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Comparing Postoperative Complications Following Internal Fixation of Distal Fibular Fractures With Either One-Third Tubular or Anatomical Distal Fibular Plates

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Abstract

Background

Ankle fractures are common and frequently treated with internal fixation using either one-third tubular plates or anatomical distal fibular plates. This study investigated whether postoperative complication rates differ between plate types.

Methodology

This retrospective cohort study included patients who underwent surgical treatment of distal fibular fractures at a regional hospital in Denmark between February 2020 and January 2024. Patients were treated with either a one-third tubular plate or an anatomical distal fibular plate. Postoperative complications, reoperations, fracture classification, surgeon experience, and baseline characteristics were recorded. Complication rates were compared using proportions with 95% confidence intervals (CIs) and chi-square tests. Patients with open fractures, multi-trauma, primary external fixation, other osteosynthesis methods, residence outside the hospital region, or death within 12 months were excluded.

Results

Among 268 included patients, 114 (42.5%) experienced one or more postoperative complications. No statistically significant difference in complication rates was observed for one-third tubular plates (101/238, 42.4%; 95% CI 36.1-48.7) and anatomical distal fibular plates (13/30, 43.3%; 95% CI 25.6-61.0; $P = 0.93$). Rates increased from 41/120 (34.2%; 95% CI 26.3-43.0) with lateral plating without additional medial or anteroposterior (AP) fixation to 59/125 (47.2%; 95% CI 38.8-55.8) with additional medial screws and 14/23 (60.9%; 95% CI 40.8-77.8) with additional AP screws ($P = 0.02$). Fracture classification, baseline characteristics, and surgeon experience were not consistently associated with complication risk.

Conclusions

No statistically significant difference in postoperative complication rates was observed between one-third tubular and anatomical distal fibular plates. However, the small anatomical plate group and potential confounding limit the interpretation of this finding. Additional medial or AP fixation was associated with higher complication rates, potentially reflecting greater fracture complexity. Larger studies with adjusted analyses are needed to further investigate these associations.

Categories: Trauma, Public Health, Orthopedics
Keywords: anatomical fibula plate, ankle fracture, distal fibula plate, internal fixation, one-third tubular plate, post-operative complications

Introduction

Ankle fractures account for about 10% of all fractures [1,2]. They affect all age groups but occur more often among the elderly, primarily due to a higher prevalence of fragility fractures [1]. Injury patterns vary from isolated distal fibular fractures to complex bimalleolar and trimalleolar fractures. Distal fibular fractures are the most common and represent approximately 55% of all ankle fractures [3,4].

Classifying ankle fractures is essential to select appropriate treatment and predict prognosis. The most commonly used classification systems are the Danis-Weber, Lauge-Hansen, and AO Foundation/Orthopaedic Trauma Association (AO/OTA) systems, all designed to evaluate ankle joint stability after injury [5,6]. The AO/OTA system is used primarily in research, while the Danis-Weber and Lauge-Hansen systems are more

frequently applied in clinical practice [7].

Operative treatment with internal fixation is the preferred option for unstable ankle fractures, unless contraindicated by comorbidities. The objective is to restore anatomical alignment, joint stability, and congruity to promote healing and reduce complications [7]. For unstable distal fibular fractures, surgeons most often use either a conventional one-third tubular plate or an anatomical distal fibular plate. Use of anatomical plates is increasing [8], with biomechanical studies indicating advantages over one-third tubular plates, particularly in osteoporotic bone [9,10].

Ankle fracture surgery carries a high risk of postoperative complications, with rates up to 40% [11,12]. Older patients and those with comorbidities face the highest risk [12-14]. Common postoperative complications include delayed wound healing, sensory disturbances, tendon irritation or rupture, hardware failure, infection, thromboembolic events, chronic pain, malunion, nonunion, and osteoarthritis [11,13,15].

