients (40%) who develop peroneal nerve palsies do not recover, leading to permanent loss of motor and/or sensory function for 7% of patients studied. None of the epidemiologic variables evaluated yielded predictive value for development of peroneal nerve palsy or subsequent resolution. Caution should be exercised in avoiding over distraction when using intraoperative distraction, especially in those cases that had staged fixation, most notably bicondylar injuries.

Level of Evidence: 4

Keywords: Tibia; plateau; fracture; peroneal; nerve; palsy; iatrogenic; complication; distraction; traction; staged

Introduction

The peroneal nerve is the most vulnerable nerve in the lower extremity to traction-type injury due to its close anatomical association with the fibular head [1]. While several case reports describe iatrogenic causes of peroneal nerve palsy secondary to intraoperative skeletal traction in the setting of lower extremity injury [1-5], no previous series have quantified the rates of peroneal nerve palsy as a sequela of open reduction internal fixation (ORIF) for tibial plateau fracture (TPF) repair.

The purpose of this review is to investigate the rate of iatrogenic peroneal nerve palsy in association with ORIF for TPF involving the lateral tibia plateau when using intraoperative distraction, along with the clinical sequela and epidemiology under a single surgeon at a high-volume, level I trauma center. This data may prove beneficial when assessing future patients with similar injuries by providing prognostic value to patient outcomes.

Methods

One hundred twenty-four patients that underwent ORIF for TPF were identified, 10 were excluded as isolated medial unicondylar tibial plateau fractures. Of the remaining 114 patients, complete medical records with one year follow up were available for 64 patients. An additional 4 patients were excluded due to development of compartment syndrome, leaving a total of 60

patients for this review. Of these 60 patients, 21 lateral unicondylar and 40 bicondylar TPFs underwent surgical ORIF. All cases utilized a femoral distractor (Synthes, U.S.A., Paoli, Pa.) to provide intraoperative traction, pneumatic tourniquet to mitigate intraoperative blood loss, and regional nerve block.

Clinical examinations were performed in the pre-operative setting, inpatient post-operative setting, and subsequent follow-up clinic visits. For the subject to be placed in the peroneal nerve palsy group, there must have been at least one of the following clinical findings documented in the electronic medical record: (1) Motor –loss of motor function to the Tibialis Anterior or Extensor Hallucis Longus. This typically manifested clinically as some degree of foot drop noted on examination. Foot eversion was not consistently assessed; (2) Sensory – Deficits of superficial cutaneous sensation to either the anterolateral lower leg/dorsum of foot (superficial fibular) or between 1st and second digits (deep fibular). This was assessed as sensation to light touch by the clinical examiner.

Statistical analysis of continuous variables was performed using the Mann-Whitney U Test with descriptive statistics reported as mean and SD. Statistical analysis of categorical variables was performed using the Pearson Chi-Square test with descriptive statistics reported as percentages and frequencies.

Surgical Technique

All patients received a pre-operative regional block and intraoperative non-sterile tourniquet. A femoral distractor was used in all cases to achieve direct visualization of the lateral tibia plateau. Self-tapping 4.5 Schanz pins were placed in the distal femur and distal tibia using percutaneous lateral approach techniques with a triple trochar to avoid nerve injury. A

curvilinear lateral approach was used with a submeniscal arthrotomy in all cases. A medial approach was routinely used for bicondylar tibia plateau fractures, with the approach taken either posterior or anterior to the deep MCL dictated by the fracture pattern. Medial approaches taken anterior to the deep MCL were typically performed using minimally invasive techniques. If a posterior medial fracture required a posterior medial plate, this was not done using minimally invasive techniques, but a full open approach was used. In all cases, dissection for the lateral approach was kept between the lateral collateral ligament and patellar tendon. Enough distraction was achieved to allow visualization of the lateral articular surface of the plateau, and distraction was removed as soon as articular reduction had been achieved in all cases. No intraoperative distraction or tourniquet time exceeded 2 hours.

Results

There were a total of 60 patients with 61 TPFs involving the lateral compartment who underwent ORIF repair during the 10-year study period. Of these 61 cases, 16% (10 of 61) subsequently developed peroneal nerve palsies in the postoperative setting, as determined by loss of motor function, sensory function, or both on documented physical examination. Sixty percent (6 of 10) of these patients experienced complete clinical resolution of symptoms with a mean recovery time of approximately 14 weeks (*SD* = 13.5; range = 1.5 – 39). Of the patients who recovered, 67% (4 of 6) did so in 6 weeks or less.

