

Smoking and trimalleolar fractures are risk factors for infection after open reduction and internal fixation of closed ankle fractures: A multicenter retrospective study of 1,201 fractures

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3 **Smoking and trimalleolar fractures are risk factors for infection after open reduction and**
4 **internal fixation of closed ankle fractures: A multicenter retrospective study of 1,201 fractures**
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10 **Abstract**

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12 *Introduction:* One of the complications of the surgical therapy for ankle fractures includes wound
13 infection. This study aimed to evaluate postoperative function and clarify the risk factors associated
14 with postoperative wound infection in patients receiving the **open reduction and internal fixation** for
15 ankle fracture through a multicenter study.
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25 *Subjects and method:* Among 1421 patients diagnosed as having closed ankle fracture and who were
26 treated by surgical therapy in 11 institutions from 2014 through 2019, 1201 patients (**men, n=512,**
27 **women, n=689; the mean (SD) age, 50.9 (15.6) years; the mean body mass index [BMI] (SD), 24.3**
28 **(4.2) kg/m²**) were included as subjects. Excluded were 220 patients due to self-termination of
29 treatment, inability to follow up after discharge, open fracture, distal tibia **shaft** fracture, and pilon
30 fracture. We extracted the following as risk factors of wound infection: age, sex, BMI, **fracture type,**
31 **injury energy** and histories of smoking, diabetes, arteriosclerosis, heart failure and myocardial
32 infarction. We conducted logistic regression analysis to investigate the risk factors of wound
33 infection using these extracted items as explanatory variables and the presence or absence of wound
34 infection as the response variable.
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57 *Results:* Wound infection occurred after surgery for closed ankle fracture in 69 the 1201 patients
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3 (5.7%). The causative organism was methicillin-susceptible Staphylococcus aureus (MSSA) in 15
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6 patients, methicillin-resistant S. aureus (MRSA) in 4 patients, Finnegoldia magna in one patient, and
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9 S. haemolyticus in one patient. **In the other patients, causative organisms were not detected, culture**
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12 **of the causative organisms was not conducted, or they were unknown.** The univariate analysis
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15 showed significant differences in sex (p=0.01) and for smoking (p=0.002), **fracture type** (p=0.02)
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18 and heart failure (p=0.042). Logistic regression analysis showed that smoking and type of fracture
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21 (trimalleolar fracture) were significant explanatory factors for infection (odds ratio 1.83 and 1.98,
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24 p=0 .040 and 0.042, respectively).

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28 *Conclusions:* At 5.7%, the rate of postoperative wound infection in closed ankle fracture was not
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31 low. Staphylococcus was the most frequent causative organism. The surgeon should pay attention
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34 infection after surgery in the patients who had a **trimalleolar fracture or smoking habits.**

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43 **Key words:** ankle fracture; infection; complication

44 45 46 **Introduction**

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50 The incidence of periarticular ankle fracture is reported to be 184 people per 100,000 person-
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53 years, and it is a common injury encountered frequently in clinical practice [1]. Generally, the
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56 clinical outcome of surgical therapy for periarticular ankle fracture is satisfactory, but one of the
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3 complications includes wound infection. The overall incidence of complications after open fracture
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6 reduction and internal fixation of a closed ankle fracture ranges from 1 to 8% depending on the
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9 investigated population [2–5]. There are some reports that patient compliance to treatment, obesity,
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12 alcohol, smoking and extended operative time are related to the risk factors of infection in
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15 periarticular ankle fracture [6–9]. In addition, in a large-scale report of 57,183 patients, diabetes,
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18 open fracture and peripheral vascular disease were related to postoperative infection of periarticular
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21 ankle fracture [10]. However, because this study used health insurance data, the association with
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24 such factors as causative organism, postoperative detailed functional outcome, and lifestyle
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27 backgrounds of smoking or alcohol consumption, is unclear.
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32 Therefore, in patients who received the **open reduction and internal fixation** for closed ankle
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34 fracture, this study aimed to clarify 1) the incidence of postoperative wound infection, 2) the
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36 causative organism of postoperative wound infection, and 3) the risk factors associated with
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39 postoperative wound infection through a multicenter study.
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47 **Subjects and method**

