Endoscopic lateral ligament repair associated with calcaneous osteotomy

Reparación endoscópica del ligamento lateral con osteotomía de calcáneo

Jorge Pablo Batista[1], Guillermo Arrondo[2], Germán Joannas[2], Jorge Del Vecchio Javier[3], Luciano Patthauer[1], Helder Pereira Duarte[4], Jordi Vega[5]

Keywords:
Ankle; Ligaments, articular; Joint instability; Osteotomy

Descriptors:
Tobillo; Ligamentos articulares; Inestabilidad de la articulación; Ostetotomía

[1] Centro Artroscópico Jorge Batista SA, Buenos Aires, Argentina.
[2] Sanatorio Dupuytren, Buenos Aires, Argentina.
[3] Fundación Favaloro, Buenos Aires, Argentina.
[4] Orthopedic Department of Póvoa de Varzim – Vila do Conde Hospital Centre; Póvoa de Varzim, Portugal; Ripoll y De Prado Sports Clinic: Murcia-Madrid FIFA Medical Centre of Excellence, Murcia, Madrid, Spain; International Centre of Sports Traumatology of the Ave, Taipas, Portugal.
[5] Human Anatomy and Embriology Unit, University of Barcelona, Barcelona, Spain; Foot and Ankle Unit, Hospital Quirón Barcelona and, iMove Traumatology Tres Torres, Barcelona, Spain.

Corresponding author:
Jorge Pablo Batista, MD.
Centro Artroscópico Jorge Batista SA
Av. Pueyrredón 2446 CABA,
Buenos Aires, Argentina CP 1119
T.E: +54-9-11-4802-4718//5598
www.cajb.com.ar
E-mail: jbatista20@hotmail.com

Conflicts of interest:
no

Received on:
June 16, 2018

Accepted on:
Feb 20, 2019

ABSTRACT

Objective: Restore lateral ankle stability and correct the underlying inframalleolar varus deformity. **Methods:** The study was performed on 15 consecutive patients (15 ankles) with chronic lateral ankle instability and cavovarus deformity who underwent endoscopic lateral ankle ligament repair using an 4,5mm knotless anchor (Smith & Nephew Plc) and a Dwyer and sliding calcaneal osteotomy throught a lateral approach fixed with a calcaneus stape plate (Arthrex Inc., Naples, FL, USA) from 2013 to 2015.Patients provided informed consent and then they were invited to a final control follow-up office visit for a detailed evaluation performed for an independent observer using the visual analogue scale (VAS), the American Orthopedic Foot and Ankle Society (AOFAS) ankle questionnaire and the evaluation of pre and post X ray Saltzman's incidences in all patients before and after surgery and during follow-ups. **Results:** Between February 2013 and November 2015, a lateral sliding osteotomy with a lateral based wedge was performed in 11 patients with a mean age of 38.7±14.6 years (range 21.5-63.4 years). All patients had a history of severe lateral ankle instability associated with a severe inframalleolar cavovarus deformity. Significant pain relief was observed from 7.1±1.8 (range 5-10) to 1.4±1.2 (range 0-4) using the visual analogue scale. The American Orthopedic Foot and Ankle Society's score improved significantly from 36.9±12.9 (range 10-60) to 88.0±10.5 (range 70-95). **Conclusions:** Endoscopic ankle ligament repair associated with calcaneal sliding osteotomy and a lateral based wedge may be an effective surgical option for severe chronic ankle instability associated with calcaneous varus deformity. Correcting alignment, restoring stability and reducing pain allows patients to walk and run properly resulting in higher quality of life.

Level of Evidence: Level IV, series of retrospective cases.

RESUMEN

Objetivo: Restaurar la estabilidad lateral del tobillo y correjir la deformidad en varo inframaleolar subyacente. **Métodos:** El estudio se realizó en 15 pacientes consecutivos (15 tobillos) con inestabilidad lateral crónica del tobillo y deformidad cavo-varo, a los que se realizó una reparación endoscópica del ligamento lateral del tobillo, con un Arpón sin nudos de 4,5 mm (Smith & Nephew Plc), una osteotomía de Dwyer (deslizante de calcáneo)) a través de un abordaje lateral y fijado con una placa de calcáneo (Arthrex Inc., Naples, FL., USA) desde 2013 al 2015. Los pacientes dieron su consentimiento informado y luego fueron invitados a una visita de control de seguimiento final en consultorio, para una evaluación detallada realizada para un observador independiente que utiliza la escala analógica visual (VAS), el cuestionario de tobillo de la American Orthopedic Foot and Ankle Society (AOFAS) y la evaluación de las incidencias de Saltzman antes y después cirugía. **Resultados:** Entre febrero de 2013 y noviembre de 2015, se realizó una osteotomía lateral deslizante con una cuña de base lateral en 11 pacientes con una edad media de 38,7±14,6 años (rango 21,5-63,4 años). Todos los pacientes tenían antecedentes de severa inestabilidad lateral del tobillo asociada con una deformidad cavovara inframaleolar grave. Se observó un alivio significativo del dolor de 7.1±1.8 (rango 5-10) a 1.4±1.2 (rango 0-4) usando la escala analógica visual. El puntaje de la American Orthopedic Foot and Ankle Society mejoró significativamente de 36.9±12.9 (rango 10-60) a 88.0±10.5 (rango 70-95). **Conclusiones:** La reparación endoscópica del ligamento del tobillo asociada con la osteotomía deslizante del calcáneo y una cuña de base lateral puede ser una opción quirúrgica eficaz para la inestabilidad crónica grave del tobillo asociada con la deformidad en varo calcáneo. La corrección de la alineación, la restauración de la estabilidad y la reducción del dolor permiten que los pacientes caminen y corran adecuadamente, lo que resulta en una mejor calidad de vida.

Nível de Evidência: Nível IV, série retrospectiva de casos.

INTRODUCTION

Lesions of the lateral ligament complex of the ankle is one of the most frequent sports-related injuries. Generally, the lateral ligament injury progresses favorably with rehabiltation protocols and medical treatment, however, the chronic lateral instability develops as a sequel in almost 30% of these patients.[1-4]

During the last fifteen years a lot of techniques had been publicated for surgical repair or reconstruction of the lateral ligaments of the ankle in patients with complains of chronic lateral ankle instability.[5-18]

Is well known the good and excelent results of these techniques in patients with mild, moderate or severe ankle instability, but many patients present severe chronic ankle instability associated with post-traumatic and idiopathic cavovarus deformity on whom conservative and orthopedic treatment failed to show acceptable results.

The use of arthroscopy in ankle ligament repair was first described by Hawkins in 1987.[19] Open, endoscopic or percutaneous procedures has gained popularity in different parts of the world, however, direct repair or reconstruction of the ligaments was often not an option in combination with calcaneal osteotomies.[12,14,16,20-27]

Morscher in 1986 presented one of the few articles in which he suggest a combination of fibulotalar syndesmoplasty with osteotomy of the calcaneus according to Dwyer in cases of patients with chronic ankle instability after a supination trauma with a pathological calcaneus varus as opposed to physiological calcaneus valgus.[28]

Chronic lateral ankle instability has been suggested to be an etiologic factor in the development of ankle arthritis.[29,30] Long term ankle incongruency or instability presumably increases ankle contact stress that exceeds the capacity of the ankle joint to repair itself or adapt.[31] Excessive varus or valgus alignment of the calcaneus or distal tibia has been shown to alter contact characteristics and ligament strain at the level of the ankle joint and therefore has the potential to contribute to ankle artritis[32, 33] (Figure 1).

