

## Original Article

# Maisonneuve fractures and ligament injuries: how to stabilize the ankle?

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## Abstract

**Objectives:** Quantify syndesmosis and deltoid injuries in Maisonneuve Fractures, identify which ligament is the most efficient in ankle stabilization, quantify the need for joint ligament repairs, and certify the ankle stability without fracture fixation.

**Methods:** Between 2007 and 2022, a total of 70 patients were included-40 with acute trauma and 30 with chronic trauma; the mean age was 35.57 years. Fifty-one patients were randomized into Groups I and II. Patients in Group I (26) received syndesmosis repair, and patients in Group II (25) received deltoid repair. Group I also received a deltoid suture when the patients were still unstable, and Group II received syndesmosis repair. Chronic patients, in addition to fixation, also received syndesmosis reconstruction.

**Results:** Ligament injuries were present in 100% of the ankles, 72.86% joint injuries, and 27.14% isolated. Syndesmosis repair stabilized 61 ankles (92.42%), and deltoid repair nine ankles (16.98%). Joint repairs were performed on 28 ankles (40%). Stable ankles without fibular fracture fixation totaled 68 (97.15%). The syndesmosis repair in Group I was efficient in 80.76%, and in Group II, the deltoid repair in 13.73%. In non-randomized patients (19), 100% of the repairs alone were efficient.

**Conclusion:** Our results concluded that the Maisonneuve fractures had 100% associated ligament injuries. Fixing the syndesmosis was significantly more efficient than repairing the deltoid in stabilizing the ankle. Repairs of both ligaments were necessary in 40% of the ankles. Stabilizing the ankle does not require addressing the high fibular fracture.

**Level of Evidence IV; Therapeutic studies - investigating the results of treatment; Case Series.**

**Keywords:** Maisonneuve fracture; Ankle joint; Ankle.

## Introduction

Maisonneuve fracture, described in 1840, involves the proximal fibula, syndesmosis, and deltoid ligament injuries<sup>(1)</sup>. Lauge-Hansen<sup>(2)</sup> describes it in terms of external pronation and rotation, and Pankovich<sup>(3)</sup> describes it in five stages with different extents of damage. Bartoníček et al.<sup>(4)</sup> reported syndesmosis injuries (100%), posterior malleolus fracture (80%), and deltoid injuries (50%) in 54 patients. The impairment of ankle function depends on the extent of the associated injuries<sup>(2-7)</sup>. Less frequent injuries are also in the literature<sup>(8-10)</sup>. Instability related to the severity of ligament injuries is recorded in the classifications<sup>(2-5,11)</sup>. The

Maisonneuve fracture is described as very unstable<sup>(3)</sup>. Pre- and intraoperative clinical and radiographic tests identify instability and the necessary ligament repair<sup>(4,12,13)</sup>. The literature lacks precise quantification regarding the percentages of isolated or combined ankle injuries and the effectiveness of their respective repairs in achieving ankle stabilization. Treatment methods vary, with conservative and surgical options<sup>(3,7)</sup>.

Some authors do not value ligament injuries and prefer conservative treatment<sup>(3,10,14)</sup>. Other authors consider this fracture unstable and recommend its surgical treatment<sup>(3,4,7,15-17)</sup>. Various surgical treatment options exist, but there is still

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no consensus in the literature regarding key aspects. These include whether or not to fix the fracture, using percutaneous surgery with or without ligament repairs, and the timing and method for syndesmosis fixation<sup>(4,14-26)</sup>.

As described by some authors, optimal ankle function requires bone consolidation, ligament stability, and proper positioning of the fibula within the syndesmotic notch<sup>(4,6,7,17-20)</sup>. Non-uniform reports of the importance and forms of these ligament repairs in the literature motivated us to conduct this study<sup>(3,4,6,14-26)</sup>.

The objectives of this prospective, quasi-randomized study are to quantify syndesmosis and deltoid injuries in Maisonneuve Fractures, identify which ligament is the most efficient in ankle stabilization, quantify the need for joint ligament repairs, and certify the ankle stability without fracture fixation.

