Arthroscopic Findings in Maisonneuve Injuries

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ABSTRACT

Objective: The purpose of this study is to analyze arthroscopic findings in Maisonneuve lesions treated by arthroscopically-assisted reduction and percutaneous fixation. **Materials and Methods:** We evaluated the registry of patients operated on between May 2013-January 2019 with acute Maisonneuve lesions, treated by arthroscopically-assisted reduction and percutaneous fixation. We analyzed arthroscopic findings (chondral or osteochondral lesions, intra-articular loose fragments, injury of the distal tibiofibular joint with or without instability, and injury of the deltoid ligament with or without medial instability). **Results:** 13 ankles in 13 patients were evaluated. 100% evidenced injury of the anterior distal tibiofibular ligament and instability of the distal tibiofibular joint. 92.30% had medial structure injuries, 76.9% with complete deltoid ligament injury with instability and 15.38% with medial malleolus fractures. In 1 patient (7.69%), no medial injury was evidenced. 84.61% of patients presented chondral or osteochondral lesions. 53.84% (7 patients) of cases had intra-articular loose fragments. **Conclusion:** Maisonneuve lesions are a consequence of high-energy trauma and present with a high incidence of intra-articular structure injuries (ligaments and articular surface). Arthroscopy is a very useful tool to identify and treat intra-articular injuries, which would otherwise not be recognized.
Key words: Injury; fracture; Maisonneuve; ankle; arthroscopy; findings.
Level of Evidence: IV

Hallazgos artroscópicos en lesiones de Maisonneuve

RESUMEN

Objetivo: Analizar los hallazgos de la artroscopia anterior de tobillo en lesiones de Maisonneuve tratadas con reducción bajo visualización artroscópica y fijación percutánea. **Materiales y Métodos:** Se evaluó el registro de pacientes con lesiones de Maisonneuve agudas tratados con reducción bajo visualización artroscópica y fijación percutánea, entre mayo de 2013 y enero de 2019. Se analizaron los hallazgos artroscópicos buscados (lesiones condrales u osteocondrales, cuerpos libres intrarticulares, lesión de la articulación tibioperonea distal con inestabilidad o sin ella, y lesión del ligamento deltoideo con inestabilidad medial o sin ella). **Resultados:** Se evaluaron 13 tobillos en 13 pacientes. Todos tenían lesión del ligamento tibioperoneo distal anterior e inestabilidad de la articulación tibioperonea distal. El 92,30% presentaba lesiones de estructuras mediales; el 76,9%, lesión completa e inestabilidad del ligamento deltoideo y el 15,38%, fracturas del maléolo tibial. Un paciente (7,69%) no tenía lesión medial. El 84,61% tenía lesiones condrales u osteocondrales y el 53,84% (7 pacientes), cuerpos libres. **Conclusiones:** La lesión de Maisonneuve es una consecuencia de un trauma de alta energía y la incidencia de lesiones de estructuras intrarticulares (ligamentarias y de la superficie articular) es alta. La artroscopia es una herramienta de gran utilidad para identificar y tratar lesiones intrarticulares que, de otra manera, no serían reconocidas.
Palabras clave: Lesión; fractura; Maisonneuve; tobillo; artroscopia; hallazgos.
Nivel de Evidencia: IV

INTRODUCTION

In 1840, Jules Maisonneuve described an injury consisting of a subcapital fracture of the fibula associated with a tear of the distal tibiofibular syndesmosis (DTFS) and injury to medial structures of the ankle, produced by a traumatic mechanism of external rotation.[1] Currently, the term Maisonneuve fracture or injury (MF) is used ambiguously to refer to ankle injuries due to external rotational forces that cause a fibula fracture in its proximal third or fourth, associated with the medial (ligament or bone) involvement of the ankle and the DTFS. These injuries remain a challenge for the attending surgeon. The therapeutic objective is to restore the bone and ligament anatomy, restoring joint biomechanics and thus reducing to a minimum the risk of osteoarthritis.[2] Anatomical