However, it remains unclear whether postoperative complication rates differ between anatomical plates and one-third tubular plates. Previous comparative studies have reported inconsistent findings regarding postoperative complications between plate types. The present study adds real-world data from a Danish regional hospital, with a relatively long follow-up period and an assessment of implant-, fracture-, and treatment-related factors. The primary objective of this retrospective cohort study was to compare the proportion of patients experiencing one or more postoperative complications following internal fixation of distal fibular fractures using either a one-third tubular plate or an anatomical distal fibular plate. The primary outcome was the occurrence of one or more postoperative complications during follow-up, including reoperation for any reason. Secondary exploratory objectives were to investigate associations between postoperative complications and fracture classification, surgeon experience, baseline patient characteristics, and the use of additional osteosynthesis alongside lateral plate fixation.

Materials And Methods

This retrospective study assessed complication rates following internal fixation of distal fibular fractures using either a one-third tubular plate (Small Fragment, DePuy Synthes, Warsaw, IN) or an Anatomic Distal Fibula Plate (Arthrex, Naples, FL) at a regional hospital in Denmark, from February 2020 to January 2024.

We identified patients through procedure codes KNHJ40-3, KNHJ50-3, KNHJ60-3, KNHJ70-3, KNHJ80-3, and KNHJ90-3 combined with relevant ICD-10 diagnostic codes DS929, DS823C, DS825, DS826, DS827A-B, DS828, DS828B, DS828D, and DS829. Data were extracted from electronic medical records between February and May 2025. The follow-up period extended from the date of surgery until the beginning of February 2025, which was used as the cutoff for complication ascertainment. All patients had a minimum potential follow-up period of 12 months. Complications and reoperations were identified through electronic patient records available within the Central Denmark Region.

Patients were excluded if they had open fractures or multiple traumatic injuries, received external fixation as initial treatment, or underwent osteosynthesis using a modality other than distal fibular plating. Medial screws, syndesmosis screws, and anteroposterior (AP) screws were permitted in combination with the distal fibular plate. Foreign citizens or individuals residing outside the hospital's region, and patients who died within 12 months after surgery, were also excluded.

The choice of implant was made as part of routine clinical practice. No standardized implant selection criteria for selecting between the two plate types were documented. Consequently, the rationale for implant selection could not be assessed retrospectively, and potential confounding by indication cannot be excluded.

All patients followed a standardized postoperative protocol. The ankle joint was immobilized in a walking boot for six weeks, with no weight bearing allowed during the first four weeks, followed by partial weight bearing. Sutures were removed at two weeks, accompanied by a single physiotherapy instruction session. At six weeks, patients underwent clinical and radiographic evaluation by the surgeon. If healing was adequate, the walking boot was discontinued and full weight bearing was permitted.

We retrieved demographic data from the Business Intelligence (BI) Data Warehouse [16], Central Denmark Region. Demographic variables included age at the time of surgery (years), height (cm), weight (kg), body mass index (BMI, kg/m^2), smoking status (yes/no), alcohol consumption (above or below 7 units/week for women and 14 units/week for men), diabetes status (yes/no), and American Society of Anesthesiologists physical status classification (ASA classification) [17]. We obtained missing demographic information, complication status, and reoperations from the electronic patient file system (EPJ), Central Denmark Region.

The primary outcome was the occurrence of one or more postoperative complications during follow-up. Postoperative complications were identified retrospectively through a review of electronic patient records. Recorded complications included infections, wound dehiscence, nerve injuries, tendon irritation or rupture, thromboembolic events, hardware failure, and reoperations for any reason, including elective hardware removal. Complications were recorded when documented in the medical records during the available follow-

up period.

We extracted data on the type of osteosynthesis and surgeon experience from EPJ. Patients were categorized according to whether additional medial or AP screws were used alongside the lateral plate. Patients without additional medial or AP screws were classified as receiving lateral plating without additional medial or AP fixation. Syndesmotic screws were permitted but were not analyzed separately and could therefore be present in all three groups. We categorized surgeon experience as intern, junior resident (program year 1 [PGY-1]), senior resident (program year 3 [PGY-3]), or attending. We also recorded the use of thromboprophylaxis.

An orthopedic trauma consultant reviewed perioperative radiographs from the local picture archiving and communication system (PACS) and classified fractures according to the Danis-Weber [18], Lauge-Hansen [19], and AO/OTA [20] classification systems.