Of the 61 cases 64% (39 of 61) were male and 36% (22 of 61) were female. The average patient age was 46 years (*SD* = 11.7; range: 25-70). Regarding fracture type, 66% (40 of 61) of TPFs were bicondylar fractures while 34% (21 of 61) were lateral unicondylar fractures.

Admitted tobacco and alcohol use was 59% (36 of 61) and 34% (21 of 61), respectively (Table 1).

Of the patients who developed peroneal nerve palsies, 40% (4 of 10) were male and 60% (6 of 10) were female, with an average age of 42 years (*SD* = 11.7; range 25-61). Eighty percent (8 of 10) of peroneal nerve palsies developed in the bicondylar fracture setting while 20% (2 of 10) occurred with lateral unicondylar fractures. In patients staged with an initial external fixator followed by definitive ORIF, the external fixator was placed using percutaneous techniques and traction manually applied to achieve appropriate reduction. Three unicondylar fractures required staged treatment and 33 bicondylar. Of the 3 unicondylar fractures requiring staged treatment, one developed a nerve palsy and 2 did not. Of the 33 bicondylar tibia plateau fractures treated staged, 8 developed a nerve palsy and 25 did not. The rate of tobacco use was 70% (7 of 10) and the rate of alcohol use was 40% (4 of 10). When compared to cases that did not develop a peroneal nerve palsy, there were no significant differences by sex (p = 0.08), age (p = 0.27), fracture type (p = 0.29), tobacco use (p = 0.44) or alcohol use (p = 0.78) (Table 2).

The average OR time (patient in room to patient out of room time) for patients who did not develop a nerve palsy was 249 minutes vs. 274 minutes for those who did develop palsy (p = 0.47). The average tourniquet time for those without palsy was 106 minutes vs 104 minutes for those who developed palsy (p = 0.82) (Table 3).

Thirty-six patients had staged external fixation prior to ORIF while 24 were treated with ORIF initially. Of the staged patients, 9 of 36 (25%) developed nerve palsy while those undergoing initial ORIF (not staged) developed palsy in only one case (1 of 24, or 4%), with staged fixation a significant risk factor vs. primary ORIF (p=0.034) for the development of nerve

palsy. Of the patients who developed nerve palsy 9 of 10 (90%) were staged with an initial external fixator prior to ORIF (Table 4).

Discussion

Peroneal nerve palsy is an established complication of skeletal traction in lower extremity injuries, leading to pain, numbness, and, in severe cases, loss of foot dorsiflexion and eversion [6]. Although potentially devastating, iatrogenic peroneal nerve palsies due to skeletal traction in the setting of fracture are scantly described in the literature, with the majority of articles consisting of case reports containing 1 or 2 patients [1-3,5]. None of the palsies described in these reports were associated with intraoperative traction for TPF repair via ORIF.

One of these reports details a 42-year-old man who sustained a closed Schatzker VI TPF from a high-speed skiing accident who underwent irrigation debridement, and revision external fixation after presenting with infection 7 days after initial external fixation for his injury [2]. The patient developed an associated peroneal nerve palsy 1-hour postoperatively while still in the post-anesthesia care unit (PACU). Due to concerns of nerve traction injury, tension on the external fixation device was relieved and both sensory and motor function were restored within 3 minutes with no subsequent complications [2]. This was the only reported case of iatrogenic peroneal nerve palsy in the setting of TPF we were able to find. This is consistent with our findings that patients with a staged approach with initial external fixation following by ORIF appeared to be at increased risk for nerve palsy. This could represent a selection bias of the most severe injuries with significant soft tissue injury or could be directly related to the staged approach itself regardless of fracture pattern.

Importantly, none of the peroneal nerve palsies in our study were identified after initial external fixation, but rather were found after staged ORIF with intraoperative distraction of less than 2 hours. The senior author has reduced the time the patient is in intraoperative distraction over the course of his career due to this concern. A temporal analysis was performed to determine if the senior surgeon's nerve palsy rate decreased over time as one might expect; however, no association was found over his 13 years in practice.

The demographics of patient sex and age in our series closely resembled those found in previous analysis of TPF demographics. An investigation encompassing 988 TPFs over a 10-year period reported 62% of patients were male with an average age of 44 years [7]. Additionally, a Brazilian retrospective study analyzing 239 TPFs treated surgically indicated that 70% of patients were male with an average age of 44 years [8]. While these metrics had no bearing on iatrogenic palsy rates, our study supports prior findings that most patients who suffer traumatic TPFs are male and in the fourth decade of life [7,8].

