Is the One-third Tubular-Hook-Plate an Alternative for Osteosynthesis in Ankle Fractures? 20 Years of Experience

¿La placa tercio de tubo como placa gancho es una alternativa de osteosíntesis en fracturas de tobillo? 20 años de experiencia

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Abstract

Introduction The use of the one-third tubular plate as a hook plate for treating ankle fractures has been considered an effective alternative for osteosynthesis in cases involving small bone fragments, multifragmentary fractures, or patients with poor bone quality. This technique was first documented in 1948. The one-third tubular plate has been successfully employed in fractures at various anatomical sites. Today, this plate is available in titanium and stainless steel with a thickness of 1.0 mm, making it suitable for areas with minimal soft tissue coverage. After two decades of use, this article presents the one-third tubular plate, used as a hook plate, as a viable and effective alternative for treating ankle fractures.

Material and Methods A descriptive retrospective study included 83 patients over 20 years. Of these, 57.84% were male, and their ages ranged from 22 to 85 years. Exposed fractures accounted for 9.6%, with 50% classified as Grade II, 38% as Grade IIIA, and 12% as Grade IIIB. All patients underwent open reduction and osteosynthesis within the first 24 hours.

Results Fracture consolidation was observed in 81.93% of cases at 12 weeks, in 4.8% between 13 and 16 weeks, and 9.6% after 16 weeks. In 3.6% of cases, consolidation was delayed, occurring between 20 and 24 weeks. Complications were reported in 3.61% of

Keywords
- fracture osteosynthesis
- ankle fractures
- one-third tubular plate
- intra-articular fractures

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cases. Additionally, one patient developed ankle osteoarthritis and only 2.49% required implant removal.

Conclusion The results demonstrate that the one-third tubular plate used as a hook plate is an effective and recommended option for ankle fracture surgery, with favorable functional outcomes, high consolidation rates, and low complication rates.

Resumen

Introducción El uso de la placa tercio de tubo como placa gancho para el tratamiento de fracturas de tobillo ha sido considerado una alternativa eficaz para la osteosíntesis en situaciones que involucran fragmentos óseos pequeños, fracturas multifragmentarias, o en pacientes con huesos de baja calidad. Esta técnica fue documentada por primera vez en 1948. La placa tercio de tubo se ha empleado exitosamente en fracturas de diversas localizaciones anatómicas. Hoy en día, esta placa está disponible en titanio y acero inoxidable con un grosor de 1,0 milímetros, siendo apropiada para zonas con escasa cobertura de tejido blando. Después de dos décadas de uso, este artículo presenta la placa tercio de tubo tipo placa gancho como una alternativa viable y efectiva para el tratamiento de fracturas de tobillo.

Material Y Métodos Se realizó un estudio descriptivo retrospectivo que incluyó a 83 pacientes a lo largo de 20 años. De estos, el 57,84% eran hombres y la edad varió entre 22 a 85 años. El 9,6% de las fracturas eran expuestas, distribuyéndose en 50% Grado II, 38% Grado IIIA, y 12% Grado IIIB. Todos los pacientes recibieron reducción abierta y osteosíntesis dentro de las primeras 24 horas.

Resultados La consolidación de las fracturas se observó en el 81,93% de los casos a las 12 semanas, en el 4,8% entre las 13 years 16 semanas, y en el 9,6% después de 16 semanas. Un 3,6% de los casos presentó retardo en la consolidación, con un proceso de consolidación entre 20 years 24 semanas. Las complicaciones se reportaron en un 3,61% de los casos. Además, un paciente desarrolló artrosis de tobillo, y solo el 2,49% requirió la extracción de implantes.

Conclusión Los resultados obtenidos demuestran que la placa tercio de tubo tipo placa gancho es una opción efectiva y recomendable en la cirugía de fracturas de tobillo, con buenos resultados funcionales, altas tasas de consolidación y bajas tasas de complicaciones.