Different types of posterior calcaneal osteotomy are used for calcaneal realignment. Calcaneal osteotomy is an extra-articular procedure that is used in the correction of cavovarus and planovalgus foot deformity and it is usually performed through a lateral approach.

Complications are rare with this procedure, but wound dehiscence, delayed union, and soft tissue or peroneal tendon fibrosis along the osteotomy site can occur and have been presented.[34] Dwyer popularized calcaneal osteotomy for the correction of cavovarus foot alignment in the 1950s. The original description was that of a removal of a laterally-based wedge to produce a neutral or valgus position of the heel. The wedge is taken proximally to the posterior articular facet.[35-37]

Figure 1. Cavus varus feets

Patients with symptomatic foot and ankle malalignment can relief their simptoms with an calcaneus osteotomy due to this correction restore the hindfoot biomechanic.

Closing wedge osteotomies (Dwyer) or single plane translational osteotomies (Sliding osteotomies) are performed through open or endoscopic techniques associated with an anterior ankle arthroscopy procedure in the majority of the times to treat the intraarticular associated lesions but without repair or reconstruct the ligaments injuried[35,36,38-40] (Figure 2).

In this study we treat these patients in two steps:

1. Anterior ankle arthroscopy (To treat the associated pathologies and repair the ATFL with a knotless anchor 4,5mm) (Smith & Nephew Plc) (Figure 3).
2. Calcaneal osteotomy: Closing wedge (Dwyer) + Single plane translational osteotomy (Lateral sliding osteotomy) (Figure 4).

Our hypothesis was that this double procedure would restore adequate lateral ankle stability and correct the cavovarus deformities in cases with severe lateral ankle ligaments injuries and deformities, which are expected to have a poor outcome with direct ligament repair alone.

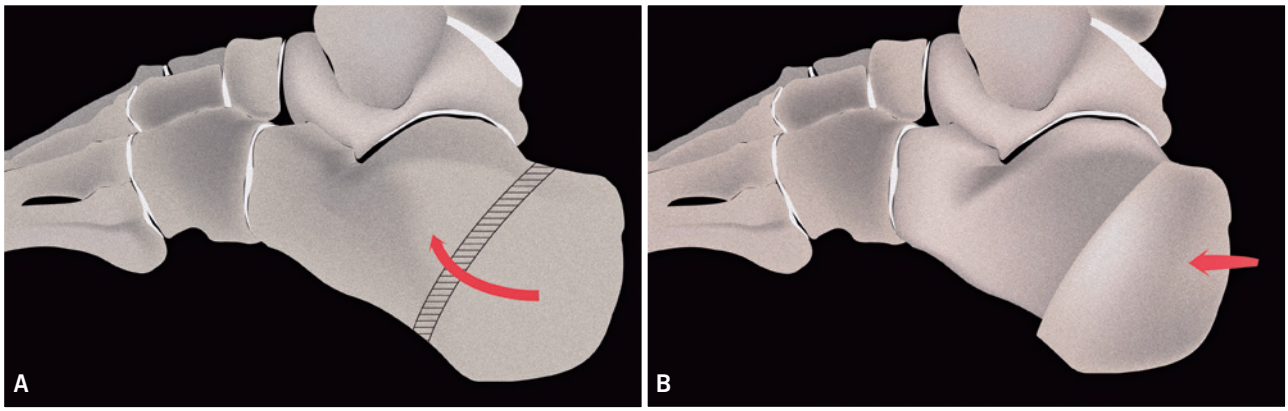


Figure 2. (A) Lateral closing wedge calcaneal osteotomy. (B) Lateral sliding calcaneal osteotomy

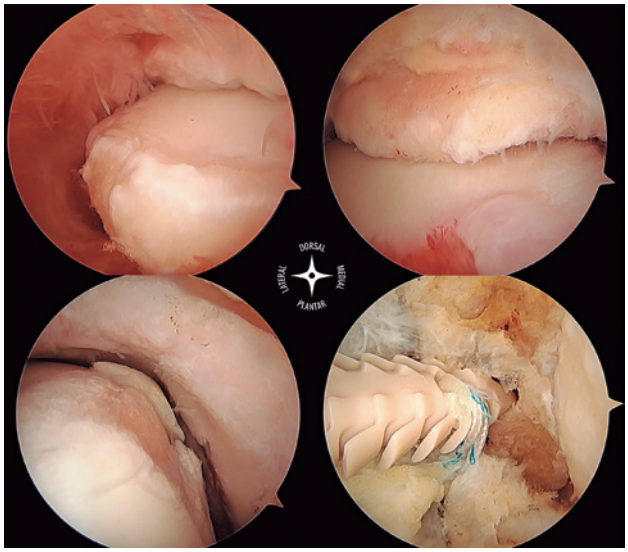


Figure 3. Arthroscopic images of associated pathology and ATFL repair

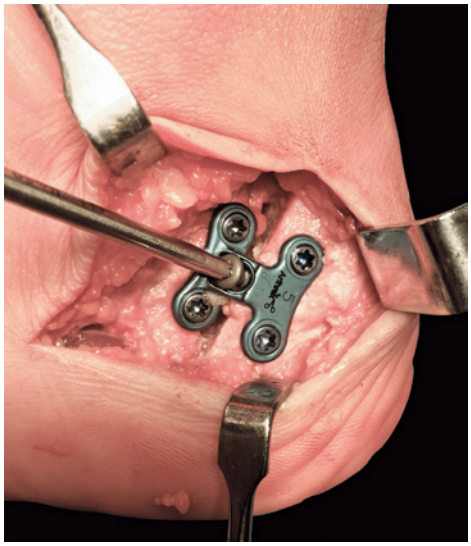


Figure 4. Combined calcaneal osteotomy

METHODS

This study was performed on 15 consecutive patients (15 ankles) with chronic lateral ankle instability and cavovarus deformity who underwent endoscopic lateral ankle ligament repair using an 4,5mm knotless anchor (Smith & Nephew Plc) and a Dwyer and sliding calcaneal osteotomy throught a lateral approach fixed with a calcaneus stape plate (Arthrex Inc., Naples, FL, USA) from 2013 to 2015. One patient had incorrect telephone number in our files and were not reachable; and three declined to visit our clinic because they live in a distant city and they came to our clinique to perform the surgery only.

We evaluated and presented the results of the operative procedures performed in the remaining 11 patients (11 ankles). There were 11 men, no women in the sample; median age at surgery was 38.7 years (range 21.5-63.4); median follow-up duration was 29 months (range, 14-42 months).

All the patients had a history of more than 3 sprains of their ankles during the last 2 years.

Clinical, and radiologic examinations were performed before surgery to objective the presence of mechanical instability and associated pathologies.