Tobacco and alcohol use have proven deleterious effects on peripheral nerve homeostasis, leading to nerve degeneration and increased risk of injury in the perioperative setting [9-12]. While our study concluded tobacco had no effect on development of palsy (p = 0.44), 70% (7 of 10) patients who developed a palsy admitted to tobacco use. This number is far above the 24% tobacco use rate of the state population in which this study was conducted [13], indicating tobacco use as a potential avenue for future investigation.

It is important to note that mechanisms such as pneumatic tourniquet-related ischemia and anesthetic neurotoxicity may also be factors contributing to the reported peroneal nerve palsy rates in this series. While both are potential etiologies of nerve palsy, multiple studies have shown no significant association between persistent lower extremity nerve palsy and pneumatic

tourniquet application [14-17] and the reported rates of neuropathic symptoms as a result of peripheral nerve blockade are typically <1% [18-20]. The reported causative nature of these mechanisms alone do not explain the conclusions of this study, demonstrating the role intraoperative skeletal traction likely plays in peripheral nerve palsy development.

Although there are case reports of delayed diagnosis of compartment syndrome with regional nerve block[21-22], there are multiple larger prospective studies showing the safety and increased patient satisfaction with regional nerve block which has become routine at many trauma centers[23-25]. However, missed compartment syndrome associated with regional nerve block is a potential contributor to the complication rate reported in this series.

In conclusion, this study details the first comprehensive review of the rate of iatrogenic peroneal nerve palsy associated with a staged approach of external fixation and ORIF with the use of intraoperative skeletal traction with pneumatic tourniquet and regional nerve block in patients who underwent ORIF for TPF repair. While the majority (60%) of patients with nerve palsy experienced complete resolution of symptoms, 6.6% (4 of 61) of total cases in our review of high energy plateau fractures resulted in permanent loss of peroneal nerve function. It is our suggestion that in cases using staged external fixation, great care be employed when subsequently applying intra-operative distraction, as this may cause a palsy, especially in bicondylar fractures.

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Legend:

Table 1: Demographics comparing those who developed peroneal nerve palsy with those who did not.

Table 2: Characteristics of patients who developed peroneal nerve palsy

Table 3: Differences in OR and tourniquet time by those with and without peroneal nerve palsy

Table 4: Peroneal nerve palsies between those with primary and staged ORIF

TABLE 1. Patient Demographics			
Patient Data	**No Palsy**	**Palsy**	***p-value***
Gender			*0.08*
Male	35	4	
Female	16	6	
Mean Age (yrs)	47	42	*0.27*
Tobacco Use (%)	29 (57%)	7 (70%)	*0.44*
EtOH Use (%)	17 (33%)	4 (40%)	*0.78*
OTA Classification			*0.29*
41-B1	3	0	
41-B2	4	0	
41-B3	14	2	
41-C1	2	1	
41-C2	5	1	
41-C3	23	6	

TABLE 2. Demographics of Peroneal Nerve Palsy Patients								
Patient	**Sex**	**Age** (yrs)	**OTA Classifcation**	**Resolution**	**Time** (wks)	**Palsy Type**	**Tobacco**	**EtOH**
1	F	39	41-C3	Y	25	Motor	Y	N
2	F	54	41-C1	N	-	Motor	N	N
3	F	46	41-C2	Y	39	Motor	Y	Y
4	F	48	41-C3	N	-	Sensory	N	N
5	M	36	41-C3	N	-	Both	Y	N
6	M	36	41-C3	Y	6	Sensory	Y	N
7	M	50	41-C3	N	-	Both	N	Y
8	F	26	41-B3	Y	6	Sensory	Y	Y
9	F	25	41-C3	Y	6	Both	Y	N
10	M	61	41-B3	Y	1.5	Both	Y	Y

Table 3. Differences in OR and tourniquet time by those with and without peroneal nerve palsy

Variable	No Palsy	Palsy	P value
OR time (mins)	249	274	0.47
Tourniquet time (mins	106	104	0.82

Table 4. Peroneal nerve palsies between those with primary and staged ORIF

Staged	Palsy	No Palsy	% palsy	P value
Yes 36	9	27	25	0.034
No 24	1	23	4.2	