Palabras Clave
- osteosíntesis de fracturas
- fracturas de tobillo
- placa tercio de tubo
- fracturas intraarticulares

Introduction

Open reduction and osteosynthesis of avulsion fractures, with small fragments, multifragmentary joint fractures, or in cases of osteoporosis,[1–5] is not free of complications; it is a challenge for the surgeon to obtain an anatomical reduction and perform stable fixation, especially if an adequate reduction is not performed and the wrong implant is chosen.[6]

Zuelzer in 1948[7] used the prefabricated hook plate for fixation of fractures with small fragments of the medial malleolus, olecranon, and tibial pilon, later Wagner[8] used it in a tibial osteotomy, but it was Weseley et al,[8,9] who modified the shape of the hooks pointed at 90 degrees in the distal foramen, to be applied to the lateral malleolus in osteoporotic bones.[8,9] In 2003, Carpenter described the use of the hook plate in base fractures of the fifth metatarsal.[10]

The hook plate has been used for fractures of the greater tuberosity of the proximal humerus,[4] the lateral malleolus,[4–6] the proximal ulna,[9,11–14] phalanges,[15–18] acetabulum,[19–23] medial malleolus,[19,24] distal ulna, and fifth metatarsal[25] with good results.

Currently, the third tube plate is available in titanium and stainless steel. It also has a low profile with a thickness of 1.0 millimeters, making it indicated in areas with minimal soft tissue coverage such as the lateral malleolus, distal tibia, olecranon, and distal ulna. The oval shape of its holes allows a certain degree of eccentric placement of the screws to generate compression at the fracture site.[26](►**Figure 1**).

After 20 years of use, this article presents the use of hook plate-type third tube plates as a viable and successful alternative for the treatment of ankle fractures.

Materials and methods

A retrospective descriptive case series study was carried out in which the hook-type third tube plate was used in ankle fractures made at the time of surgery. 83 patients were included, over a period of 20 years (average follow-up of

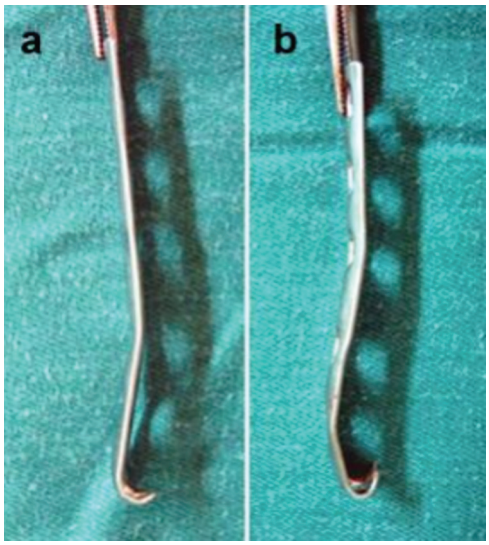

Fig. 1 (a) One-third tubular-hook-plate for lateral malleolus poorly molded, (b) Appropriately molded hook-type third tube plate for lateral malleolus.

12 years), from January 2002 to June 2022 in Quito - Ecuador, where 48/83 (57.84%) patients were male, with an age range from 22 to 85 years. 90.3% of the sample were closed fractures and the remaining 9.6% were exposed, according to Gustillo's classification,[28] 50% Grade II, 38% Grade IIIA, and 12% Grade IIIB. We used AO classification[22], 13% type 44A, 65% type 44 B, and 22% type 44C, all patients underwent open reduction and osteosynthesis in the first 24 hours of evolution from the moment the fracture occurred. In 18% of cases, a hook plate was used on the medial and posterior malleolus as a buttress, with lateral, medial, posterolateral, or posteromedial approaches used depending on the case.

One-third tubular plates (DePuy Synthes, Warsaw, Indiana, United States) were used, cutting the one-third tubular plates at the most distal hole level and bending them to form pointed hooks. The plate was then molded according to the anatomy of the bone that was going to be fixed. It is important to bend the ends in such a way that they are parallel to the plate and separated, so that they enter the respective fragment, especially for the malleoli. When the plate is placed for a buttress effect, the hooks must be perpendicular to the plate so that the proximal screws compress the fracture focus when approaching the bone. Occasionally, it is necessary to asymmetrically bend the plate hooks to better fit the distal end of the bone, to obtain adequate fixation of the bone fragments.

