



## Frequency and risk factors of complications after surgical treatment of ankle fractures : a retrospective study of 433 patients

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Ankle fractures are frequently treated using surgical interventions, and are associated with a high rate of postoperative complications. We wonder if complications can be anticipated and correlated to patient demographics, lifestyle, fracture or surgery related factors. We retrospectively reviewed all medical reports of patients who underwent ankle fracture surgery between 2013 and 2017. We focused our risks factors analysis on 5 common complications : poor wound healing, surgical site infection, malunion, nonunion and chronic pain. Multivariate logistic regression was performed to analyze significant risk factors for these complications. We identified 433 patients. Complications were present in 26% of the cases. The most frequent complication was poor wound healing (10%) associated with deep surgical site infection in 6%. Malunion was found in 7% and nonunion in 3%. Seven percent of patients suffered from chronic pain. More severe fractures happened to be a risk factor for poor wound healing ( $p = 0,032$ ) and malunion ( $p < 0,001$ ). Open fractures had respectively 6 to 9 times more mal- ( $p = 0,012$ ) and nonunion ( $p = 0,018$ ). Overweight patients with alcohol abuse were doubling their chances of cutaneous ( $p = 0,030$ ) and infectious ( $p = 0,040$ ) complications, and tripling their risks of ankle fracture nonunion ( $p = 0,003$ ). Female and patients operated at night ( $p = 0,045$ ) seemed to be more at risk to develop chronic pain ( $p = 0,028$ ). Complications of ankle fracture treatment are frequent and their risks increases with more complex and open fractures. This study brings new evidence concerning the combined effect of overweight and alcohol abuse on poor wound healing, surgical site infection and non-union.

**Keywords :** Ankle fracture ; surgery ; post-operative complications.

### INTRODUCTION

Ankle fractures are the most common intra-articular fractures of a weight bearing joint, accounting for 9% of all fractures (1). They occur within a wide range of patients. Ankle fractures represent 21% of all sports-related injuries and these injuries have a greater incidence in males in their early twenties (26). Furthermore, among elderly patients, ankle fractures are the third most common fracture (32) and their incidence rate has been reported to be increasing (9,28,30,32).

Surgical treatment of ankle fractures is frequent (26) and is reported to improve patient functional outcome and quality of life (3). This treatment mainly consists of open reduction and internal fixation (ORIF). However, complications following

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surgical treatment are not rare with rates increasing to 40% in the elderly (20). Post-operative wound complications are the most recurrent encountered problem with deep infections producing the most devastating consequences (24). The incidence of surgical site infections varies considerably in the literature, ranging up to 6% (16,17,18,19, 24,27). Infection increases the risk of poor functional outcome (12) and may inflate healthcare costs by more than 300% (19). In some cases, infections may lead to permanent disability, amputation or death (16). Other common complications include malunion, nonunion, osteoarthritis, chronic pain, persistent disability, neurologic lesions, and thromboembolic events (13,17).

When considering complications, various risks factors are notably significant. In addition to the characteristics of the injury, such as severity of fracture and soft tissue alterations, other key factors predisposing to wound complications include patient comorbidities and substance use, as well as surgery related aspects (17).

Complexity of the fracture, unsatisfactory reduction or loss of achieved reduction may lead to ankle malunion (17,18). An alteration in articular congruency results in chronic pain, functional impairment and deterioration of the articular cartilage (17). Malunion can also lead to fracture nonunion. Other factors such as infection, diabetes, obesity, tobacco use, diabetes, alcohol abuse and advanced age also contribute to the development of nonunion (4,10,17,23). Given the common occurrence of ankle fractures and their increasing incidence, the purpose of this retrospective cohort study is to determine the complication rate and the intrinsic and extrinsic risks factors. The results could improve patient care by helping practitioners to apprehend the risk of postoperative complication. We focused on complications such as poor wound healing, surgical site infection, chronic pain, mal and nonunion using a large (n=433) single center database. Our hypothesis is that complications after ankle fracture surgery are frequent, especially regarding soft tissues healing. We also suspect that patient with abusive lifestyle habits (obesity, alcohol and tobacco) are more at risk of developing poor soft tissues healing and surgical site infections.