Clinical talar tilt test and anterior drawer test and overall limb alignment was assessed with attention to any concomitant knee or tibia deformity that may have contributed to the hindfoot mal-alignment.

Antero-posterior and lateral radiographs of the feet and ankles were taken to exclude malleolar or talar old fractures that can result from ankle sprains. Saltzman's view in 20º and 45º were performed to evaluate the alignment of the limbs of all the patients pre and post op.

Magnetic resonance imaging (MRI) examinations were performed on all patients too in order to evaluate associated intra-articular lesions[41,42] (Figure 5).

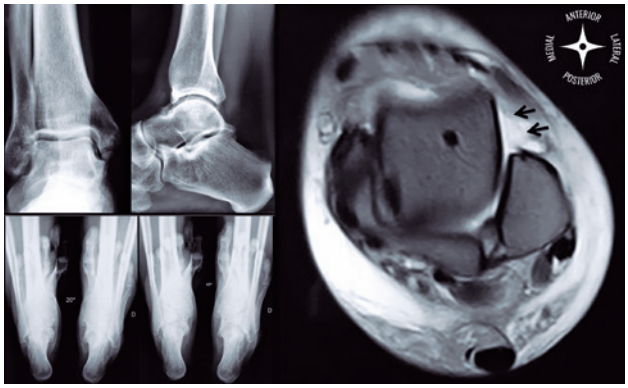


Figure 5. Estándar AP and Saltzman incidentes and MRI showing ATFL rupture

The indication for this combinated procedure were patients with severe chronic ankle instability associated with post-traumatic and idiopathic cavovarus deformity on patients on whom conservative and orthopedic treatment failed to show results.

The absolute contraindication was osteoarthritis of the subtalar joint, however there were relative contraindications too: irreducible hindfoot instability, deep or superficial infections, neurovascular impairment of the lower extremity, Charcot arthropathy, severe osteoporosis, elderly patients, diabetes mellitus and smokers.

Patients provided informed consent and then they were invited to a final control follow-up office visit for a detailed evaluation performed for an independent observer using the visual analogue scale (VAS), the American Orthopedic Foot and Ankle Society (AOFAS) ankle questionnaire and the evaluation of pre and post X ray Saltzman's incidences in all patients before and after surgery and during follow-ups.

SURGICAL TECHNIQUE

First step: anterior ankle arthroscopy

The patients were placed in supine position, both the hip and the knee were extended with the ankle on the tip of the table to allow flexo-extension movement during the surgery. Anterior ankle arthroscopy was performed using two classic anteromedial and anterolateral portals described by Prof. van Dijk et al.[43,44] (Figure 6).

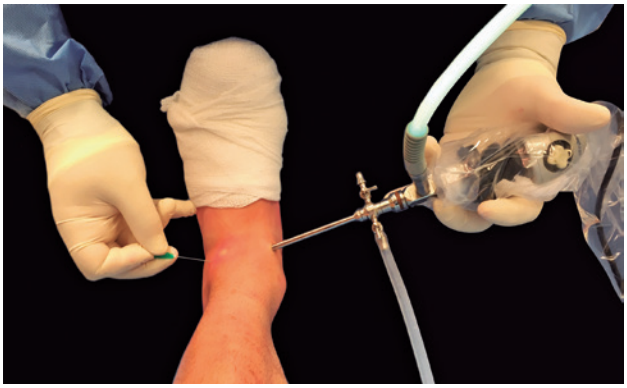


Figure 6. Anterior ankle artrhoscopy

Distraction of the ankle was not used during this arthroscopic procedure routinely. A 4-mm 30° arthroscope is introduced through anteromedial portal. The ankle is positioned in maximum dorsiflexion to relaxe the capsular joint and to obtain the optimal view of the lateral gutter.

In this position, anterolateral portal is made by transillumination taking care of the superficial peroneal nerve (Figure 7). We explored the anterior talocrural joint and treated the associated pathology (sinovial processes, osteochondral lesions, tibial spurs, osteophytes and talar beaks) (Figure 8).

Prior to reattach the ligament, it should be defined if the anterior talofibular ligament (ATFL) present a parcial or complete lesion and if the calcaneofibular ligament (CFL) is broken (Figure 9). The remanent of the anterior talofibular ligament (ATFL) should be repaire under direct arthroscopic visualization.

Figure 7. Anterolateral portal performed by transilumination

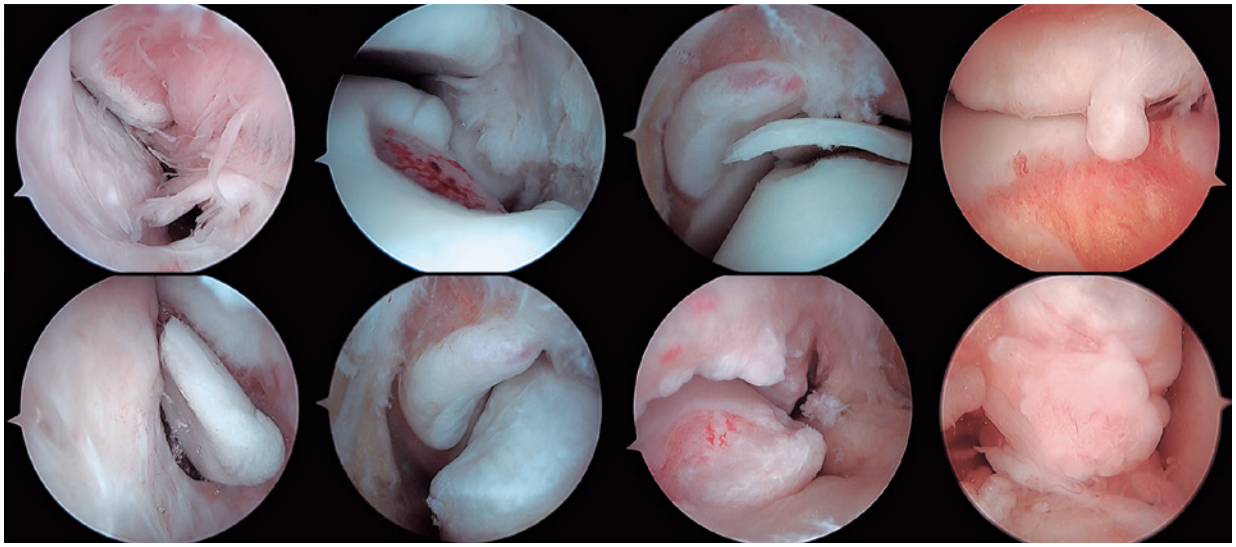


Figure 8. Intraarticular associated pathology in patients with CAI (Chronic ankle instability)

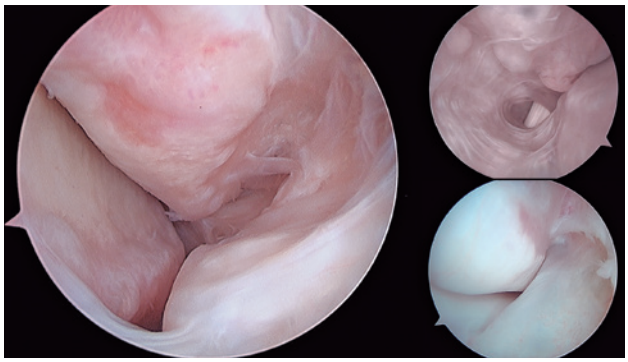


Figure 9. Arthroscopic images of the lateral gutter with different grades of ATFL ruptures

