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Original Article

Treatment of ankle fractures with fibular nail: clinical and imaging evaluation

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Abstract

Objective: Perform a clinical and imaging evaluation of patients with ankle fractures submitted to osteosynthesis with locked nails.

Methods: Twenty-five patients submitted to surgery using the locked intramedullary nailing technique were selected between April 2018 and December 2022. Patients were over 55 years of age, with an increased risk for healing complications. The American Orthopaedic Foot & Ankle Society (AOFAS) score and visual analog pain (VAS) scale were used for clinical evaluation. The imaging parameters used were the talocrural angle, the medial clear space, and the tibiofibular anterior line.

Results: The AOFAS score was evaluated with a mean of 83.48 (± 15.34), a minimum of 40, and a maximum of 98 points. The mean in the VAS scale was 2.56 points (± 2.50), with a minimum of 0 and a maximum of 8. The difference between the mean and the reference value (2 mm) was 0.38 mm in the tibiofibular anterior line. Regarding the medial clear space, 100% presented values within the reference (up to 4 mm). In the talocrural angle, the mean was 80.19 (± 2.93), with a minimum of 73.5 and a maximum of 86.29, within normal values.

Conclusion: Osteosynthesis of ankle fractures using locked intramedullary nails seems to be an alternative for older patients at increased risk. Despite not showing a satisfactory reduction in syndesmosis reduction, in most cases, the method showed good functional results in medium-term follow-ups.

Level of Evidence II; Therapeutic Studies; Prospectived comparative study.

Keywords: Ankle fractures; Fracture fixation, intramedullary; Elderly; Ankle Joint; Fracture healing.

Introduction

Ankle fractures are very frequent injuries, with an incidence of 184 per 100,000 people per year, with 20 to 30% of cases occurring in older people and showing an incidence with progressive increase in this population[(1,2)]. In this group of patients, osteoporosis and comorbidities such as diabetes, dementia, and renal failure may represent challenges to treatment[(3)]. Local and systemic complications are more common in this group, and medical professionals should be vigilant to avoid them.

The classic treatment of ankle fractures is performed by open reduction and internal fixation with lateral malleolus plate and screws. This procedure often requires greater tissue dissection with a potential risk of soft tissue devitalization. With relative frequency, there are complications such as difficulty in healing, skin necrosis, and even implant exposure[(3)].

Techniques with less tissue invasion and aggression were developed to mitigate such complications, which reduce hospitalization time and promote early rehabilitation[(4,5)].

Fibula intramedullary fixation techniques were created more than 30 years ago and have undergone development and improvement in the last two decades[(6)]. Currently, there are already locked nails available that allow the insertion of screws to close the tibiofibular syndesmosis[(6)]. The starting point of treatment with the intramedullary nail is a non-

Study performed at the Hospital Francisco José Neves - Unimed BH, Minas Gerais, MG, Brazil.

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anatomical reduction of the fracture but respecting the soft tissues with little interference with the biology of fracture consolidation. Another advantage is that it does not cause skin prominence or require a second removal procedure.

Adequate fracture reduction is indispensable to prevent joint congruence and post-traumatic arthrosis[7]. Studies comparing intramedullary nails with locking plates show lower complication rates and greater resistance to nail failure, encouraging using this material in unstable ankle fractures[8,9]. In addition, a systematic review comparing functional results showed similar results between the two groups after 12 months[10]. However, few studies show long-term follow-up and postoperative radiographic/tomographic evaluation.

The objective of this study is to perform a postoperative clinical evaluation with a radiographic and tomographic correlation of ankle fracture reduction after osteosynthesis with locked nails, analyzing the fibula length, tibiotalar reduction, and syndesmosis through parameters already defined in the literature.