## PATIENTS AND METHODS

In a single university teaching hospital; 433 medical records of patients treated surgically for ankle malleolus fracture from 2013 to 2017 were analyzed retrospectively. Patients with missing data or with pilon fractures and metaphyseal and/or diaphyseal tibial fractures were excluded from the study. Patients with history of bone and ankle joint infection, previous ankle fracture and those suffering from ankle osteoarthritis were also excluded. All patients were over 18 years old. We collected patient data for demographics, injury pattern, comorbidities, lifestyle factors, surgery related aspects and postoperative complications. The mean follow-up was 1 year [range, 30-days to 5 years]. Patient and surgery characteristics were tested for association with any complication. This study focused on 5 types of complications, poor wound healing, surgical site infection, chronic pain, malunion and nonunion.

Each patient's age, gender, BMI, American Society of Anesthesiologists (ASA) score at the time of surgery was collected from hospital records. Patient comorbidities and lifestyle factors that could influence wound healing and fracture consolidation were analyzed. Specifically, smoking status, alcohol overconsumption and presence of diabetes were recorded. Alcohol overuse was defined as a daily intake of > 2 units. We considered that one unit equals 10 grams of alcohol (2).

The type of fracture was determined by radiographic analysis. We separated medial unimalleolar (medial UM), lateral unimalleolar (lateral UM), Maisonneuve-type (MN), bimalleolar (BM), and trimalleolar (TM) fractures. If a BM (or TM) fracture had a ligamentous injury at one side of the joint, the fracture was considered as an "equivalent" BM (or TM) fracture. Lateral malleolar fractures were classified according to the Weber classification (A : distal to ankle joint, B : at the level of tibiofibular ligaments, C : above the ankle joint). The Gustilo and Anderson Classification was used to characterize all open fractures.

Primary surgical treatment was open reduction and internal fixation (ORIF). Plates were generally used for lateral malleolar fracture fixation, and screws

for the medial and posterior malleoli. The type of lateral plating technique was discerned. Likewise, we noted if a temporary external fixation was utilized before ORIF. We also asked ourselves if the risk of complications is greater when patients are operated during the evening or night (> 6:30PM) had a greater risk of complications. The length of each surgical procedure was noted. The use of resorbable or non-resorbable suture was noted from surgery reports in each patient, in order to determine if this was a risk factor for cutaneous complications or not.

Type of complications were categorized. Wound complications included wound edge necrosis, dehiscence (reopening of wound) and delayed healing (> 30 days). Surgical site infections were divided into two categories, superficial and deep infections (8). Deep infection was considered when suggestive clinical signs were present with positive intraoperative findings of infection spreading onto the hardware. Suggestive local clinical signs included for example late stage wound reopening, unexplained local inflammation, wound complications resisting to medical treatment, persistent or purulent fluid discharge, hardware exposition. These signs were at times accompanied by systemic and/or biologic evidences of infection. Deep surgical site infection was treated surgically followed by short administration of intravenous antibiotics relayed by long term (6 weeks to 3 months) specific oral antibiotic treatment. Superficial infections, without bone contact and/or exposition of hardware, were treated with wound care.

Bone malunion and nonunion were assessed on x-rays. Extra-articular deformity (valgus or varus), articular incongruity (talar tilt or shift) and possible fracture mal-reduction of each malleolus were searched. Additionally, we looked for fibula shortening (using Weber's ball technique), medial (> 4mm in mortise views) and tibiofibular (> 6mm) clear space widening. Posterior malleolus malalignment was considered when superior of ¼ of articular surface and displaced more than 2mm. The presence of bridging callus or disappearance of fracture line was considered as a radiological union. Severe talocrural osteoarthritis was defined as

grade 3-4 according to the Kellgren and Lawrence classification.

The diagnosis of complex regional pain syndrome was retained, based on clinical "Budapest diagnostic criteria" (15).

