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# Treatment of Maisonneuve fractures using a plate, TightRope® syndesmosis fixation, and arthroscopic assistance

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## Summary

**Objective**. To retrospectively evaluate short- and medium-term clinical and radiographic outcomes and the timing of return to sport in patients with Maisonneuve fractures treated in our operational unit by stabilization using a suture-button system and plate combined with arthroscopic assistance (SBPAA).
**Methods**. Between January 2018 and December 2020, 8 patients took part in the study and underwent clinical and radiographic follow-up at 1, 3, 6, and 12 months during which we clinically re-evaluated the syndesmosis and determined values for tibiofibular overlap and medial clear space (MCS).
**Results**. Patients returned to full weight-bearing walking on average in the ninth week and to sport in 7.5 months. Radiographic parameters continued to improve during follow-up. Two patients reported long-term complications (residual joint stiffness and complex regional pain syndrome).
**Conclusions**. Despite the limitations due to the small number of patients, this study highlights the importance of intraoperative arthroscopy in recognizing and treating associated osteochondral lesions and enabling proper evaluation of the syndesmosis. In addition, the combination of robustness and elasticity provided by the use of a double TightRope and plate mimics the normal anatomy of the syndesmosis and guarantees a rapid return to sporting activity.

**Key words:** sports medicine, Maisonneauve fracture, syndesmosis, ankle arthroscopy, suture-button fixation

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## Introduction

Maisonneuve fracture was described for the first time in 1840 by the French surgeon Jules Germain Francois Maisonneuve [1] and represents around 5% of ankle fractures treated surgically [2]. A Maisonneuve fracture complex (MFC) refers to a combination of a fracture of the proximal fibula with an injury to the tibiofibular syndesmosis and a lesion of the deltoid ligament or an avulsion fracture of the apex of the medial malleolus. Typically, the pathogenetic mechanism responsible for the injury involves a pronation-external rotation of the ankle [3] and commonly occurs during sport activity undertaken by patients (most frequently skiing, trekking, cycling, ice skating, and dancing) [4].

According to the Lauge-Hansen classification based on the trauma-triggering mechanism, Maisonneuve fractures can be classified as Lauge-Hansen PER (pronation and external rotation) [5]. The AO classification identifies this type of fracture as 44.C3.

Diagnosis is based on clinical evaluation and careful radiographic analysis. The clinical tests used to identify potential instability are the pronation-external rotation test, Cotton test, squeeze test and crossed-leg test [6]. Radiographically, three projections of the ankle are essential: anteroposterior (AP), direct lateral (LL), and internal oblique (mortise). The most important radiographic parameters are the tibiofibular overlap (measured in AP projection, this represents the overlap space between the tibia and fibula at the fibular notch of the tibia and must be > 5 mm) and the medial clear space (MCS) (measured in mortise projection, this represents the clear space between the lateral margin of the medial malleolus and the medial margin of the talus and must be < 4 mm) [7,8].

MRI and CT scans are reserved for selected cases and are used primarily for pre-operative planning rather than diagnosis.

The type of treatment to be used for Maisonneuve lesions remains a topic of debate in the medical literature. Conservative treatment is reserved primarily for partial injuries of the lower tibiofibular ligament apparatus in which there is no evidence of clinical and radiographic instability of the syndesmosis, although it is often difficult to differentiate between partial and total injuries [2,9]. Surgical treatment is reserved for other injuries in which signs of instability of the tibiotarsal joint are evident, either acutely or after short-term re-evaluation of the initial trauma [10].

The objective of surgical treatment is firstly to reduce and synthesize the medial malleolus fracture or to repair the deltoid ligament injury and then stabilize the syndesmosis using various techniques based on the experience of different authors (resorbable or non-resorbable trans-syndesmotic screws, suture-button system, ligamentoplasty) [2]. Literature sources have yet to agree on the ideal means of synthesis [11].

The objective of our study was to retrospectively evaluate the short- and medium-term clinical and radiographic outcomes and the timing of return to sport in patients suffering from Maisonneuve injuries treated in our operational unit by stabilization using a suture-button system and one-third tubular plates combined with arthroscopic assistance (SBPAA).

## Materials and methods

### Sample examined

From January 2018 to December 2020, 18 patients with Maisonneuve injuries underwent surgery to stabilize the syndesmosis. Patients with Maisonneuve fractures occurring as a result of trauma during sporting activity and treated using SBPAA were included in the study. Of the initial population of 18 patients, the injury was a consequence of sporting activity in 66.7% (12 cases). Eight of these patients (44.4%) underwent syndesmosis stabilization surgery using a plate and suture-button system (TightRope®, Arthrex) with intra-operative arthroscopic assistance. Eight patients therefore met inclusion criteria and were recruited for the study. The mean age was 45.13 years (range 35-58 years). Six patients were male (75%) and two female (25%).