Methods

This is a retrospective study approved by the Institutional Review Board under the number 3.739.529. All patients signed an informed consent form. The study included patients submitted to surgery due to unstable ankle fractures, classified as Weber types B and C, using locked intramedullary nails-a minimally invasive technique. The surgeries were performed between April 2018 and December 2022 by the foot and ankle surgery team at Hospital Francisco José Neves. The inclusion criteria were patients over 55 years of age with increased risk for healing complications and infection (patients with diabetes, smokers, adverse soft tissue conditions, or very old age). All patients were submitted to postoperative radiographs and computed tomography. Among the 53 patients submitted to surgery during the period, five died, and 25 met the inclusion criteria and participated in the imaging analysis. Of these 25 patients, 21 were female and four male, with a mean age of 74.04 years (± 10.46), ranging from 57 to 92 years. The mean follow-up time was 37.16 months (± 16.5), ranging from 6 to 58 months. The mean time of the surgical procedure was 4.56 days (0 to 30 days) from the date of the fracture.

Regarding comorbidities, 92% of patients had some clinical comorbidities under treatment; 21 patients were hypertensive, ten had diabetes, three had chronic obstructive pulmonary disease, and two had heart disease. In addition, five patients were chronic smokers.

Among the 25 patients, ten fractured the right side and 15 the left. Regarding the type of fracture, five had an isolated fracture of the lateral malleolus with a complete injury of the deltoid ligament, nine had a bimalleolar fracture, and 11 patients had a trimalleolar fracture. Among the 20 patients with bi-or trimalleolar fractures, ten had the fixation of the medial malleolus using one cannulated screw, seven by percutaneous technique, and three by open technique; in five cases, the medial malleolus was fixed with two cannulated screws and another five patients by medial sutures. Of the 11 patients with posterior malleolus fracture, only three required fixations, performed by a cannulated screw passed through the percutaneous posterolateral.

Patients with less than six months after surgery, under 55 years, with a fibular canal smaller than 3.0 mm in diameter, and patients who did not adequately perform imaging control were excluded from the study.

Surgical technique

Three foot and ankle surgeons (RAG, AHG, and JMBM) performed the surgery following the same principles and positioning[11]. Patients were submitted to spinal anesthetic block and cardiovascular monitoring, positioned in dorsal decubitus with a pad under the hip on the fractured side to maintain the limb at 30º internal rotation (Figure 1). The operated limbs were subjected to asepsis with a chlorhexidine solution and later with an alcohol-based solution.

In all cases of bi-or trimalleolar fractures, except for one patient, the lateral malleolus was addressed first. The initiative to start with the medial malleolus was motivated by the comminution of the fibula in this case and the subsequent loss of height reference during reduction.

The surgical technique was performed following the steps below:

1. Small longitudinal inframalleolar incision of 1.0 cm;
2. Introduction of guide through the lower end of the fibula under fluoroscopic; view (Figure 2);
3. Drilling of distal fragment channel up to 7.0 mm;
4. Drilling of proximal fragment up to 4.0 mm;
5. Introduction and passage of the locked nail (Hexagon Ind. E Com. Ltda®, Itapira/SP, Brazil) after an internal rotation maneuver of the foot, eventually using a percutaneous reducing clamp (Figure 3);

Figure 1. Patients position on the operating table.

6. Distal locking with two screws;
7. Open or percutaneous medial fixation with one or two cannulated screws (Hexagon Ind. E Com. Ltda®, Itapira/SP, Brazil) or sutures with Aciflex 5.0 (Ethicon, Johnson and Johnson do Brasil®);
8. Syndesmosis fixation through the nail with one or two screws;
9. Fixation of the posterior malleolus when necessary through the percutaneous posterolateral.

Postoperative period

Patients were followed up in outpatient consultations one, two, three, six, and twelve weeks after the surgical procedure and later at six and twelve months.

After a minimum follow-up of six months, all patients were submitted to radiographs and computed tomography to confirm fracture consolidation and evaluate the reduction.

The radiographs were performed in anteroposterior, anteroposterior views with 15º internal and lateral rotation without weight-bearing. In the anteroposterior view, with 15º internal rotation, the talocrural angle and medial clear space were marked and measured to verify the possibility of fibular shortening.