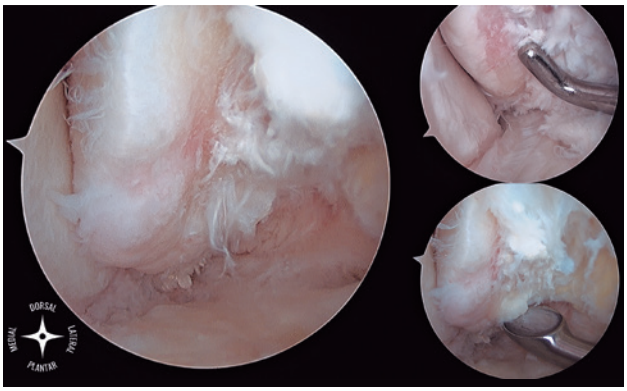


Figure 10. Curettage of the ATFL footprints

The footprint for the fibular attachment of the lateral collateral ligaments is debrided with a shaver or a curette introduced through the anterolateral portal (Figure 10).

Perform the hole on the footprint in the distal tip of the fibula through the iniciator of the anchor by drilling. The drill was directed from anterior to posterior, and parallel to the plantar plane as well as the plane of the lateral gutter (Figure 11). A suture passer Mini Scorpion (Arthrex Inc., Naples, FL, USA), a 2:0 or 0 nonabsorbable suture, and a 4,5mm knotless anchor (Foot Print Ultra 4.5mm, Smith & Nephew Plc) were used for ligament repair (Figure 12, 13).

The Mini Scorpion suture passer is introduced through the anterolateral portal, and under direct arthroscopic visualization, the remanent ATFL is

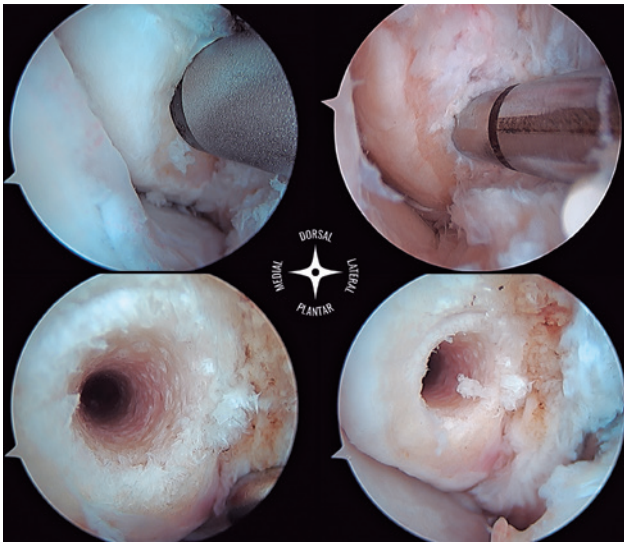


Figure 11. Fibula hole

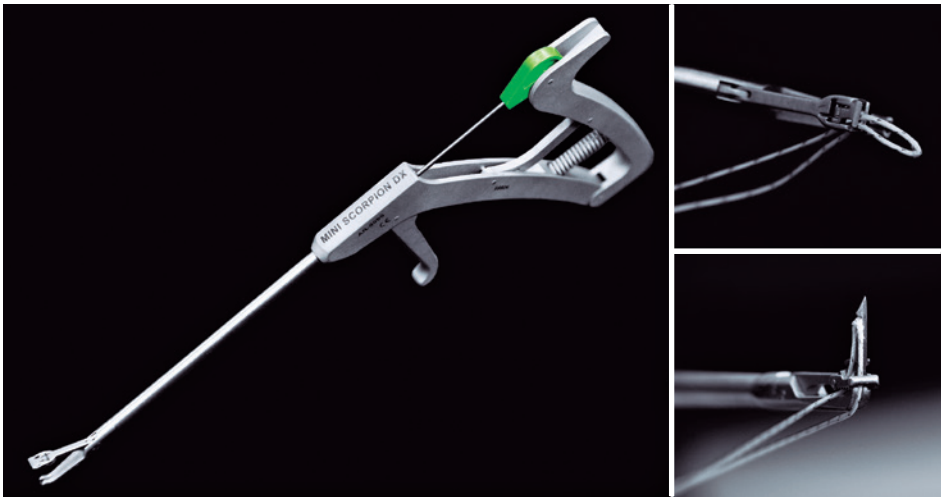


Figure 12. Mini Scorpion sutture pass (Arthrex)

Figure 13. Foot print Ultra 4,5mm knotless anchor (Smith and Nephew)

penetrated from lateral to medial with a double suture. The suture is pulled back with the Mini Scorpion gripper through the anterolateral portal (Figure 14). Pull back the suture to be sure if there is a firm and acceptable capture of the remanent tissue. The limbs of the suture are passed through the hole in the upper side of the knotless anchor (Figure 15). Be careful that the tension of the suture can be modified only before introducing the anchor. Once the anchor is introduced by impactation, the tension of suture can not be modified. Cut the remanent suture with an specific endoscopic scissor (Figure 16).