A bivariate analysis using the chi-square test was performed to test the probability of having more severe fracture (BM, TM and MN vs UM fractures) depending on patients' characteristics (age > 65y, BMI > 25kg/m<sup>2</sup>, gender, substance abuse, diabetes, ASA-score).

For multivariate analysis, Sigmaplot 14.0 de SPSS was used. A multivariate logistic regression analysis was performed to determine if patient and surgery characteristics were significant risk factors for the development of these complications. The patient's variables included demographics (age, gender), preoperative comorbidities (ASA status, BMI, diabetes), lifestyle habits (active smoking and alcohol abuse) and fracture attributes (presence of skin opening, numbers of malleoli touched and type of lateral malleolar fracture according to the Weber classification). The parameters inherent to surgery were duration, time of day (before or after 18H30), timing (numbers of days after fracture), type of lateral malleolar fixation and skin suture (non-resorbable vs resorbable), temporary use of external fixation, and lastly, quality of post-operative reduction.

After statistical analysis, all p-values under 0,05 were considered as significant.

## RESULTS

A total of 433 patients were included in this study. Mean age was 51 years old [MIN : 18, MAX :91]. Our cohort counted 187 men (43%) and 247 (57%) women. The mean age of men was 45 years old and 54 years old for the women. Of the 433 patients included, 25% were over 65 years old and 34% under 40 years old.

In total, 59% of patients had a BMI superior or equal to 25 kg/m<sup>2</sup>. The mean BMI was 27 Kg/m<sup>2</sup> [MIN : 16,8 ; MAX : 53,1]. 37% are overweight and 22% were obese. 7% had diabetes, 2% required a daily insulin intake. 39% of patient were ASA 1, and 62% of them were 40 years old or under. 56% were

Table 1. — Demographic data of the study cohort

Variable	N	%	Mean	Min/ Max	Standard deviation	Median	Complication (%)
<b>Patients</b>	433	100					26
Follow-up (months)			12	1; 60	9	11	
Age (years)			51	18; 91	18	51	
– ≥ 65	110						34
– ≥[18-40]	147						28
– ≥Male			45				18
– ≥Female			55				
<b>Gender</b>							
– ≥Male	187	43					26
– ≥Female	246	57					27
<b>BMI (kg/m<sup>2</sup>)</b>			27	17; 53	5	26	
– ≥Normal < 25							22
– ≥Overweight [25; 30]	160	37					29
– ≥Obese ≥ 30	95	22					28
<b>ASA score</b>							
– ≥1	168	39					21
– ≥2	242	56					28
– ≥3	23	5					39
<b>Active smokers</b>	94	22					23
<b>Alcohol overconsumption (&gt;100gr per week)</b>	60	14					32
– < 75gr/day	30	7					
– ≥ 75gr/day	30	7					

Table 2. — Demographics of severe fractures (BM, TM, MN vs UM fractures)

	<b>Tobacco Or alcohol abuse</b>	<b>Diabetes</b>	<b>BMI &gt;25</b>	<b>Age ≥65y</b>	<b>ASA 2/3</b>
<b>All</b>	NS	NS	<0,05	<0,001	<0,05
<b>Women</b>	NS	<0,05	Ns	<0,001	<0,05
<b>Men</b>	NS	NS	Ns	NS	NS

ASA 2. A quarter of our cohort had a daily alcohol intake (25%). In 14%, the alcohol consumption was abusive (> 100gr per week). 22% patients of the cohort were active smokers.

Otherwise, overweight (BMI>25), aged (> 65y) and fragile patients (ASA 2/3) seemed to be more at risk to develop more severe fractures after bivariate analysis. The same observation was made for diabetics in the female population (Table 2).

Of the 433 patients, 39% had an UM fracture. Most of them were lateral malleolar fractures (89%), mainly represented by Weber B-type fractures (76%). 36% had an BM fracture, also principally

represented by Weber B fractures (77%). 13% of BM fractures were considered as equivalent BM fractures. 22% were TM fractures, 73% of which were Weber B-Type fracture, and 23% Weber C. Equivalent TM fractures counted for 4%.