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How to cite this article: Rofrano M, Herrera H. Arthroscopic Findings in Maisonneuve Injuries. *Rev Asoc Argent Ortop Traumatol* 2022;87(1):5-14.
https://doi.org/ 10.15417/issn.1852-7434.2022.87.1.1350

reduction is not easy given the complexity of the local anatomy and the low sensitivity of intraoperative radioscopy. The best clinical outcomes in ankle fractures are obtained when anatomical reduction and joint stability are achieved. Even if this has been achieved, the outcomes are not always optimal. This could be due to ligament injuries, chondral or osteochondral injuries, or intra-articular loose bodies that occur at the time of fracture and are not recognized during surgery.[3] Articular cartilage involvement in acute ankle fractures has a high incidence, 70% according to Loren and Ferkel[4] and 79.2% according to Hintermann et al.[5] This information is relevant because the initial damage of the articular cartilage is an independent predictive factor of the development of post-traumatic osteoarthritis.[6]

Arthroscopy is a useful tool for identifying and treating intra-articular lesions that would otherwise go unnoticed. In addition, it provides prognostic information on the medium- and long-term clinical outcomes. In MFs specifically, arthroscopic assistance allows the anatomical reduction of the fibula under direct vision in the tibial incision.[4,7,8]

The objective of this study was to analyze the findings of anterior ankle arthroscopy in MFs treated by reduction under arthroscopic visualization and percutaneous fixation.

MATERIALS AND METHODS

We evaluated the records of patients with acute MF (<6 weeks) diagnosed with anteroposterior and lateral leg radiographs (Figure 1), treated by reduction under direct arthroscopic visualization and percutaneous internal fixation between May 2013 and January 2019.

Figure 1. Anteroposterior leg radiographs. Maisonneuve injuries are observed. **A.** Patient 8. **B.** Patient 2.

We recorded their sex, age, affected side, the context where the injury occurred (sports activity or not), and the presence of medial injury (bone or ligament). On a table, we reported the arthroscopic findings from the anterior compartment of the ankle (chondral or osteochondral lesions, the presence of intra-articular loose bodies, ligament injury of the distal tibiofibular joint with or without instability, and ligament injury of the deltoid ligament with or without medial instability).

Exclusion criteria

Patients with previous degenerative ankle disease (grade I or higher of the Cheng[9] classification), history of fracture in the affected ankle, neuroarthropathy, rheumatoid arthritis, polytrauma *(Injury Severity Score* ≥16) and exposed fractures.

Surgical technique and postoperative management

The patient was placed on the table in the supine position as distally as possible to facilitate dorsal flexion of the ankle at the necessary time, under spinal block and sedation. A hemostatic cuff was placed in the inguinofemoral region inflated at 270 mmHg and the homolateral glute was raised to prevent external rotation of the limb. Conventional anterior arthroscopic portals (anteromedial and anterolateral) were performed at the level of the joint interline for anterior ankle arthroscopy. Arthroscopy was performed with saline solution, without a pressure pump and without a distraction system, with a STORZ arthroscope with 4 mm optics, 30° inclination, and a Stryker 4 mm shaver. The anterior compartment of the ankle was examined with a Ferkel-type systematic evaluation.[10] Once the arthroscope was inserted into the joint, the systematic evaluation was carried out in 11 steps, as follows: 1) general visualization of the anterior compartment, 2) medial malleolus tip (with evaluation of the deltoid ligament), 3) medial groove, with evaluation of the deltoid ligament by stress maneuver in pronation and external rotation, 4) "Harty's notch" with manual distraction or without it, by the first assistant, 5) anterior end of the tibia and talus, 6) anteroexternal angle, 7) DTFS, 8) external groove, 9) talar neck, 10) talar dome, with maximum plantar flexion, 11) talar dome and tibial plafond, with manual distraction by the first assistant. Chondral or osteochondral lesions, presence of intra-articular loose bodies, anterior distal tibiofibular ligament (ADTFL) injury, DTFS instability, deltoid ligament injury, and medial ligament instability were evaluated. Arthroscopic regularization of the ligament stumps of the injured ADTFL was carried out, thus facilitating the correct visualization of the distal tibiofibular joint. The loose bodies found were extracted and the hemorrhagic synovitis was shaved. Depending on the case, we continued with the regularization of the chondral or osteochondral lesion. We continued with the reduction of the fibula within the tibial incision, under direct arthroscopic visualization, through an internal rotation and reversal of the hindfoot maneuver and the use of a sharp-tipped clamp. A reduction was considered to be adequate when a complete closure of the distal tibiofibular articular space and the continuity of the cartilage of the anterior lip of the tibia with the one in the anterior side of the fibula were achieved (Figure 2B).