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51 This was a retrospective multicenter study conducted after obtaining approval from the Ethical
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54 Review Board of our University and the informed consent of the patients. Our University played a
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57 key role in collecting fracture cases in which surgical therapy was performed in its affiliated
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3 hospitals, and in building a database (TRON: Trauma Research of Nagoya). We extracted cases of
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6 ankle fracture treated by surgical therapy from this database.
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9 10 *Subjects*

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12 Among 1421 patients diagnosed as having closed ankle fracture and who were treated by surgical
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14 therapy in 11 institutions from 2014 through 2019, 1201 patients (men, n=512, women, n=689; the
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16 mean (SD) age, 50.9 (15.6) years; the mean body mass index [BMI] (SD), 24.3 (4.2) kg/m²) were
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19 included as subjects. Excluded were 220 patients due to self-termination of treatment (n=65),
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22 inability to follow up after discharge (n=44), open fracture (n=34), distal tibia shaft fracture (n=32),
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29 pilon fracture (n=15) and multiple injured subjects (n=30) (Fig. 1)
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31 32 *Surgical procedure and postoperative treatment*

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35 The indication for surgery and the performance of preoperative steel wire traction or external
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38 fixation were determined at the discretion of each operator in each institution. General anesthesia or
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41 spinal anesthesia was used during surgery. According to the AO/ASIF principle of fracture repair
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44 [11], the patient was placed in the supine or lateral position and treated with open reduction and
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47 internal fixation. The medial malleolus was fixed with tension band wiring (TBW) or cannulated
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50 cancellous screw (CCS), and the lateral malleolus was fixed with TBW or locking plate, and the
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54 posterior malleolus was fixed with CCS. In general, postoperative care consisted of an
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65 appliance/plaster cast for 2 to 4 weeks, and the patients performed a non-weight bearing regimen for

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3 4 to 6 weeks. Six months after the surgery, the results were evaluated with the American
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6 Orthopaedic Foot and Ankle Score (AOFAS) [12].
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10 *Diagnosis of surgical site infection*

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12 Surgical site infections that occurred within one year after surgery were targeted [13]. We
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14 assessed the wound infection by applying the Centers for Disease Control and Prevention (CDC)
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16 criteria 2017 for defining surgical site infections.[14] We separated into superficial and deep
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18 infectious according to the criteria. Superficial infection was defined as below; 1) date of event
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20 occurs within 30 days after operative procedure, 2) involves only skin and subcutaneous tissue of the
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22 incision, 3) patient has a purulent drainage from the superficial incision, organism identified from a
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24 specimen from the superficial incision or subcutaneous tissue by a culture, 4) patient has localized
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26 pain, tenderness, swelling, erythema or heat. Deep infection was defined as below; 1) The date of
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28 event occurs within 30 or 90 days after the operative procedure, 2) involves deep soft tissues of the
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30 incision, 3) patient has a purulent drainage from the deep incision, 4) patient has a fever (>38°C),
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32 localized pain or tenderness, an abscess or other evidence of infection involving the deep incision
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34 that is detected on gross anatomical or histopathologic exam, or imaging test. The diagnosis of the
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36 superficial or deep infection was made by the surgeon.
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53 *Clinical evaluation*

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57 As risk factors of wound infection, we extracted age, sex, BMI, fracture type, injury energy
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3 (high-energy or low-energy), dislocation (a loss of apposition between the ankle articulations) and
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6 histories of smoking, diabetes, arteriosclerosis, heart failure and myocardial infarction. Diabetes,
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9 arteriosclerosis, heart failure and myocardial infarction were diagnosed based on the previous
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12 diagnosis, clinical findings and/or the use of specific medications according to the previous
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15 report.[17] Fracture **type** were classified as unimalleolar, bimalleolar and trimalleolar fractures,
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18 respectively [7]. We defined dislocation as a loss of apposition between the ankle articulations in
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21 antero-posterior radiograph or lateral radiograph.[18] Injuries were classified into two groups.
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24 Injuries such as a fall on level ground or from a bed were classified as low-energy trauma, and those
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27 such as traffic accident or fall from a high place were classified as high-energy trauma [17].
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31 *Statistical analysis*

