Soft Tissue Complications and Timing of Surgery in Patients with a Tongue-type Displaced Intra-Articular Calcaneal Fracture; An International Retrospective Cohort Study.

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ABSTRACT

Introduction: Tongue-type displaced intra-articular calcaneal fractures (DIACF) are associated with a specific pattern of fracture displacement in contrast to joint depression fractures. This may result in tension of soft tissue in the posterior part of the heel. Tension-induced ischemia can result in skin necrosis. The objectives of this study were to investigate whether patients with tongue-type calcaneal fractures exert a higher risk of complications, especially of the posterior soft tissues, than joint depression type fractures. Also, late interventions (*e.g.,* antibiotics, debridements, and amputations) and the effect of timing of surgery on the complication rate was assessed.

Methods: In this international retrospective cohort study, data of adult patients with a DIACF in the period January 1, 2005 to December 31, 2015 were extracted from patients' medical files. Descriptive, univariate, and multivariable analyses were performed in SPSS.

Results: A total of 560 patients with 632 DIACF were included (295 tongue-type and 337 non-tongue-type fractures). At hospital presentation, 20.3% of the patients with a tongue-type fracture had compromised posterior soft tissue versus 12.8% with non-tongue-type fractures ($p=0.032$). However, corrected for potential confounders the risk was no longer statistically significant (OR 1.497; 95% CI 0.831-2.696). Patients with a TT-DIACF had a 1.2 to 3.4-fold higher rate of any local wound complication (deep infections, and full thickness lesions, $p<0.03$). In addition they had 2.0 to 8.0-fold more intravenous antibiotics, debridements, soft tissue coverage procedures and amputations ($p<0.03$). Patients who underwent surgery within two days after trauma had a higher risk to develop any complication, in particular superficial infections, when compared to surgery between 3-7 days, but no significant difference between 3-7 and ≥ 8 days could be demonstrated.

Conclusion: Despite the fact that patients with a tongue-type fracture developed posterior skin and soft tissue compromise nearly twice as often, this difference disappeared after correction for confounders. The overall complication risk was increased in patients with tongue-type calcaneal fractures as compared to patients with a non-tongue-type fracture. Postponing surgery (3-7 days or ≥ 8 days) in patients without severe (soft tissue) injuries, did not affect outcome.

INTRODUCTION

According to Essex-Lopresti displaced intra-articular calcaneal fractures (DIACFs) can be divided, into either tongue-type or joint depression patterns (1). In a tongue-type DIACF, the fracture line disperses longitudinally from the articular surface and exits posteriorly through the calcaneal tuberosity. Hereby, the posterior tuberosity fragment is displaced superiorly and dorsally due to traction of the Achilles tendon and plantar fascia. This specific pattern of fracture displacement easily results in significant pressure on and tension to the skin covering the posterior part of the calcaneus. Too much or prolonged tension may aggravate trauma-induced soft tissue injury, due to additional soft tissue ischemia, and finally necrosis, and thus converting a closed fracture into an open one (Figure 1). Posterior skin compromise is described to occur in 21% of the patients with tongue-type calcaneal fractures (2).

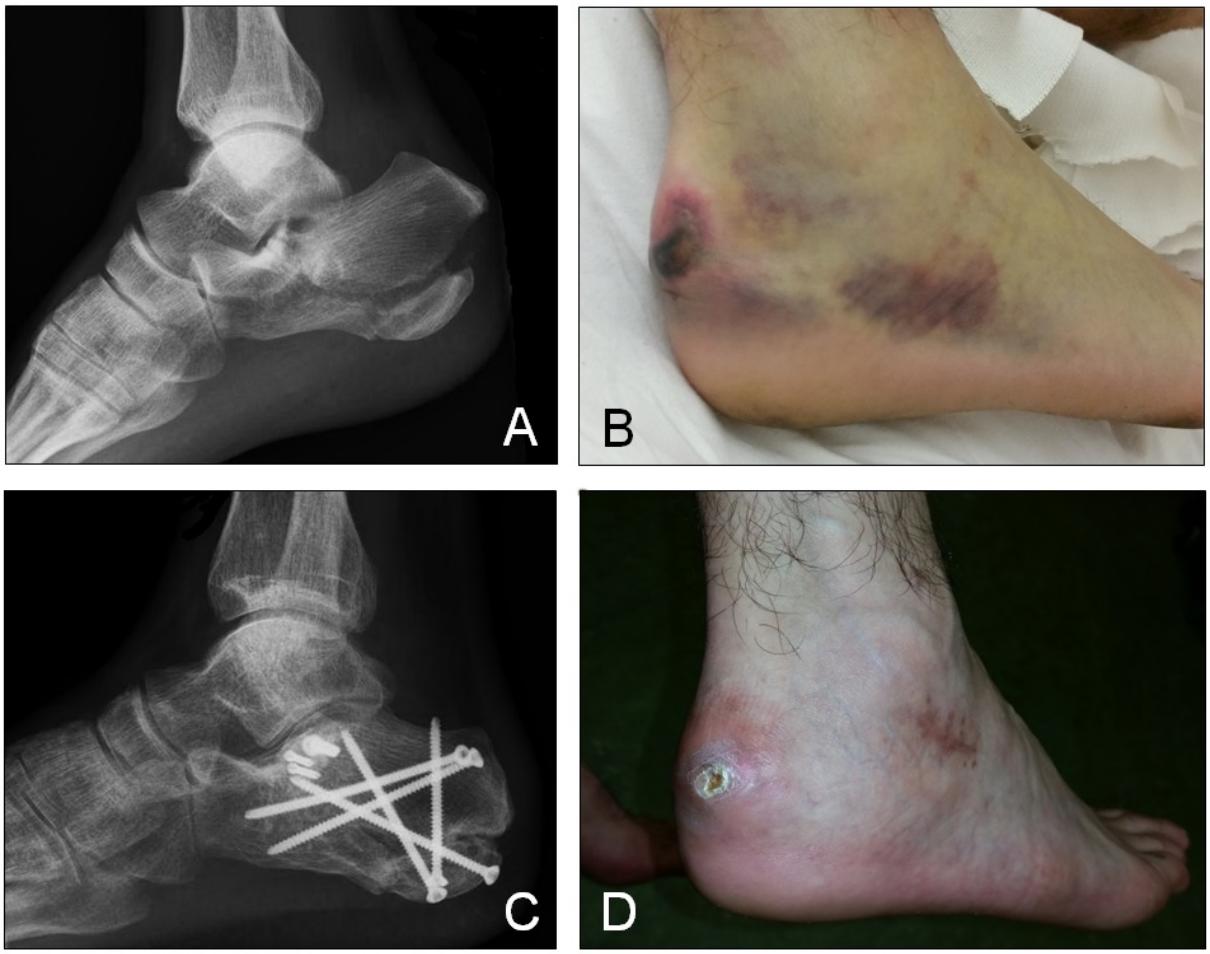

Figure 1. A. Lateral radiograph of a tongue-type DIACF at first hospital presentation, with severe displacement of the posterior tuberosity of the calcaneus. **B.** Presence and impending posterior soft tissue compromise (*e.g.,* hematoma, blisters, and necrosis) due to the specific fracture displacement resulting in high tension on the skin. **C.** Status after Open Reduction and Internal Fixation (ORIF), 5 months after trauma. **D.** Wound healing after ORIF via Sinus Tarsi Approach.

Displaced intra-articular calcaneal fractures are often managed operatively (3). Postoperative wound infections occur frequently, often resulting in delayed wound healing and prolonged length of hospital stay, and sometimes in permanent iatrogenic disability (4, 5). In order to decrease the number of wound complications, it was thought that patients would benefit from delayed operative fixation of calcaneal fractures (6). However, failure to detect ongoing soft

tissue deterioration during the (pre-operative) period may also lead to additional soft tissue morbidity (1, 5). It is the question whether a delayed surgical procedure is suitable for all calcaneal fractures.

It is hypothesized that delayed surgery of tongue-type DIACFs turns reversible skin ischemia (*i.e.,* compromised skin perfusion due to the specific fracture displacement) into irreversible skin necrosis (2, 7). Tongue-type DIACFs might even be considered as a surgical urgency. To date, little has been reported on posterior soft tissue complications associated with tongue-type calcaneal fractures.

The primary aim, of this study was to compare the rate of posterior soft tissue compromise in adult patients with a tongue-type versus non-tongue-type DIACF. Secondary aims were 1) to compare the rate of other complications; 2) to compare the rate of late interventions; and 3) to examine the effect of timing of surgery on the complication rate.

METHODS

Study design

In this international, retrospective cohort study patients were identified from hospital records based upon their ICD-10 (International Coding of Diseases, 10th revision) code S92.0, Diagnosis Related Group (DRG; in Dutch, DBC) code 236, or hospital specific surgical intervention codes. Data were extracted from the patient's medical files in the three participating hospitals.

Adult patients aged 18 years or older who were treated for a unilateral or bilateral DIACF (Essex-Lopresti tongue-type or joint depression type and Sanders type II-IV) between January 1, 2005 and December 31, 2015 were eligible for inclusion if a clinical follow-up of at least three months was documented. Patients suffering from local skin conditions that were not related to the fracture itself, but could influence outcome (*e.g.*, burn or chemical wounds or pre-existing skin conditions in the affected foot region for example resulting from diabetes mellitus or venous insufficiency) and patients with a pathological calcaneal fracture were excluded.

Data collection

Patient characteristics (*i.e.,* gender, age at trauma, ASA grade, Body Mass Index (BMI), comorbidities, and medication use), injury characteristics (*i.e.*, date of trauma, affected side, trauma mechanism, fracture classifications (1, 8), soft tissue compromise, injury classifications (9), and radiographic fracture displacement measurements (2, 10)), treatment characteristics (*i.e.*, admission duration, method of swelling reduction, treatment type: Open Reduction and Internal Fixation (ORIF), Closed Reduction and Internal Fixation (CRIF), primary arthrodesis or non-operative treatment (*i.e.,* plaster cast, a pressure bandage or PTB-Brace), initial soft tissue coverage), complications, and late interventions were obtained from the electronic patient's medical files.