The tomographic evaluation (Alexion Advance, Canon®) was performed to confirm the fracture consolidation and evaluate the other parameters of joint reduction. In the axial evaluation at 10 mm proximal to the ankle articular line, the parameter of the tibiofibular line was measured, and the distance between the anterolateral surface of the fibula and

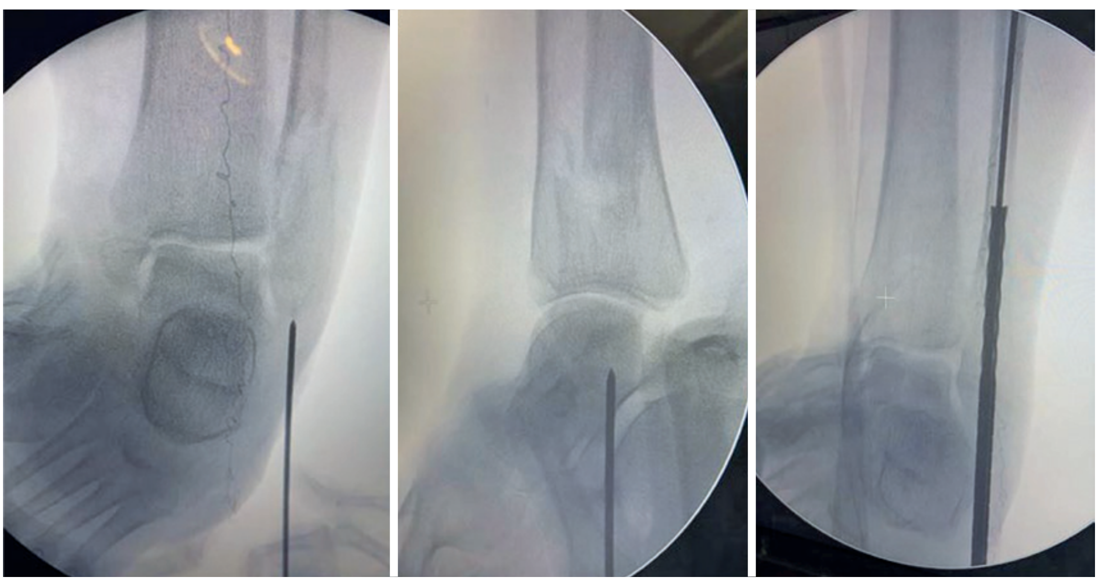

Figure 2. Guide introduction under fluoroscopic view and milling of the spinal canal.

Figure 3. Nail introduction and distal locking.

the anterolateral border of the tibia[10] was recorded (Figure 4). These parameters were used to evaluate the tibiofibular syndesmosis reduction and tibiotarsal joint congruence and performed only on the operated side. The results were compared with the reference values described in the literature.

The patients were evaluated after a minimum follow-up of six months (mean of 37.1 months) and submitted to analysis using the American Orthopaedic Foot & Ankle Society (AOFAS) score[12] and visual analog pain (VAS) scale[13].

Statistical analysis

An exploratory analysis was performed using the Shapiro-Wilk test to determine the data normality with continuous distribution. Considering the parametric nature of the data, measures of central tendency (mean and standard deviation), minimum and maximum values, and the 95% confidence interval (95% CI) of each variable were obtained.

The Bland-Altman plot was used to evaluate the agreement between the values obtained in the radiographic and tomographic evaluation (tibiofibular anterior line, medial clear space, and talocrural angle) regarding the reference values of each parameter. This graph allows a visual analysis of the overall agreement and the identification of possible discrepancies between the two measures. Statistical analysis was performed using Microsoft Excel® and STATA® software (version 14.0, Stata Corporation, College Station, TX, USA).

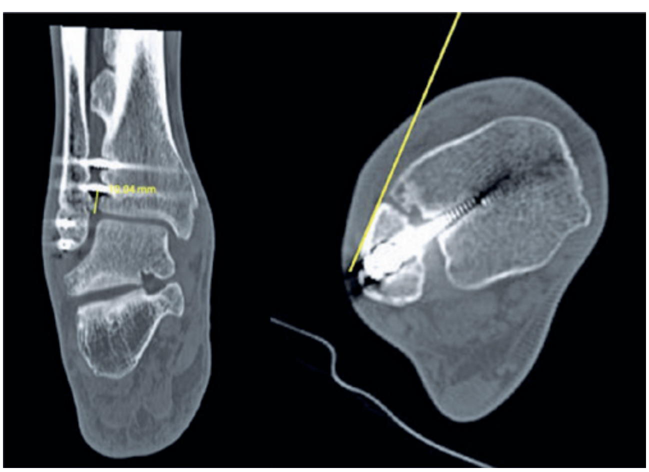

Figure 4. Axial tomographic section showing tibiofibular line marking.