Statistics

Both age and BMI were summarized using means and standard deviations, and their distributions were compared between the two patient groups (complications vs. no complications) using t-tests. Follow-up time was summarized by the median and interquartile range. The distribution of follow-up time was compared between the two patient groups using a Wilcoxon rank-sum test. All categorical variables were summarized by counts and percentages, and their distributions were compared between the two patient groups using a chi-square test. We considered *P*-values less than 0.05 statistically significant.

Statistical analyses were performed using SAS version 9.4 (SAS Institute Inc., Cary, NC) and StataNow version 19.5 (StataCorp LLC, College Station, TX). Missing data were not imputed, and statistical comparisons were based on the available observations for each variable. No a priori sample size calculation was performed, as the study included all eligible patients treated within the predefined study period.

All statistical comparisons were unadjusted. No multivariable regression or other adjusted analyses were performed. The analyses were intended to provide exploratory comparisons of complication rates between groups rather than to establish independent associations or causal effects. Potential confounding, particularly related to fracture complexity, patient characteristics, and implant selection, was therefore not accounted for in the statistical comparisons.

Results

Exclusion

From February 2020 to January 2024, a total of 384 patients were identified through the relevant procedure and diagnostic codes. After removal of seven duplicates, 377 patients were screened for eligibility. Of these, 109 patients were excluded: 27 were foreign citizens or individuals residing outside the hospital's region, three died within 12 months after surgery, two had open fractures, six received primary external fixation, 65 underwent another method of osteosynthesis, three had other significant injuries, and six were excluded because of erroneous registration or missing imaging. Three patients met two exclusion criteria. A total of 268 patients were therefore included in the analysis (Figure *1*).

