Tibial Shaft and Pilon Fractures With Associated Syndesmotic Injury: A Matched Cohort Assessment

Kevin F. Purcell, MD, MPH, MS,[a] Patrick F. Bergin, MD,[a] George V. Russell, MD, MBA,[a] Matt L. Graves, MD,[a] LaRita C. Jones, PhD,[a] and Clay A. Spitler, MD[b]

Objective: To determine the outcomes of pilon and tibial shaft fractures with syndesmotic injuries compared with similar fractures without syndesmotic injury.

Design: Retrospective case–control study.

Setting: Level 1 trauma center.

Patients/Participants: All patients over a 5-year period (2012–2017) with tibial shaft or pilon fractures with a concomitant syndesmotic injury and a control group without a syndesmotic injury matched for age, OTA/AO fracture classification, and Gustilo–Anderson open fracture classification.

Intervention: Preoperative or intraoperative diagnosis of syndesmotic injury with reduction and fixation of both fracture and syndesmosis.

Main Outcome Measurement: Rates of deep infection, nonunion, unplanned reoperation, and amputation in patients with a combined syndesmotic injury and tibial shaft or pilon fracture versus those without a syndesmotic injury.

Results: A total of 30 patients, including 15 tibial shaft and 15 pilon fractures, were found to have associated syndesmotic injuries. The matched control group comprised 60 patients. The incidence of syndesmotic injury in all tibial shaft fractures was 2.3% and in all pilon fractures was 3.4%. The syndesmotic injury group had more neurologic injuries (23.3% vs. 8.3% $P = 0.02$), more vascular injuries not requiring repair (30% vs. 15%, $P = 0.13$), and a higher rate compartment syndrome (6.7% vs. 0%, $P = 0.063$). Segmental fibula fracture was significantly more common in patients with a syndesmotic injury (36.7% vs. 13.3%, $P = 0.04$). Fifty percent of the syndesmotic injury group underwent an unplanned reoperation with significantly more unplanned reoperations (50% vs. 27.5%, $P = 0.04$). The syndesmotic group had a significantly higher deep infection rate (26.7% vs. 8.3% $P = 0.047$) and higher rate of amputation (26.7% vs. 3.3% $P = 0.002$) while the nonunion rate was similar (17.4% vs. 16.7% $P = 0.85$).

Conclusions: Although syndesmotic injuries with tibial shaft or pilon fractures are rare, they are a marker of a potentially limb-threatening injury. Limbs with this combined injury are at increased risk of deep infection, unplanned reoperation, and amputation. The presence of a segmental fibula fracture should raise clinical suspicion to evaluate for syndesmotic injury.

Key Words: tibial shaft, pilon, syndesmosis, open fracture, segmental fibula

Level of Evidence: Prognostic Level III. See Instructions for Authors for a complete description of levels of evidence.

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INTRODUCTION

Distal tibiofibular syndesmotic injuries have been extensively studied in rotational ankle fractures,[1–4] and malreduction of the syndesmosis and missed syndesmotic injuries lead to poorer functional outcomes. Even with recognition and reduction, the presence of a syndesmotic injury is associated with poorer function.[5–9] Although more common in ankle fractures, high-energy tibial shaft and pilon fractures can also lead to instability of distal tibiofibular joint.[10–12] Injuries to the proximal tibiofibular joint have also been noted to be a marker for increased complications in proximal tibia fractures.[13]

Most injuries to the syndesmosis are the result of a rotational force applied to the ankle, but there are a myriad of mechanisms that can cause fractures in the tibia.[7] Multiple previous studies have investigated the incidence of ankle injuries in tibial shaft fractures, and involvement of the ankle has been noted in 9%–64% of tibial shaft fractures, depending on fracture location.[10–12] The use of computed tomography (CT) scan in fractures of the distal one-third tibia has increased the preoperative diagnosis of associated ankle fractures, but even CT scan can overlook some occult injuries.[14] Most of the investigation of ankle injuries in tibial shaft fractures has focused on the posterior malleolus with relatively little discussion on the syndesmosis.[14–20]

Herzog et al[13] described the outcomes of tibial fractures with an associated proximal tibiofibular dislocation. Their work clearly demonstrated that the presence of a proximal tibiofibular joint dislocation in the setting of a tibial plateau

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From the [a]Department of Orthopaedic Surgery and Rehabilitation, University of Mississippi Medical Center, Jackson, MS; and [b]Department of Orthopaedic Surgery, University of Alabama at Birmingham, Birmingham, AL.
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Reprints: Clay A. Spitler, MD, Department of Orthopaedic Surgery, University of Alabama at Birmingham, 510 20th St South, Birmingham, AL 35294 (e-mail: caspitler@uabmc.edu).