Compromise was defined as the lack of sufficient blood supply for soft tissue to remain viable. Compromise is defined as a reversible condition, but could potentially result in more severe (*e.g.,* infection), or irreversible conditions (*e.g.,* necrosis). Soft tissue compromise is limited to the posterior part of the foot. Compromise at the anterior, lateral, and medial side were not registered as compromise, nor was compromise caused by external trauma. In this study the following conditions are registered as compromise, when occurred within three weeks post trauma (until the start of initial operative intervention, for patients treated operatively): hematoma, contusion, blisters, threatened skin (*i.e.,* pallor or collateral blanchable redness of the skin), ischemia, partial thickness lesion (*i.e.,* loss of integrity of the skin and subcutaneous tissue as result of prolonged ischemia), and full thickness lesion (*i.e.* communicating with periosteum, open fracture).

The following post-operative complications, although not all causally related to the operation, were collected: abrasion, hematoma, swelling, blisters, pallor, partial or full

thickness lesion, necrosis, superficial infection (*i.e.,* non-operative treatment, no admission, possibly oral antibiotics), deep infection (*i.e.,* surgical intervention, admission, possibly intravenous antibiotics), compartment syndrome, implant failure, secondary dislocation, malalignment, non-union, sural nerve injury, tendon injury, paresthesia, persistent pain, or arthritis.

Fracture displacement was determined as described by Gardner *et al.* (2). The posterior facet (PF) angle was used to determine the plantar rotation of the PF of the calcaneus relative to the talus and was the primary radiographic measurement of fracture displacement. This was measured as the angle between the PF articular surface on the fracture fragment and the PF articular surface of the talus on the lateral radiograph (Figure 2). In addition, the research physician measured Böhler's angles.

In patients with bilateral fractures, the injury of the right foot was leading for stratification into either the tongue-type or the non-tongue-type group. Patients who had additional injuries were described as 'polytrauma'.

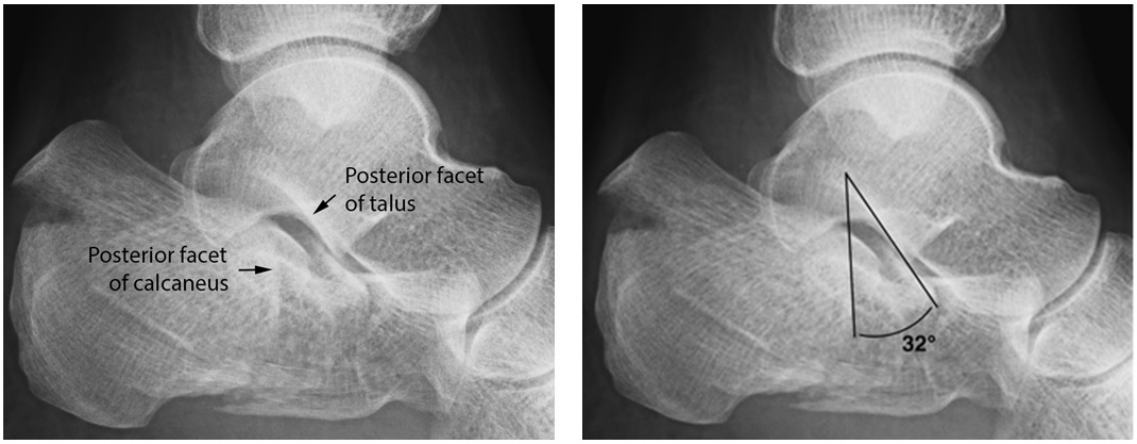

Figure 2. Fracture displacement according to Gardner *et al*. (2)

Statistical analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 21.0 (SPSS, Chicago, Ill., USA). The Youden index was analyzed using MedCalc version 14.10.2 (MedCalc Software, Ostend, Belgium). Normality of continuous data were tested with the Shapiro-Wilk test, and homogeneity of variances was tested using the Levene's test. A p-value < 0.05 was taken as threshold of statistical significance in all statistical tests, and all tests were two-sided. Missing values were not imputed.

Descriptive analysis was performed in order to report patient characteristics, injury-related variables and treatment-related variables per group. Differences between groups will be tested using Student's T-test or Mann-Whitney U-test (parametric and non-parametric continuous data, respectively) or a Chi-squared or Fisher's exact test (categorical data).

Univariate analysis of the rate of posterior soft tissue compromise was done using a Chi-squared test. Multivariable analysis was done as secondary analysis. Treatment and variables that may potentially confound the association between fracture type and soft tissue compromise were included in this model as covariate. Covariates were selected based upon literature data, by eyeballing the descriptive statistics and the covariates with a $p<0.200$ in the univariate analysis (Supplemental Tables 2-12). The beta values were reported as odd's ratio (OR) with 95% confidence interval and p-value.

RESULTS

In total 735 patients were identified. After applying the inclusion criteria (23 patients were younger than 18 years, 104 patients did not have a DIACF, and 43 patients had a follow up less than three months), 565 patients were eligible for inclusion. Five patients were excluded; one patient had a pre-existent local skin condition that was not related to the fracture, two patients had a primary amputation, and two patients had an unknown Essex-Lopresti classification). This resulted in 560 included patients with 632 fractures (72 bilateral fractures). Of the patients with bilateral fractures, eighteen patients had a tongue-type fracture on the right side and a non-tongue-type fracture on the left side and were analyzed in the tongue-type group. Eleven patients had a non-tongue-type fracture on the right foot and a tongue-type on the left and were therefore analyzed in the non-tongue-type group. Fractures were classified according to the Essex-Lopresti classification in 295 (46.7%) tongue-type calcaneal fractures and 337 (53.3%) non-tongue-type fractures (*i.e.*, joint-depression type or severely comminuted calcaneal fractures).

Posterior soft tissue compromise

The mean age of the patients in the tongue-type group was significantly lower than those in the non-tongue-type group (42 versus 46 years, p = 0.006) (Supplemental Table 1). Other covariates such as gender, BMI, ASA scores, smoking status, alcohol consumption, comorbidities (except psychiatric), and medication usage did not differ significantly between patients with a tongue-type fracture and patients with a non-tongue-type fracture. Significantly more patients had a psychiatric disorder in the tongue-type fracture group (18.6% versus 11.6%, p = 0.027). In the tongue-type group 247 (83.7%) patients were treated operatively compared with 285 (84.6%) patients in the non-tongue-type group (p = 0.827). Significantly more polytrauma patients were observed in the tongue-type group (47.6% versus 38.9%, p = 0.040). A significantly larger amount of patient had contralateral lower extremity injuries (18.6% versus 11.7%, p = 0.031), pelvic injuries (13.8% versus 8.1%, p = 0.039) and spine injuries (20.9% versus 12.1%, p = 0.005) in the tongue-type group.

Posterior soft tissue compromise at hospital presentation was documented in 37 (20.3%) of 182 tongue-type fractures, versus 26 (12.8%) of the 203 non-tongue-type fractures (p = 0.032). A tongue-type fracture appeared to be a risk factor for developing posterior soft tissue compromise as compared to non-tongue-type fractures (OR 1.715; 95% CI 1.012-2.909; Table 1), but after correction for confounders this was no longer significant (OR 1.497; 95% CI 0.831-2.696). In the supplemental tables 1-12 the various covariates used in the multivariable analysis are shown.

Patients with a tongue-type fracture who developed compromised soft tissue posterior on the heel had a median fracture displacement (according to Gardner *et al.* (2)) of 22.5° (SD 14.7) whereas patients who did not develop this compromise had a median displacement of 19.8° (SD 14.8). This difference was not significant (p = 0.288). Also, no significant differences were found for other complications (*i.e.,* superficial and deep infections, full thickness lesion, necrosis and non-unions), it only differed for partial thickness lesions.

Table 1: Posterior soft tissue compromise and complications in tongue-type versus non-tongue-type DIACFs

Variable	OR (95% CI)	P-value	OR (95% CI)	P-value
	Crude		Adjusted	
Posterior soft tissue compromise[A]	**1.715 (1.012-2.909)**	**0.045**	1.497 (0.831-2.696)	0.179
Complications				
Any complication[B]	**1.546 (1.121-2.130)**	**0.008**	**1.813 (1.178-2.791)**	**0.007**
Infection[C]	1.351 (0.925-1.974)	0.120	**1.728 (1.082-2.761)**	**0.022**
Superficial[D]	1.003 (0.622-1.618)	0.989	1.209 (0.700-2.088)	0.496

Deep[E]	**1.695 (1.074-2.673)**	**0.023**	1.619 (0.948-2.767)	0.078
Lesions				
Full Thickness[F]	**3.585 (1.404-9.155)**	**0.008**	**3.043 (1.063-8.714)**	**0.038**
Partial Thickness[G]	1.208 (0.674-2.164)	0.526	0.702 (0.329-1.498)	0.360
Necrosis[H]	1.777 (0.925-3.413)	0.084	1.244 (0.590-2.621)	0.566
Non-union[I]	1.236 (0.586-2.605)	0.578	1.172 (0.454-3.024)	0.743

OR is shown for tongue-type fractures compared with non-tongue-type fractures.
Data are shown as Odds Ratio (OR) with (95% Confidence Interval (CI)) and analyzed using a multivariable logistic regression model. Outcomes are corrected for all relevant covariates with p<0.200 after univariate analysis (shown in supplemental tables 2-12).

A. Corrected for Böhler's angle at trauma, smoking, psychiatric disorder.
B. Corrected for BMI, Delay to Emergency Department, Böhler's angle at trauma, Hospital length of stay, ASA class, smoking, open or closed fractures, soft tissue injury at trauma, Diabetes Mellitus, additional injury, operative or non-operative treatment.
C. Corrected for BMI, Böhler's angle at trauma, Hospital length of stay, smoking, open or closed fractures, operative or non-operative treatment.
D. Corrected for Age, BMI, smoking, open or closed fractures, comorbidities, medication, soft tissue injury at trauma, operative or non-operative treatment.
E. Corrected for Böhler's angle at trauma, Hospital length of stay, smoking, open or closed fractures, operative or non-operative treatment.
F. Corrected for Hospital length of stay, smoking, operative or non-operative treatment.
G. Corrected for Delay to Emergency Department, Böhler's angle at trauma, Hospital length of stay, smoking, trauma mechanism, unilateral or bilateral fractures, additional injury, operative or non- operative treatment.
H. Corrected for Hospital length of stay, ASA class, smoking, open or closed fractures, soft tissue injury at trauma, time to surgery, operative or non-operative treatment.
I. Corrected for BMI, Böhler's angle at trauma, Hospital length of stay, smoking, trauma mechanism, open or closed fractures, soft tissue injury at trauma, operative or non-operative treatment.