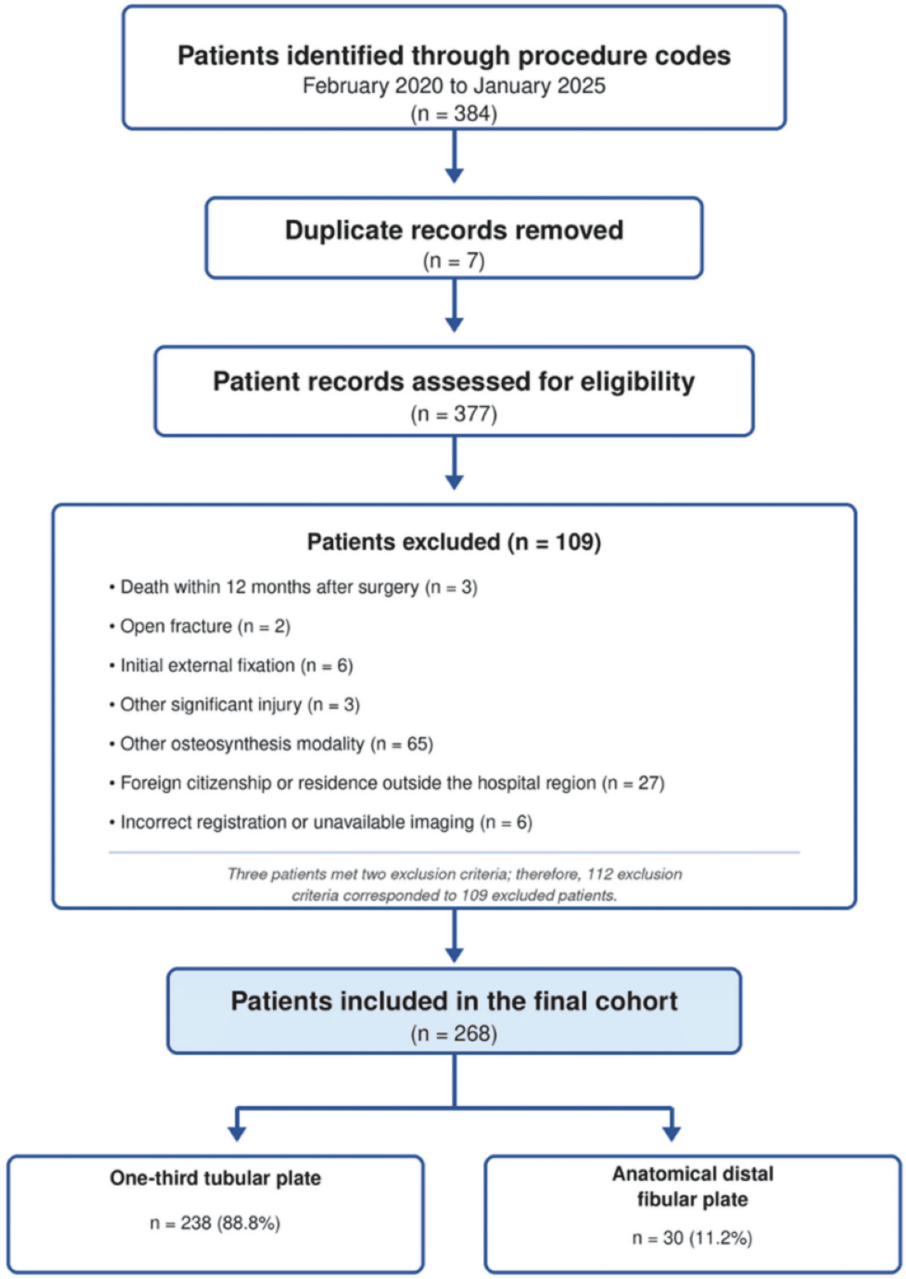

FIGURE 1: Patient selection and distribution according to plate type.

A total of 384 patients were identified through procedure codes. After removing duplicate records and applying the exclusion criteria, 268 patients were included in the final cohort and classified according to plate type.

Baseline demographics

Women represented 62.3% of the cohort (167). The mean age at the time of surgery was 57.9 years, the mean BMI was 28.4 kg/m², and 217 patients (81%) were classified as either ASA-1 or ASA-2. Patients with and without complications did not differ significantly in terms of gender, age, BMI, ASA classification, alcohol consumption, smoking status, or thrombosis prophylaxis. The median follow-up time was 36 months (interquartile range (IQR) 25-47), and follow-up time did not differ significantly between patients with complications (38 months, IQR 25-48) and those without complications (34 months, IQR 25-48) (Table *1*).

Demographics	All patients	Patients without complications	Patients with complications	Test statistic	*P*-value
Number of patients (*n*, %)	268 (100.0)	154 (57.5)	114 (42.5)	-	-
Gender (female, *n*, %)	167 (62.3)	95 (61.7)	72 (63.2)	0.06	0.81
Age in years, mean (SD)	57.9 (15.5)	59.4 (15.8)	55.9 (14.9)	1.82*	0.07
Smoking status (*n*, %)	-	-	-	4.39	0.11
Yes	71 (26.5)	34 (22.1)	37 (32.5)	3.62	0.06
No	192 (71.6)	116 (75.3)	76 (66.7)	2.42	0.12
Missing	5 (1.9)	4 (2.6)	1 (0.9)	1.06	0.84
Alcohol consumption (above RWA, %) (*n*, %)	-	-	-	0.04	0.98
Yes	40 (14.9)	23 (14.9)	17 (14.9)	<0.001	0.996
No	213 (79.5)	122 (79.2)	91 (79.8)	0.01	0.90
Missing	15 (5.6)	9 (5.8)	6 (5.3)	0.04	0.84
BMI in kg/m^2, mean (SD)	28.4 (5.6)	28.7 (5.6)	28.1 (5.7)	0.79*	0.43
ASA classification (*n*, %)	-	-	-	4.48	0.34
ASA 1	59 (22.0)	39 (25.3)	20 (17.5)	2.31	0.13
ASA 2	158 (59.0)	88 (57.1)	70 (61.4)	0.49	0.48
ASA 3	49 (18.3)	26 (16.9)	23 (20.2)	0.48	0.49
ASA 4	1 (0.4)	0 (0.0)	1 (0.9)	1.36	0.24
Missing	1 (0.4)	1 (0.6)	0 (0.0)	0.74	0.39
Thrombosis prophylaxis (*n*, %)	-	-	-	0.30	0.86
Yes	18 (6.7)	11 (7.1)	7 (6.1)	0.11	0.75
No	239 (89.2)	136 (88.3)	103 (90.4)	0.28	0.60
Missing	11 (4.1)	7 (4.5)	4 (3.5)	0.18	0.67
Diabetes (*n*, %)	-	-	-	0.12	0.73
Yes	24 (9.0)	13 (8.4)	11 (9.6)	-	-
No	244 (91.0)	141 (91.6)	103 (90.4)	-	-