A fluoroscopic control was performed to finally proceed to percutaneous fixation with 4 mm cannulated screws from fibula to tibia parallel and proximal to the tibial incision, 1 or 2, according to the surgeon's criteria. In patients with medial malleolus fracture, we initially performed a joint inspection and then proceeded with the reduction and osteosynthesis percutaneously, with arthroscopic assistance and fluoroscopy, and with two 3.5 or 4 mm partially threaded cannulated screws. Once the medial malleolus was fixated, a new arthroscopic control was carried out following the 11 steps mentioned above. At the end of the surgery, the limb was immobilized with a posterior plaster cast until the first dressing at 48-72 h and then changed to a walker boot for four weeks. From the second week onward, progressive ankle mobility exercises were indicated. Weight-bearing was restricted until the removal of the suprasyndesmal screws at the twelfth week. After removing them, the patient began on-field rehabilitation as needed.

Definition of arthroscopic findings

ADTFL lesion: abnormal or discontinuous line, avulsion of its proximal or distal insertion.

Instability of the distal tibiofibular joint: separation between the tibia and the fibula ≥2 mm upon a stress maneuver in external rotation (Figure 2A).[11,12]

Complete injury or instability of the deltoid ligament: complete ligament tear, bone avulsion, or separation between the articular surface of the medial malleolus and the medial talar articular surface ≥5 mm upon stress maneuvers in pronation and external rotation of the foot.[7,13]

Extent of articular cartilage injury: we used the *International Cartilage Repair Society* (ICRS) classification: grade 1, fibrillation or superficial fissures; grade 2, injury extending down to less than 50% of the total cartilage depth; grade 3, injury extending beyond 50% of the total cartilage depth without compromising the subchondral bone; grade 4, osteochondral injury with subchondral bone involvement.[14]

Location of the chondral or osteochondral lesion in the talus: we used Raikin's[15] topographic classification and, when it was not possible to use it, we considered it non-classifiable and its location was explained in a descriptive way.

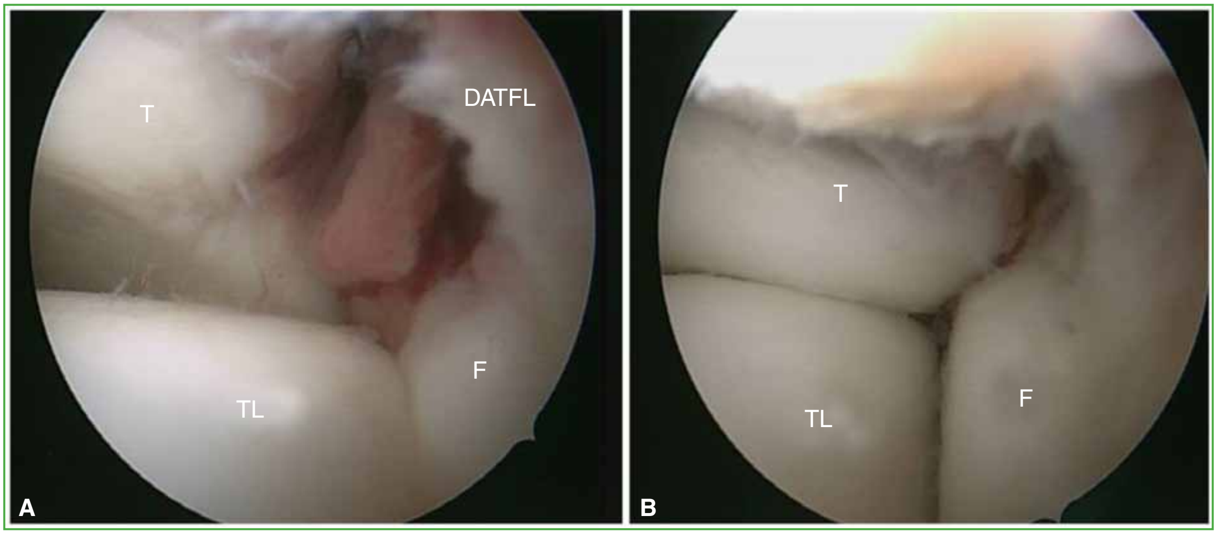

Figure 2. Patient 5. Anterior ankle arthroscopy with focus on distal tibiofibular syndesmosis. **A.** Instability evidenced by diastasis of distal tibiofibular syndesmosis, >2 mm. Anterior distal tibiofibular ligament injury. **B.** Reduction of distal tibiofibular syndesmosis. T = tibia, F = fibula, Tl = talus, DATFL = distal anterior tibiofibular ligament.