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or shaft fracture was indicative of a severe injury with high rates of compartment syndrome and peroneal palsy. We believe that the combination of a tibial shaft or pilon fracture and a longitudinal disruption of the interosseous membrane and syndesmosis in the distal tibiofibular joint has significant consequences and indicates a more severe injury than an isolated tibial shaft or pilon fracture without syndesmotic disruption. The purpose of this study was to investigate the outcomes of distal tibiofibular disruption in tibial shaft or pilon fractures and compare them with similar fractures without a syndesmotic injury. We hypothesized that concomitant distal tibiofibular disruption would serve as a marker of severe injury and this injury pattern would lead to worse clinical outcomes in tibial shaft or pilon than isolated tibial shaft and pilon fractures.

MATERIALS AND METHODS

After receiving Institutional Review Board approval, a retrospective review was performed of all patients who sustained a tibial shaft and/or pilon fracture and an associated injury of the distal tibiofibular syndesmosis over a 5-year period (July 2012–July 2017) at a single Level 1 trauma center. All patients were treated by 1 of the 4 orthopaedic trauma surgeons (G.V.R., M.L.G., P.F.B., and C.A.S.) at our facility. An institutional database was used to identify all patients with an operative tibial shaft (n = 652) or pilon fracture (n = 441) over the study period. We then identified all patients who had a syndesmotic injury within this cohort. Syndesmotic injury was defined as any radiographic evidence of static or dynamic widening of the distal tibiofibular clear space on intraoperative fluoroscopy after definitive stabilization of the tibia (see **Figures**, **Supplemental Digital Contents 1 and 2**, http://links.lww.com/JOT/B511 and http://links.lww.com/JOT/B512). Posterior malleolar fractures were not considered syndesmotic injuries. It is our standard practice to assess the stability of the distal tibiofibular syndesmosis with dynamic dorsiflexion external rotation testing at the conclusion of every tibial shaft or pilon fracture case. If there was any ambiguity about syndesmotic injury, a Cotton test was performed to confirm syndesmotic disruption when an open approach to the fibula had already been performed.[21] All patients with syndesmotic injury were treated with reduction and stabilization of the syndesmosis (see **Figure**, **Supplemental Digital Content 3**, http://links.lww.com/JOT/B513). Open reduction of the syndesmosis was not performed unless direct visualization was possible through the existing surgical approach. Reduction of the syndesmosis was performed as described by Summers et al. All syndesmotic injuries were fixed with one or two 3.5-mm quadricortical screws. All syndesmotic reductions were deemed to be within 1 mm of replicating the contralateral ankle on plain mortise and lateral radiographs immediately postoperatively. On identification, qualifying patient participants were grouped according to whether they experienced a tibial shaft or pilon fracture with ("syndesmosis group") or without a syndesmotic injury. From those patients without a syndesmotic injury, a 2:1 matched cohort was created using the institutional database. The control group was matched to the "syndesmosis group" for age, Orthopaedic Trauma Association/AO (OTA/AO) fracture classification,[22] and Gustilo–Anderson (GA) open fracture classification[23] by an author who was blinded to patient outcomes. When perfect agreement for each patient was not possible, we defaulted to a more severe injury being included in the control group (ie, older patient or higher GA classification).