Complications and late interventions

As secondary objectives the rate of other complications and late interventions in patients with a tongue-type versus non-tongue-type calcaneal fracture was examined. In total 59.2% of the patients developed a complication. In patients with a tongue-type fracture significantly higher rates of overall complications (64.7% versus 54.3%, p = 0.009), deep infections (17.3% versus 11.0%, p = 0.028), and full thickness lesions (6.1% versus 1.8%, p = 0.006) occurred.

The univariate OR for patients with a tongue-type versus patients with a non-tongue-type calcaneal fracture are shown in Figure 3. In the total study population, patients with a tongue-type fracture have an increased risk to develop any complication (OR 1.546; 95% 1.121-2.130), posterior soft tissue compromise (OR 1.715; 95% CI 1.012-2.909), deep infections (OR 1.695; 95% CI 1.074-2.673), and full thickness lesions (OR 3.585; 95% CI 1.404-9.155) compared to patients with non-tongue-type fractures. The operatively treated patients with a tongue-type fracture had a higher risk to develop any complication (OR 1.709; 95% CI 1.198-2.438), deep infection (OR 1.795; 95% CI 1.108-2.907), and full thickness lesions (OR 3.221; 95% CI 1.240-8.364) than operatively treated patients with a non-tongue-type fracture. No significant difference between fracture types were found in non-operated patients. A multivariable analysis (Table 1) showed a significant higher risk for patients with tongue-type fractures of developing any complication (OR 1.813; 95% CI 1.178-2.791) and

full thickness lesions (OR 3.043; 95% CI 1.063-8.714), but no significant higher risk of deep infections (OR 1.619; 95% CI 0.948-2.767).

Although the total rate of late interventions did not differ between the two fracture groups, significantly more amputations (2.4% versus 0.3%, p = 0.028), more debridements (14.9% versus 7.1%, p = 0.002), more treatment with intravenous antibiotics (15.3% versus 7.7%, p = 0.003), and more soft tissue coverage procedures (12.2% versus 5.3%, p = 0.003) were performed in patients with a tongue-type fracture.

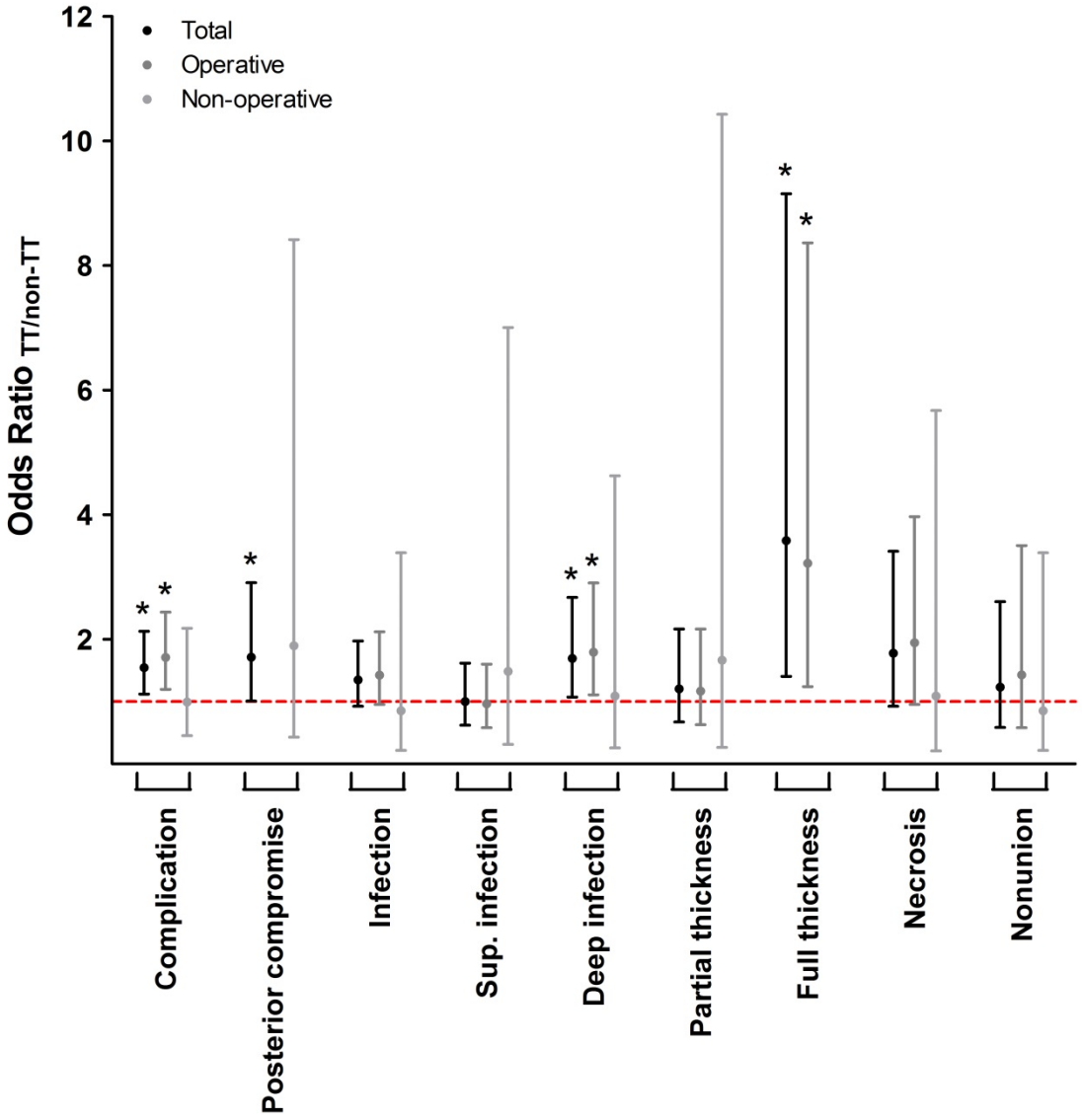

Figure 3. Odds Ratios (OR) for patients with tongue-type versus non-tongue-type calcaneal fractures. OR are shown for the total study population and for the operated and non-operated patients separately. OR are shown with a 95% Confidence Interval. The dotted red line represents OR=1; *, significance. Not enough data was available in the operative group to analyse the risk for posterior compromise and in the non-operatively treated group for full thickness lesions.

Timing of surgery in patients with tongue-type calcaneal fractures

Next the relation between time to surgery and rate of (soft tissue) complications in patients with tongue-type DIACFs was investigated. Depending on the time to surgery, clinical relevance, and number of patients, patients with tongue-type DIACFs were stratified in four

categories; operated between 0-2 days, 3-7 days, 8-14 days, and ≥ 15 days. The surgical delay differed significantly in patients who developed infections (p=0.009), deep infections (p=0.034), full thickness lesions (p=0.002), and non-union (p=0.016), data is shown in Supplemental Tables 6,8,9, and 12. For these categories, the OR for the various outcomes are depicted in Figure 4. Operatively treated patients ($OR_{surgery}$) had a higher risk to develop any complication (OR 2.312; 95% CI 1.236-4.324) or an infection (OR 4.197; 95% CI 1.446-12.073) than non-operatively treated patients. Patients who underwent surgery within two days after trauma (t=0-2d) had an higher risk to develop any complication (OR 3.548; 95% CI 1.176-10.711), and any infection (OR 2.920; 95% CI 1.095-7.787), in particular superficial infections (OR 4.144; 95% CI 1.230-13.763) than surgery between 3-7 days after trauma. The remaining outcomes (*e.g.,* deep infection, partial and full thickness lesions, necrosis and non-union) did not statistically significant differ in the various time to surgery categories. No significant difference could be demonstrated between a surgical delay of 8 days or more (8-14 days or ≥ 15 days) and 3-7 days.