In two cases (25%) an associated injury was detected arthroscopically (in both cases this was an osteochondral lesion of the medial talar dome treated using microfractures) (Tab. I) [12].

Patients who met these inclusion criteria underwent clinical and radiographic follow-up using three projections (AP, LL, and mortise) at 1, 3, 6, and 12 months. At each check-up, the clinical stability of the syndesmosis was re-evaluated and the tibiofibular overlap and MCS values for each patient were determined.

**Table I. Sample and study parameters.**

| Age | Sex | Sport | Associated injuries | Full weight-bearing (weeks) | Return to sport (months) | Complications |
|---|---|---|---|---|---|---|
| 56 | M | Skiing | No | 8 | 6 | No |
| 43 | F | Cycling | No | 9 | 7 | No |
| 35 | M | Trail Running | No | 8 | 7 | No |
| 42 | M | Ski mountaineering | OCL* medial talus | 10 | 12 | No |
| 40 | F | Cycling | No | 8 | 6 | No |
| 50 | M | Skiing | OCL* medial talus | 11 | 8 | CRPS** |
| 37 | M | Cycling | No | 8 | 5 | No |
| 58 | M | Mountaineering | No | 10 | 9 | Stiffness |
| *osteochondral lesion; ** complex regional pain syndrome | | | | | | |

## Surgical procedure

The surgical procedure is performed with the patient supine and involves two stages: one open and the other arthroscopic. In the operating theatre, amplioscopic assistance is required to confirm the diagnosis using an externally rotated valgus test (Fig. 1) and to verify the correct restoration of syndesmosis joint alignment.

A direct lateral approach is made to the distal fibula and thus to bone level, taking care not to damage the periosteum. Using a scope for monitoring, the position of the 4-hole tubular one-third plate is selected, in line with the required biometric criteria for stabilization of the syndesmosis (which envisage the positioning of the synthesis medium between 2 and 4 cm proximally to the tibiotarsal joint and with a posteroanterior inclination of 20°), and temporarily stabilized using the two 'button and suture' traction systems, which will be tensioned later (Figs. 2-3).

**Figure 1. Intra-operative radiographic confirmation of syndesmosis injury using an externally rotated valgus test.**

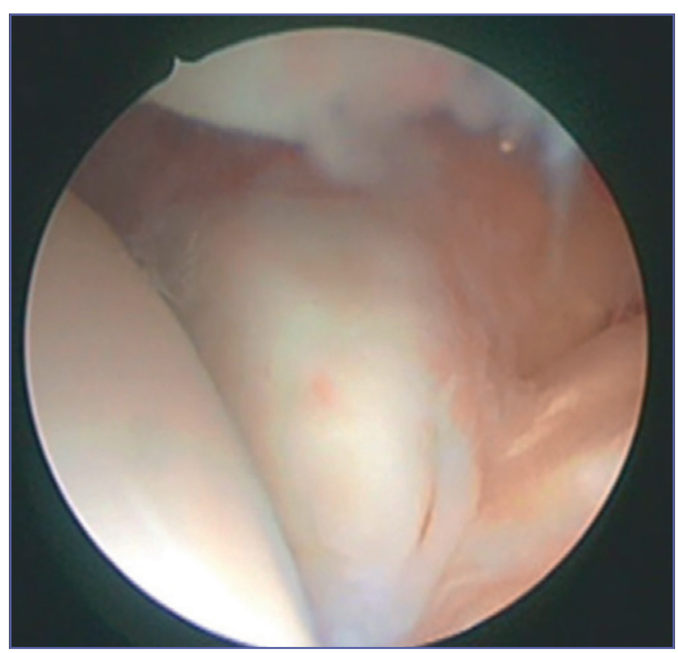
**Figures 2-3. Application and radiographic control of the correct positioning of the SB system that will be tensioned subsequently.**

**Figure 4. Drive-through test to evaluate the degree of instability of the syndesmosis.**

At this point, arthroscopic surgery is performed by means of two standard anteromedial and anterolateral accesses in order to diagnose any associated lesions (for example, osteochondral lesions may be treated at this stage, taking advantage of the increased laxity resulting from the instability) and to assess the degree of instability of the syndesmosis (by means of the palpation hook passed through the tibiofibular space or through the optic itself using a test referred as the drive-through test) (Fig. 4). It is also possible to ascertain the degree of integrity of the deltoid ligament and the level of the fracture. The next step involves tensioning the two traction systems with amplioscopic evaluation of the restoration of the overlap sign (OS) and, simultaneously, arthroscopic evaluation of the correct tibiofibular alignment (Figs. 5-6). Once the syndesmosis has been stabilized, it is possible to treat the deltoid ligament injury using arthroscopic or mini-open suturing of the deltoid ligament, or through reinsertion using anchors (Fig. 7).