TABLE 1: Demographics.

RWA (recommended weekly allowance): 7 units per week for women and 14 units per week for men.

BMI (body mass index): kg/m².

ASA (American Society of Anesthesiologists) Physical Status Classification.

Test statistics are reported as χ^2 values, except those marked with an asterisk (*), which represent t-statistics.

Fracture classification

Within the AO/OTA classification, most fractures were categorized as 44-B3 (143/268, 53.4%), followed by 44-B1 (46/268, 17.2%), 44-B2 (47/268, 17.5%), 44-C1 (20/268, 7.5%), and 44-C2 (12/268, 4.5%). Complication

rates did not differ significantly between AO/OTA subtypes.

The Lauge-Hansen classification showed a similar distribution. SER-4 was the most common injury mechanism (164/268, 61.2%), and complication rates did not differ significantly between categories.

In the Danis-Weber classification system, most fractures were classified as Weber B (228/268, 85.1%). Although the overall comparison across Weber classifications was not statistically significant ($P = 0.053$), an exploratory category-specific comparison showed a lower complication rate among patients with Weber B fractures compared with those with Weber A or C fractures ($P = 0.04$) (Table 2).

Fracture classification	All patients	Patients with no complications (*n* = 154)	Patients with complications (*n* = 114)	Test statistic	*P*-value
AO-OTA (*n*, %)	-	-	-	4.03	0.40
44-B1	46 (17.2)	31 (20.1)	15 (13.2)	2.24	0.13
44-B2	47 (17.5)	29 (18.8)	18 (15.8)	0.42	0.52
44-B3	143 (53.4)	79 (51.3)	64 (56.1)	0.62	0.43
44-C1	20 (7.5)	9 (5.8)	11 (9.6)	1.37	0.24
44-C2	12 (4.5)	6 (3.9)	6 (5.3)	0.29	0.59
Lauge-Hansen classification (*n*, %)	-	-	-	11.52	0.12
SA2	1 (0.4)	0 (0.0)	1 (0.9)	1.36	0.24
SER2	50 (18.7)	33 (21.4)	17 (14.9)	1.83	0.18
SER3	21 (7.8)	16 (10.4)	5 (4.4)	3.27	0.07
SER4	164 (61.2)	90 (58.4)	74 (64.9)	1.16	0.28
PA2	1 (0.4)	1 (0.6)	0 (0.0)	0.74	0.39
PER3	7 (2.6)	5 (3.2)	2 (1.8)	0.57	0.45
PER4	16 (6.0)	6 (3.9)	10 (8.8)	2.77	0.10
PA3	8 (3.0)	3 (1.9)	5 (4.4)	1.34	0.25
Weber classification (*n*, %)	-	-	-	5.86	0.053
A	2 (0.7)	0 (0.0)	2 (1.8)	2.72	0.10
B	228 (85.1)	137 (89.0)	91 (79.8)	4.31	0.04**
C	38 (14.2)	17 (11.0)	21 (18.4)	2.93	0.09

TABLE 2: Fracture classification systems.

Test statistics are reported as χ^2 values.
Significant *P*-value ($P < 0.05$) are reported with an (**).

Overall, 78 patients (29.1%) underwent reoperation, including hardware removal. Wound dehiscence occurred in 35 patients (13.1%), and 19 patients (7.1%) experienced hardware failure. Ten patients (3.7%) developed infection. Tendon irritation or rupture occurred in nine patients (3.4%), and six patients (2.2%) sustained nerve injury. One patient (0.4%) experienced a thromboembolic event (Table 3).