Patient charts and radiographs were reviewed for demographic information, comorbidities, tobacco consumption, length of follow-up, mechanism of injury, associated neurovascular injuries, compartment syndrome, associated visceral or appendicular injuries, and fracture patterns. The exclusion criteria were skeletal immaturity, limbs without adequate distal perfusion (GA type 3C fractures), and lack of adequate follow-up. Follow-up required in both groups was until bony union or the development of a significant postoperative complication (defined as deep infection, amputation, unplanned return to the operating room, or nonunion). Outcomes analyzed included neurovascular injury, deep infection, nonunion, unplanned reoperation, and amputation. The syndesmotic group (pilon and shaft fractures) and pilon control group were restricted to 10–12 weeks of limited weight-bearing while the tibial shaft fracture control group patients were allowed weight-bearing to tolerance. Neurologic injury was defined as partial or complete motor impairment and/or abnormal/absent sensation in a dermatomal pattern. Vascular injuries not requiring repair were identified either on CTA or by direct observation during open fracture debridement. Deep infection was characterized as any infection that warranted a return to the operating room for irrigation and debridement with administration of postoperative intravenous antibiotics. Nonunion was defined as any patient who required a return to the operating room for the purpose of promoting bone healing (including planned staged bone grafting of segmental bone defects treated with the induced membrane technique). The minimum follow-up period was to bony union for all patients (patients with a major complication [infection, nonunion, and amputation] before union were included). A composite variable of reoperation for any reason was also assessed: these reoperations included nonunion, infection, implant removal, and gastrocnemius recession. To analyze our variables of interest, we used the Fisher exact test and χ^2 analyses for categorical variables and Student t tests for continuous variables. Statistical significance was defined as a P value <0.05.

RESULTS

A total of 30 patients with a tibial shaft or pilon fracture (15 pilon and 15 tibial shaft fractures) with associated syndesmotic injury were identified and included in the study group. The control group comprised 60 patients who were matched for age, GA classification, and OTA/AO fracture classification. The incidence of syndesmotic injury over the study period was similar in tibia shaft fractures (2.3%) and pilon fractures (3.4%) (P = 0.292). The average length of follow-up was 446 days (9–1380) in the syndesmosis group and 458 days in the control group. The rate of staged management with an external fixator in the syndesmotic group was 47%, whereas the rate of external fixation was 50% in the control group.

The demographic and injury classification comparisons between the 2 groups are detailed in Table 1. There were no statistical differences between the groups' demographics and injury classifications. There were no GA IIIC fractures included in either group, but both groups had patients who sustained arterial injuries that did not warrant surgical intervention per vascular surgery consultation because all limbs remained perfused distally. There were no differences between the 2 groups in time to antibiotic administration or operative debridement in open fracture management.

The syndesmosis group had higher rates of neurologic injury (23.3% vs. 8.3%; $P = 0.02$), vascular injury (30% vs. 15.7%, $P = 0.13$), and compartment syndrome (6.7% vs. 0%, 9 = 0.063) in comparison with the control group (Table 2). Neurologic injuries included only 4 sensory and 3 motor and sensory deficits. At the final follow-up, only 28.6% (2 of 7 patients) of the neurologic injuries had shown partial recovery; both nerve recoveries were partial motor recovery. Despite the OTA/AO fracture classification matching identically, the syndesmotic group had a significantly higher rate of segmental fibula fracture (36.7% vs. 13.3%; $P = 0.04$).

The clinical outcomes of the 2 groups are listed in Table 3. The 2 groups had similar rates of nonunion (17.4% vs. 16.7 $P = 0.85$) and segmental bone defects after open fracture debridement (6.7% vs. 10%, $P = 0.26$). Patients with segmental bone defects had antibiotic cement spacers placed and underwent planned staged bone grafting to promote bony healing and were included as nonunions. The syndesmotic injury group underwent significantly more unplanned reoperations than the control group (50% vs. 26.7%, $P = 0.04$), developed significantly more deep infections (26.7% vs. 8.3%, $P = 0.047$), and required amputation more frequently (26.7% vs. 3.3%; P 0.002) (Table 3). Unplanned reoperation causes in the study group included 5 for nonunion, 8 for deep infection, and 2 for painful retained implants with associated gastrocnemius equinus.

In the analysis of the tibial shaft fractures with syndesmosis injury, the syndesmotic injury group had higher rates of reoperation ($P = 0.16$), number of reoperations ($P = 0.23$), deep infection ($P = 0.17$), and amputation ($P = 0.49$) (Table 4).When analyzed separately, pilon fractures with syndesmosis injury had higher rates of reoperation($P = 0.24$), number of reoperations($P = 0.035$), deep infection($P = 0.18$), and amputation($P = 0.002$) (Table 5).