## Results

Patients regained full weight-bearing walking on average at week 9 (range 8-11). All patients were able to return to their pre-injury sports practice in 7.5 months (range 5-12).
Two patients reported long-term complications: in one case residual joint stiffness which has been treated increasing frequency and duration of rehabilitation and in another case complex regional pain syndrome (CRPS) which required treatment with bisphosfonates (Neridronate) and magnetotherapy.



**Figures 5-6. Tensioning of the SB fixation and radiographic and arthroscopic evaluation of the correct recovery of tibiofibular joint alignment.**

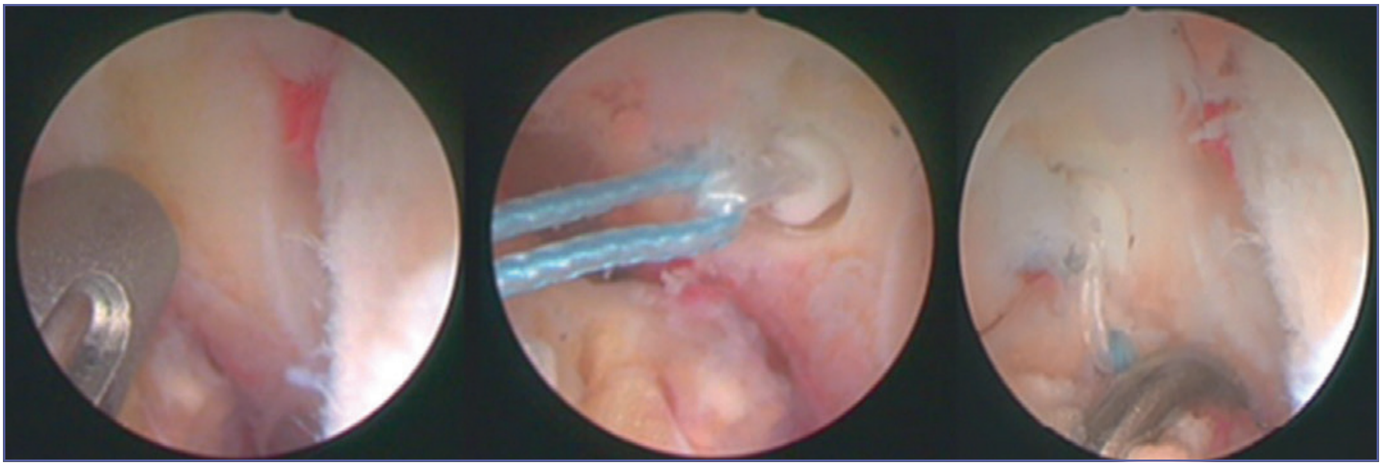


**Figure 7. Arthroscopic reinsertion of the deltoid ligament using resorbable anchors.**

These complications were the cause of the delay in achieving full weight-bearing status and the timing of the return to sport compared to the other patients. During serial radiographic follow-ups, OS and MCS were found to be restored, remaining within a normal range over time in all eight patients.

## Discussion

Syndesmosis injuries can occur in isolation or in combination with a fracture of the fibula. The most common trauma mechanism is characterized by external rotation with dorsiflexion of the tibiotarsal joint. This causes the talus to rotate in the tibial mortise and the fibula to rotate externally and move in a posterolateral direction, with consequent stress on the anteroinferior tibiofibular ligament. The other structures often involved are the posteroinferior tibiofibular ligament and interosseous tibiofibular ligament [13].

This type of injury occurs primarily among sportsmen and women and represents an orthopedic challenge because of possible sequelae in the event of inadequate treatment: delay and/or inability to return to competitive sporting activity [14], possible development of early osteoarthritis, persistent pain, functional limitation and persistent tibiofibular diastasis [15].

A correct diagnosis is, therefore, the first step towards therapeutic success.

In our experience, if an adequate clinical assessment of the ankle cannot be performed due to excessive swelling or pain in A&E, it is useful to apply the PRICE (Protection-Rest-Ice-Compression-Elevation) protocol and perform a sub-acute clinical and radiographic re-evaluation. Various studies have shown that x-rays alone do not recognize about half of ankle instabilities, which are then confirmed by more accurate methods [16].

However, to date there is still no gold standard in the medical literature for the treatment of syndesmosis injuries. The systems most often employed are the rigid system using tri- or quadricortical screws and the dynamic system involving suture-button fixation. To enable a correct reduction of the syndesmosis, the fibula must be repositioned in the fibular notch of the tibia.