## Methods

This study included 70 patients (49 men and 21 women) with a mean age of 35.57 years, comprising 40 acute and 30 chronic cases, all diagnosed with Maisonneuve fractures and treated between February 2007 and November 2022. Inclusion criteria encompassed patients with indirect trauma and an oblique or spiral fracture in the proximal third of the fibula, while those with direct trauma and horizontal fractures were excluded. Additionally, three patients with the same trauma mechanism but without visible fibular fractures were included.

Patients diagnosed with Maisonneuve fractures in the emergency department underwent a thorough ankle examination and radiographic assessment. In cases of pain, anteroposterior (AP) stress radiography was performed in pronation and external rotation, applying force within the patient's pain tolerance, without anesthesia. Patients exhibiting talar inclination, an increased medial clear space of the ankle (greater than 4 mm), or lateral displacement of the talus were referred for surgery.

Patients with a delayed diagnosis were evaluated at the hospital's Foot and Ankle Outpatient Clinic due to persistent pain and/or ankle instability following three months of conservative treatment. Clinical and radiographic assessments confirmed the diagnosis of Maisonneuve fracture and ankle instability, leading to their surgical referral.

In the operating room under spinal anesthesia, AP stress radiography was repeated to confirm ligament injuries. The 51 patients with joint syndesmosis and deltoid ligament injuries were divided into Groups I (26 patients) and Group II (25 patients) and treated randomly. Patients with isolated deltoid injuries (02) or syndesmosis (17) were not randomized.

Acute patients in Group I underwent percutaneous syndesmosis fixation using one or two 4.5 mm cortical screws, with a smooth tunnel in the fibula and fixation to one or two tibial cortices. Chronic patients in Group I underwent open syndesmosis reconstruction using fibular and tibial periosteal flaps, secured with two trans-syndesmotic screws fixing four cortical screws. Patients in Group II underwent

deltoid ligament repair along with the anteromedial capsule, using transosseous sutures or anchors placed in the medial malleolus or the talar neck. After the initial procedure in each group, a new AP stress radiograph was performed. If instability persisted in Group I, medial capsule/ligament repair was also performed. For Group II, if the ankle remained unstable, acute cases underwent syndesmosis fixation, while chronic cases required syndesmosis reconstruction and fixation. Additionally, two acute cases in Group II had syndesmosis fixation performed despite medial repair already achieving stabilization.

The fibula fracture was addressed and surgically fixed in two chronic patients with unstable ankles—one presenting with common fibular nerve compressive syndrome and the other with pseudoarthrosis and fibular shortening. After surgery, all ankles underwent AP stress radiographs to assess the stability achieved. Postoperatively, all patients were immobilized for six weeks without weight-bearing. Skin stitches were removed after three weeks. Full weight-bearing was allowed at the end of the sixth week, with walking permitted for one hour per day starting from the third postoperative month, as tolerated by each patient. Syndesmosis screws were removed after eight months, at which point impact activities were authorized. Clinical and radiographic follow-ups were conducted every two months, with a final evaluation performed at least 12 months postoperatively. The ankle and hindfoot American Orthopaedic Foot and Ankle Society (AOFAS) score and the Visual Analog Scale (VAS) were used as assessment criteria. To compare treatment efficacy between groups, statistical analysis was conducted using the Chi-square test, with a significance level set at 5%.

## Results

Traffic trauma was the most common cause of injury, followed by sports-related incidents, domestic accidents, and professional ballet training. Ligament injuries were present in all ankles, either as isolated or combined injuries (Table 1).

Syndesmosis repair was performed in 66 ankles, while deltoid ligament in 53. The percentages and methods of repair are shown in Table 2.

**Table 1.** Types of trauma and incidences of ligament injuries

Category	Details
<b>Cause</b>	<ul style="list-style-type: none"> <li>- Traffic accidents: 27 cases (38.57%)</li> <li>- Sports-related incidents: 23 cases (32.85%)</li> <li>- Domestic accidents: 19 cases (27.14%)</li> <li>- Professional ballet training: 1 case (1.42%)</li> </ul>
<b>Ligament injuries</b>	<ul style="list-style-type: none"> <li>- Present in 100% of ankles</li> <li>- 51 ankles with combined injuries (72.85%)</li> <li>- 19 ankles with isolated injuries (27.14%)</li> <li>- 2 Deltoid e 17 syndesmosis</li> </ul>

Syndesmosis repair successfully stabilized 61 ankles but was unsuccessful in five cases. Deltoid ligament repair was effective in only nine cases, while 44 repairs were unsuccessful. Group I (Syndesmosis repair) had an 80.76% success rate, with 19.23% of repairs failing. Group II (Deltoid ligament repair) had a significantly lower success rate of 8%, with 92% of repairs failing (Table 3).