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35 Statistical analysis was conducted with the use of EZR software version 1.40 (Jichi Medical
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38 University, Tochigi Prefecture) [19]. Categorical variables were analyzed by Fisher's exact test.
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41 Continuous variables with normal distribution were analyzed by *t*-test, and those with non-normal
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44 distribution were analyzed by the Mann-Whitney U Test. Subsequently, using logistic-regression
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47 analysis, the risk factors were identified with the presence or absence of infection as the response
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51 variable and with all factors examined in this study as the explanatory variables.
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57 **Results**

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3 Patient backgrounds are shown in Table 1. Wound infection occurred in 69 of the 1201 patients
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6 (5.7%) after surgery for closed ankle fracture. The mean of AOFAS score in the patients with
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9 infection was significantly lower than that without infection at the 6 months after surgery (90.1
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12 (range: 29-100) vs. 95.3 (range: 42-100), $P=0.0016$). The causative organism was methicillin-
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15 susceptible *Staphylococcus aureus* (MSSA) in 15 patients, methicillin-resistant *S. aureus* (MRSA) in
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18 4 patients, *Fingoldia magna* in one patient, and *S. haemolyticus* in one patient. In the other patients,
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21 causative organisms were not detected, culture of the causative organisms was not conducted, or
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24 they were unknown. When factors related to the postoperative infection were examined, the results
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27 of univariate analysis showed significant differences for sex ($p=0.01$) and for smoking ($p=0.002$),
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30 fracture type ($p=0.02$) and heart failure ($p=0.042$). Logistic-regression analysis showed that smoking
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33 and fracture type (trimalleolar fracture) were significant explanatory factors of the infection. (odds
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36 ratio 1.83 and 1.98, $p=0.040$ and 0.042, respectively) (Table 2)
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44 Discussion

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47 In this large-scale study, to identify the factors of postoperative wound infection in closed ankle
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50 fracture, we retrospectively analyzed the relationship between patient background and postoperative
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53 infection in 1201 patients. The study revealed that the infection rate was 5.7% (69 patients), that
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3 *Staphylococcus* was the most frequent causative organism, and that smoking or trimalleolar fracture
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6 were significantly related to an increased risk of wound infection.
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10 In large studies of about 1000 or more cases, the infection rate was reported to be 6.1 to 6.8%,
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12 which was similar to the results of the present study [7,9]. A prior study using a hospital discharge
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14 database of 57,183 patients showed that the overall rate of wound infections dropped to 1.44% [10].
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17 Although, the observation time matters in the analysis of infections, the discharge database did not
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20 include late infections after discharge. In addition, this report does not include superficial infections
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23 that do not require readmission, which may underestimate the subsequent reoperation rate. In the
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26 present study, 19 of the cases of infection in which the primary causative organism was confirmed
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29 were by MRSA. In a report of 1510 cases, the most common causative bacteria in 66 of those cases
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32 were polymicrobial and then *S. aureus* [20]. We thus think that staphylococcal infection should be
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38 considered first when infection is observed.
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42 This study showed smokers had a significantly increased risk of infection with an odds ratio
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45 of 1.89 compared to nonsmokers. In a cohort study of 906 cases examining the influence of
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48 smoking on postoperative complications following ankle fracture, the probability that smokers
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51 would have a deep infection was 6 times higher than that of nonsmokers [8]. There is also a report
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54 that smoking does not influence the soft tissues, and a postoperative prospective study of closed
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3 ankle fracture did not find a significant difference in 154 cases [17]. However, the problem in these
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6 studies was that the overall number of samples was small.
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10 Trimalleolar fracture is the risk factor of infection in our study. A previous retrospective study
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12 also showed Weber type C fracture was one of the independently risk factor. This is probably due
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14 to the inherently unstable nature of this fracture type, which often requires stronger fixation. [7]
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19 This study has some limitations. First, this is a retrospective study using a clinical database,
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21 and because the subjects were not randomly assigned, the possibility of selection bias must be
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23 considered. Second, 15% of the patients dropped out of the study, and they may be patients with
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25 poor outcomes, which could influence the results. **Third, we had a case of infection at a maximum**
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27 **of 52 weeks in our cohort. The follow-up period of the non-infected group in our study (9.8**
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29 **months) was significantly shorter than that of the infected group (20.8 months). Therefore, it is**
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31 **possible that we are underestimating the actual incidence of infection.** Fourth, a previous report
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33 revealed that the soft tissue problems are an independently risk factor of soft tissue complication
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35 in ankle fracture.[17] Soft tissue evaluation should be included in future studies. There was no data
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37 on the status of soft tissue damage in our database.
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50 **Conclusions**