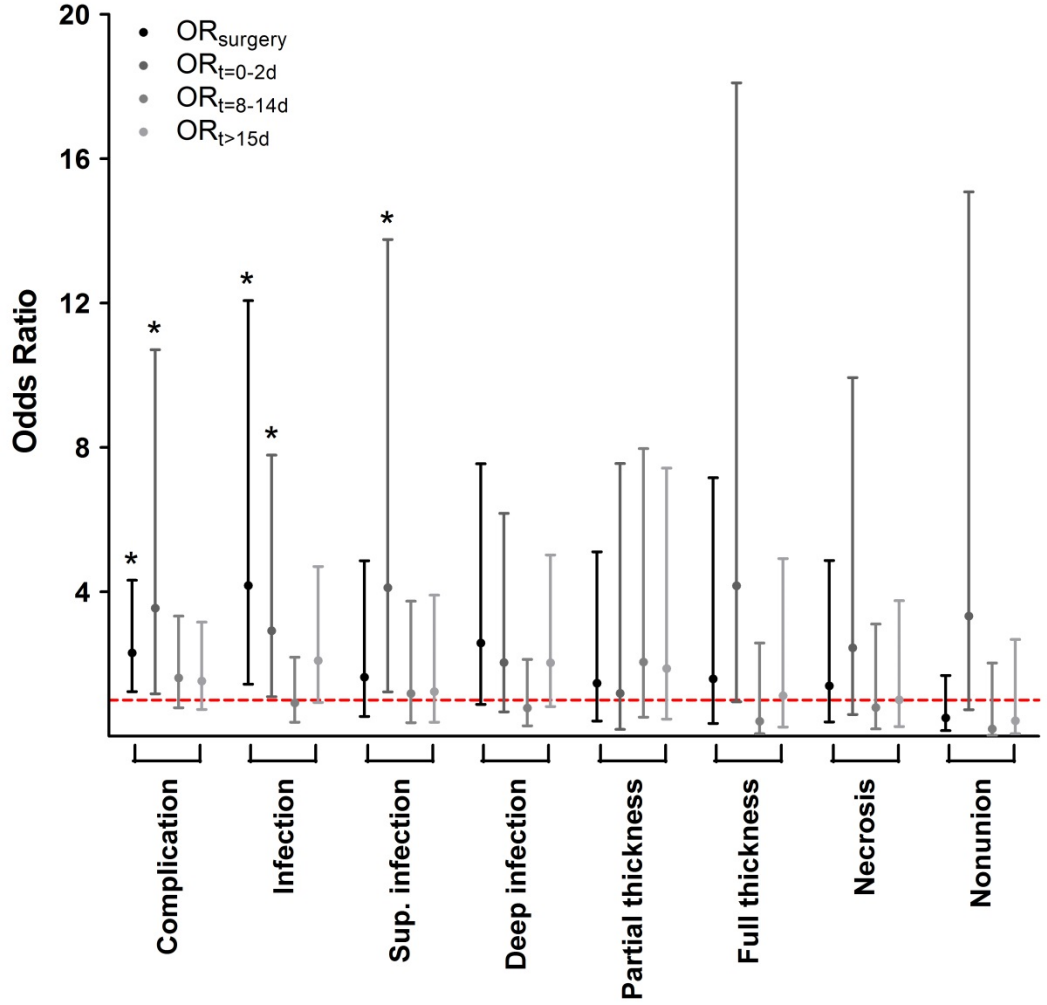

Figure 4. Odds Ratios (OR) for patients with a tongue-type DIACF. The 'time to surgery' categories (t=0-2, t=8-14, and t ≥ 15 days) are shown with 3-7 days as reference. OR are shown with a 95% Confidence Interval. The dotted red line represents OR=1. Complication is the overall complication risk, and is subdivided in infection, partial and full thickness laesions, necrosis and nonunion. Infection in turn is subdivided in superficial and deep infections. $OR_{surgery}$, OR for operated patients; *, significance.

In the subgroup of patients who underwent surgery at the day of trauma (N=20), the median fracture displacement was larger than in the total operated group (33° versus 18°), Böhler's angle was more flattened (-5.5° (P_{50}-P_{75} -38.3 – 18.5) versus 8.0° (P_{50}-P_{75} -4.0 – 17.0)) and the hospital length of stay was longer (23 days (P_{50}-P_{75} 7 – 54) versus 7 days (P_{50}-P_{75} 5-15)). Furthermore, this subgroup had overall higher rates of adverse outcomes, in particular: comorbidities (62.5% versus 39.8%), High Energy Trauma (100% versus 61.0%), additional injuries (72.2% versus 41.2%), open fractures (55.0% versus 4.4%), posterior compromise (25.0% versus 9.9%), complications (85.0% versus 61.3%), infections (35.0% versus 23.9%), necrosis (20.0% versus 5.8%), and revision surgeries (80.0% versus 51.5%).

DISCUSSION

This study shows that posterior skin and soft tissue compromise at hospital presentation occurred in 20.3% of the patients with a tongue-type fracture versus 12.8% in patients with a non-tongue-type fracture. This result is in line with the findings of Gardner *et al.,* who studied solely tongue-type calcaneal fractures and found posterior skin compromise in 20.9% (29 of total 139) of the tongue-type fractures at hospital presentation (2). Although posterior skin and soft tissue compromise occurred nearly twice as often in patients with a tongue-type fracture than in patients with a non-tongue-type fracture, this statistically significant difference disappeared after correction for confounders. Nevertheless, our findings and the current literature should alert clinicians about the potential pathomechanism of the specific fracture displacement in tongue-type calcaneal fractures (2, 7, 11, 12), to prevent soft tissue damage and the disastrous sequelae (13). Awareness of orthopaedic trauma surgeons about these risks should guide treatment decision (*e.g.,* urgent fracture reduction and frequent monitoring of soft tissue conditions) to improve patient' outcomes and reduce complications.

The results of this study furthermore demonstrated an increased risk of developing overall complications, deep infections, and full thickness lesions in patients with a tongue-type DIACF compared with patients with a non-tongue-type fracture. To our knowledge, no other studies did investigate these specific outcomes in tongue-type fractures.

Patients with a tongue-type fracture were significantly more often polytrauma patients (47.6% versus 38.9%). This might be caused by the higher rate of high energy trauma (falls from height) in the tongue-type group. Whether this in turn is due to the significant higher rate of psychiatric disorders in this group not investigated in this study. Gardner *et al.* found 54% additional injuries in patients with tongue-type fractures (2), which is in line with our findings.

In this study, fracture displacement did not significantly differ between patients with tongue-type fractures with and without posterior soft tissue compromise (22.5° versus 19.8°, $p = 0.288$). This is in contrast with Gardner *et al.*, who found that patients with tongue-type fractures and posterior skin compromise had a significantly greater fracture displacement (36° versus 25°, $p = 0.007$, OR = 1.03) (2). One explanation for the discrepancy between Gardner *et al.* and this study could that, in this study, fracture displacement was also measured when the inferior tuberosity fragment was tilted. This can theoretically result in an undervaluation of the true fracture displacement according to Gardner's method. The fracture displacement did differ significantly between both fracture types, when it concerned partial thickness lesion. Finding a reliable model which could measure the relation between fracture displacement and skin tension would be of value for surgeons to adjust treatment strategy. In this model not only tension but also pressure due to dorsal displacement should be taken into account. Currently, such a risk model is not available. A recent study describes fracture displacement via the talo-tuber angle and talo-tuber distance (12), this might be a suggestion for future research.

One of the limitations associated with the retrospective design of this study is the data completeness in medical files. In daily practice, the post-traumatic skin condition is often not noted in medical files or noted without the exact location of a lesion. The incompleteness of medical files might explain why no evidence for a statistical significantly higher risk of posterior soft tissue compromise in tongue-type fractures could be demonstrated. Partly due to this limitation, the statistical power was insufficient to adequately answer the primary objective. The moderate file keeping and the related absence of evidence resulted in a need to double the number of patients required for a statistical power of 80%. With the current number of 560 included patients (632 calcaneal fractures), the statistical power was 50.1%. However, a prospective study with that number of patients would be challenging.

Patients treated operatively within two days seem to have a higher risk to develop any complication and (superficial) infections. Surgery within two days might not be urgent enough

for specific patient as ischemia by then is often already developed into necrosis, hereafter complications are impermeable. Surgical urgencies might be defined as surgery performed within six hours. In this study, very few patients (N=20) underwent surgery at the day of trauma. Although this number of patients is too low to prove statistical significant differences, descriptive analysis was performed in order to investigate whether this subgroup differed from the remaining total study population. Data suggests that these patients (operated at the day of trauma) were selected for immediate surgery based on their overall worse clinical conditions or injury severity at hospital presentation. These patients are more likely to develop complications. Unfortunately, the question whether earlier surgery of (tongue-type) calcaneal fractures would reduce the rate of complications could not be answered based on the data provided in this study. In order to determine exactly when to operate these tongue-type fractures, prospective (randomized) studies are needed.

CONCLUSION

Despite the fact that patients with a tongue-type fracture developed posterior skin and soft tissue compromise nearly twice as often, this significant difference disappeared after correction for confounders. Patients with tongue-type calcaneal fractures had an increased risk of developing local soft tissue complications compared with patients with a non-tongue-type fracture. Although postponing surgery 3-7 or ≥ 8 days does not affect outcome, this study could not prove that patients with tongue-type fractures require immediate surgery.

SUPPLEMENTAL MATERIAL

Table 1: Demographic data for the study population, separated as tongue-type or non-tongue-type DIACF

Variable		Total group			Tongue-type			Non-tongue-type			P-value
		N			N			N			
Patient characteristics[1]		**560**			**253**			**307**			
Age (years)		558	44	(34-56)	252	42	(33-55)	302	46	(36-58)	**0.006**
Male gender		560	424	(75.7%)	254	192	(75.9%)	307	232	(75.6%)	1.000[A]
BMI		491	24.2	(21.6-27.4)	224	23.7	(21.4-27.1)	268	24.8	(21.6-27.5)	0.066
ASA	ASA 1	493	274	(55.6%)	222	128	(57.7%)	271	146	(53.9%)	0.702[B]
	ASA 2		192	(38.9%)		84	(37.8%)		108	(39.9%)	
	ASA 3		23	(4.7%)		9	(4.1%)		14	(5.2%)	
	ASA 4		4	(0.8%)		1	(0.5%)		3	(1.1%)	
Smoking	Current	477	250	(52.4%)	213	110	(51.6%)	264	140	(53.0%)	0.422[B]
	Previous		53	(11.1%)		20	(9.4%)		33	(12.5%)	
	Never		174	(36.5%)		83	(39.0%)		91	(34.5%)	
Alcohol		469	307	65.5%)	211	137	(64.9%)	258	170	(65.9%)	0.846[A]
Comorbidities	Diabetes Mellitus	535	25	(4.7%)	242	8	(3.3%)	293	17	(5.8%)	0.218[A]
	Arterial insufficiency		13	(2.4%)		5	(2.1%)		8	(2.7%)	0.780[A]
	Venous insufficiency		3	(0.6%)		3	(1.2%)		0	(0.0%)	0.093[A]
	Psychiatric		79	(14.8%)		45	(18.6%)		34	(11.6%)	**0.027[A]**
	Cardiac		52	(9.7%)		17	(7.0%)		35	(11.9%)	0.058[A]
	Respiratory		24	(4.5%)		10	(4.1%)		14	(4.8%)	0.835[A]
	Alcohol abuse		27	(5.0%)		14	(5.8%)		13	(4.4%)	0.553[A]
	Narcotic abuse		54	(10.1%)		23	(9.5%)		31	(10.6%)	0.773[A]
Medication		520	132	(25.4%)	234	58	(24.8%)	286	74	(25.9%)	0.840[A]
	NSAID		11	(2.1%)		3	(1.3%)		8	(2.8%)	0.360[A]
Injury characteristics[1]		**560**			**253**			**307**			
Trauma	HET, fall (height)	538	266	(49.4%)	244	130	(53.5%)	296	136	(46.1%)	0.261[B]
	HET, traffic		41	(7.6%)		14	(5.8%)		27	(9.2%)	
	HET, other		18	(3.3%)		8	(3.3%)		10	(3.4%)	
	LET, stairs		93	(17.3%)		35	(14.4%)		58	(19.7%)	
	LET, fall (other)		106	(19.7%)		51	(21.0%)		55	(18.6%)	
	LET, other		14	(2.6%)		5	(2.1%)		9	(3.1%)	
Affected side	Unilateral	560	488	(87.1%)	253	204	(80.6%)	307	284	(92.5%)	**< 0.001[A]**
	Bilateral		72	(12.9%)		49	(19.4%)		23	(7.5%)	
Additional injuries											
Polytrauma		558	239	42.8%)	252	120	(47.6%)	306	119	(38.9%)	**0.040[A]**
Additional injured regions	1	558	122	(21.9%)	252	55	(21.8%)	306	67	(21.9%)	0.124[B]
	2		40	(7.2%)		20	(7.9%)		20	(6.5%)	
	≥ 3		76	(13.6%)		45	(17.9%)		31	(10.1%)	

Continuous data are shown as median (P_{25}-P_{75}) and analyzed using a Mann-Whitney U-test. Categoric data are shown as N (%) and analyzed using a [A]Fisher's Exact test or [B]Chi-squared test, as applicable. Data are expressed per patient[1] or per fracture[2].