Results

Considering the AOFAS score (Table 1), the patients analyzed had a mean of 83.48 points (± 15.34), with a minimum of 40 and a maximum of 98 points. On the VAS, the mean was 2.56 points (± 2.50), with a minimum of 0 (no pain) and a maximum of 8 (severe pain). To categorize the pain using this instrument, 60.00% of patients (15/25) presented mild pain (score from 0 to 2), 36.00% (9/25) moderate pain (score from 3 to 7) and only 4.00% (1/25) severe pain (score = 8).

The results comparing the values obtained in the three parameters of the tomographic evaluation vs. the reference values of each of the parameters are shown in table 2. In the tibiofibular anterior line, the difference between the mean and the reference value (2 mm) was 0.38 mm. When analyzing the individual values, it was observed that 48.00% of patients (12/25) presented values within the reference limit (2 mm), 28% (7/25) presented values between 2 mm and 4 mm, while 24.00% (6/25) presented values above 4 mm.

Regarding the medial clear space, 100% of the sample presented values within the reference limit (4 mm). In the analysis of the talocrural angle, the mean of the differences obtained between the values of each patient and the reference also suggests compliance with the reference limit (83° ± 4). However, in the individual analyses, it was observed that 28.00% of patients (7/25) presented values below 79°, outside the limit established in the literature (Table 2).

The Bland-Altman plot was used to identify the possible discrepancies between the values obtained in the radiographic and tomographic evaluation (tibiofibular anterior line, medial clear space, and talocrural angle) regarding the reference values of each parameter. Figure 5 shows the concordance analysis of the differences between the values presented in the tibiofibular anterior line and the reference value. The difference between these two measurements was 0.38 mm (continuous line), with limits of concordance (95%) of 3.76 and 4.53 mm (lower and upper dashed lines). According to these results, most points are concentrated

Table 1. Descriptive analysis of age, tomographic evaluation, and AOFAS and VAS scores

Patients (n = 25)	Mean	± SD	Min	Max	95%CI	
Age (years)	74.04	10.46	57	92	69.72	78.36
Follow-up (months)	37.16	16.50	6	58	30.35	43.97
Tibiofibular anterior line (mm)	2.38	2.12	0	8.22	1.51	3.26
Medial clear space (mm)	2.55	0.72	1.41	3.98	2.25	2.85
Talocrural angle (º)	80.19	2.93	73.5	86.29	78.98	81.39
AOFAS	83.48	15.34	40	98	77.15	89.81
VAS	2.56	2.50	0	8	1.53	3.59

SD: Standard deviation; Min: Minimum value; Max: Maximum value; 95%CI: 95% confidence interval; AOFAS: American Society of Foot and Ankle Surgery; VAS: Visual Analogue Pain Scale.

within the normal limits, indicating a good concordance between the measures. However, one point was above this limit, suggesting a specific case of disagreement (difference between the values of 6.22 mm).

Figure 6 shows the concordance analysis of the differences between the values presented in the medial clear space and the reference value, All patients were concentrated within the normal limits, indicating good concordance between the measures. The difference between these two variables was -1.45 mm (continuous line), with limits of concordance (95%) of -2.86 and -0.05 mm (lower and upper dashed lines) (Figure 6).

Figure 7 shows the concordance analysis of the differences between the talocrural angle and the reference value. The difference between these two measurements was -0.62 mm (continuous line), with limits of concordance (95%) of -3.20 and 1.95 mm (lower and upper dashed lines). According to these results, most points are concentrated within the normal

Table 2. Comparison between the mean obtained in the tomographic evaluation and the reference values

	Reference value	Means (± SD)	Difference between means and reference value
Tibiofibular anterior line (mm)			
	Up to 2 mm	2.38 mm (± 2.12)	0.38 mm
		n	**%**
	Up to 2 mm	12	48.00
	2 mm to 4 mm	7	28.00
	> 4 mm	6	24.00
	Total	**25**	**100.00**
Medial clear space (mm)			
	Up tp 4 mm	2.55 mm (± 0.72)	-1.45 mm
		n	**%**
	Até 4 mm	25	100.00
	Total	**25**	**100.00**
Talocrural angle (º)			
	83º (± 4)	80.19º (± 2.93)	-0.62º
		n	**%**
	79º to 87º	18	72.00
	< 79º	7	28.00
	Total	**25**	**100.00**

n: Absolute frequency.