Characteristic	All patients	Patients treated with a one-third tubular plate	Patients treated with an anatomical distal fibular plate
Number of patients (*n*, %)	268 (100)	238 (88.8)	30 (11.2)
Number of patients with postoperative complications (*n*, %)	114 (42.5)	101 (42.4)	13 (43.3)
Complication type (*n*, %)			
Infection	10 (3.7)	9 (3.8)	1 (3.3)
Wound dehiscence	35 (13.1)	30 (12.6)	5 (16.7)
Nerve injury	6 (2.2)	6 (2.5)	0 (0.0)
Tendon rupture or Irritation	9 (3.4)	6 (2.5)	3 (10)
Thromboembolic events	1 (0.4)	1 (0.4)	0 (0.0)
Hardware failure	19 (7.1)	17 (7.1)	2 (6.7)
All reoperations, including hardware removal	78 (29.1)	71 (29.8)	7 (23.3)

TABLE 3: Complication overview.

A total of 24 patients (9.0%) had diabetes. Among those, 11 patients (45.8%) developed postoperative complications, including reoperation. This rate did not differ significantly from that in patients without diabetes. However, 10 of the 11 patients with diabetes who developed postoperative complications developed infection or wound dehiscence.

Method of osteosynthesis

A total of 238 patients (88.8%) were treated with a one-third tubular plate, while 30 patients (11.2%) received an anatomical distal fibular plate. Among patients treated with a one-third tubular plate, 101 of 238 patients (42.4%, 95% CI 36.1-48.7) developed postoperative complications, compared with 13 of 30 patients (43.3%, 95% CI 25.6-61.0) treated with an anatomical distal fibular plate. No statistically significant difference in complication rates was observed between the groups ($P = 0.93$).

Additional medial or AP screw fixation alongside a lateral plate was associated with higher postoperative complication rates. Syndesmotic screws were not analyzed separately and could be present in all three groups. Among patients treated with a lateral plate alone, 41 of 120 patients (34.2%, 95% CI 26.3-43.0) developed postoperative complications. In comparison, 59 of 125 patients (47.2%, 95% CI 38.8-55.8) treated with additional medial screws developed complications, as did 14 of 23 patients (60.9%, 95% CI 40.8-77.8) treated with additional AP screws ($P = 0.02$) (Table *4*).

Variable	All patients	Patients with no complications (*n* = 154)	Patients with complications (*n* = 114)	Test statistic	*P*-value
Additional medial or AP fixation alongside lateral plating (*n*, %)	-	-	-	7.71	0.02**
None	120 (44.8)	79 (51.3)	41 (36.0)	6.23	0.01**
Medial screws	125 (46.6)	66 (42.9)	59 (51.8)	2.08	0.15
AP screws	23 (8.6)	9 (5.8)	14 (12.3)	3.46	0.06
Implant (*n*, %)	-	-	-	0.009	0.93
One-third tubular plate	238 (88.8)	137 (89.0)	101 (88.6)	0.009	0.93
Anatomical distal fibular plate	30 (11.2)	17 (11.0)	13 (11.4)	0.009	0.93

TABLE 4: Osteosynthesis and implant.

Test statistics are reported as χ^2 values.
Significant *P*-value ($P < 0.05$) are reported with an (**)

Syndesmotic screws were not analyzed separately and could be present in all three groups.

AP, anteroposterior

Surgeon's experience

Procedures performed by junior residents (PGY-1) had the lowest observed complication rate (28/86, 32.6%; 95% CI 23.6-43.0), compared with interns (21/46, 45.7%; 95% CI 32.0-60.0), senior residents (8/15, 53.3%; 95% CI 30.1-75.2), and attending surgeons (57/120, 47.5%; 95% CI 38.9-56.2). However, complication rates did not differ significantly across levels of surgeon experience (overall $P = 0.17$) (Table 5).