Continuation Table 1: Demographic data for the study population, separated as tongue-type or non-tongue-type DIACF

Variable			Total group			Tongue-type			Non-tongue-type			P-value
			N			N			N			
Injury characteristics[2]			**632**			**295**			**337**			
Affected side		Right	632	333	(52.7%)		155	(52.5%)		178	(52.8%)	1.000[A]
Sanders classification	IIA		584	128	(21.9%)	270	47	(17.4%)	314	81	(25.8%)	**0.027[B]**
		IIB		163	(27.9%)		82	(30.4%)		81	(25.8%)	
		IIC		60	(10.3%)		36	(13.3%)		24	(7.6%)	
		IIIAB		98	(16.8%)		39	(14.4%)		59	(18.8%)	
		IIIAC		40	(6.8%)		23	(8.5%)		17	(5.4%)	
		IIIBC		31	(5.3%)		15	(5.6%)		16	(5.1%)	
		IV		64	(11.0%)		28	(10.4%)		36	(11.5%)	
Open fractures			632	37	(5.9%)	295	21	(7.1%)	337	16	(4.7%)	0.236[A]
Gustilo & Anderson	1		25	10	(40.0%)	14	6	(42.9%)	11	4	(36.4%)	0.563[A]
		2		4	(16.0%)		3	(21.4%)		1	(9.1%)	
		3		11	(44.0%)		5	(35.7%)		6	(54.5%)	
Treatment characteristics[2]			**632**			**295**			**337**			
Operative treatment			632	532	(84.2%)	295	247	(83.7%)	337	285	(84.6%)	0.827[A]
Non-operative	Plaster cast		93	67	(72.0%)	44	35	(79.5%)	49	32	(65.3%)	0.062[B]
	Pressure bandage			6	(6.5%)		4	(9.1%)		2	(4.1%)	
	Other			20	(21.5%)		5	(11.4%)		15	(30.6%)	
	Delayed treatment		560	277	(49.5%)	253	122	(48.2%)	307	155	(50.5%)	0.611[A]
	Logistics		276	187	(67.8%)	121	73	(60.3%)	155	114	(73.5%)	**0.027[B]**
	Treatment other injury			61	(22.1%)		36	(29.8%)		25	(16.1%)	
	Other			24	(8.7%)		12	(9.9%)		2	(7.7%)	
	General condition			3	(1.1%)		0	(0.0%)		3	(1.9%)	
	Clinical deterioration			1	(0.4%)		0	(0.0%)		1	(0.9%)	

Table 2: Covariates for the total study population separated as TT versus non-TT

Variable		Non-tongue-type	Tongue-type	P-value
Gender (Male)		232 (75.6%)	192 (75.9%)	1.000[A]
Age (years)		45 (36-57)	42 (32-54)	**0.006**
BMI		24.8 (21.6-27.5)	23.7 (21.4-27.1)	0.066
ASA	I	146 (53.9%)	128 (57.7)	0.702[B]
	II	108 (39.9%)	84 (37.8%)	
	III	14 (5.2%)	9 (4.1%)	
	IV	3 (1.1%)	1 (0.5%)	
Smoking	Current	140 (53.0%)	110 (51.6%)	0.422[B]
	Previous	33 (12.5%)	20 (9.4%)	
	Never	91 (34.5%)	83 (39.0%)	
Medication use		212 (74.1%)	176 (75.2%)	0.840
Trauma mechanism				0.129[A]
	LET	127 (39.1%)	94 (33.0%)	
	HET	198 (60.9%)	191 (67.0%)	
Time trauma to ED		0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.260
Gardner's angle		N.D.	17.0 (7.0-30.0)	N.D.
Böhler's angle		9.0 (-3.0-18.0)	6.0 (-6.3-17.0)	**0.022**
Side				**0.000**[A]
	Unilateral	284 (92.5%)	204 (80.6%)	
	Bilateral	23 (7.5%)	49 (19.4%)	
Fracture				0.236[A]
	Open	321 (95.3%)	274 (92.9%)	
	Closed	16 (4.7%)	21 (7.1%)	
Soft tissue compromise		86 (25.5%)	92 (31.2%)	0.132[A]
	Posterior	26 (7.7%)	37 (12.5%)	**0.047**[A]
Additional injury		119 (38.9%)	120 (47.6%)	**0.040**[A]
Time trauma to surgery		11.0 (5.0-17.0)	10.0 (6.0-16.0)	0.363
Hospital length of stay		7.0 (5.0-14.0)	8.0 (5.0-18.0)	0.167

[A], Fisher's Exact Test; [B], Pearson Chi-Square test. ED, Emergency Department.

Table 3: Covariates for operated patients separated as TT versus non-TT

Variable		Non-tongue-type	Tongue-type	P-value
Gender (Male)		200 (75.5%)	163 (75.8%)	1.000[A]
Age (years)		45 (36-57)	41 (32-53)	**0.004**
BMI		24.8 (21.8-27.4)	23.7 (21.4-26.6)	0.068
ASA	I	139 (55.2%)	124 (61.1%)	0.294[B]
	II	98 (38.9%)	70 (34.5%)	
	III	12 (4.8%)	9 (4.4%)	
	IV	3 (1.2%)	0 (0.0%)	
Smoking	Current	125 (52.7%)	95 (50.3%)	0.751[B]
	Previous	25 (10.5%)	18 (9.5%)	
	Never	87 (69.7%)	76 (40.2%)	
Medication use		60 (23.8%)	46 (22.5%)	0.824
Trauma mechanism				0.172[A]
	LET	112 (40.3%)	82 (34.3%)	
	HET	166 (59.7%)	157 (65.7%)	
Time trauma to ED		0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.210
Gardner's angle		N.D.	18.0 (8.0-30.0)	N.D.
Böhler's angle		8.0 (-3-18.0)	6.0 (-8.0-15.0)	**0.025**
Side				0.001[A]
	Unilateral	246 (92.8%)	178 (82.8%)	
	Bilateral	19 (7.2%)	37 (17.2%)	
Fracture (Open/Closed)				0.480[A]
	Open	16 (5.6%)	18 (7.3%)	
	Closed	269 (94.4%)	229 (92.7%)	
Soft tissue compromise		71 (24.9%)	82 (33.2%)	**0.044**
	Posterior	23 (8.1%)	32 (13.0%)	0.086
Additional injury		102 (38.5%)	100 (46.5%)	0.078
Time trauma to surgery		11.0 (5.0-17.0)	10.0 (6.0-16.0)	0.363
Hospital length of stay		7.0 (5.0-14.0)	7.5 (5.0-17.0)	0.304

[A], Fisher's Exact Test; [B], Pearson Chi-Square test. ED, Emergency Department.

Table 4: Covariates for the study population with versus without posterior compromise

Variable		No posterior compromise	Posterior compromise	P-value	OR (95% CI) adjusted
Gender (Male)		376 (74.9%)	48 (82.8%)	0.257[A]	
Age (years)		43 (33-56)	46 (37-56)	0.334	
BMI		24.5 (21.5-27.4)	23.6 (21.6-26.9)	0.803	
ASA	I	244 (55.7%)	30 (54.5%)	0.259[B]	
	II	168 (38.4%)	24 (43.6%)		
	III	23 (5.3%)	0 (0.0%)		
	IV	3 (0.7%)	1 (1.8%)		
Smoking	Current	224 (52.2%)	26 (54.2%)	0.874[B]	1.236 (0.649-2.355)
	Previous	47 (11.0%)	6 (12.5%)		1.497 (0.550-4.076)
	Never	158 (36.8%)	16 (33.3%)		
Comorbidities		278 (57.8%)	29 (53.7%)	0.565[A]	
	Diabetes Mellitus	24 (5.0%)	1 (1.9%)	0.498[A]	
	Psychiatric disorder	68 (14.1%)	11 (20.4%)	0.226[A]	
Medication use		117 (25.1%)	15 (28.3%)	0.619[A]	
Trauma mechanism				0.212[A]	
	LET	194 (35.4%)	27 (43.5%)		
	HET	354 (64.6%)	35 (56.5%)		
Time trauma to ED		0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.962	
Gardner's angle		16.0 (6.0-29.0)	20.0 (11.3-32.8)	0.151	
Böhler's angle		8.0 (-5.0-18.0)	6.5 (-6.0-12.5)	0.132	0.997 (0.980-1.014)
Side				1.000[A]	
	Unilateral	437 (87.1%)	51 (87.9%)		
	Bilateral	65 (12.9%)	7 (12.1%)		
Fracture (Open/Closed)				0.402[A]	
	Open	32 (5.6%)	5 (7.9%)		
	Closed	537 (94.4%)	58 (92.1%)		
Fracture type				**0.047**[A]	1.497 (0.831-2.696)
	Non-tongue-type	311 (54.7%)	26 (41.3%)		
	Tongue-type	258 (45.3%)	37 (58.7%)		
Soft tissue compromise		115 (20.2%)	63 (100.0%)	**0.000**[A]	
Time trauma to surgery		11.0 (6.0-17.0)	8.0 (4.0-13.0)	**0.008**	
Hospital length of stay		7.0 (5.0-16.0)	8.0 (5.0-11.0)	0.655	

Univariate OR (95% CI) for tongue-type fractures: **1.715 (95% CI 1.012-2.909, p=0.045).**

[A], Fisher's Exact Test; [B], Pearson Chi-Square test; OR, Odds Ratio. Significant p-values and OR are marked bold. The 95% CI spanning 1 means no significant difference. A univariate p-value < 0.200 was chosen as threshold for including covariates (relevant for the outcome) in the multivariate analysis. In the multivariate analysis Gardner's angle was not included since the angle was only measured in tongue-type calcaneal fractures.