In one case, the formation of non-bloody blisters was evident, a situation that did not prevent surgical intervention within the first 24 hours. The hospitalization time was 2 to 5 days. Prophylactic antibiotics were administered in 3 doses with first-generation cephalosporins.

Immobilization was done with a posterior plaster splint only in the 18 patients who presented type 44C ankle dislocation fracture (22%) and an external fixator was placed in only 3 patients due to the severity of the wounds and instability, for four weeks. (►**Figure 2**)

The stitches were removed 15 days after surgery, subsequently, physiotherapy with partial weight bearing was started in the patients who were not placed with immobilization. Clinical and radiographic controls were carried out at 6 weeks, 3, 4, 5, 6, and 12 months after surgery, then controls were carried out every year to define definitive medical discharge.

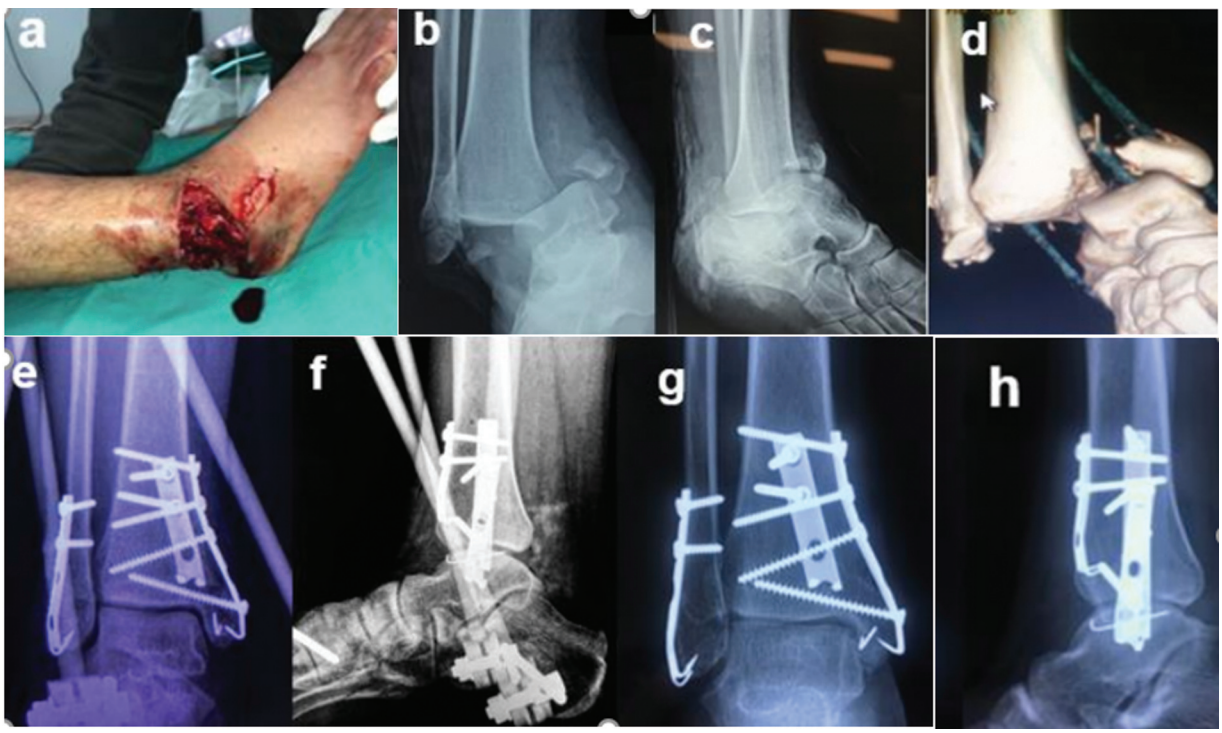

Fig. 2 (a) Clinical image of the open ankle fracture, (b-c): AP and L X-ray of the ankle with trimalleolar infrasyndesmal dislocation fracture, (d) Computed tomography (reconstruction), (e-f) immediate post-operative AP and L X-ray with osteosynthesis with third tube hook plates for each malleolus stabilization with external fixation, (g-h) AP and L X-ray 11 months post-surgery, with consolidation observed of fractures.