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52 At 5.7%, the rate of postoperative wound infection in closed ankle fracture was not low.
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57 Staphylococcus was the most frequent causative organism. The surgeon should pay attention
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3 infection after surgery in the patients who had a **trimalleolar fracture or smoking habits**.
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Highlights

- This multicenter retrospective study showed a 5.7% (69/1201 patients) of wound infection after surgery for ankle fracture.
- *Staphylococcus* was the most frequent causative organism.
- Smoking and trimalleolar fracture were significant risk factors for infection.

Figure legend

Fig. 1. Patient flow in this study.

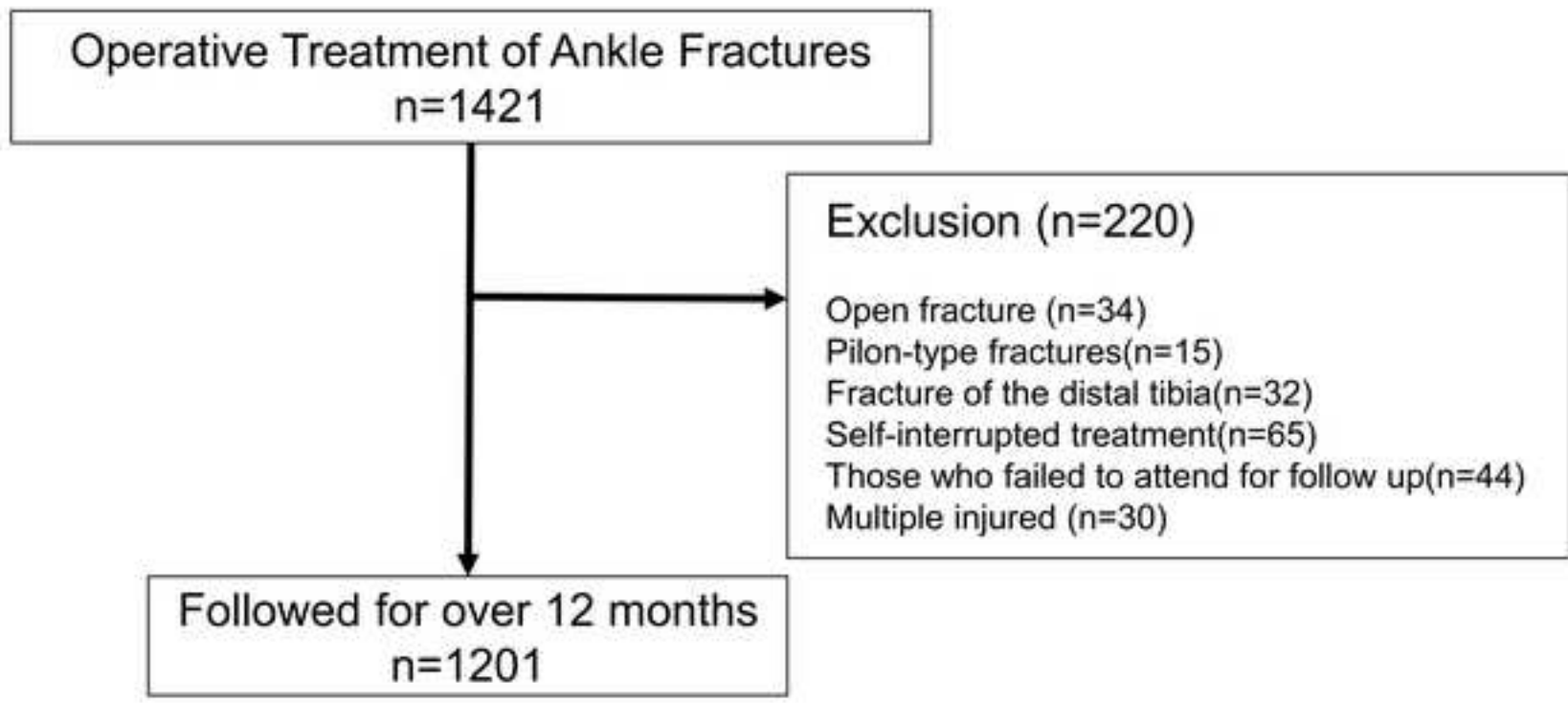


Table 1

Patient demographics

	Infection (n=69)	Non-infection (n=1132)	P value
Age, median (SD)	51.62 (21.60)	50.33 (18.99)	0.589
Sex, n (%)			0.009*
Male	50 (72.5)	639 (56.4)	
Female	19 (27.5)	493 (43.6)	
Body mass index, kg/m ² (SD)	24.53 (4.99)	24.01 (4.19)	0.328
Smoking status, Yes, (%)	23 (33.3)	190 (17.4)	0.002*
Type of fracture site (%)			0.024*
Unimalleolar (n=558)	23 (4.1)	535 (95.9)	
Medial	5	104	
Lateral	18	429	
Posterior	0	2	
Bimalleolar (n=332)	19 (6.1)	313 (93.9)	
Medial-Lateral	10	288	
Medial-Posterior	1	3	
Lateral-Posterior	8	22	
Trimalleolar (n=311)	27 (8.7)	284 (91.3)	
Mechanism of injury (%)			
Low	52 (65.8)	819 (70.8)	0.678
High	27 (34.2)	333 (28.8)	
Dislocation, Yes (%)	19 (27.5)	217 (19.2)	0.117