DISCUSSION

In this case–control study, we found that a concomitant syndesmotic injury with a tibial shaft or pilon fracture was associated with significantly higher rates of neurologic injury, reoperation, deep infection, and amputation than the control group without a syndesmotic injury. We believe that the data support the identification of a distal syndesmotic injury in a tibial shaft or pilon fracture as a marker of a severely traumatized limb, similar to a proximal tibiofibular dislocation as described by Herzog et al.[13] The recognition of this combined injury can be used in addition to other known risk factors to provide some prognostic information to the patient and surgeon about the severity of the injury. The outcomes of tibial shaft fractures and the incidence and sequela of some concomitant ankle injuries have been well described[24–32]; however, there is no previous study analyzing the outcomes of syndesmotic injury in tibial shaft and pilon fractures. Syndesmotic fixation in pilon fractures has recently been encouraged for patients with syndesmotic and "syndesmotic equivalent" injuries (small fracture fragments of the tibia or fibula at the level of the syndesmotic attachments) as a means to decrease the rate of posttraumatic arthritis.[11] In this study, there was a significantly higher rate of complications despite recognition and treatment of the syndesmotic injury. The injuries assessed in our study were all purely ligamentous injuries unlike in the study by Haller et al who also included syndesmotic equivalent injuries, and this might account for some of the differences in outcomes.

TABLE 1. Demographics and Injury Classifications

	Syndesmosis Group (n = 30)	Control Group (n = 60)	P
Age	40.9	41.0	0.96
Female	33.3%	36.7%	0.76
OTA/AO 43A	3.3%	3.3%	1.00
OTA/AO 43B	20%	20%	1.00
OTA/AO 43C	20%	23.3%	0.72
OTA/AO 42A	10%	3.3%	0.20
OTA/AO 42B	23.3%	23.3%	1.00
OTA/AO 42C	26.7%	26.7%	1.00
Open fracture	63.3%	66.6%	0.21
Gustilo–Anderson 3A	43.3%	35%	0.85
Gustilo–Anderson 3B	20%	20%	0.65
Smoker	36.7%	53.3%	0.11
Diabetes	16.7%	30%	0.16
Ipsilateral fractures	36.7%	56.7%	0.08

TABLE 2. Injury Characteristics

	Syndesmosis Group (n = 30)	Control Group (n = 60)	*P*
Segmental fibula fracture (%)	36.7	13.3	0.04*
Vascular injury (%)	30	15	0.13
Neurologic injury (%)	23.3	8.3	0.02*
Compartment syndrome (%)	6.7	0	0.063
Required flap coverage (%)	20	23.3	0.65
Average time to antibiotics (min)	52.5	96	0.55
Average time to debridement in open fractures (min)	146	224	0.41

*Significance level was set at $P < 0.05$.

We believe that the increased rate of complications seen in these combination injuries indicates a higher amount of energy absorbed by the limb at the time of injury than similar fractures without a syndesmotic injury. This is suggested in our data by higher rates of neurologic and vascular injury and postsurgical soft tissue complications/infection in the syndesmotic group. We believe that this indicates the severity of injury and energy imparted to the limb are among the most important factors associated with complications in these patients.

When analyzed separately with their respective controls, the pilon and shaft groups had similar outcomes with the exception of a trend toward a higher rate of amputation in the pilon group (40% vs. 12%, $P = 0.09$) (Tables 4 and 5). We account the higher rate of amputation as most likely because of the limited soft tissue coverage options in the distal tibia, but the small size and retrospective nature of the study do not allow us to make definitive conclusions regarding this difference. Although tibial shaft and pilon fractures historically have different sets of complications inherent to the injury, the pilon and shaft fractures with syndesmosis injury in this series had very similar complication profile in relation to both bone healing and soft tissue/infection-related complications. The diagnosis of syndesmosis injury in these fractures can allow surgeons to provide more complete counseling to patients in the perioperative period.