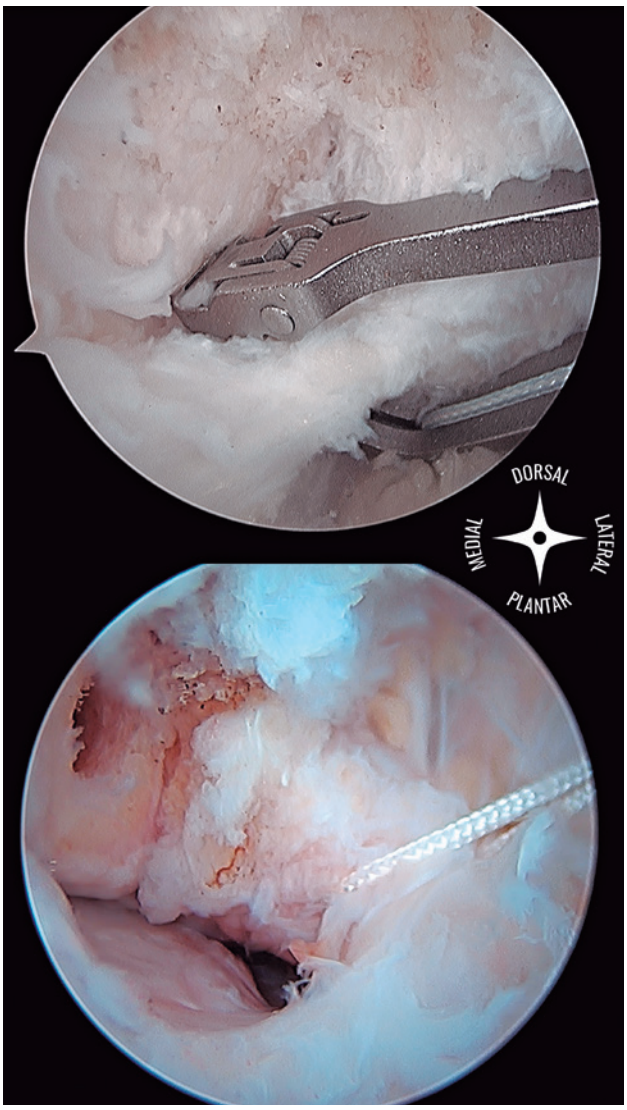
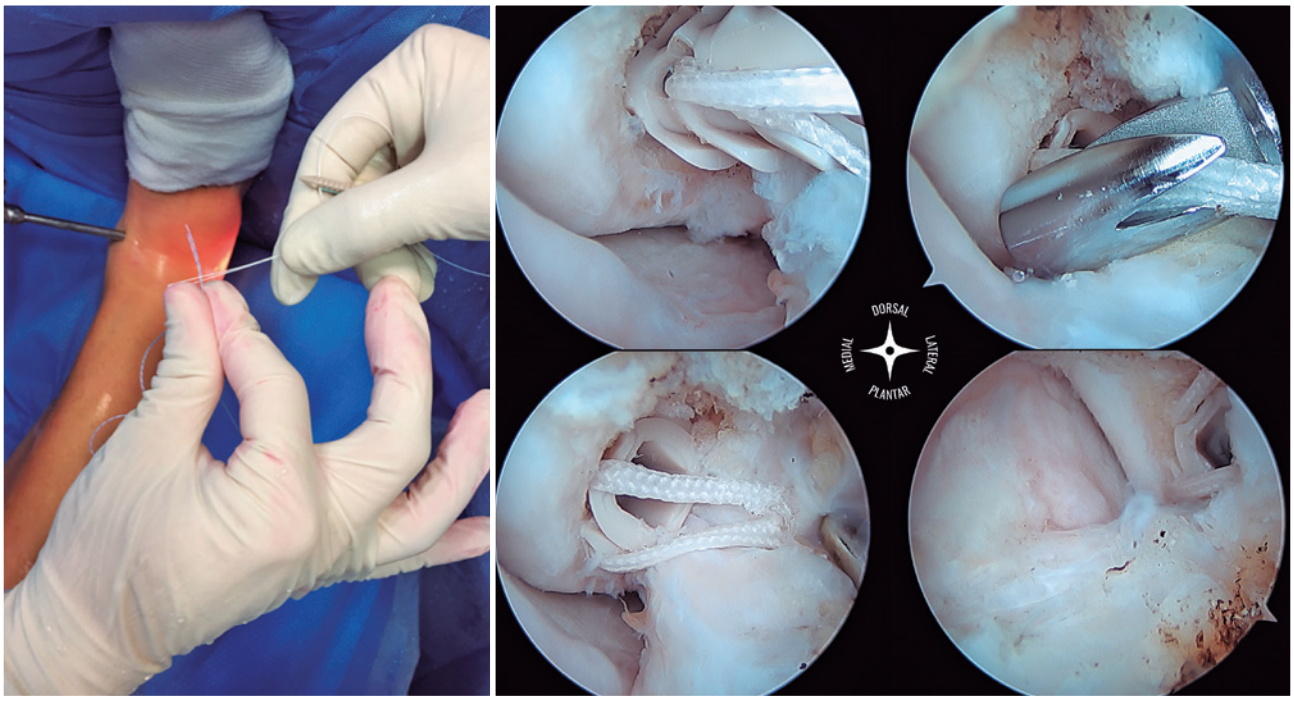


Figure 14. Catching the remmanent ATFL with the Mini Scorpion



Figures 15 y 16. Introducing the knottless anchor

Second step: calcaneal osteotomy

The patient may be repositioned in either the lateral position. The lateral calcaneous cortex was exposed through a lateral incision. An "L shaped" mini extensile lateral incision may be used to elevate a full thickness skin flap (Figure 17). This preserves the integrity of the lateral calcaneal artery reducing the risk of edge ischemia, infection, and wound breakdown.

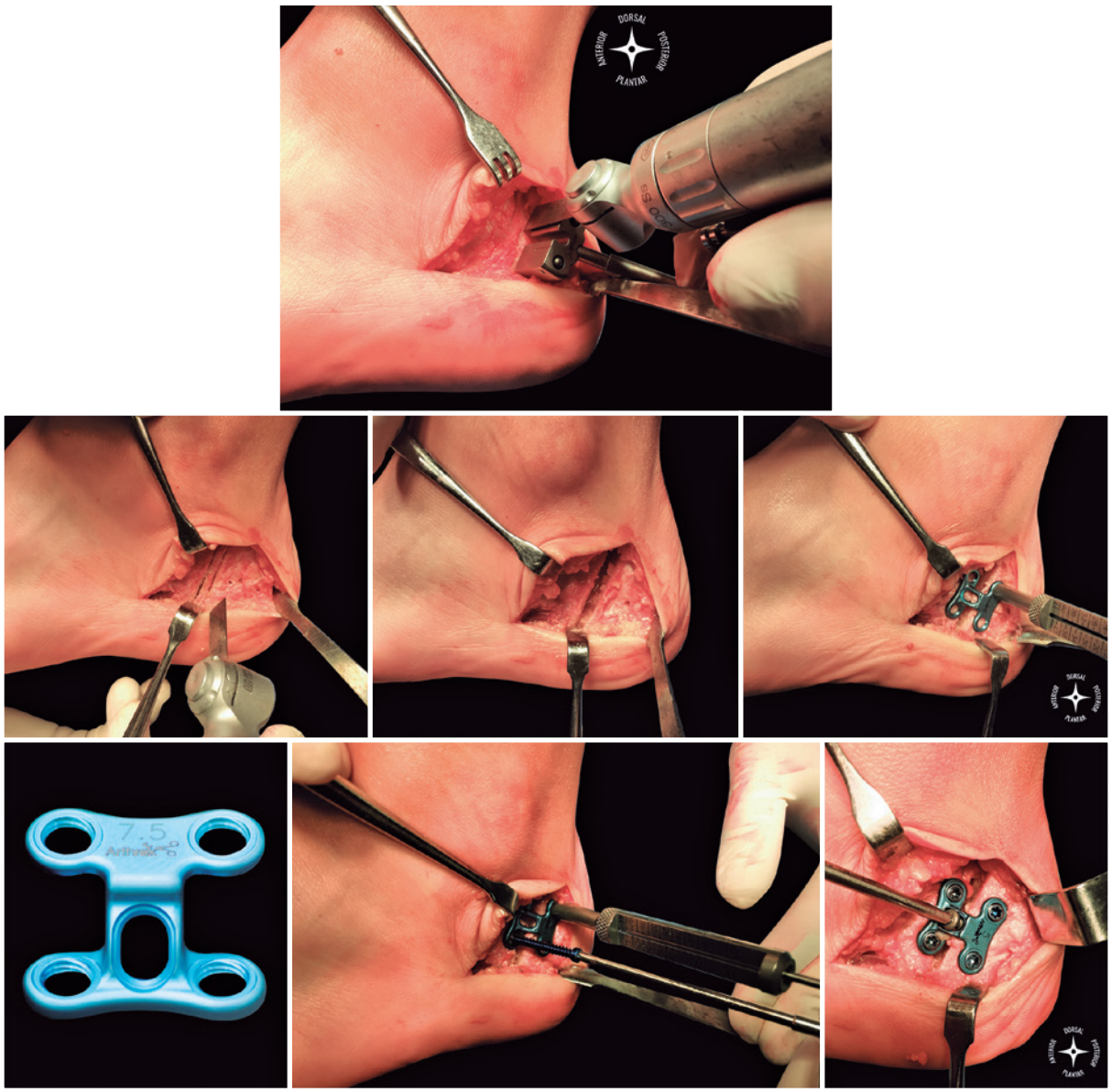
Figure 17. "L" incisión in the lateral side of the calcaneous