RESULTS

Characteristics of the sample

Between May 2013 and January 2019, 16 fractures were treated and 13 of 16 patients met the inclusion criteria. The sample included 12 men (92.30%) and one woman (7.7%), with a mean age of 39.1 years (range 18-69). The right side was affected in seven cases (53.85%) whereas the left side was affected in six (46.15%). All reported trauma in external rotation with their foot fixed on the ground, nine (69.23%) suffered the injury during sports practices (Table 1).

Distal tibiofibular syndesmosis

We observed an ADTFL lesion and instability of the distal tibiofibular joint in 100% of the patients.

Deltoid ligament and medial malleolus

Twelve patients (92.30%) had lesions of medial structures; 10 (76.9%), a complete injury with instability of the deltoid ligament; two (15.38%), a fracture of the tibial malleolus. In one patient (7.69%), no medial lesion was observed (Table 2).

Table 1. Characteristics of the sample

Patient	Age	Sex	Side	Injury in sports practice
1	18	M	R	Yes
2	36	M	R	Yes
3	36	M	R	Yes
4	39	M	R	Yes
5	37	M	L	Yes
6	22	M	L	Yes
7	50	M	R	No
8	54	M	L	No
9	26	M	L	Yes
10	69	F	L	No
11	35	M	R	Yes
12	26	M	L	Yes
13	61	M	R	No

M = male, F = female, R = right, L = left.

Table 2. Record of ligament injuries and fractures of the medial malleolus

	Deltoid ligament				
Patient	**No injury**	**Complete-unstable injury**	**DATFLI**	**DTFSI**	**MMF**
1	Yes	No	Yes	Yes	No
2	No	Yes	Yes	Yes	No
3	No	Yes	Yes	Yes	No
4	No	Yes	Yes	Yes	No
5	No	Yes	Yes	Yes	No
6	No	Yes	Yes	Yes	No
7	No	Yes	Yes	Yes	No
8	No	Yes	Yes	Yes	No
9	No	Yes	Yes	Yes	No
10	No	No	Yes	Yes	Yes
11	No	No	Yes	Yes	Yes
12	No	Yes	Yes	Yes	No
13	No	Yes	Yes	Yes	No

DATFLI = distal anterior tibiofibular ligament injury, DTFSI = distal tibiofibular syndesmosis instability, MMF = medial malleolus fracture.

Chondral or osteochondral injuries and intra-articular loose bodies (Table 3).

Table 3. Record of chondral-osteochondral injuries, intra-articular loose bodies and their topographic location

Patient	ATL Injury	CL or OCL in the talus	Raikin Area	CL or OCL in the talus (not classifiable according to Raikin)	ICRS	LB
1	No	No		No		No
2	No	Yes	4	No	4	Yes
3	No	Yes	Unclassifiable	Yes, MTS injury (Raikin zone 4)	2	No
4	Sí	Yes	1	No	3	Yes
5	No	Yes	Unclassifiable	Yes, MTS injury (Raikin zone 4)	4	Yes
6	No	Yes	Unclassifiable	Yes, MTS injury (Raikin zone 4)	4	Yes
7	No	Yes	3	No	3	No
8	No	No		No		No
9	No	Yes	3	No	3	No
10	No	Yes	Unclassifiable	Yes, MTS injury (Raikin zone 4)	2	Yes
11	Sí	Yes	3	No	4	Yes
12	No	Yes	1	No	3	Yes
13	No	Yes	4	No	2	No

ATL = anterior tibial lip, CL = chondral lesion, OCL = osteochondral lesion, ICRS = classification of the *International Cartilage Repair Society*, LB = loose bodies, MTS = medial talar surface.

84.61% of patients had chondral or osteochondral injuries and intra-articular loose bodies. Two had an injury to the anterior lip of the tibia, one corresponded to a displaced simple avulsion fracture and the other, to a comminuted impacted fracture. Eleven (84.61%) had a chondral or osteochondral lesion in the talus. In seven cases, it was possible to classify talar lesions topographically, according to Raikin:[15] two patients with lesion in zone 1, three in zone 3, and two in zone 4. In four cases, this classification could not be applied, since the lesion was in the medial articular surface of the talus, approximately in Raikin's zone 4 (Figure 3B).