5% had open fractures, 20% was Gustilo 1 type, 55% Gustilo 2, and 25% Gustilo 3.

Forty-three percent of patients had their fracture surgically treated within 48 hours. Forty-four percent had their definitive surgical treatment before week 3 because of poor soft tissues. Only 10 patients had their treatment after 3 weeks. 12,4% have had an external fixation before. Five days was

Table 3. — Fractures characteristics

Variable	N	%	A	B	C
<b>Patients</b>	433	100			
<b>Fracture Type</b>	433	100			
– UM lateral	152	35	14	116	22
– UM medial	18	4			
– BM (Equivalent)	154 (56)	36 (13)	10	118	26
– MN	15	3			
– TM (Equivalent)	94 (18)	22 (4)	3	69	22
<b>Lateral malleolus (Weber)</b>	399	92			
– A	27	7			
– B	302	76			
– C	70	17			
<b>Open (Gustilo classification)</b>	20	5			
– 1	4	20			
– 2	11	55			
– 3	5	25			

the average delay for surgery (without considering period of temporary external fixation).

The surgery took an average of one hour for UM and MN fractures. For BM and TM fractures, the mean duration of definitive treatment was one-hour et forty-five minutes.

Almost a third of patients was operated during the evening (incision after 6:30pm) or night. Evening and night surgeries were performed with fewer and less orthopedic specialized staff. The surgeons were residents in their final year of residency.

The type of suture used was usually non-resorbable (84%)

Fixation of lateral malleoli was usually performed by compression screw(s) then neutralization plating (80%). Anatomical locked plating was used in 14% of all cases, and mostly on osteoporotic bone or/and comminuted fractures. Other types of lateral malleolus fixation (cerclages, intramedullary k-wires, screws, external fixation and arthrodesis) were rare and combined, represented 6%.

Twenty six percent of the patients presented complications. Some had multiple complications.

The most common one was wound complications (10%), mainly represented by surgical wound dehiscence, characterized by skin opening after 2 weeks. Eighty-four percent of these complications concerned the lateral side of the ankle. Late dehiscence was observed in 3 patients within the

year of initial surgery (wound reopening after 4 to 10 months), revealing deep surgical site infection in all these cases. The average occurrence of early dehiscence (< 3months post-op) happened at 6 weeks (Minimum = 2 weeks ; Maximum = 10 weeks). 18% of all dehiscence needed skin grafting neurocutaneous/muscle local flaps. 83% of the wounds that presented necrosis required surgical washing/debridement, and in 50% of these cases a local flap coverage was added. All patients with large defects requiring local flap/skin graft coverage had deep surgical site infections. Most of them were fragile patients (87% ASA 2-3) with more severe fractures (87% BM/TM fractures), and 25% of them initially had an open joint (Gustilo 2-3). None of them were known smokers. However, 4 out of the 5 patients who needed a sural flap coverage had diabete (Table 5).

Surgical site infection concerned 26 patients (6%). We separated superficial from profound localization of infection. 2 were considered superficial and evolved positively with adapted wound dressings and close medical follow-up. Nevertheless, the majority was deep surgical site infection (88%). One patient presented a septic ankle joint but remained three days with an open Gustilo 3 ankle before asking for medical care. All infected ankles presented local cutaneous troubles. Inversely, many of these skin complications reflected an infection.