A single plane translational osteotomy was made initially with an oscillating saw and finished with a bone chisel (Figure 18). Be careful in order to avoid over-penetration of the saw blade toward medial neurovascular structures. The osteotomy is then gently distracted with a laminar spreader.

The objective of the translational osteotomies of the calcaneus is to realign the posterior part of the foot tripod through a simple transverse osteotomy at the body of the calcaneus. The tuberosity can then be translated laterally in order to correct the varus of the hindfoot. We suggest translate the calcaneal tuberosity while the ankle is in full plantarflexion to relax the Achilles tendon.

In this moment we add a lateral closing wedge osteotomy. An 6-10mm lateral-based wedge of bone is removed prior to the osseous stabilization. It displaces the weight-bearing portion of the heel laterally while redirecting the plantar surface into more valgus (Figure 19).

Authors like M Carmont consider that this technique is advantageous when there is overloading on the lateral edge of the heel.[37,45] The osteotomy was stabilized with a blocked staple plate followed by wound closure. (Arthrex Inc., Naples, FL, USA) (Figure 20).



Figures 18, 19 and 20. Different stops of combined calcaneal osteotomy fixed with Step Plate (Arthrex)

A compressive bandage and a walking boot keeping the ankle in 90 degrees is indicated in all patients and maintained for 6 weeks. Crutches are used for three weeks. No weight bearing was indicated for two weeks. Fourteen days after surgery the patients showed partial weight bearing, and after this time gradually full weight bearing was allowed.

Thromboprophylaxis was used in patients who were over 30 years old.

Balance training and proprioceptive exercises were encouraged. Before starting sports activities, when patients experienced ankle instability and a giving way sensation, they were advised to delay their sports activities and were encouraged to concentrate more on balance training and peroneal strengthening exercises.

RESULTS

After a mean follow-up of 29 months (range 14-42 months), a significant pain relief was observed from 7.1±1.8 (range 5-10) to 1.4±1.2 (range 0-4) using the visual analogue scale (VAS). The American Orthopedic Foot and Ankle Society's score (AOFAS) was checked

preoperatively and at final follow-up examination by an experienced surgeon. It's score improved significantly from 36.9±12.9 (range 10-60) to 88.0±10.5 (range 70-95).

Patients were asked to rate their overall satisfaction with their surgical results as "very satisfied", "satisfied", "fair", or "dissatisfied".

Eight patients (72,7 %) were very satisfied with the results, three patients (27,2 %) were satisfied and we didn't found patients that were fair or dissatisfied with this combinated procedure.

Three patients who gave a "satisfied" rating for the result did not return to their previous level of daily life or sports activity. However, none of them had an episode of ankle instability again

One of the patients with a "very satisfied" result presented a mild sprain that did not require medication or immobilization and allowed him to continuos with his physical activity.

Standard X ray and Saltzman incidences were performed in all the patients at the moment of the last evaluation. The angle between the axis of the lower leg and the heel was altered from 10.1 degrees±1.3 degrees SD varus to a normal value of 4.18 degrees±0.9 degrees SD valgus.

Two patients had pain in the portals until six months after the surgery and this symptomatology improved alter rehabilitation and masaje over the portals.

No skin complications or infection were documented in this work.

Results demonstrated significant improvement in the weight-bearing alignment of the involved foot, additional stability to the ankle, and improved rearfoot function.

DISCUSSION

The surgical treatment of symptomatic ankle instability can be approach through different techniques: anatomical repairs, non-anatomical procedures and anatomical reconstructions.[5-13,26,27] The Broström procedure is the classic repair of the lateral ligaments and in several ocassions is associated with the Gould procedure, which is an augmentation with a proximal advancement of the inferior extensor retinaculum.[8-10] These techniques (Anatomical repairs) are still considerated the gold standard for treatment of symptomatic chronic instability.[11-13,15,26,27] Although the modified Broström procedure is widely used for the surgical treatment of chronic lateral ankle instability, contraindications have now been suggested after further experience with this direct ligament repair, including failed previous reconstructive surgery, the presence of long-standing ankle instability, generalizad ligamentous laxity or increased size or weight. Lateral ankle ligament reconstruction using an allograft or autograft tendon is used for a lot of surgeons and it's recommended for patients with chronic lateral ankle instability with severely attenuated or deficient lateral ankle ligaments, which are expected to have a poor outcome with direct ligament repair alone.[46-48]

Recently, several authors have reported good results using an arthroscopy-assisted lateral ligament repair.[11,12,14,20,27,49,50] Most of them also attempted to reinforce the repair by using the inferior external retinaculum (IER) but found that this was both technically difficult and added significant surgery time to the procedure.[51,52] There is also concern that when using the IER, this is not strictly an anatomical repair since its calcaneal attachment is 10mm anterior to that of the calcaneofibular ligament (CFL) and this may thus restrict full plantar flexion of the ankle. The need to reinforce lateral ligament repair with the IER is therefore debatable.[52,53]

Complications related to the superficial peroneal nerve have been reported with arthroscopic and percutaneous techniques in the ankle.[54-58]

Neuritis of the superficial peroneal or sural nerve, and pain or discomfort due to a prominent anchor or suture knot are the most frequent complications reported.[11,12,14] Clinical research studies show good results of calcaneal osteotomies, most of which include the procedure associated with other techniques. Kraus described a modification of lateral closing wedge technique combined with lateral translation to minimize the amount of shortening from wedge resection and presented a very good result with this combinated technique.[45]

Barg et al. presented very good results with Dwyer osteotomies in 31patients. All of them had a substantial inframalleolar cavovarus deformity with preoperative moment arm of the calcaneus of -17.9±3.3mm, which improved significantly to 1.6±5.9mm and a significantly improved of The American Orthopaedic Foot and Ankle Society score and pain relief. [39]

The most important complications with calcaneal osteotomies include under correction, nonunion and local complications to the sural nerve and skin. Tarsal tunnel syndrome has been associated too with lateralizing

calcaneal osteotomy in patients with greater translation of the osteotomy and osteotomies performed more anteriorly on the tuberosity.[37,59] To types of approach can be used for osteotomies. An "L shaped" mini extensile lateral incision or an oblique incision. With oblique incisions in lateral surgical approaches to the calcaneus, nerve injuries has been well studied in the anatomy and trauma literature, and can result in transitory or permanent irritation along the course of the sural nerve at the heel with neuroma formation and distal dysesthesia.[60,61]

Overcorrection is an uncommon complication and has been reported only in one case for a planovalgus foot overcorrected into varus by medial slide osteotomy. Screw heads can cause pain if are placed in the posteroinferior tuberosity and are potential sources of hardware related pain.[62] The most important findings of the present study was that arthroscopic lateral ankle ligament repair asocciated with a combinated osteotomy (closing wedge + lateral sliding osteotomy) showed significant improvements AOFAS score, VAS, correct alignment of the hindfoot and achieved mechanical stability without significant complications.