Table 1 Consolidation Time Statistics Summary

Consolidation Time	
Mean	11,96875
Standard Error	0,25964123
Median	12
Mode	12
Standard Deviation	2,93750524
Sample Variance	8,62893701
Kurtosis	8,37683027
Skewness Coefficient	-0,4573465
Range	24
Minimum	0
Maximum	24
Sum	1532
Count	128

Of the total sample, 7.2% presented ligament instability following osteosynthesis, requiring respective repairs. Autologous bone grafting was necessary in 4.8% of cases. In segmental fractures of the distal fibula extending to the distal diaphysis, overlapping one-third tubular plates were used to increase the plate length due to the unavailability of long tubular plates (more than 12 holes).

Results

The consolidation of the fractures was observed at 12 weeks in 68 patients (81.93%) of the cases, between 13 years and 16 weeks in 4 patients (4.8%), more than 16 weeks in patients (9.6%), 3 patients (3.6%) presented delayed union, of which only two agreed to undergo reoperation for placement of autologous bone graft, in which fracture consolidation was observed after 20 years and 24 weeks, one patient of the three cases presented non-union at the focus of the proximal segmental diaphyseal fracture of the fibula that did not compromise the stability of the ankle and no reintervention was necessary. (►**Table 1**)

Complications were reported: a case of loosening of screws, resolved by superimposing plates to increase the working surface, a case of non-anatomical reduction and poor molding of the plate, resolved by revision osteosynthesis. (►**Figure 3**)

A case of infection was reported in a patient with an open fracture of the tibia, which did not compromise the stability of the osteosynthesis performed in the fibula, making it necessary to remove the tibial implant and place an external fixator as a definitive treatment.

Of the total number of cases, only one case evolved into ankle osteoarthritis, without osteosynthesis failure. (►**Figure 4**).

3.61% of the total cases presented limitation of ankle dorsiflexion, without preventing activities of daily living.

Finally, only 2.49% of patients underwent implant removal. (►**Figure 5**) (►**Table 2**)

To correlate variables and determine the outcomes of the hook-type one-third tubular plate as a successful osteosynthesis alternative, a Dummy variable model will be applied to transform qualitative data into quantitative data. Subsequently, Students' t-tests will be used to identify a correlation factor through Pearson's parametric analysis.

By combining the use of the hook-type one-third tubular plate as an independent osteosynthesis method, without employing other techniques, with potential complications, the findings indicate that, for the sample, there is a 97.5% probability that using only the hook-type one-third tubular plate is a stable method for consolidation. With a Pearson coefficient of 0.04, it can be inferred that there is no significant relationship between the use of the hook-type one-third tubular plate and complications, provided the technique is performed correctly. (►**Table 3**)

The use of a hook plate presents a probability of success of 97.5% in terms of consolidation, its failure in the cases observed is the product of poor technique, likewise, the correlation coefficient is 0.04, which demonstrates that when using this fixation method there are no alterations in the consolidation of the fractures or in their time. (►**Table 4**)

Discussion

Articular fractures, multifragmentary fractures in poor-quality bones, and avulsion fractures with small fragments can be treated with various methods. If an adequate reduction and initial stabilization are not performed, it can lead to new