No chondral-osteochondral lesions were found in the articular surfaces of the fibular malleolus, tibial malleolus and tibial plafond. According to the ICRS classification, four patients had a type 4 lesion; four, a type 3 lesion; and three, a type 2 lesion. In 53.84% (7 cases), intra-articular loose bodies were found and required excision (Figure 3A). Treatment consisted of resection of loose bodies and excision or regularization of osteochondral lesions. Fixation was attempted only in one case (patient 2) (osteochondral fragment visible on radiographs), but the size and fragility of the lesion forced excision.

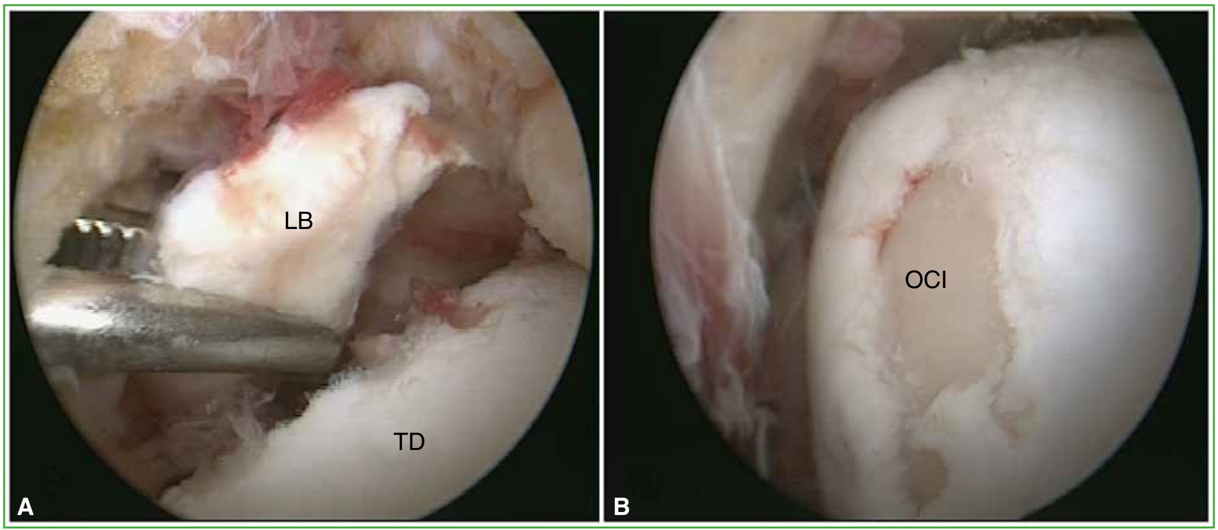

Figure 3. Patient 5. Anterior ankle arthroscopy. **A.** Intra-articular chondral loose body that required excision. **B.** Osteochondral injury on the medial articular surface of the talus. TD = talar dome, LB = loose body, OCI = osteochondral injury.

DISCUSSION

The term MF is currently used to refer to fractures of the proximal third or quarter of the fibula associated with involvement of medial structures (ligament or bone) of the ankle, as a result of trauma with deforming force in external rotation. These injuries account for 3.5% of ankle fractures and are more common in young men.[16,17] The epidemiological distribution of our sample is similar to those of the published series.

The classic interpretation of the mechanism of injury in this type of fracture describes it as a consequence of trauma in external rotation with initial involvement of medial structures (fracture by avulsion of the tibial malleolus or injury to the deltoid ligament) continuing with the ligament injury of the DTFS, and then the proximal fracture of the fibula.[1] Today, the mechanism by which these types of injuries occur remains a controversial issue. According to Lauge-Hansen,[18] MFs would be secondary to stage III or IV trauma in pronation and external rotation, with involvement of medial structures (bone or ligament), injury to the DTFS and the interosseous membrane to the level of the fibula fracture. Several studies have analyzed interosseous membrane involvement using magnetic resonance imaging. Nielson et al.[19] showed that the location of the fibula fracture does not necessarily correlate with the level of the interosseous membrane tear. Manyi et al.[20] studied 12 patients and found membrane injuries in all of them, but they did not extend more than 112 mm proximally from the joint interline in any case. On the other hand, Pankovich[21] described a mechanism of injury by supination and external rotation, as proposed by Lauge-Hansen.[18]

In MFs, DTFS injury is a constant. According to Loren and Ferkel,[4] all pronation and external rotation fractures cause injury and instability of the DTFS. Yoshimura et al.[17] analyzed the arthroscopic findings of four cases (4 ankles) with MF treated surgically, and reported that all had an injury to the ADTFL and the interosseous ligament, without involvement of the posterior distal tibiofibular ligament. Bartonicek et al.[16] published the broadest series of this particular condition with 54 patients and reported that only ADTFL and interosseous ligament were constant injuries. The interosseous membrane was almost always affected, but only in its distal third and only exceptionally the lesion reached the fracture line. In our series, everyone had ADTFL compromise and DTFS instability. These findings coincide with those of the currently published literature.