CONCLUSION

Endoscopic ankle ligament repair associated with calcaneal sliding osteotomy and a lateral based wedge may be an effective surgical option in patients with severe chronic ankle instability associated with idiopatic or posttraumatic calcaneous varus deformity. Correcting alignment, restoring stability and reducing pain allows patients to walk and run properly resulting in higher quality of life.

REFERENCES

1. Bosien WR, Staples OS, Russell SW. Residual disability following acute ankle sprains. J Bone Joint Surg Am. 1955;37-A(6): 1237-43.
2. Freeman MA. Instability of the foot after injuries to the lateral ligament of the ankle. J Bone Joint Surg Br. 1965;47(4): 669-77.
3. Garrick JG. The frequency of injury, mechanism of injury, and epidemiology of ankle sprains. Am J Sports Med. 1977;5(6):241-2.
4. Ekstrand J, Tropp H. The incidence of ankle sprains in soccer. Foot Ankle. 1990;11(1):41-4.
5. Watson-Jones R. Recurrent forward dislocation of the ankle joint. J Bone Joint Surg. 1952;34B:519-22.
6. Evans DL. Recurrent instability of the ankle; a method of surgical treatment. Proc R Soc Med. 1953;46(5):343-4.
7. Snook GA, Chrisman OD, Wilson TC. Long-term results of the Chrisman-Snook operation for reconstruction of the lateral ligaments of the ankle. J Bone Joint Surg Am. 1985;67(1):1-7.
8. Broström L. Sprained ankles. V. Treatment and prognosis in recent ligament ruptures. Acta Chir Scand. 1966;132(5):537-50.
9. Broström L. Sprained ankles. VI Surgical treatment of "chronic" ligament ruptures. Acta Chir Scand. 1966 132(5):551-65.
10. Gould N, Seligson D, Gassman J. Early and late repair of lateral ligament of the ankle. Foot Ankle. 1980;1(2):84-9.
11. Corte-Real NM, Moreira RM. Arthroscopic repair of chronic lateral ankle instability. Foot Ankle Int. 2009;30(3):213-7.
12. Acevedo JI, Mangone PG. Arthroscopic lateral ligament reconstruction. Tech Foot Ankle Surg. 2011;10(3):111-6.
13. Clanton TO, Viens NA, Campbell KJ, Laprade RF, Wijdicks CA. Anterior talofibular ligament ruptures, part 2: biomechanical comparison of anterior talofibular ligament reconstruction using semitendinosus allografts with the intact ligament. Am J Sports Med. 2014;42(2):412-6.
14. Vega J, Golanó P, Pellegrino A, Rabat E, Peña F. All-inside arthroscopic lateral collateral ligament repair for ankle instability with a knotless suture anchor technique. Foot Ankle Int. 2013;34(12):1701-9.
15. Guillo S, Bauer T, Lee JW, Takao M, Kong SW, Stone JW, et al. Consensus in chronic ankle instability: aetiology, assessment, surgical indications and place for arthroscopy. Orthop Traumatol Surg Res. 2013;99(8 Suppl):S411-9.
16. Takao M, Glazebrook M, Stone J, Guillo S. Ankle arthroscopic reconstruction of lateral ligaments (Ankle Anti-ROLL). Arthrosc Tech. 2015;4(5):e595-600.
17. Matsui K, Burgesson B, Takao M, Stone J, Guillo S, Glazebrook M; ESSKA AFAS Ankle Instability Group. ESSKA AFAS Ankle Instability Group Minimally invasive surgical treatment for chronic ankle instability: a systematic review. Knee Surg Sports Traumatol Arthrosc. 2016;24(4):1040-8.
18. Michels F, Pereira H, Calder J, Matricali G, Glazebrook M, Guillo S, Karlsson J; ESSKA-AFAS Ankle Instability Group, Acevedo J, Batista J, Bauer T, Calder J, Carreira D, Choi W, Corte-Real N, Glazebrook M, Ghorbani A, Giza E, Guillo S, Hunt K, Karlsson J, Kong SW, Lee JW, Michels F, Molloy A, Mangone P, Matsui K, Nery C, Ozeki S, Pearce C, Pereira H, Perera A, Pijnenburg B, Raduan F, Stone J, Takao M, Tourné Y, Vega J. Searching for consensus in the approach to patients with chronic lateral ankle instability: ask the expert. Knee Surg Sports Traumatol Arthrosc. 2018;26(7):2095-102.
19. Hawkins RB. Arthroscopic stapling repair for chronic lateral instability. Clin Podiatr Med Surg. 1987;4(4):875-83.
20. Nery C, Raduan F, Del Buono A, Asaumi ID, Cohen M, Maffulli N. Arthroscopic-assisted Broström-Gould for chronic ankle instability: a long-term follow-up. Am J Sports Med. 2011; 39(11):2381-8.
21. Guillo S, Archbold P, Perera A, Bauer T, Sonnery-Cottet B. Arthroscopic anatomic reconstruction of the lateral ligaments of the ankle with gracilis autograft. Arthrosc Tech. 2014;3(5):e593-8.
22. Guillo S, Cordier G, Sonnery-Cottet B, Bauer T. Anatomical reconstruction of the anterior talofibular and calcaneofibular ligaments with an all-arthroscopic surgical technique. Orthop Traumatol Surg Res. 2014;100(8 Suppl):S413-7.
23. Takao M, Matsui K, Stone JW, Glazebrook MA, Kennedy JG, Guillo S, et al.; Ankle Instability Group. Arthroscopic anterior talofibular ligament repair for lateral instability of the ankle. Knee Surg Sports Traumatol Arthrosc. 2016;24(4):1003-6.
24. Michels F, Cordier G, Burssens A, Vereecke E, Guillo S. Endoscopic reconstruction of CFL and the ATFL with a gracilis graft: a cadaveric study. Knee Surg Sports Traumatol Arthrosc. 2016;24(4):1007-14.