Table 4. — Surgery characteristics

Variable	N	% (N)	Relative % (n)	Mean	Min; Max	Standard deviation	Median
<b>Patients</b>	433	100					
Delay before surgery (days)	433	100		5	0; 34	6	12
– ≤ 1	187	43					
– [2; 7]	123	28					
– [8; 14]	80	18					
– [15; 21]	33	8					
– > 21	10	2					
External fixation before ORIF	54	12					
Type of fixation of lateral malleolus	399	92	(n=399)				
– Neutralization plating	321		80				
– Anatomical locked plating	55		14				
– Pins with cerclage, intramedullary pins or screws	10		2				
– External fixation	8		2				
– Arthrodesis	5		1				
Evening & overnight surgery*	126	29					
Type of suture	424	98	(n=424)				
– Non-resorbable	356		84				
– Resorbable	68		16				
Length of surgery (minutes)				88	30; 350	39	80
– Lateral UM				68	30; 150	22	60
– Medial UM				62	30; 180	36	50
– BM				100	40; 350	40	90
– TM				111	30; 240	39	105
– MN				62	35; 100	25	50
Post-operative unsatisfactory quality of reduction	37	8	(n=37)				
– UM (N=170)	1	1	3				
– BM (N=154)	16	10	43				
– TM (N=95)	17	18	46				
– MN (N=15)	3	20	8				

Table 5. — Demographics of severe skin defects

	Diabetes	Age > 60 years	ASA 2-3	G2-G3 opening	Female	BM/TM fractures	Deep infection
<b>Flap coverage</b>	3/6	6/6	5/6	0	4/6	5/6	6/6
<b>Skin grafting</b>	0	0	2/2	2/2	1/2	2/2	2/2

In fact, of wound dehiscence and edges necrosis, respectively 67% and 50% revealed deep surgical site infection. Seventy-four percent of patients with deep infection had their hardware removed.

The second most common complication was malunion (7%). Lateral malleolus malunion was the most frequent (65% of reported malunions). Distal tibiofibular incongruity concerned 37,5% of

malunions as well as medial malleolar malalignment. Posterior malleolus malalignment was visualized in two patients. BM and TM fractures had more unsatisfactory quality of reduction (respectively 10 and 17%), than UM fractures (0,6%). However, MN-type fracture had a high rate of mal-reduction, who has reached 20% (Table 4).

Table 6. — Complications

	N	%	Deep infection (%)	Wound dressing (%)	Washing/Debridement (%)	Number & type of grafts/flaps (%)
<b>Patients</b>	433					
Patients with complications	114	26				
Cutaneous	44	10				
– Delay of healing	7	16		7 (100)		
– Dehiscence	27	61	18 (67)	8 (30)	19 (70)	2 reverse flow sural flaps 1 short peroneal muscle flap 2 skin grafts (18)
– Wedge necrosis	6	14	3 (50)	1 (17)	5 (83)	3 reverse flow sural flaps (50)
– Unexplained exaggerated redness, swelling	4	9	3 (75)	1 (25)	3 (75)	
Infection	26	6				
– Superficial	2	8		2 (100)		
– Deep	23	88			23 (100)	
– Septic ankle joint	1	4			1 (100)	
Chronic pain	29	7				
– CRPS type 1	17	57				
– Other	12	41				
Malunion	32	7	8 (25)			
– Tibio-fibular distal joint	12	37				
– Lateral malleolus	21	66				
– Medial malleolus	12	37				
– Posterior malleolus	2	6				
Nonunion	12	3	6 (50)			
Tibiotalar OA	17	4	6 (35)			

Table 7. — Other complications

DVT	3
Pulmonary embolism	1
Instability	1
Stiffness	2
Tibio-fibular ossification	1
Paresis of CPN	3
PT/Fibular Tendinitis	3
PTT incarceration	2
Hypoesthesia superficial fibular nerve territory	3
Hardware unsealing/breakage	2
Plate intolerance	2
Anterior/posterior impingement	2

Nonunion represented 3% of the patients with complications. Half were septic non-unions.

We found 4% of the patients suffering from KL 3-4 tibiotalar osteoarthritis. 35% had a previous history of deep surgical site infection.

Third most prevalent complication was chronic pain (7%). For more than a half of these (58,6%) the diagnosis of complex regional pain syndrome was retained.

Other complications were similarly noted. We recorded three patients with common peroneal nerve paresis (CPN) and three with hypoesthesia in the superficial fibular nerve (SFN) territory. Posterior tibial tendon (PTT) was found incarcerated twice and primarily unremarked. In those cases, a reoperation was needed to achieve correct fracture reduction. Posterior tibial tendon was inflamed in 2 cases, and fibular tendons in one case. Three patients developed deep venous thrombosis (DVT), one of which had a pulmonary embolism (Table 7).