The analysis of the involvement of medial structures is a challenge. The most frequent medial injury involved a ligament (76.9%). Fractures of the medial malleolus accounted for 15.38% and no medial lesion of any kind was detected in one case (7.69%). Yoshimura et al.[17] reported medial involvement in all their patients with MF, one case with fracture of the medial malleolus and three with rupture of the deltoid ligament. On the other hand, Bartonicek et al.[16] recorded 50% of ligament injuries, 37% of tibial malleolus fractures, and did not detect medial injuries in 13%. The absence of medial injury would imply that the mechanism and sequence of the injury would not always be the same. We believe that MF could, then, be the product of trauma in pronation and external rotation, but also in supination and external rotation.

The finding of chondral or osteochondral injuries in acute ankle fractures varies between 20% and 88.9%, according to the literature.[22] Fractures caused by external rotational forces are associated with a higher incidence of intra-articular injuries.[6,14] Berndt and Harty[23] proposed that the main force generating injuries would be torsional. According to them, when the tibia is in internal rotation and the foot-ankle in forced dorsiflexion, an impaction of the lateral portion of the talus against the articular margin of the fibula occurs, thus resulting in potential injuries to the lateral portion of the talus. With the tibia in external rotation and plantar flexion and inversion of the foot-ankle, a medial impaction of the tibiotalar joint would occur, causing medial lesions in the talar dome. Yoshimura et al.[17] described chondral or osteochondral lesions in all patients with MF and all were located in the posteromedial aspect of the talus. According to Loren and Ferkel,[4] mechanisms of pronation injury are related to a higher incidence of lesions in the lateral talar portion. The pronation of the foot would probably overload the talus over the lateral portion of the tibial plafond and the medial fibula, predisposing to joint damage of the lateral portion of the talus. They also concluded that DTFS instability is associated with a higher risk of talar dome involvement. Hintermann et al.[5] prospectively evaluated arthroscopic findings in 288 patients (148 men and 140 women, mean age 45.6 years) with acute ankle fractures. According to the AO/Danis-Weber classification, 14 fractures were type A; 198, type B; and 76, type C. They detected cartilage lesions in 228 ankles (79.2%): in the talus (69.4%), the distal tibia (45.8%), the fibula (45.1%) and the medial malleolus (41.3%). The frequency and severity of osteochondral damage are higher in type C fractures than in type B fractures. In our series, 84.61% (11 patients) had chondral or osteochondral lesions. This higher prevalence could be due to the fact that everyone had suffered high-energy trauma in external rotation. We did not detect chondral or osteochondral involvement in the articular surfaces of the fibula, tibia, or tibial plafond. Two patients had involvement of the anterior lip of the tibia: a displaced simple avulsion fracture and a comminuted impacted fracture. In 11 (84.61%), a chondral or osteochondral lesion of the talus was detected and, in seven cases, it was possible to classify it topographically according to Raikin. We have not found a pattern of injury to the talus. Two patients had involvement in Raikin's zone 1; three, in zone 3; and two, in zone 4. In four cases, this classification could not be applied, since the lesion was in the medial articular surface of the talus, two of them with severe involvement (ICRS type 4). Most likely, this type of injury is produced by a mechanism of supination and external rotation, in which trauma could initially be generated between the articular surface of the talus and the medial malleolus. According to the ICRS classification, four patients had a type 4 lesion; four, a type 3 lesion; and three, a type 2 lesion. This could mean that they were produced by high-energy trauma with significant damage to the articular surface. The precise mechanism by which traumatic injuries to the articular surface of the talus occur is not yet conclusive.