Some authors argue that x-ray alone is not sufficient to assess the correctness of tibiofibular joint alignment and that CT assessment of the region is therefore necessary [17].

In an intraoperative context, the use of arthroscopy is a viable alternative to CT scanning, and has gained significant prominence as it allows us to assess not only possible instability of the syndesmosis but also possible associated osteochondral lesions, and to treat them in the same session [4]. Ankle instability due to an injury to the syndesmosis or the deltoid ligament is assessed arthroscopically through positivity of the so-called drive-through sign, which involves being able to pass an instrument with a diameter of 2.9 mm easily into the medial recess between the talar dome and medial malleolus [18].

Arthroscopy is also used as SBPAA to check intraoperatively that the fibular malleolus has been correctly reduced into the tibial notch, after which it is fixed using a suture-button system. This system provides stability to the syndesmosis while avoiding the rigidity typical of trans-syndesmotic screws. In fact, the use of suture-button fixation means the syndesmosis has greater elasticity and is better able to mimic normal anatomy than with trans-syndesmotic screws. Indeed, it has been observed that under axial load and rotational torque stresses, a suture-button fixation enables the physiological movements of the syndesmosis without presenting significant differences in displacement compared with screw systems, although the latter are slightly more stable [19].

While it does have considerable advantages in terms of elasticity and robustness, the suture-button technique is not without complications. The principal complications are: possible perforation of the great saphenous vein, entrapment of the posterior tibial tendon, soft tissue irritation from decubitus if the sutures are cut too short, and cut-out of the system from the cortical structure of the fibula. This latter complication may be caused by a small exposure of the site of the TightRope entry hole, the large diameter of the burr or the irregular profile of the distal fibula, all of which are conditions that potentially contribute to the risk of cortical fracture [20].

In our experience, to avoid cut-out of the button and to better distribute the load, we used a one-third tubular plate on the fibula, with a double TightRope passing through the corresponding holes, in order to provide better mechanical strength and to reduce tibiofibular movements in the sagittal plane compared to the use of a single suture-button system.

Other advantages of the SB technique compared to trans-syndesmotic screws are the limited immobilization of the ankle, which causes an alteration to the equilibrium of the tibial mortise and thus degenerative phenomena affecting the joint cartilage [21], and an early return to weight-bearing [22,23]. Furthermore, SB is a permanent system that does not require removal subsequently, as it does not alter the elasticity of the tibiotarsal joint or cause loss of syndesmosis reduction during follow-up [24,25].

Conversely, removal is mandatory if a rigid system with trans-syndesmotic screws is used to reduce the rigidity and discomfort caused by the screws and to remove the screws if they break or loosen. In the latter two cases, there is also the risk of syndesmotic diastasis [26].

A recent study has shown that it may be useful to first perform an operation with a one-third tubular plate on the fibula and two trans-syndesmotic screws so that the bones can heal properly, with this being replaced at six weeks with a double TightRope to allow full weight-bearing and articulation while avoiding the risk of tibiofibular diastasis and simultaneously allowing the syndesmosis time to repair properly [27]. However, this would inevitably lead to increased costs because of the need for a second surgery [28]. Besides, the double surgery requirement in addition to increased costs, increases the risks associated with anesthesia and combines the possible complications of the two different surgical procedures.

## Conclusions

While demonstrating certain limitations such as the small size of the sample and the need for a certain degree of technical expertise in ankle arthroscopy and in the correct positioning of the SB system to avoid cut-out, this study also highlights the important role of intra-operative arthroscopy in approaching syndesmosis injuries in sports patients with MCF. In fact, arthroscopy is essential in immediately recognizing and treating associated osteochondral lesions and enabling proper syndesmosis repair under direct vision. Furthermore, the use of a double TightRope and a one-third tubular plate on the fibula has proven to be a valuable treatment that combines robustness and elasticity to mimic the normal anatomy of the syndesmosis and guarantees excellent functional results and a rapid return to sporting activity. An equally important factor is that an SB system does not need to be removed (except in extremely rare cases), with considerable economic savings for the health system. Despite these promising results, we hope that new studies with larger samples and more data will be conducted in the future.

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### Conflict of interest statement

The Authors declare no conflict of interest.

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### Author contributions

LP made substantial contributions to all the following five points: conceived and designed the analysis; collected the data; contributed data or analysis tools; performed the analysis; wrote the paper. GL, SS, AD were involved in drafting the manuscript and revising it critically for important intellectual content. DM, AS, RC made contributions to the analysis and interpretation of data. GFC, FC were involved in revising the manuscript critically and gave final approval for the version to be published.

### Ethical consideration

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee(s) and with the Helsinki Declaration (as revised in 2013). The study was approved by the institutional review board of our hospital. Written informed consent was obtained from the patients. The Authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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