External fixation before surgery, Yes (%)	8 (11.6)	81 (7.16)	0.16
Diabetes, Yes (%)	11 (15.9)	117 (10.3)	0.157
Arteriosclerosis, Yes (%)	3 (4.3)	15 (1.3)	0.080
Myocardial infarction, Yes (%)	4 (5.8)	25 (2.2)	0.080
Heart failure, Yes (%)	3 (4.3)	11 (1.0)	0.042*
Waiting time to surgery, day, mean (range)	0.39 (0-11)	0.88 (0-25)	0.12
Operative time, min, mean	102 (20-327)	103 (20-453)	0.87

(range)			
Weeks when the infection was diagnosed, weeks, median (range)	9 (1-52)		
Follow-up period, month, mean (range)	20.8 (6-40)	9.81 (6-24)	<0.001

SD Standard deviation, *P<0.05

Table 2 risk factor of infection using multiple regression analysis

	Odds ratio (95% confidence interval)	P value	VIF
Age	0.997 (0.98, 1.01)	0.74	1.12
Sex			1.07
Female	1 (Ref)		
Male	1.81 (0.99, 3.26)	0.054	
Body mass index	1.01 (0.95, 1.07)	0.86	1.03
Smoking status			1.08
No	1 (Ref)		
Yes	1.83 (1.03, 3.28)	0.040*	
Type of fracture			1.09
Unimalleolar	1 (Ref)		
Bimalleolar	1.45 (0.75, 2.83)	0.27	
Trimalleolar	1.98(1.02, 3.85)	0.043*	
Mechanism of injury			1.04
Low	1 (Ref)		
High	1.05 (0.59, 1.85)	0.86	
Dislocation			1.21
No	1 (Ref)		
Yes	1.27 (0.64, 2.53)	0.50	
External fixation before surgery			1.18
No	1 (Ref)		
Yes	1.05 (0.42, 2.66)	0.92	
Diabetes			1.06
No	1 (Ref)		
Yes	1.48 (0.70, 3.10)	0.30	

Arteriosclerosis				1.15
No	1 (Ref)			
Yes	2.13 (0.42, 10.8)	0.36		
Myocardial infarction				1.09
No	1 (Ref)			
Yes	2.08 (0.61, 7.2)	0.24		
Heart failure				1.19
No	1 (Ref)			
Yes	2.68 (0.50, 14.3)	0.25		
Waiting time to surgery	0.92 (0.79,1.06)	0.25		1.01
Operative time	0.99 (0.99,1.00)	0.32		1.13

VIF Variance Inflation Factor