The high incidence of articular cartilage injuries produced in the context of ankle fractures could explain why the final outcomes do not always correlate solely with the reduction and stability achieved. The prognosis is determined at the time of the accident. Cartilage damage occurs when the talus rotates or moves in the ankle mortise until the fracture occurs.[5] Stufkens et al.[6] demonstrated that cartilage involvement in acute ankle fractures diagnosed by arthroscopy is a predictive factor for the development of post-traumatic osteoarthritis. Lesions in the talus and tibia are associated with poor long-term outcomes, specifically deep ones (>50% of the thickness of the cartilage) in the anterior and lateral aspect of the talus and those located in the medial malleolus.[6]

It was not the objective of this study to evaluate the implications of chondral damage found on functional outcomes. However, we should mention that in cases with type 4 lesions of the ICRS classification, the clinical outcomes were regular or poor, regardless of location. Three out of four patients with these injuries were unable to resume their sports activity at pre-fracture levels and physical examination revealed a reduction in range of motion compared to that of the healthy contralateral ankle. Moreover, two of these four patients underwent a new arthroscopy (18 and 27 months after the initial surgery). In both cases, we observed marked arthrofibrosis, anterior tibial osteophytosis, and fibrocartilage at the site where the osteochondral lesion was initially located (Figure 4).

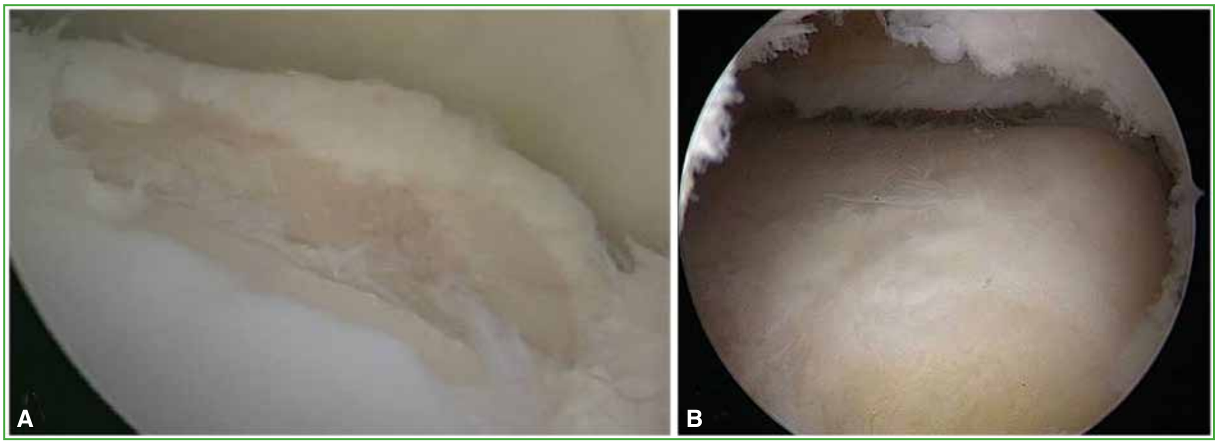

Figure 4. Patient 2. Anterior ankle arthroscopy with focus on the medial portion of the tibiotalar joint. **A.** Osteochondral injury in the talar dome, ICRS 4, Raikin zone 4, in acute stage. **B.** Fibrocartilage in Raikin zone 4, in the last arthroscopy.

MF is a consequence of high-energy trauma and is associated with a high incidence of intra-articular (ligament and articular surface) injuries. Arthroscopy is a very useful tool to identify and treat these otherwise unnoticed injuries.

Conflict of interests: The authors declare they do not have any conflict of interests.

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REFERENCES

1. Maisonneuve JG. Recherches sur la fracture du péroné. *Arch Gen Med* 1840;7:165-187, 433-473.
2. Bauer M, Jonsson K, Nilsson B. Thirty-year follow-up of ankle fractures. *Acta Orthop Scand* 1985;56(2):103-6. https://doi.org/10.3109/17453678508994329
3. van Dijk CN, Verhagen RAW, Tol JL. Arthroscopy for problems after ankle fracture. *J Bone Joint Surg Br* 1997;79(2):280-4. https://doi.org/10.1302/0301-620x.79b2.7153
4. Loren GJ, Ferkel RD. Arthroscopic assessment of occult intra-articular injury in acute ankle fractures. *Arthroscopy* 2002;18(4):412-21. https://doi.org/10.1053/jars.2002.32317
5. Hintermann B, Regazzoni P, Lampert C, Stutz G, Gächter A. Arthroscopic findings in acute fractures of the ankle. *J Bone Joint Surg Br* 2000;82(3):345-51. https://doi.org/10.1302/0301-620x.82b3.10064
6. Stufkens SA, Knupp M, Horisberger M, Lampert C, Hintermann B. Cartilage lesions and the development of osteoarthritis after internal fixation of ankle fractures: a prospective study. *J Bone Joint Surg Am* 2010;92(2):279-86. https://doi.org/10.2106/JBJS.H.01635
7. Sherman TI, Casscells N, Rabe J, McGuigan FX. Ankle arthroscopy for ankle fractures. *Arthrosc Tech* 2015;4(1):e75-e79. https://doi.org/10.1016/j.eats.2014.11.004
8. Ferkel RD, Orwin JF. Arthroscopic treatment of acute ankle fractures and postfracture defects. En: Ferkel RD (ed). *Arthroscopic surgery: The foot and ankle*. Philadelphia: Lippincott-Raven; 1996;185-200.