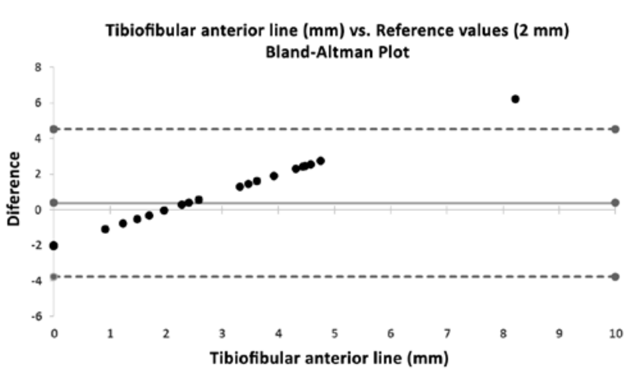

Figure 5. Bland-Altman plot (n = 25): concordance analysis between the values presented in the tibiofibular anterior line and the reference value. The bias was 0.38 ± 2.12 mm (continuous line). The limits of concordance (95%) were 3.76 and 4.53 mm (lower and upper dashed lines).

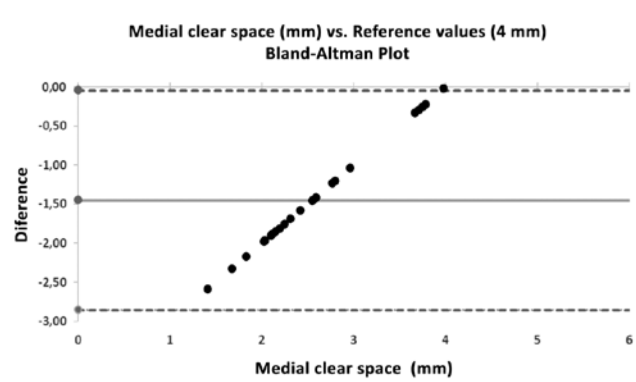

Figure 6. Bland-Altman plot (n = 25): concordance analysis between the values presented in the medial clear space and the reference value. The bias was -1.45 ± 0.72 mm (continuous line). The limits of concordance (95%) were -2.86 and -0.05 mm (lower and upper dashed lines).

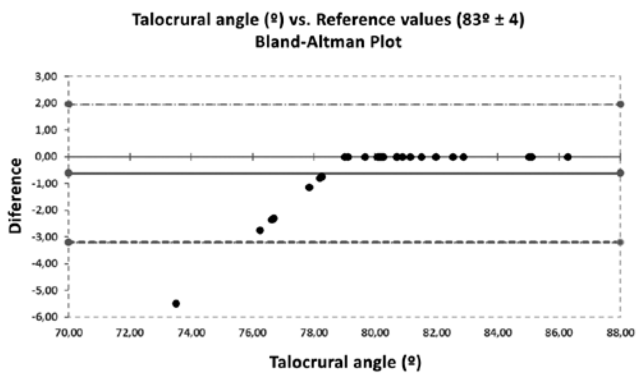

Figure 7. Bland-Altman plot (n = 25): concordance analysis between the values presented in the talocrural angle and the reference value. The bias was -0.62 ± 1.31 mm (continuous line). The limits of agreement (95%) were -3.20 and 1.95 mm (lower and upper dashed lines).

limits, indicating good concordance between the measures. However, one point fell below this limit, suggesting a specific case of disagreement (difference between the values of -5.50 mm).

In postoperative outpatient evaluation, six complications (24%) were observed: two superficial infections (8%), two medial wound dehiscence (8%), one deep infection (4%), and venous thrombosis event (4%) after one month. Patients with superficial infection were treated with oral antibiotics, and cases of wound dehiscence and deep infection were submitted to surgical debridement and use of intravenous antibiotic therapy.