Table 5: Covariates for the study population with versus without complications

Variable		No Complications	Complications	P-value	OR (95% CI) adjusted
Gender (Male)		171 (77.0%)	253 (74.9%)	0.615[A]	
Age (years)		43 (34-57)	44 (34-56)	0.464	
BMI		23-8 (21.2-26.8)	24.7 (21.8-27.5)	0.067	**1.074 (1.016-1.135)**
ASA	I	99 (52.9%)	175 (57.2%)	**0.047**[B]	
	II	71 (38.0%)	121 (39.5%)		1.166 (0.738-1.840)
	III	15 (8.0%)	8 (2.6%)		**0.097 (0.011-0.867)**
	IV	2 (1.1%)	2 (0.7%)		
Smoking	Current	105 (57.1%)	145 (49.5%)	0.268[B]	0.653 (0.411-1.036)
	Previous	19 (10.3%)	34 (11.6%)		0.939 (0.431-2.046)
	Never	60 (32.6%)	114 (38.9%)		
Comorbidities		87 (41.0%)	141 (43.7%)	0.592[A]	
	Diabetes Mellitus	14 (6.6%)	11 (3.4%)	0.096[A]	0.507 (0.180-1.424)
Medication use		49 (24.0%)	83 (26.3%)	0.607[A]	
Trauma mechanism				0.347[A]	
	LET	95 (38.55)	126 (34.7%)		
	HET	152 (61.5%)	237 (65.3%)		
Time trauma to ED		0.0 (0.0-0.0)	0.0 (0.0-0.0)	**0.014**	0.947 (0.872-1.028)
Gardner's angle		14.0 (7.0-30.0)	19.0 (7.5-29.0)	0.374	
Böhler's angle		0.0 (10.0-19.0)	6.0 (-7.0-16.0)	**0.001**	**0.984 (0.970-0.997)**
Side				0.439[A]	
	Unilateral	197 (88.7%)	291 (86.1%)		
	Bilateral	25 (11.3%)	47 (13.9%)		
Fracture (Open/Closed)				**0.000**[A]	3.010 (0.631-14.362)
	Open	3 (1.2%)	34 (9.1%)		
	Closed	255 (98.8%)	340 (90.9%)		
Fracture type				**0.009**[A]	**1.813 (1.178-2.791)**
	Non-tongue-type	154 (59.7%)	183 (48.9%)		
	Tongue-type	104 (40.3%)	191 (51.1%)		
Soft tissue compromise		56 (21.7%)	122 (32.6%)	**0.003**[A]	**1.777 (1.087-2.905)**
	Posterior	23 (8.9%)	40 (10.7%)	0.501[A]	
Additional injury		86 (38.9%)	153 (45.4%)	0.138[A]	0.950 (0.586-1.540)
Surgery		206 (79.8%)	326 (87.2%)	**0.015**[A]	1.646 (0.783-3.461)
Time trauma to surgery		10.0 (5.0-16.0)	11.0 (6.0-16.0)	0.527	
Delay to surgery				0.080[B]	
0-2 days		22 (10.8%)	42 (13.1%)		
3-7 days		57 (28.1%)	59 (18.4%)		
8-14 days		62 (30.5%)	110 (34.4%)		
>15 days		62 (30.5%)	109 (34.1%)		
Hospital length of stay		7.0 (4.0-14.0)	8.0 (5.0-18.0)	**0.013**	1.012 (0.996-1.028)

Univariate OR (95% CI) for tongue-type fractures: **1.546 (95% CI 1.121-2.130, p=0.008).**
[A], Fisher's Exact Test; [B], Pearson Chi-Square test.

Table 6: Covariates for the study population with versus without infections

Variable		No Infection	Infection	P-value	OR (95% CI) adjusted
Gender (Male)		329 (75.6%)	95 (76.0%)	1.000[A]	
Age (years)		44 (34-56)	45 (33-56)	0.976	
BMI		24.1 (21.4-26.9)	25.0 (22.0-28.7)	0.072	**1.109 (1.047-1.174)**
ASA	I	209 (56.0%)	65 (54.2)	0.293[B]	
	II	140 (37.5%)	52 (43.3%)		
	III	20 (5.4%)	3 (2.5%)		
	IV	4 (1.1%)	0 (0.0%)		
Smoking	Current	194 (53.3%)	56 (49.6%)	0.780[B]	1.124 (0.682-1.853)
	Previous	40 (11.0%)	13 (11.5%)		1.289 (0.579-2.870)
	Never	130 (35.7%)	44 (38.9%)		
Comorbidities		173 (42.1%)	55 (44.4%)	0.679[A]	
	Diabetes Mellitus	20 (4.9%)	5 (4.0%)	0.812[A]	
Medication use		98 (24.4%)	34 (28.6%)	0.401[A]	
Trauma mechanism				1.000[A]	
	LET	174 (36.3%)	47 (35.9%)		
	HET	305 (63.7%)	84 (64.1%)		
Time trauma to ED		0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.915	
Gardner's angle		16.0 (6.0-29.0)	22.5 (8.8-33.3)	0.050	
Böhler's angle		9.0(-4.0-18.0)	7.0 (-10.0-17.0)	**0.028**	0.989 (0.976-1.003)
Side				0.547[A]	
	Unilateral	381 (87.6%)	107 (85.6%)		
	Bilateral	54 (12.4%)	18 (14.4%)		
Fracture (Open/Closed)				**0.003**[A]	2.233 (0.874-5.704)
	Open	21 (4.2%)	16 (11.7%)		
	Closed	474 (95.8%)	121 (88.3%)		
Fracture type				0.123[A]	**1.728 (1.082-2.761)**
	Non-tongue-type	272 (54.9%)	65 (47.4%)		
	Tongue-type	223 (45.1%)	72 (52.6%)		
Soft tissue compromise		133 (26.9%)	45 (32.8%)	0.198[A]	
	Posterior	50 (10.1%)	13 (9.5%)	1.000[A]	
Additional injury		183 (42.3%)	56 (44.8%)	0.682[A]	
Surgery		404 (81.6%)	128 (93.4%)	**0.001**[A]	2.491 (0.965-6.431)
Time trauma to surgery		9.0 (5.5-15.0)	13.0 (5.8-17.3)	**0.044**	
Delay to surgery				**0.009**[B]	
0-2 days		47 (11.9%)	17 (13.4%)		
3-7 days		95 (24.0%)	21 (16.5%)		
8-14 days		139 (35.1%)	33 (26.0%)		
>15 days		115 (29.0%)	56 (44.1%)		
Hospital length of stay		7.0 (5.0-15.0)	8.0 (5.0-20.0)	**0.034**	1.003 (0.990-1.016)
Complication		237 (47.9%)	137 (100.0%)	**0.000**[A]	
	Partial thickness	27 (5.5%)	22 (16.1%)	**0.000**[A]	
	Full thickness	8 (1.6%)	16 (11.7%)	**0.000**[A]	
	Necrosis	19 (3.8%)	21 (15.3%)	**0.000**[A]	

Univariate OR (95% CI) for tongue-type fractures: 1.351 (95% CI 0.925-1.974, p=0.120).
[A], Fisher's Exact Test; [B], Pearson Chi-Square test

Table 7: Covariates for the study population with versus without superficial infections

Variable		No Superficial Infection	Superficial Infection	P-value	OR (95% CI) adjusted
Gender (Male)		369 (75.8%)	55 (75.3%)	1.000[A]	
Age (years)		43 (33-55)	47 (36-57)	0.178	1.003 (0.982-1.024)
BMI		24.2 (21.5-26.9)	25.2 (22.0-28.7)	0.073	**1.102 (1.031-1.178)**
ASA	I	236 (55.9)	38 (53.5%)	0.331[B]	
	II	160 (37.9%)	32 (45.1%)		
	III	22 (5.2%)	1 (1.4%)		
	IV	4 (0.9%)	0 (0.0%)		
Smoking	Current	220 (53.9%)	30 (43.5%)	0.254[B]	0.809 (0.447-1.465)
	Previous	43 (10.5%)	10 (14.5%)		1.074 (0.449-2.571)
	Never	145 (35.5%)	29 (42.0%)		
Comorbidities		191 (41.3%)	37 (50.7%)	0.161[A]	1.318 (0.629-2.765)
	Diabetes Mellitus	21 (4.5%)	4 (5.5%)	0.764[A]	
Medication use		107 (23.8%)	25 (35.2%)	0.055[A]	1.708 (0.779-3.744)
Trauma mechanism				1.000A	
	LET	195 (36.3%)	26 (35.6%)		
	HET	342 (63.7%)	47 (64.4%)		
Time trauma to ED		0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.421	
Gardner's angle		17.0 (7.0-30.0)	20.0 (8.0-30.0)	0.882	
Böhler's angle		8.0 (-5.0-18.0)	7.0 (-8-17.0)	0.433	
Side				0.710A	
	Unilateral	423 (86.9%)	65 (89.0%)		
	Bilateral	64 (13.1%)	8 (11.0%)		
Fracture (Open/Closed)				0.113[A]	2.011 (0.732-5.529)
	Open	29 (5.2%)	8 (10.4%)		
	Closed	526 (94.8%)	69 (89.6%)		
Fracture type				1.000[A]	1.209 (0.700-2.088)
	Non-tongue-type	296 (53.3%)	41 (53.2%)		
	Tongue-type	259 (46.7%)	36 (46.8%)		
Soft tissue compromise		148 (26.7%)	30 (39.0%)	**0.030**[A]	1.606 (0.896-2.878)
	Posterior	56 (10.1%)	7 (9.1%)	1.000[A]	
Additional injury		207 (42.7%)	32 (43.8%)	0.899[A]	
Surgery		462 (83.2%)	70 (90.9%)	0.096[A]	1.511 (0.573-3.987)
Time trauma to surgery		10.0 (6.0-16.0)	13.0 (5.0-18.0)	0.151	
Delay to surgery				0.121[B]	
0-2 days		53 (11.7%)	11 (15.9%)		
3-7 days		106 (23.3%)	10 (14.5%)		
8-14 days		153 (33.7%)	19 (27.5%)		
>15 days		142 (31.3%)	29 (42.0%)		
Hospital length of stay		8.0 (5.0-15.0)	7.0 (5.0-17.3)	0.959	
Complication		297 (53.3%)	77 (100.0)	**0.000**[A]	
	Partial thickness	40 (7.2%)	9 (11.7%)	0.173[A]	
	Full thickness	16 (2.9%)	8 (10.4%)	**0.005**[A]	
	Necrosis	29 (5.2%)	11 (14.3%)	**0.005A**	