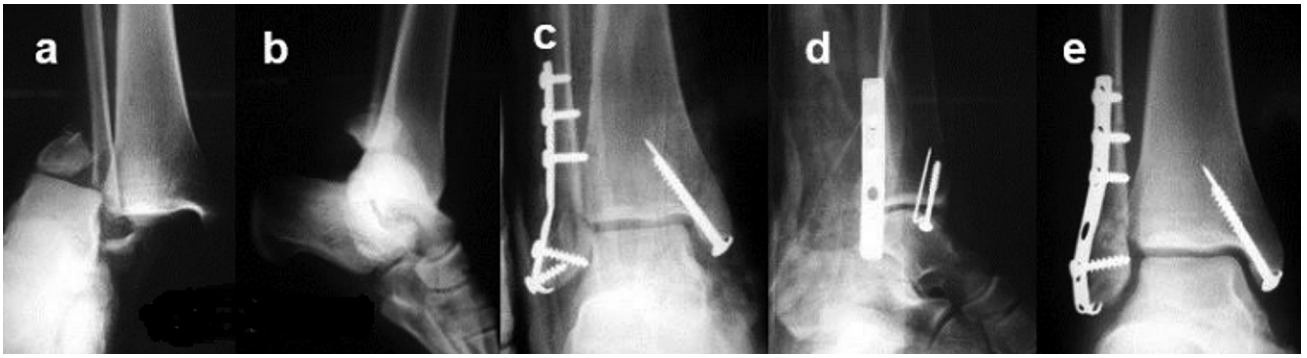

Fig. 3 (a-b): Preoperative AP and L X-ray, bimalleolar infrasyndemal fracture dislocation, (c-d) Postoperative X-ray shows inadequate molding of the hook plate and valgus reduction of the lateral malleolus. (e): Postoperative reintervention X-ray with adequate plate molding.

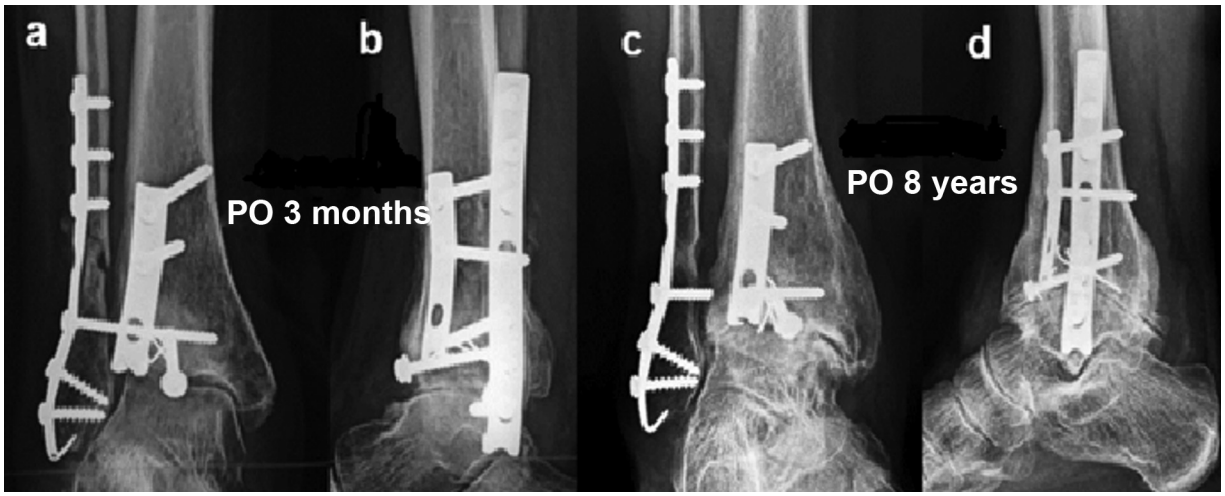

Fig. 4 (a-b) AP and L X-ray of the ankle with a 3-month postoperative period, delayed consolidation of the fibula fracture is observed, (c-d) AP and L X-ray of the ankle with an 8-year postoperative period, consolidation of the fibula fracture is observed in the fibula and tibiotalar osteoarthritis. PO: 3 meses = PO 3 months PO: 8 años = PO 8 years

Fig. 5 (a) Clinical image of grade IIIA exposed fracture dislocation, (b-c) preoperative AP and L X-ray of the ankle, trans and suprasyndemal bimalleolar dislocation fracture of the ankle, (d-e) immediate postoperative AP and L X-ray, (f) X-ray Ankle AP 1 year of evolution, (g) Ankle AP X-ray after implant removal.

surgical interventions, leaving serious sequelae that would limit or hinder the daily activity, work, or sports activity of a patient. It is important to choose the appropriate material for each case; implants with anatomical and blocked designs imply a high cost and are not always available, especially in public hospitals in developing countries.

In our setting, the premolded hook plate and the locked anatomical plate alone cost between $750 to $1100 compared to 65 dollars for the one-third tubular plate. A cost of approximately 92% lower is observed, that is, a patient would save approximately 92% by choosing the method presented in this article as a method of osteosynthesis.