Variable	All patients	Patients with no complications (*n* = 154)	Patients with complications (*n* = 114)	Test statistic	*P*-value
Surgeon experience (*n*, %)	-	-	-	6.35	0.17
Intern	46 (17.2)	25 (16.2)	21 (18.4)	0.22	0.64
Junior resident (PGY-1)	86 (32.1)	58 (37.7)	28 (24.6)	5.16	0.02**
Senior resident (PGY-3)	15 (5.6)	7 (4.5)	8 (7.0)	0.76	0.38
Attending	120 (44.8)	63 (40.9)	57 (50.0)	2.19	0.14
Missing	1 (0.4)	1 (0.6)	0 (0.0)	0.74	0.39

TABLE 5: Surgeon experience.

Test statistics are reported as χ^2 values.
Significant *P*-value ($P < 0.05$) are reported with an (**).

PGY-1, program year 1; PGY-3, program year 3

Discussion

In this retrospective study, we analyzed 268 patients who underwent surgical treatment of distal fibular

fractures to investigate whether postoperative complication rates differed between conventional one-third tubular plates and anatomical distal fibular plates.

The overall complication rate was 114/268 (42.5%) following lateral plate osteosynthesis, and the most common complications were reoperation (78/268, 29.1%), wound dehiscence (35/268, 13.1%), and hardware failure (19/268, 7.1%).

Complication rates did not differ significantly between plate types (P = 0.93). Complication rates were 101/238 (42.4%; 95% CI 36.1-48.7) for one-third tubular plates and 13/30 (43.3%; 95% CI 25.6-61.0) for anatomical distal fibular plates.

Additional osteosynthesis beyond lateral plating was associated with higher complication rates (P = 0.02). We found no significant difference in complication risk between one-third tubular plates and anatomical distal fibular plates. No statistically significant associations were observed between postoperative complications and age, BMI, smoking status, alcohol intake, ASA classification, or diabetes. Complication rates were also not associated with lower levels of surgical training. Among patients with diabetes who developed postoperative complications, 10 of 11 experienced infection or wound dehiscence. However, this descriptive finding should be interpreted cautiously due to the small subgroup size.

Our complication rate of 114/268 (42.5%) aligns with previous studies reporting postoperative complication rates of up to 40% after ankle fracture surgery [11,12]. Other studies report considerably lower rates of around 28% [13,14]. Differences in complication definitions and follow-up duration likely explain this variation. For example, a Spanish study from 2024 included reoperations for hardware failure but excluded elective procedures such as syndesmotic screw removal [14]. This definition of complications may account for the lower rate of 28%, compared with 114/268 (42.5%) in our study. In our study, we included elective hardware removal for all reasons as a reoperation. Consequently, variations in definitions and follow-up durations limit direct comparison of complication rates across studies.

We found no significant difference in complication rates between one-third tubular plates and anatomical distal fibular plates. However, there was a substantial imbalance between the number of patients in the two implant groups, with 238 patients receiving a one-third tubular plate and 30 patients receiving an anatomical distal fibular plate. The rationale for implant selection was not systematically recorded. Therefore, potential confounding by indication cannot be excluded, as implant choice may have been influenced by fracture characteristics, bone quality, surgeon preference, or institutional practice. Furthermore, the relatively small number of patients treated with anatomical distal fibular plates may have limited the statistical power to detect differences in complication rates between implant groups. Therefore, the absence of a statistically significant difference should not be interpreted as evidence of equivalence between the two plate types.

Previous studies report inconsistent findings regarding complication rates between one-third tubular plates and anatomical distal fibular plates [21-24]. A recent meta-analysis from 2025 compared postoperative clinical and radiological outcomes and found fewer wound complications and shorter operative times with one-third tubular plating [15]. We did not observe a lower risk of wound complications in our cohort, and we did not record operative time. The small number of patients treated with anatomical distal fibular plates may have limited our ability to detect potential differences between implant types.