Joint repair of both ligaments was necessary in 28 ankles (40%). In the 19 non-randomized patients, isolated repairs were 100% successful. Stable ankles at the end of surgery without high fibular fracture fixation totaled 68 (97.15%).

Five ankles in Group I (four acute and one chronic) required additional deltoid repair due to persistent instability. Deltoid repair successfully stabilized two acute Group II ankles and two non-randomized cases. Successful deltoid repairs: 6 using anchors, 3 using transosseous sutures. Unsuccessful deltoid repairs: 23 total-5 using anchors, 18 using transosseous sutures. All ankles at the end of surgery were submitted to AP stress radiograph and showed stability (Table 4).

**Table 2.** Percentages and methods of ligament repairs

Category	Details
<b>Repairs</b>	- Syndesmosis repaired in 66 ankles - Deltoid ligament repaired in 53 ankles
<b>Syndesmosis repair</b>	- 57 ankles with 2 screws/4 cortices (81.44%) - 7 ankles com 1 screw/4 cortices (10%) - 6 ankles com 2 screws/3 cortices (8.57%)
<b>Deltoid repair</b>	- 12 ankles with anchors (22.64%) - 41 ankles with transosseous sutures (77.36%)

**Table 3.** Percentages of efficiency of ligament repairs

Category	Details
<b>Repair efficiency</b>	- Syndesmosis: successful in 61 ankles (92.42%), unsuccessful in 5 (7.57%) - Deltoid: successful in 9 ankles (16.98%), unsuccessful in 44 (83.02%)
<b>Results per Group</b>	- Group I (syndesmosis): successful in 80.76%, unsuccessful in 19.23% - Grupo II (deltoid): successful in 8%, unsuccessful in 92%

**Table 4.** Efficiency of syndesmosis and deltoid repairs

	Ligament injuries	Nº patients	Repairs	Successful	p
Combined 72.85%	Syndesmosis + Deltoid	51	Syndesmosis = 66 Deltoid = 53	61 - 92.42% 09 - 16.98%	0.00001
Isolated 27.14%	Syndesmosis Deltoid	17 02	Treated separately		
100%	70	70	70 patients 100% ligament repairs	Stable ankles 70 = 100%	
2.85%		2	With an approach to fibula fracture		

One chronic patient with joint repairs developed late instability, experiencing occasional ankle “falsehood” at 12 months postoperatively. Clinical and radiographic tests showed syndesmosis instability. At 15 months post-operative, incipient signs of ankle arthrosis and occasional pain were noted. The patient underwent reconstruction and syndesmosis fixation, and by 12 months post-revision surgery, the ankle was stable but with some residual pain.

Syndesmosis repair was significantly more effective than deltoid ligament repair ( $p = 0.00001$ ) in ankle stabilization-in both the complete series (Table 5) and group comparisons (Table 6). Functional outcomes at 12 months postoperatively are detailed in Tables 7 and 8.

## Discussion

We align with authors who classify Maisonneuve fracture as an ankle injury due to the associated injuries occurring at the ankle<sup>(1-6)</sup>. The external rotation force initially impacts the ankle before propagating to the proximal fibula, directly compromising ankle function due to sustained injuries<sup>(2-5,9)</sup>. Acute patients typically present ankle-related complaints during their initial visit. Undiagnosed patients often seek further medical care due to persistent ankle dysfunction. Our series has 30 patients whose diagnosis was made late. The incidence of Maisonneuve fractures is difficult to determine due to frequent underdiagnosis, with reported rates ranging from 1% to 11% in the literature<sup>(3-7,10)</sup>. Our service identified an incidence of 7.82%, which we consider high, aligning with Pankovich's reported rate of 5%<sup>(3)</sup>. Our study presents a larger case series than Bartoníček et al.<sup>(4)</sup>, who described 54 acute cases, as it also includes 30 chronic patients. The predominance of male patients (49 men and 21 women) is consistent with data reported in the literature<sup>(21)</sup>.