25. Michels F, Cordier G, Guillo S, Stockmans F; ESKKA-AFAS Ankle Instability Group. Endoscopic ankle lateral ligament graft anatomic reconstruction. Foot Ankle Clin. 2016;21(3):665-80.
26. Batista JP, Del Vecchio JJ, Patthauer L, Ocampo M. Arthroscopic lateral ligament repair through two portals in chronic ankle instability. Open Orthop J. 2017;11:617-32.
27. Batista JP. Artroscopía de tobillo. Bases y fundamentos. Ciudad Autônoma de Buenos Aires: Librofutbol; 2017.
28. Morscher E, Hefti F, Baumann JU. [Combined lateral ligament-plasty and calcaneus osteotomy in recurrent foot dislocation]. Orthopade. 1986;15(6):461-5.German.
29. Harrington KD. Degenerative arthritis of the ankle secondary to long-standing lateral ligament instability. J Bone Joint Surg Am. 1979;61(3):354-61.
30. Rieck B, Reiser M, Bernett P. [Post-traumatic arthrosis of the upper ankle joint in chronic insufficiency of the fibular ligament]. Orthopade. 1986;15(6):466-71. German.
31. Buckwalter JA, Saltzman CL. Ankle osteoarthritis: distinctive characteristics. Instr Course Lect. 1999; 48:233-41.
32. Steffensmeier SJ, Saltzman CL, Berbaum KS, Brown TD. Effects of medial and lateral displacement calcaneal osteotomies on tibiotalar joint contact stresses. J Orthop Res. 1996;14(6):980-5.
33. Resnick RB, Jahss MH, Choueka J, Kummer F, Hersch JC, Okereke E. Deltoid ligament forces after tibialis posterior tendon rupture: effects of triple arthrodesis and calcaneal displacement osteotomies. Foot Ankle Int. 1995;16(1):14-20.
34. Mendicino RW, Catanzariti AR, Reeves CL. Posterior calcaneal displacement osteotomy: a new percutaneous technique. J Foot Ankle Surg. 2004;43(5):332-5.
35. Dwyer FC. Osteotomy of the calcaneum for pes cavus. J Bone Joint Surg Br. 1959;41(1):80-6.
36. Dwyer FC. The present status of the problem of pes cavus. Clin Orthop Relat Res. 1975;106:254-75.
37. Tennant JN, Carmont M, Phisitkul P. Calcaneus osteotomy. Curr Rev Musculoskelet Med. 2014;7(4):271-6.
38. Hintermann B, Knupp M, Barg A. [Osteotomies of the distal tibia and hindfoot for ankle realignment]. Orthopade. 2008;37(3):212-8. German.
39. Barg A. Hörterer H, Jacxsens M, Wiewiorski M, Paul J, Valderrabano V [Dwyer osteotomy: Lateral sliding osteotomy of calcaneus]. Oper Orthop Traumatol. 2015;27(4):283-97. German.
40. Lui TH. Percutaneous posterior calcaneal osteotomy. J Foot Ankle Surg. 2015;54(6):1188-92.
41. Saltzman CL, el-Khoury GY. The hindfoot alignment view. Foot Ankle Int. 1995;16(9):572-6.
42. Reilingh ML, Beimers L, Tuijthof GJ, Stufkens SA, Maas M, van Dijk CN. Measuring hindfoot alignment radiographically: the long axial view is more reliable than the hindfoot alignment view. Skeletal Radiol. 2010;39(11):1103-8.
43. van Dijk CN, Scholte D. Arthroscopy of the ankle joint. Arthroscopy. 1997 Feb;13(1):90-6.
44. van Dijk CN, van Bergen CJ. Advancements in ankle arthroscopy. J Am Acad Orthop Surg. 2008;16(11):635-46.
45. Kraus JC, Fischer MT, McCormick JJ, Klein SE, Johnson JE. Geometry of the lateral sliding, closing wedge calcaneal osteotomy: review of the two methods and technical tip to minimize shortening. Foot Ankle Int. 2014;35(3):238-42.
46. Coughlin MJ, Schenck RC Jr, Grebing BR Jr, Treme G Jr. Comprehensive reconstruction of the lateral ankle for chronic instability using a free gracilis graft. Foot Ankle Int. 2004;25(4):231-41.
47. Ahn JH, Choy WS, Kim HY. Reconstruction of the lateral ankle ligament with a long extensor tendon graft of the fourth toe. Am J Sports Med. 2011;39(3):637-44.
48. Jung HG, Kim TH, Park JY, Bae EJ. Anatomic reconstruction of the anterior talofibular and calcaneofibular ligaments using a semitendinosus tendon allograft and interference screws. Knee Surg Sports Traumatol Arthrosc. 2012;20(8):1432-7.
49. Kim ES, Lee KT, Park JS, Lee YK. Arthroscopic anterior talofibular ligament repair for chronic ankle instability with a suture anchor technique. Orthopedics. 2011;34(4):1-5.
50. Matsui K, Takao M, Miyamoto W, Innami K, Matsushita T. Arthroscopic Broström repair with Gould augmentation via an accessory anterolateral port for lateral instability of the ankle. Arch Orthop Trauma Surg. 2014;134(10):1461-7.
51. Aydogan U, Glisson RR, Nunley JA. Extensor retinaculum augmentation reinforces anterior talofibular ligament repair. Clin Orthop Relat Res. 2006;442(442):210-5.
52. Dalmau-Pastor M, Yasui Y, Calder JD, Karlsson J, Kerkhoffs GM, Kennedy JG. Anatomy of the inferior extensor retinaculum and its role in lateral ankle ligament reconstruction: a pictorial essay. Knee Surg Sports Traumatol Arthrosc. 2016;24(4):957-62.
53. Behrens SB, Drakos M, Lee BJ, Paller D, Hoffman E, Koruprolu S, et al. Biomechanical analysis of Brostrom versus Brostrom-Gould lateral ankle instability repairs. Foot Ankle Int. 2013;34(4): 587-92.
54. Barber FA, Click J, Britt BT. Complications of ankle arthroscopy. Foot Ankle. 1990;10(5):263-6.
55. Ferkel RD, Heath DD, Guhl JF. Neurological complications of ankle arthroscopy. Arthroscopy. 1996;12(2):200-8.
56. Ferkel RD, Small HN, Gittins JE. Complications in foot and ankle arthroscopy. Clin Orthop Relat Res. 2001;391:89-104.
57. de Leeuw PA, Golanó P, Sierevelt IN, van Dijk CN. The course of the superficial peroneal nerve in relation to the ankle position: anatomical study with ankle arthroscopic implications. Knee Surg Sports Traumatol Arthrosc. 2010;18(5):612-7.
58. Zengerink M, van Dijk CN. Complications in ankle arthroscopy. Knee Surg Sports Traumatol Arthrosc. 2012;20(8):1420-31.
59. Den Hartog BD, DiGiovanni CW, VanValkenburg SM, et al. Nerve Injury associated with lateral calcaneal osteotomy, in American orthopaedic foot and ankle specialty day. American Academy of Orthopaedic Surgeons Annual Meeting. New Orleans, LA; 2014.
60. Eastwood DM, Irgau I, Atkins RM. The distal course of the sural nerve and its significance for incisions around the lateral hindfoot. Foot Ankle. 1992;13(4):199-202.
61. Haugsdal J, Dawson J, Phisitkul P. Nerve injury and pain after operative repair of calcaneal fractures: a literature review. Iowa Orthop J. 2013;33:202-7.
62. Maskill MP, Maskill JD, Pomeroy GC. Surgical management and treatment algorithm for the subtle cavovarus foot. Foot Ankle Int. 2010;31(12):1057-63.