In our cohort, the category most implicated as a significant risk factor for complications was overweight patients with an abusive consumption of alcohol. In fact, these patients were twice likely

Table 8. — Results of multiple logistic regression for 5 types of complication

Independent Variables	Coefficient ± SE	Odds Ratio [LCI-UCI]	P value	Relative Risk
<b>INFECTION</b>				
BMI>25 plus Alcohol abuse	0.881 ± 0.46	2.414 [0.96-6.04]	0.04	2.13
<b>WOUND POOR HEALING</b>				
TM fracture	1.162± 0.54	3.196 [1.10-9.23]	0.032	1.52
BMI>25 plus Alcohol abuse	0.853± 0.39	2.346 [1.08-5.06]	0.030	2.02
<b>MALUNION</b>				
BM fracture	1.866 ± 0.82	6.463 [1.28-32.42]	0.023	1.89
TM fracture	2.746 ± 0.82	15.575 [3.14-77.21]	<0.001	2.56
Open fracture	1.657± 0.66	5.246 [1.45-18.98]	0.012	6.53
<b>NON-UNION</b>				
Open fracture	2.178 ± 0.92	8.828 [1.46-53.49]	0.018	9.38
Alcohol abuse	1.098 ± 0.44	2.998 [1.27-7.06]	0.012	2.31
BMI>25 plus Alcohol abuse	1.823 ± 0.62	6.191 [1.86-20.55]	0.003	3.03
<b>CHRONIC PAIN</b>				
Female population	1.092± 0.49	2.979 [1.12-7.89]	0.028	8.32
Surgery during evening/night	0.950± 0.48	2.586 [1.02-6.55]	0.045	1.68

SE: Standard Error. LCI: 5% Confidence Lower – UCI: 95% Confidence Upper.

to have skin and infectious complications and three times more likely to suffer from ankle nonunion. Abusive consumption of alcohol alone was also a risk factor for nonunion (RR = 2,31).

More severe and open ankle fractures appeared as well to be risk factors for complications. Tri-malleolar fractures revealed to have more skin troubles. On the other hand, tri-malleolar and bi-malleolar fractures gave a higher rate of malunion similar to open fractures. In our cohort, all open fractures were tri or bi-malleolar fractures. Open fractures are six times more at risk to have malunion, and nine times more non-unions.

Concerning chronic pain syndrome, women seemed to be 8 times more at risk than men. Patients operated at the evening/night also appeared to be more at risk. In our study, smoking did not appear to be a risk factor for complications.

## DISCUSSION

According to the results of this single center, retrospective cohort study, surgically-treated ankle fractures are associated with a high complication rate. In fact, more than one quarter of patients (26%) developed one or several complications. The overall complication rate after open reduction and internal

fixation (ORIF) of ankle fractures varies widely in the literature from 1% to 40% (3,14,26). These important differences can be explained by the variability in the types of population and complication studied and the dissimilar lengths of follow-up. Complications after ORIF of ankle fractures can be attributed to patient, fracture, surgery and rehabilitation factors.

The most frequent complication was poor wound healing (10%), mainly represented by surgical wound dehiscence (61%). Wound complications include wound edge necrosis, wound dehiscence, superficial infection, and deep infection (24). In our study, deep surgical infection accounted for 6% of all patients with complications. After our statistical analysis, the only factor that revealed to be statistically significant for both cutaneous problems ( $p = 0,03$ ) and infection ( $p = 0,04$ ) was overweight patients with abusive alcohol consumption. They were doubling their risks. The adverse effect of alcohol abuse, was already described in other studies. However, definitions of alcohol abuse differ and, as in the Olsen & al. 2017 study, quantity of alcohol was not defined in occasional consumption. Tonnesen & al. 1991, found that the alcohol abusers developed significantly more early complications, especially infections, after surgery (31). Other studies have mixed results. In Ovaska & al.'s study, the