Table 2 Summary of plate use versus complications statistics

	Plates use	Complication
Mean	1	0,0859375
Variance	0	0,079170768
Observations	128	128
Hypothesized Mean Difference	0	
Degrees of Freedom	127	
t Statistic	36,7534785	
P(T <= t) One-Tail	7,72595E-70	
Critical Value of t (One-Tail)	1,656940344	
P(T <= t) Two-Tail	1,54519E-69	
Critical Value of t (Two-Tail)	1,978819535	

Table 3 Summary of plate use versus consolidation statistics

	Hook plate	Consolidation
Mean	0,328125	0,7890625
Variance	0,222194882	0,167753445
Observations	128	128
Pearson Correlation Coefficient	0,02304905	
Hypothesized Mean Difference	0	
Degrees of Freedom	127	
t Statistic	-8,499896657	
P(T <= t) One-Tail	2,20136E-14	
Critical Value of t (One-Tail)	1,656940344	
P(T <= t) Two-Tail	4,40271E-14	
Critical Value of t (Two-Tail)	1,978819535	

Table 4 Summary Statistics of Plate Usage Versus Union Delay

	Plate	*Consolidation delay*
Mean	1	0,1171875
Variance	0	0,104269193
Observations	128	128
Pearson Correlation Coefficient	0,03	
Hypothesized Mean Difference	0	
Degrees of Freedom	127	
t Statistic	30,93110624	
P(T <= t) One-Tail	2,81019E-61	
Critical Value of t (One-Tail)	1,656940344	
P(T <= t) Two-Tail	5,62037E-61	
Critical Value of t (Two-Tail)	1,978819535	

After conducting bibliographic research, limited information has been found about this method, with limited cases reported using the hook-type third tube plate. Panchbhavi et al[5] described the hook plate plus 2 screws technique in ankle fractures in older adults or osteoporotic bones, reporting that it is a technique that provides stable fixation with good clinical results and consolidation of the fractures.

Zahn et al[29] demonstrated that the contoured locking plate may be more advantageous than the non-contoured locking plate in their biomechanical study of cadavers. Another biodynamic study carried out by Bariteau et al[30] in bone models demonstrated that the locked plate was superior to the third tube plate in comminuted fractures. However, Vajapey et al,[24] compare the use of two compression screws versus a "homemade" hook plate in fractures of the medial malleolus, despite having complications of 18% and 35% respectively, no significant differences were comparing these two fixation systems obtaining the consolidation of the fractures.

Know et al,[9] modify the hooks so that a cancellous screw can be placed in a better direction and provide greater rotational stability, in fractures of the distal third of the fibula. Yin et al[12] used the third tubular-hook-plate in 60 patients with avulsion fractures around the joints, reporting excellent and good results in 95% of the cases, concluding that it is a reliable fixation method, with high rates of recovery of joint function and its use is convenient.

In this study, one case of reoperation due to poor surgical technique was reported. Fracture consolidation was achieved in 78 patients, 3 patients experienced delayed union, and only one case of nonunion was observed. Therefore, the hook-type one-third tubular plate is considered a viable osteosynthesis alternative for comminuted distal malleolar fractures or fractures with poor bone quality, provided the technique is properly applied.

The study's limitations include its retrospective descriptive design, the absence of comparative analysis with anatomically locked plates or prefabricated hook-locked plates, and the lack of functional assessments using established scales. Additionally, no studies were conducted to evaluate the degree of osteoporosis in patients with poor bone quality, as the study's objective was to demonstrate the stability of this method as an osteosynthesis alternative until fracture consolidation. Nevertheless, the significant number of cases successfully treated with the hook-type one-third tubular plate highlights its relevance and applicability, particularly in our local context.

Conclusions

The hook-type one-third-tubular plate made during surgery is an osteosynthesis alternative for the fixation of ankle fractures. If the anatomically locked plates or prefabricated hook-locked plates are not available, stable fixation can be achieved until the consolidation of the ankle fractures with small distal fragments, easy to reproduce, satisfactory results can be obtained, with few complications and reinterventions, if an anatomical reduction is obtained, and the technique is properly performed.

Conflict of Interest
None.

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