9. Cheng YM, Huang PJ, Hong SH. Low tibial osteotomy for moderate ankle arthritis. *Arch Orthop Trauma Surg* 2001;121(6):355-8. https://doi.org/10.1007/s004020000243
10. Ferkel RD. Diagnostic arthroscopic examination. In: Ferkel RD (ed). *Arthroscopic surgery: The foot and ankle.* Philadelphia: Lippincott-Raven; 1996;103-18.
11. Ogilvie-Harris DJ, Reed SC. Disruption of the ankle syndesmosis: diagnosis and treatment by arthroscopic surgery. *Arthroscopy* 1994;10(5):561-8. https://doi.org/10.1016/s0749-8063(05)80015-5
12. Takao M, Ochi M, Oae K, Naito K, Uchio Y. Diagnosis of a tear of the tibiofibular syndesmosis. The role of arthroscopy of the ankle. *J Bone Joint Surg Br* 2003;85(3):324-9. https://doi.org/10.1302/0301-620x.85b3.13174
13. Van den Bekerom MP, Mutsaerts EL, van Dijk CN. Evaluation of the integrity of the deltoid ligament in supination external rotation ankle fractures: a systematic review of the literature. *Arch Orthop Trauma Surg* 2009;129(2):227-35. https://doi.org/10.1007/s00402-008-0768-6
14. Brittberg M, Winalski CS. Evaluation of cartilage injuries and repair. *J Bone Joint Surg Am* 2003;85(Suppl 2):58-69. https://doi.org/10.2106/00004623-200300002-00008
15. Elias I, Zoga AC, Morrison WB, Besser MP, Schweitzer ME, Raikin SM. Osteochondral lesions of the talus: localization and morphologic data from 424 patients using a novel anatomical grid scheme. *Foot Ankle Int* 2007;28(2):154-61. https://doi.org/10.3113/FAI.2007.0154
16. Bartonicek J, Rammelt S, Kassper S, Malík J, Tucek M. Pathoanatomy of Maisonneuve fracture based on radiologic and CT examination. *Arch Orthop Trauma Surg* 2019;139(4):497-506. https://doi.org/10.1007/s00402-018-3099-2
17. Yoshimura I, Naito M, Kanazawa K, Takeyama A, Ida T. Arthroscopic findings in Maisonneuve fractures. *J Orthop Sci* 2008;13(1):3-6. https://doi.org/10.1007/s00776-007-1192-4
18. Lauge-Hansen N. Fractures of the ankle II. Combined experimental-surgical and experimental-roentgenologic investigations. *Arch Surg* 1950;60(5):957-85. PMID: 15411319
19. Nielson JH, Sallis JG, Potter HG, Helfet DL, Lorich DG. Correlation of interosseous membrane tears to the level of the fibular fracture. *J Orthop Trauma* 2004;18(2):68-74. https://doi.org/10.1097/00005131-200402000-00002
20. Manyi W, Guowei R, Shengsong Y, Chunyan J. A sample of Chinese literature MRI diagnosis of interosseous membrane injury in Maisonneuve fractures of the fibula. *Injury* 2000;31(Suppl3):C107-10. https://doi.org/10.1016/s0020-1383(00)80038-8
21. Pankovich AM. Maisonneuve fracture of the fibula. *J Bone Joint Surg Am* 1976;58(3):337-42. PMID: 816799
22. Chen XZ, Chen Y, Liu CG, Yang H, Xu XD, Lin P. Arthroscopy-assisted surgery for acute ankle fractures: A systematic review. *Arthroscopy* 2015;31(11):2224-31. https://doi.org/10.1016/j.arthro.2015.03.043
23. Berndt AL, Harty M. Transchondral fractures (osteochondritis dissecans) of the talus. *J Bone Joint Surg Am* 1959;41:988-1020. PMID: 13849029