Univariate OR (95% CI) for tongue-type fractures: 1.003 (95% CI 0.622-1.618, p=0.989).
[A], Fisher's Exact Test; [B], Pearson Chi-Square test

Table 8: Covariates for the study population with versus without deep infections

Variable		No Deep Infection	Deep Infection	P-value	OR (95% CI) adjusted
Gender (Male)		367 (76.0%)	57 (74.0%)	0.775[A]	
Age (years)		44 (34-56)	44 (32-54)	0.503	
BMI		24.2 (21.4-27.0)	24.7 (22.1-28.9)	0.181	
ASA	I	237 (56.6%)	37 (50.0%)	0.324[B]	
	II	157 (37.5%)	35 (47.3%)		
	III	21 (5.0%)	2 (2.7%)		
	IV	4 (1.0%)	0 (0.0%)		
Smoking	Current	211 (51.3%)	39 (59.1%)	0.499[B]	1.392 (0.784-2.471)
	Previous	47 (11.4%)	6 (9.1%)		0.996 (0.350-2.838)
	Never	153 (37.2%)	21 (31.8%)		
Comorbidities		197 (42.9%)	31 (40.8%)	0.803[A]	
	Diabetes Mellitus	21 (4.6%)	4 (5.3%)	0.769[A]	
Medication use		113 (25.2%)	19 (26.4%)	0.884[A]	
Trauma mechanism				0.715[A]	
	LET	189 (35.9%)	32 (38.1%)		
	HET	337 (64.1%)	52 (61.9%)		
Time trauma to ED		0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.283	
Gardner's angle		16.0 (7.0-30.0)	24.5 (8.8-33.3)	0.090	
Böhler's angle		9.0 (-4-18.0)	5.0 (-14.0-15.5)	**0.023**	0.993 (0.978-1.008)
Side				0.143[A]	
	Unilateral	425 (88.0%)	63 (81.8%)		
	Bilateral	58 (12.0%)	14 (18.2%)		
Fracture (Open/Closed)				**0.011**[A]	**2.504 (1.001-6.262)**
	Open	26 (4.8%)	11 (12.5%)		
	Closed	518 (95.2%)	77 (87.5%)		
Fracture type				**0.028**[A]	1.619 (0.948-2.767)
	Non-tongue-type	300 (55.1%)	37 (42.0%)		
	Tongue-type	244 (44.9%)	51 (58.0%)		
Soft tissue compromise		150 (27.6%)	28 (31.8%)	0.444[A]	
	Posterior	52 (9.6%)	11 (12.5%)	0.441[A]	
Additional injury		206 (42.8%)	33 (42.9%)	1.000[A]	
Surgery		452 (83.1%)	80 (90.9%)	0.082[A]	1.544 (0.626-3.807)
Time trauma to surgery		10.0 (6.0-16.0)	12.5 (5.5-17.0)	0.210	
Delay to surgery				**0.034**[B]	
0-2 days		54 (12.2%)	10 (12.5%)		
3-7 days		102 (23.0%)	14 (17.5%)		
8-14 days		153 (34.5%)	19 (23.8%)		
>15 days		134 (30.2%)	37 (46.2%)		
Hospital length of stay		7.0 (5.0-15.0)	9.5 (6.0-21.0)	**0.006**	1.010 (0.997-1.024)
Complication		286 (52.6%)	88 (100.0%)	**0.000**[A]	
	Partial thickness	31 (5.7%)	18 (20.5%)	**0.000**[A]	
	Full thickness	9 (1.7%)	15 (17.0%)	**0.000**[A]	
	Necrosis	21 (3.9%)	19 (21.6%)	**0.000**[A]	

Univariate OR (95% CI) for tongue-type fractures: **1.695 (95% CI 1.074 – 2.673 , p=0.023)**.
[A], Fisher's Exact Test; [B], Pearson Chi-Square test

Table 9: Covariates for the study population with versus without full thickness lesion

Variable		No Full thickness lesion	Full thickness lesion	P-value	OR (95% CI) adjusted
Gender (Male)		409 (75.7%)	15 (75.0%)	1.000[A]	
Age (years)		44 (34-56)	43 (31-54)	0.440	
BMI		24.2 (21.5-27.2)	26 (22-28)	0.146	
ASA	I	266 (56.2%)	8 (40.0%)	0.482[B]	
	II	181 (38.3%)	11 (55.0%)		
	III	22 (4.7%)	1 (5.0%)		
	IV	4 (0.8%)	0 (0.0%)		
Smoking	Current	243 (52.6%)	7 (46.7%)	0.896[B]	1.019 (0.373-2.786)
	Previous	51 (11.0%)	2 (13.3%)		1.316 (0.257-6.751)
	Never	168 (36.4%)	6 (40.0%)		
Comorbidities		218 (42.3%)	10 (50.0%)	1.000[A]	
	Diabetes Mellitus	24 (4.7%)	1 (5.0%)		
Medication use		126 (25.2%)	6 (30.0%)	0.606[A]	
Trauma mechanism				0.185[A]	
	LET	216 (36.8%)	5 (21.7%)		
	HET	371 (63.2%)	18 (78.3%)		
Time trauma to ED		0.0 (0.0-0.0)	0 (0-0)	0.477	
Gardner's angle		18.0 (7.0-30.0)	12.0 (2.5-23.0)	0.332	
Böhler's angle		8.0 (-5.0-18.0)	9.0 (-25.0-20.0)	0.580	
Side				0.733[A]	
	Unilateral	471 (87.2%)	17 (85.0%)		
	Bilateral	69 (12.8%)	3 (15.0%)		
Fracture (Open/Closed)				**0.000**[A]	
	Open	25 (4.1%)	12 (50.0%)		
	Closed	583 (95.9%)	12 (50.0%)		
Fracture type				**0.006**[A]	**3.043 (1.063-8.714)**
	Non-tongue-type	331 (54.4%)	6 (25.0%)		
	Tongue-type	277 (45.6%)	18 (75.0%)		
Soft tissue compromise		162 (26.6%)	16 (66.7%)	**0.000[A]**	
	Posterior	59 (9.7%)	4 (16.7%)	0.286[A]	
Additional injury		228 (42.4%)	11 (55.0%)	0.358[A]	
Surgery		510 (83.9%)	22 (91.7%)	0.403[A]	1.197 (0.265-5.399)
Time trauma to surgery		10.5 (6.0-16.0)	5.0 (0.0-17.0)	**0.022**	
Delay to surgery				**0.002**[B]	
0-2 days		56 (11.2%)	8 (36.4%)		
3-7 days		112 (22.4%)	4 (18.2%)		
8-14 days		170 (33.9%)	2 (9.1%)		
>15 days		163 (32.5%)	8 (36.4%)		
Hospital length of stay		7.0 (5.0-15.0)	15.0 (7.0-54.8)	**0.002**	**1.020 (1.002-1.037)**
Complication		350 (57.6%)	24 (100.0%)	**0.000**[A]	
	Infection	121 (19.9%)	16 (66.7%)	**0.000**[A]	
	Sup. infection	69 (11.3%)	8 (33.3%)	**0.005**[A]	
	Deep infection	73 (12.0%)	15 (62.5%)	**0.000**[A]	
	Necrosis	28 (4.6%)	12 (50.0%)	**0.000**[A]	

Univariate OR (95% CI) for tongue-type fractures: **3.585 (95% CI 1.404-9.155, p = 0.008)**.
[A], Fisher's Exact Test; [B], Pearson Chi-Square test

Table 10: Covariates for the study population with versus without partial thickness lesion