We documented one case of pseudoarthrosis and one of delayed consolidation, findings not commonly reported in the literature. However, we believe that bone consolidation alone does not guarantee a favorable outcome, as optimal ankle function also depends on the stability provided by ligament repairs, as recommended by Stufkens et al.<sup>(7)</sup>.

Syndesmosis and deltoid ligament injuries are reported in the literature with varying prevalence and diagnostic methods<sup>(1-5)</sup>. Pakarinen et al.<sup>(12)</sup> used external rotation stress

without foot pronation but concluded that this method alone is insufficient for diagnosing syndesmosis instability intraoperatively. Stoffel et al.<sup>(13)</sup> described the same test to identify deltoid ligament injuries, stating that it is more effective for diagnosing syndesmosis injuries. Our study systematically assessed syndesmosis and deltoid ligament injuries through clinical and radiographic examinations, following the methods described by Bartoniček et al.<sup>(4)</sup> and Puddu et al.<sup>(22)</sup>. To diagnose ligament injuries, we performed simultaneous pronation and external rotation stress tests. Stress radiographs in the emergency room were conducted without anesthesia, with a medial clear space opening greater than 4 mm considered indicative of deltoid ligament injury<sup>(4,16)</sup>.

**Table 5.** Efficiency of repairs – within Groups 1 and 2

Group	Successful	Unsuccessful	p
Syndesmosis – GROUP I	80.76%	19.23%	0.00001
Deltoid – GROUP II	8%	92%	

**Table 6.** Joint repairs of both ligaments in the same ankle

	Patients	Percentage
Patients who required repairs of both ligaments for ankle stabilization	28	40%

All patients in this series had confirmed isolated and/or combined ligament injuries intraoperatively, consistent with findings reported by Bartoniček et al.<sup>(4)</sup>.

The treatment of Maisonneuve fractures and their associated injuries remains non-uniform, with few authors advocating for direct fibular fixation<sup>(17)</sup>. Deltoid ligament injuries are often undervalued, and some authors, including Pankovich<sup>(3)</sup>, Merrill<sup>(14)</sup>, Zeegers et al.<sup>(18)</sup>, and Harper<sup>(20)</sup>, do not repair them. Conversely, Weber<sup>(5)</sup>, Stufkens et al.<sup>(7)</sup>, Johnson et al.<sup>(19)</sup>, and Kim et al.<sup>(26)</sup> recommend deltoid ligament repair to ensure ankle stabilization and prevent late dysfunction.

Numerous authors recommend syndesmosis fixation<sup>(4-7,16,27)</sup>, but there is no consensus on the method. Percutaneous and open fixation techniques are commonly reported. Various methods include one or two screws (3.5 mm or 4.5 mm), securing three or four cortices, or Suture Button fixation (one or two buttons)<sup>(2,4-7,15,16,21-27)</sup>.

All 70 patients were treated surgically, and all ligament injuries were repaired. High fibular fractures were not directly addressed, as described by Stufkens et al.<sup>(7)</sup>. Deltoid ligament repair was performed, following recommendations from multiple authors<sup>(4,7,19,26)</sup>, using anchors where available or transosseous sutures. Our results indicate a high failure rate (83.02%) for both suture methods, with anchors showing superior effectiveness. However, due to unequal sample sizes between treatment methods, a definitive conclusion regarding the superiority of anchors cannot be drawn.

**Table 7.** Results of the evaluation with the AOFAS criteria

	AOFAS PREOPERATIVE					AOFAS POSTOPERATIVE				
	Mean	n	SD	Min	Max	Mean	n	SD	Min	Max
<b>ACUTE</b>	50.25	40	7.33	25	60	87.00	40	6.28	70	100
I	49.21	19	8.54	25	60	87.37	19	7.33	70	100
II	51.19	21	6.10	35	60	86.67	21	5.32	75	95
<b>CHRONIC</b>	44.03	30	6.86	30	60	86.83	30	5.80	75	95
I	45.63	19	7.14	35	60	86.58	19	5.79	75	95
II	41.27	11	5.61	30	50	87.27	11	6.07	75	95
<b>Total</b>	47.59	70	7.73	25	60	86.93	70	6.04	70	100

AOFAS: The ankle and hindfoot American Orthopaedic Foot and Ankle Society; SD: Standard deviation; Min: Minimum; Max: Maximum.