increased risk of infection associated with alcohol abuse was not significant in multivariable analysis. Olsen & al. 2017, also found a higher risk in these patients although statistical significance was not maintained after confounding factors adjustment. Nevertheless, this previous study had a markedly increased risk of infection in obese patients. The effect of obesity is less certain than alcohol abuse in the literature. The evidence is conflicting and sparse (16). Stauss & al 2007, described a possible increase of fracture severity (more B and C than A's) in the obese population, although there was no difference in terms of incidence of open fractures nor fracture-dislocations between the obese and non-obese groups.

Concerning the influence of the fracture type on the wound healing, a retrospective investigation of surgically treated ankle fractures suggested a higher incidence of soft tissue complications in the AO types B2/B3 fractures compared to other types of fractures (6). In our study, more severe fractures appeared to be more at risk of developing cutaneous problems. In fact, the group of TM fractures with MN-fractures were found to be more at risk than UM and BM fractures ( $p = 0,032$  ;  $RR = 1,52$ ). Inversely, most of patients with severe skin defects had more severe fractures (87% BM/TM fractures) and 25% of them initially had an open joint (Gustilo 2-3). All the severe skin complications requiring secondary sural flap coverage occurred in fragile patients over 60 years-old (ASA 2-3) of which 80% of them had diabetes. However, we did not have enough patients treated with local flaps to prove the role of these patients' characteristics in the occurrence of severe cutaneous complications. Surprisingly, active smoking was not a risk factor, as in Olsen & al. 2017 and Höiness & al. 2003 studies, unlike Nassel & al. 2011 that described that smokers had six times higher odds of developing a deep infection compared with nonsmokers. Belmont & al. 2015 corroborated that smoking is as significant modifiable risk for major local complications and Zaghoul & al. 2013 an increased risk of all complications (33). Cutaneous complications did not appear to be influenced by the type of suture used for skin closure (resorbable vs non-resorbable) nor the technique of lateral plating performed, as in the Petrucelli & al. 2017

comparing third tubular plate to LCP distal fibula plate (21). However, according to Schepers & al. 2011 there was a tripling increase in wound healing complications with locking plates (25). In our study, the use of temporary external fixation was also not a risk factor, which can be explained by the lessening incidence of wound complications by delaying surgery until post-traumatic swelling, fracture blisters, or abrasions have subsided (11). Additionally, Höiness & al. 2001 found greater incidence of postoperative wound complications when minimal preoperative soft tissues injuries were present. Thus, our study showed that delayed surgery was not a risk factor as in other studies (8,10). However, Schepers & al 2013 recommends surgery within the first day to lower risks of infectious wound complications. The published literature shows variable results with regard to the timing of surgery. We agree with Zahghoul & al 2013 who suggested that larger prospective series is needed to clarify the effect of waiting time to surgery.

Another common complication found in our series was malunion (7%), largely represented by fibular shortening and malrotation (66%) like described by van Wensen & al. 2011 and Thodarson & al. 2012 (20,29). The complexity of the fracture, unsatisfactory reduction or loss of the achieved reduction may lead to ankle fracture malunion (29). In our study, complexity of fracture and quality of reduction seemed also to have a role in malunions. In fact, TM (+ MN) [ $p < 0,001$   $RR 2,56$ ] and BM fractures [ $p = 0,023$   $RR 1,89$ ] doubled risks for malunion and open fractures (implying more severe injuries) multiplied their risks by six. All malunions were attributed to a postoperative unsatisfactory reduction, loss of achieved reduction, or in two cases, unnoticed primary distal tibio-fibular lesions. The repercussions of malunion have widely been reported in the literature. Failure to restore the ankle's anatomy leads to altered loading of the tibiotalar joint with subsequent post-traumatic arthritis and poor functional outcomes (17). However, the role of malunion on poor functional outcomes have not been analyzed in this study because of sparse and non-standardized medical findings. Additionally, the incidence of OA was underestimated because of short and variable follow-ups.