Variable		No Partial thickness lesion	Partial thickness lesion	P-value	OR (95% CI) adjusted
Gender (Male)		391 (75.3%)	33 (80.5%)	0.572[A]	
Age (years)		44 (34-56)	43 (34-57)	0.850	
BMI		24 (21-27)	25.1 (22.6-27.2)	0.439	
ASA	I	255 (56.2%)	19 (48.7%)	0.529[A]	
	II	175 (38.5%)	17 (43.6%)		
	III	21 (4.6%)	2 (5.1%)		
	IV	3 (0.7%)	1 (2.6%)		
Smoking	Current	226 (51.2%)	24 (66.7%)	0.087[B]	1.822 (0.790-4.205)
	Previous	48 (10.9%)	5 (13.9%)		1.041 (0.211-5.143)
	Never	167 (37.9%)	7 (19.4%)		
Comorbidities		207 (41.8%)	21 (52.5%)	0.244[A]	
	Diabetes Mellitus	25 (5.1%)	0 (0.0%)	0.244[A]	
Medication use		118 (24.5%)	14 (35.9%)	0.127[A]	
Trauma mechanism				**0.049**[A]	0.666 (0.260-1.705)
	LET	209 (37.3%)	12 (24.5%)		
	HET	352 (62.7%)	37 (75.5%)		
Time trauma to ED		0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.096	0.552 (0.131-2.327)
Gardner's angle		16.0 (6.5-29.0)	28.5 (21.3-40.0)	**0.009**	
Böhler's angle		8.5 (-4-18.0)	-5.0(-18.0-11.0)	**0.001**	0.983 (0.964-1.002)
Side				**0.029**[A]	1.269 (0.534-3.016)
	Unilateral	457 (88.1%)	31 (75.6%)		
	Bilateral	62 (11.9%)	10 (24.4%)		
Fracture (Open/Closed)				**0.018**[A]	
	Open	30 (5.1%)	7 (14.3%)		
	Closed	553 (94.9%)	42 (85.7%)		
Fracture type				0.553[A]	0.702 (0.329-1.498)
	Non-tongue-type	313 (53.7%)	24 (49.0%)		
	Tongue-type	270 (46.3%)	25 (51.0%)		
Soft tissue compromise		158 (27.1%)	20 (40.8%)	**0.047**[A]	
	Posterior	59 (10.1%)	4 (8.2%)	0.807[A]	
Additional injury		215 (41.6%)	24 (58.5%)	**0.048**[A]	1.618 (0.664-3.944)
Surgery		488 (83.7%)	44 (89.8%)	0.313[A]	1.605 (0.449-5.741)
Time trauma to surgery		10.0 (6.0-16.0)	13.0 (5.8-18.0)	0.336	
Delay to surgery				0.149[A]	
0-2 days		57 (11.9%)	7 (16.3%)		
3-7 days		112 (23.3%)	4 (9.3%)		
8-14 days		158 (32.9%)	14 (32.6%)		
>15 days		153 (31.9%)	18 (41.9%)		
Hospital length of stay		7.0 (5.0-15.0)	13.0 (8.0-31.0)	**0.001**	**1.022 (1.004-1.040)**
Complication		325 (55.7%)	49 (100.0%)	**0.000**[A]	
	Infection	115 (19.7%)	22 (44.9%)	**0.000**[A]	
	Sup. infection	68 (11.7%)	9 (18.4%)	0.173[A]	
	Deep infection	70 (12.0%)	18 (36.7%)	**0.000**[A]	
	Necrosis	27 (4.6%)	13 (26.5%)	**0.000**[A]	

Univariate OR (95% CI) for tongue-type fractures: 1.208 (95% CI 0.674-2.164, p = 0.526)
[A], Fisher's Exact Test; [B], Pearson Chi-Square test

Table 11: Covariates for the study population with versus without necrosis

Variable		No Necrosis	Necrosis	P-value	OR (95% CI) adjusted
Gender (Male)		395 (75.4%)	29 (80.6%)	0.553[A]	
Age (years)		44 (33-56)	46 (37-58)	0.463	
BMI		24 (21-27)	25 (20-28)	0.851	
ASA	I	258 (56.2%)	16 (47.1%)	0.147[B]	
	II	175 (38.1%)	17 (50.0%)		1.303 (0.613-2.768)
	III	23 (5.0%)	0 (0.0%)		N.D.
	IV	3 (0.7%)	1 (2.9%)		
Smoking	Current	235 (52.7%)	15 (48.4%)	0.650[B]	1.766 (0.625-4.984)
	Previous	48 (10.8%)	5 (16.1%)		0.795 (0.344-1.837)
	Never	163 (36.3%)	11 (35.5%)		
Comorbidities		216 (42.9%)	12 (37.5%)	0.585[A]	
	Diabetes Mellitus	24 (4.8%)	1 (3.1%)	1.000[A]	
Medication use		124 (25.4%)	8 (25.0%)	1.000[A]	
Trauma mechanism				1.000[A]	
	LET	207 (36.3%)	14 (35.9%)		
	HET	364 (63.7%)	26 (64.1%)		
Time trauma to ED		0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.371	
Gardner's angle		17.0 (7.0-29.0)	19.0 (5.0-34.3)	0.756	
Böhler's angle		8.0 (-5-17.8)	9.0 (-10.0-20.0)	0.962	
Side				0.798[A]	
	Unilateral	457 (87.2%)	31 (86.1%)		
	Bilateral	67 (12.8%)	5 (13.9%)		
Fracture (Open/Closed)				**0.000**[A]	2.693 (0.874-8.302)
	Open	27 (4.6%)	10 (25.0%)		
	Closed	565 (95.4%)	30 (75.0%)		
Fracture type				0.101[A]	1.244 (0.590-2.621)
	Non-tongue-type	321 (54.2%)	16 (40.0%)		
	Tongue-type	271 (45.8%)	24 (60.0%)		
Soft tissue compromise		156 (26.4%)	22 (55.0%)	**0.000**[A]	**3.174 (1.411-6.995)**
	Posterior	55 (9.3%)	8 (20.0%)	**0.049**[A]	
Additional injury		222 (42.5%)	19 (52.8%)	0.605[A]	
Surgery		498 (84.1%)	34 (85.0%)	1.000[A]	0.545 (0.183-1.623)
Time trauma to surgery		10.0 (6.0-16.0)	9.0 (2.8-18.0)	0.362	
Delay to surgery				0.223[B]	
0-2 days		57 (11.6%)	7 (21.2%)		
3-7 days		111 (22.7%)	5 (15.2%)		
8-14 days		164 (33.5%)	8 (24.2%)		
>15 days		158 (32.2%)	13 (39.4%)		
Hospital length of stay		7.0 (5.0-15.0)	12.0 (6.0-21.0)	**0.041**	1.010 (0.991-1.029)
Complication		334 (56.4%)	40 (100.0%)	**0.000**[A]	
	Infection	116 (19.6%)	21 (52.5%)	**0.000**[A]	
	Sup. infection	66 (11.1%)	11 (27.5%)	**0.005**[A]	
	Deep infection	59 (11.7%)	19 (47.5%)	**0.000**[A]	
	Partial thickness	36 (6.1%)	13 (32.5%)	**0.000**[A]	
	Full thickness	12 (2.0%)	12 (30.0%)	**0.000**[A]	

Univariate OR (95% CI) for tongue-type fractures: 1.777 (95% CI 0.925-3.413, p=0.084)
[A], Fisher's Exact Test; [B], Pearson Chi-Square test

Table 12: Covariates for the study population with versus without non-union

Variable		No Non-union	Non-union	P-value	OR (95% CI) adjusted
Gender (Male)		130 (24.3%)	6 (25.0%)	1.000[A]	
Age (years)		44 (34-56)	48 (35-57)	0.716	
BMI		24.2 (21.5-27.2)	25.4 (23.0-30.8)	**0.034**	**1.191 (1.077-1.317)**
ASA	I	265 (56.3%)	9 (40.9%)	0.208[A]	
	II	179 (38.0%)	13 (59.1%)		
	III	23 (4.9%)	0 (0.0%)		
	IV	4 (0.8%)	0 (0.0%)		
Smoking	Current	241 (52.9%)	9 (52.9%)	0.554[B]	0.201 (0.019-2.174)
	Previous	51 (11.2%)	2 (9.5%)		1.162 (0.439-3.072)
	Never	164 (36.0%)	10 (47.6%)		
Comorbidities		215 (42.0%)	13 (56.5%)	0.198[A]	
	Diabetes Mellitus	25 (4.9%)	0 (0.0%)	0.617[A]	
Medication use		124 (24.9%)	8 (34.8%)	0.327[A]	
Trauma mechanism				0.064[A]	1.365 (0.440-4.235)
	LET	216 (37.0%)	5 (18.5%)		
	HET	367 (63.0%)	22 (81.5%)		
Time trauma to ED		0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.372	
Gardner's angle		17.0 (7.0-29.8)	22.0 (4.5-38.0)	0.490	
Böhler's angle		8.0 (-5.0-18.0)	2.0 (-20.0-13.0)	**0.042**	0.980 (0.956-1.004)
Side				0.534[A]	
	Unilateral	468 (87.3%)	20 (83.3%)		
	Bilateral	68 (12.7%)	4 (16.7%)		
Fracture (Open/Closed)				**0.005**[A]	2.489 (0.540-11.473)
	Open	31 (5.1%)	6 (20.7%)		
	Closed	572 (94.9%)	23 (79.3%)		
Fracture type				0.704[A]	1.172 (0.454-3.024)
	Non-tongue-type	323 (53.6%)	14 (48.3%)		
	Tongue-type	280 (46.4%)	15 (51.7%)		
Soft tissue compromise		166 (27.5%)	12 (41.4%)	0.137[A]	2.127 (0.759-5.962)
	Posterior	60 (10.0%)	3 (10.3%)	1.000[A]	
Additional injury		226 (42.2%)	13 (56.5%)	0.200[A]	
Surgery		512 (84.9%)	20 (69.0%)	**0.033**[A]	0.158 (0.053-0.472)
Time trauma to surgery		10.0 (6.0-16.0)	6.5 (0.8-14.3)	0.070	
Delay to surgery				**0.016**[B]	
0-2 days		57 (11.3%)	7 (35.0%)		
3-7 days		113 (22.5%)	3 (15.0%)		
8-14 days		168 (33.4%)	4 (20.0%)		
>15 days		165 (32.8%)	6 (30.0%)		
Hospital length of stay		7.0 (5.0-15.0)	9.0 (6.0-34.0)	0.081	1.017 (0.997-1.038)
Complication		345 (57.2%)	29 (100.0%)	**0.000**[A]	
	Infection	124 (20.6%)	13 (44.8%)	**0.004**[A]	
	Sup. infection	69 (11.4%)	8 (27.6%)	**0.017**[A]	
	Deep infection	78 (12.9%)	10 (34.5%)	**0.003**[A]	
	Partial thickness	45 (7.5%)	4 (13.8%)	0.271[A]	
	Full thickness	22 (3.6%)	2 (6.9%)	0.303[A]	

Univariate OR (95% CI) for tongue-type fractures: 1.236 (95% CI 0.586-2.605, p=0.578)
[A], Fisher's Exact Test; [B], Pearson Chi-Square test

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