Although these combined injuries are rare, we do believe that the timely diagnosis of syndesmotic injury is crucial to be able to provide optimal care and prevent later complications.[11] We found that a segmental fibular fracture was significantly more common in patients with syndesmotic injuries. Although it is our practice to fluoroscopically assess the stability of the syndesmosis at the conclusion of fracture fixation in all tibial shaft, pilon, and ankle fractures, preoperative identification of a segmental fibula fracture should heighten all surgeons' attention to the possibility of a syndesmotic injury.

The limitations of this study are primarily related to its retrospective nature, lack of functional outcomes, and relatively small sample size. Fortunately, these combination injuries are rare, but their frequency makes them challenging to study and a larger multicenter study would provide more information. In addition, the size of the study precluded the use of multivariate analysis of independent risk factors. Vascular injuries were identified by either the use of CT angiography (CTA) or direct observation during open fracture debridement, and we acknowledge that CTA was not used in every case, which could be a confounding factor. However, the same clinical criteria for CTA were used in both the injury and control groups which would limit the impact of the lack of uniformity. The control group was composed of fractures matched for age, OTA/AO fracture classification, and GA open fracture classification. Whenever an exact match was not possible to obtain a fair comparison of the groups, a more severe injury was selected for the control group (this typically meant selecting a higher GA classification). We used a 2:1 comparison group to improve the quality of the comparison group but were not able to use a 3:1 control group because of an inadequate number of GA 3B fractures to be included in the control group during the study period. It is also possible

TABLE 3. Comparison of Postoperative Outcomes

	Syndesmosis Group (n = 30)	Control Group (n = 60)	*P*
Patients requiring reoperation (%)	50	26.7	0.04*
Average no. of reoperations per patient	1.3	0.50	0.01*
Segmental bone defect (%)	6.7	10	0.26
Nonunion (%)	17.4	16.7	0.85
Deep infection (%)	26.7	8.3	0.047*
Amputation (%)	26.7	3.3	0.002*

*Significance level was set at $P < 0.05$.

TABLE 4. Tibial Shaft With Syndesmosis Outcomes

	Shaft Syndesmosis Group (n = 15)	Control Group (n = 30)	*P*
Patients requiring reoperation (%)	50	30	0.16
Average no. of reoperations per patient	1.0	0.54	0.23
Nonunion (%)	18.1	16.1	0.85
Deep infection (%)	26.7	6.7	0.17
Amputation (%)	13.3	6.7	0.49

that the OTA/AO fracture classification may have provided a better matched cohort, but the retrospective nature of the study and our database did not allow for its inclusion. Despite matching the groups for age, GA classification, and OTA/AO classification, while there was no significant statistical difference between the 2 groups in the incidence of compartment syndrome, the only patients (2/30 patients, 6.7%) with compartment syndrome were in the syndesmosis injury group. The sequela of compartment syndrome can lead to increased complications/reoperation rates and certainly could have played a role in the differences of outcomes between the groups. The definition of nonunion included those patients who had segmental bone defects and required planned staged bone grafting. Although this does meet the Federal Drug Administraion definition of nonunion, we included these as nonunions because without secondary surgery, no bony healing could be anticipated in these cases.[33] This definition was applied across both groups so that it should not introduce undue bias. In the future, we believe that future studies across multiple sites would be beneficial to better understand the effect of syndesmotic injury and tibial shaft and pilon fractures.

Syndesmotic disruption is not commonly seen in conjunction with tibial shaft and pilon fractures, but a segmental fibula fracture should alert clinical suspicion of this combined injury. A syndesmotic injury in combination with a pilon or tibial shaft fracture should serve as an indicator of a severely traumatized limb, and the patient and surgeon can expect significantly higher rates of reoperation, deep infection, and amputation when compared with similar fractures without syndesmotic injury. Similar to injuries of the proximal tibiofibular joint,[13] a syndesmotic injury in tibial shaft or pilon is a marker of a devastating injury fraught with complications.

TABLE 5. Pilon With Syndesmosis Outcomes

	Pilon Syndesmosis Group (n = 15)	Control Group (n = 30)	*P*
Patients requiring reoperation (%)	53.3	23.8	0.24
Average no. of reoperations per patient	1.6	0.38	0.035*
Nonunion (%)	23.1	19.1	0.79
Deep infection (%)	26.7	10	0.18
Amputation (%)	40	0	0.002*

*Significance level was set at $P < 0.05$.

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