Like malunions, non-unions can have detrimental effects on patient well-being. Non-unions can lead to continued debilitating pain, instability and late posttraumatic OA (4). In our series, non-unions accounted for 3% of all complications. Risk factors for nonunion can be intrinsic or extrinsic (4). Nonunion is more likely to occur if there is poor blood supply, instability, mal-reduction, and/or interposed soft tissues into the fracture site. Many intrinsic factors have been described, such as infection, diabetes, advanced age, obesity, alcohol abuse and tobacco use (4,10,17,23). In our series, of all non-unions, half had an underlying infection, half were malunited, and a third were primary open fractures. Our multivariate statistical analysis showed that open fractures multiply risk by nine ( $p = 0,018$ ) and in our overweight with alcohol abuse patient group by three ( $p = 0,012$ ). Alcohol abuse alone doubled the risks of nonunion. However, diabetes, advanced age and tobacco use did not reveal themselves as risks factors for non-consolidation of malleolar fractures sites.

Persistent ankle pain was the last complication analyzed in our study. It represented 7% of all patients' complications. Thus, etiology and type of pain (mechanic, neuropathic, ...) were often not clearly defined in medical records. Yet, 58% were attributed to CRPS type 1. Our multivariate statistical analysis interestingly found that female patients had eight times more risk of developing this complication ( $p = 0,028$ ) and that patients operated in the evening/night were almost twice at risk ( $p = 0,045$ ). We have no explanation for these results. We did not evaluate the impact of patient's psychological traits (anxiety, depression, ...), and if early mobilization could reduce sympathetic dystrophy like suggested in Leyes & al. 2003 study. Is sensitivity to pain higher in the female population? While sex differences in pain sensitivity have demonstrated increasing importance in both clinical and experimental studies conducted in the past few decades, the results remain debated (5). Is the evening/nighttime surgery could also impact patient's pain threshold?

The strength of this present study lies in the large number of medical reports studied. The investigation was conducted in the same hospital. Consequently,

the patient care followed the same philosophy but was carried out by different surgeons with different surgical techniques. Being a retrospective study was the biggest limitation of this study. Clinical findings on medical reports were not standardized. Functional outcomes were not objectively evaluated, so instability and stiffness are certainly underestimated. Fracture and postoperative evolution were interpreted on standard x-rays at irregular intervals, thus some of the complications could have passed unnoticed or being noticed tardively. We only had two X-Ray observers and intra- and inter-observer discrepancies on X-ray analysis were not calculated. Additionally, length of surgery was not correlated to the type of trauma. The short and inhomogeneous follow-up (30-days to 5 years), could influence the true rate of complications, especially for nonunion, osteoarthritis, chronic pain and poor functional outcomes. Moreover, some of patients may have continued their medical care elsewhere.

Most importantly our study found that complications following surgical treatment of ankle fractures are frequent. We found that overweight patients with abusive alcohol consumption are more at risk of developing wound problems, surgical site infections and non-union. In this population group, we should pay extra attention to their soft tissues during surgery and opt for less invasive and faster techniques. Longer administration of prophylactic antibiotics should be tested in these patients with higher risk of surgical site infection. In these patients, wound management should be frequent during the six first weeks and an x-ray at 6 months should be systematically performed to detect non-unions. We should also emphasize patient lifestyle education.

For severe fractures, osteosynthesis should be supervised by experienced surgeons, given the higher risk of malunion. Night-time operations, especially on women should be avoided as much as possible, because chronic pain seems to be related to this factor. Generally, a standardized protocol in terms of clinical examination, imaging control, as well as frequency and duration of follow-up could improve patient care and help us detect and evaluate complications and their risk factors.

## CONCLUSION

Our large retrospective study suggests that poor wound healing, surgical site infection, malunion, nonunion and chronic pain are frequent complications following internal fixation of ankle fractures. This study brings new evidence concerning the combined effect of overweight and alcohol abuse on cutaneous complications and surgical site infection.

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