**Table 8.** Results of the evaluation with the VAS criteria

	VAS PREOPERATIVE					VAS POSTOPERATIVE				
	Mean	n	SD	Min	Max	Mean	n	SD	Min	Max
<b>ACUTE</b>	7.78	40	1.42	5	10	1.55	40	1.06	0	5
I	7.89	19	1.63	5	10	1.53	19	1.26	0	5
II	7.67	21	1.24	6	10	1.57	21	0.87	0	4
<b>CHRONIC</b>	8.13	30	1.04	5	10	2.07	30	1.28	1	7
I	8.05	19	1.18	5	10	2.16	19	1.46	1	7
II	8.27	11	0.79	7	10	1.91	11	0.94	1	4
<b>Total</b>	7.93	70	1.28	5	10	1.77	70	1.18	0	7

VAS: Visual Analog Scale; SD: Standard deviation; Min: Minimum; Max: Maximum.

Acute syndesmosis injuries (40 cases) were fixed percutaneously with trans-syndesmotic screws, as reported by Obeid et al.<sup>(15)</sup>, Sproule et al.<sup>(16)</sup>, and Hansen et al.<sup>(22)</sup>. Chronic lesions (30 cases) were reconstructed with periosteal flaps and also underwent fixation. The majority of cases were treated using two 4.5 mm screws fixing four cortices, as recommended by Stufkens et al.<sup>(7)</sup> and Hansen et al.<sup>(22)</sup>. Our results align with the literature, which suggests no significant differences in syndesmosis fixation methods using screws<sup>(15,16,22)</sup>. Suture Button fixation was not used, as it was unavailable in our service. However, we acknowledge its importance-Shimozono et al.<sup>(21)</sup>, in a meta-analysis, highlighted its superior outcomes and rare complications, recommending it for syndesmosis stabilization.

The method of syndesmosis stabilization is important, but not indispensable. However, we strongly emphasize that proper fibular positioning within the syndesmotic notch is essential, a principle reinforced by multiple authors<sup>(4,6,7,17,18,21-24,27)</sup>.

It is possible to achieve ankle stability and good functional outcomes in Maisonneuve fractures through appropriate


ligament repairs, without directly addressing the fibula, as shown by the AOFAS and VAS scores recorded in our study.

The strengths of our study are the systematic identification of ligament injuries, ensuring comprehensive assessment and treatment, and using stress radiographs during surgery to confirm final ankle stability.

Our study has some limitations in the heterogeneous patient population, including both acute and chronic cases, which underwent different syndesmosis treatments, and the surgeries were performed by multiple surgeons, leading to variability in surgical techniques.

## Conclusion

Our results concluded that the Maisonneuve fractures had 100% associated ligament injuries. Fixing the syndesmosis was significantly more efficient than repairing the deltoid in stabilizing the ankle. Repairs of both ligaments were necessary in 40% of the ankles. Stabilizing the ankle does not require addressing the high fibular fracture.

**Authors' contributions:** Each author contributed individually and significantly to the development of this article: JVP \*(<https://orcid.org/0000-0003-1445-9464>) Conceived and planned the activities that led to the study, performed the surgeries, interpreted the results of the study, wrote the article, participated in the review process; CABP \*(<https://orcid.org/0000-0003-0401-1164>) Conceived and planned the activities that led to the study, performed the surgeries, interpreted the results of the study, wrote the article, participated in the review process; FSB \*(<https://orcid.org/0000-0001-6073-8523>) Conceived and planned the activities that led to the study participated in the review process; EMT \*(<https://orcid.org/0009-0005-5078-4434>) Conceived and planned the activities that led to the study participated in the review process; RSP \*(<https://orcid.org/0000-0003-1702-1302>) Conceived and planned the activities that led to the study participated in the review process; BHBP \*(<https://orcid.org/0009-0001-5534-8018>) Conceived and planned the activities that led to the study, participated in the review process. All authors read and approved the final manuscript. \*ORCID (Open Researcher and Contributor ID) 

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