Another important finding was the significantly higher complication rate in patients who required additional osteosynthesis alongside lateral plating, including medial or AP screws. This may reflect greater fracture complexity or instability, which are associated with an increased risk of postoperative complications [13,14]. A British retrospective study from 2019 examined AO/OTA fracture subgroups and patient-reported outcomes after a minimum follow-up of six years. The study demonstrated that trimalleolar fractures (B3) led to worse outcomes than bimalleolar fractures (B2 and C), which again had worse outcomes than isolated lateral malleolar fractures (B1) [25]. Furthermore, a systematic review from 2022 reported better outcomes with early surgical intervention and suggested that reconstruction of joint stability through fixation within 48 hours of injury may reduce complication rates [26]. Together, these findings suggest that fracture complexity, soft-tissue injury, and time to restoration of joint stability may influence postoperative complications after ankle fracture surgery, although these factors could not be fully evaluated in our study.

Detailed surgical parameters, including plate length, screw configuration, and the use of syndesmotic fixation, were not systematically recorded. Furthermore, it was not possible to determine whether additional medial or AP fixation was planned preoperatively or decided intraoperatively. Therefore, the potential influence of these surgical factors on postoperative complications could not be evaluated in detail.

We found no statistically significant associations between patient-related factors such as age, BMI, ASA classification, smoking status, or alcohol consumption and postoperative complications. This contrasts with previous studies that identify these factors as risk factors for complications [27-29]. However, the absence of statistically significant associations does not exclude clinically relevant relationships, particularly given the limitations of the study design and the potential for selection bias. A possible explanation could be selection

bias related to the choice of treatment. Surgeons may treat patients with severe comorbidity or higher frailty nonoperatively or with intramedullary fibular or retrograde tibial fixation, which would lead to exclusion from the present study. As a result, these patients may be underrepresented in our cohort treated with plate osteosynthesis.

In publicly funded healthcare systems under financial pressure, implant cost may influence implant selection. In 2018, an economic analysis compared prices of anatomical plates and tubular plates used to treat fibular fractures [30]. The analysis compared average price differences between one-third tubular plates and anatomical plates across the United States and found a mean cost of $90.86 for a one-third tubular plate versus $746.97 for an anatomical plate [30]. Because the implant price depends on local agreements, the degree of cost differences varies between institutions. Implant cost is an additional consideration in implant selection. However, the present findings do not establish equivalent clinical outcomes between the two plate types.

The observed lower complication rate in procedures performed by junior residents (PGY-1) may reflect case selection and supervision rather than differences in surgical performance. We speculate that senior surgeons often manage more complex fractures, which may confound this association.

Strengths of this study include a relatively large patient cohort and a long median follow-up period of three years. Furthermore, the study population reflects everyday clinical practice at a Danish regional hospital, supporting the clinical relevance of the findings. However, several limitations must be acknowledged. The retrospective, single-center design introduces a risk of selection and information bias and may limit the generalizability of the findings. The substantial imbalance between the implant groups, particularly the small anatomical plate group, limits the precision of the primary comparison. Furthermore, all statistical comparisons were unadjusted, and potential confounding factors could not be accounted for.

The primary outcome included a heterogeneous range of complications, including elective hardware removal, which may differ substantially in clinical severity. As complications were identified retrospectively through medical record review, no standardized diagnostic criteria were applied prospectively for each complication type. This may have particularly affected the classification and reporting of less severe complications. Reoperations included both complication-related procedures and elective hardware removal, but these were not analyzed separately. Differences in follow-up duration and the retrospective ascertainment of complications may also have influenced the observed complication rates.

The secondary analyses involved multiple unadjusted comparisons and should therefore be considered exploratory and hypothesis-generating rather than evidence of independent associations. Functional outcomes were not assessed. Furthermore, complications and reoperations treated outside the Central Denmark Region may not have been captured, potentially resulting in underreporting of postoperative complications.

Conclusions

In conclusion, internal fixation of distal fibular fractures was associated with a substantial rate of postoperative complications. No statistically significant difference in complication rates was observed between one-third tubular and anatomical distal fibular plates. However, the small anatomical plate group and potential confounding limit the interpretation of this finding, which should not be considered evidence of equivalence between the two plate types. Additional medial or AP fixation was associated with higher complication rates, potentially reflecting greater fracture complexity. Larger studies with adjusted analyses are needed to further investigate these associations.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

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