Discussion

Our results indicated that the surgical treatment of ankle fractures with fixation of the lateral malleolus using a locked intramedullary nail showed satisfactory functionality and reduced the incidence of complications. Regarding the imaging parameters, the medial clear space and the talocrural angle were within the reference limits in most patients. However, the tibiofibular anterior line showed a greater variation in less than half of the cases but within the reference values proposed by Gifford et al.[10]. Based on these findings, after intramedullary fixation, syndesmosis reduction was observed, not totally satisfactory in most patients, leading to the hypothesis that this may not be reflected in a worse functional outcome in the studied population. These findings align with previous results in the literature, which demonstrated that the surgical treatment of ankle fractures through an intramedullary nail results in satisfactory functionality[14].

Our study evaluated the syndesmosis reduction through the tibiofibular anterior line in the axial section of computed tomography, which correlates with an appropriate syndesmosis reduction[10]. This parameter is relevant since an inadequate reduction can trigger complications, including premature arthrosis, with worse clinical outcomes[15]. In addition, it is known that nail treatment, due to its lower aggressiveness compared to open reduction and internal fixation with plate and screws, is associated with a lower incidence of skin complications[14,16], with surgical wound dehiscence being the main complication, occurring more frequently in diabetic patients[17].

The same favorable functionality results are observed when evaluating young patients. However, due to the lower incidence of wound complications, this population did not obtain a significant benefit compared to the treatment with open reduction and internal fixation[18]. In addition, a biomechanical investigation demonstrated nail superiority in relation to plate fixation when exposed to rotational stress, presenting greater failure torque in the first method, thus corroborating the stability of this type of construct for unstable fractures[5]. Thus, the modest correlation between imaging parameters, suggesting an inadequate syndesmosis reduction in most patients, and the good functional outcome is related to the nail treatment may be associated with a stable fixation and consolidation rate comparable to traditional plate treatment[5].

A limitation of this study was the short follow-up period, which may have been insufficient to assess long-term complications such as the development of post-traumatic arthrosis. Another relevant limitation concerns the diverse pattern of fractures and fixation techniques of the medial malleolus, with no comparison being made among the results of unimalleolar and bi- and trimalleolar fractures.

It is important to highlight that the analyzed population had a mean age of 74.04 years, within the age group that is often associated with comorbidities resulting in hospitalizations for reasons other than fractures, compromising the follow-up. Additionally, the study period was the same as the coronavirus pandemic and post-pandemic, during which many individuals avoided leaving their homes, potentially affecting re-evaluations. Due to these challenges, it was difficult to collect data and evaluate some patients, impacting the sample size. The results presented are clinically relevant because, as well as previous publications, they support using nails in populations at high risk of postoperative complications, especially wound dehiscence.

It is important to emphasize that the retrospective design, the absence of a control group or comparison with other osteosynthesis methods, and the absence of randomization in the treatment selection are also limitations. Future studies could compare imaging outcomes between nail and plate fixation, providing a deeper understanding of the relationship between reduction quality and the treatment method adopted.

Conclusion

Osteosynthesis of ankle fractures using locked intramedullary nails seems to be an alternative for older patients at increased risk. Despite not showing a satisfactory reduction in syndesmosis reduction, in most cases, the method showed good functional results in medium-term follow-ups.

Authors' contributions: Each author contributed individually and significantly to the development of this article: RAG *(https://orcid.org/0000-0003-3056-9401), and AHG *(https://orcid.org/0000-0002-3644-4928), and JMBM *(https://orcid.org/0000-0002-4224-8149), and WVF *(https://orcid.org/0000-0001-8087-8435), and BJP *(https://orcid.org/0000-0001-5470-8766), and GHCF *(https://orcid.org/0000-0001-8689-3417), and PFSD *(https://orcid.org/0000-0001-7584-8290) Conceived and planned the activity that led to the study, data collection, bibliographic review. RAG *(https://orcid.org/0000-0003-3056-9401) Wrote this article. All authors read and approved the final manuscript.*ORCID (Open Researcher and Contributor ID) iD.

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