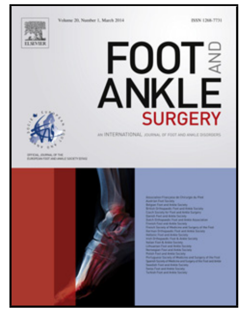

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Prospective Study of the "Inside-Out" Arthroscopic Ankle Ligament Technique: Preliminary Result

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ABSTRACT

Background: Lateral ankle ligament injury is among the most common orthopedic injuries. The objective of this study is to present the preliminary prospective results of treatment using the *"Inside-Out"* variant of the fully arthroscopic Broström-Gould technique.

Methods: Twenty six patients were included: 20 male and 6 female, aged 19-60 years, mean 41 years. All patients had positive "anterior drawer" and "talar tilt" tests. When necessary, cartilage injuries were treated with microfracture and arthroscopic resection for anterior impingement; three patients had hindfoot varus, on whom Dwyer osteotomy was performed; one patient had peroneal tendinopathy and was treated with tendoscopic debridement and another one had partial injury of the deltoid ligament, which was treated by direct repair.

Two arthroscopic surgery portals were used; the anteromedial and anterolateral. After careful inspection of the joint, the anterior surface of the fibula was cleaned to resect the remains of the anterior talo-fibular ligament. An anchor with two sutures was placed on the anterior aspect of the fibula, 1 cm from the distal apex of the malleolus. The sutures were passed through the remnant of the anterior talo-fibular ligament as well as the extensor retinaculum using special curved needles. Duncan knots were used to tie the ligament and the inferior extensor retinaculum while the ankle was kept in a neutral position. Patients were kept immobilized non-weight bearing for 2 weeks and were then allowed to start weight bearing in a removable protective boot for 4 weeks. The patients were able to return to sporting activities 6 months after surgery.

Results: After a mean follow-up of 27 months (range 21- 36 months), patients were functionally evaluated using the American Orthopedics Foot and Ankle Society (AOFAS) ankle score. The mean preoperative value was 58 points, while the mean postoperative value increased to 90 points. One patient had paresthesia in the superficial fibular nerve area, which resolved spontaneously.

Conclusion: Despite the limited cohort and the relatively short follow-up period, the use of the "inside-out" arthroscopic technique may be considered as a valid option for the treatment of chronic ankle instability.

Level of Evidence: IV, Cases Series

Keywords: Broström-Gould; Arthroscopy; Inside-Out; Ankle Instability; Clinical Outcomes

INTRODUCTION

Ankle sprain is a common injury in sports, accounting for approximately 85% of injuries to this joint specially in athletes[12-14.] A major number of theses sprains occur with inversion and plantar flexion of the foot. The ATFL is injured in approximately 80% of cases, the CFL in 50-75% and the PTFL in at least 10% of these events[12,17,22.]

Non-surgical treatment of ankle sprains leads to excellent results in most cases and is the suggested initial approach in the acute phase. Functional treatment is superior to purely immobilizing classical treatment using proprioceptive training, with an emphasis on the everter muscles. The success rate of this treatment option is approximately 80%. and If this approach fails, patients could manifests with chronic instability symptoms such as pain, recurrent sprains and discomfort when walking on uneven ground. When conservative treatment fails, surgery may be indicated.[4,20]

The original technique of Broström, modified by Gould, is established as the gold standard in the literature for surgical treatment. Encouraged by the excellence results obtained through minimally invasive surgical techniques in various areas of orthopedics, especially when using arthroscopy, foot and ankle surgeons started to look for new alternatives to reduce morbidity, improve function and maintain the quality of the techniques already approved by the literature and common sense.[16] Recently, authors have reported results were very encouraging with the arthroscopy Bröstrom-Gould technique in two strands: the arthroscopically assisted procedure and the full arthroscopic technique.[2,3,15,24]

The aim of this study is to present the preliminary clinical outcome in patients with chronic ankle instability who underwent surgical treatment with the arthroscopic Broström-Gould procedure using the "Inside-Out" full arthoscopic technique.

MATERIALS AND METHODS

We prospectively evaluated 26 patients, between November 2011 and October 2014, submited to a arthoscopic broström-Gould procedure using the "Inside-Out"technique to treat chronic ankle instability. The mean age was 42 years, with a range of 19 to 60 years. Twelve patients were athletes at amateur level. Preoperatively all patients had pain and showed signs of ankle instability.

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. Radiographs under manual stress, with the ankle in a neutral position, were performed and compared with the healthy side. These tests were also conducted during the post-operative follow-up. We considered a positive test when anterior displacement was 10 mm and the talar tilt was 10 degrees above the healthy side.[8] Magnetic resonance imaging (MRI) examinations were performed on all patients to investigate associated intra-articular lesions.

All patients underwent non-operative treatment for at least 6 months. We used the following inclusion criteria: positive anterior drawer test, pain, giving away and recurrent instability of the ankle secondary to an injury to the lateral ligament complex after the aforementioned period of physical therapy and bracing. The exclusion criteria were: neuromuscular disorders, obesity (BMI>30), previous ligamentous reconstruction failure, patient with generalized joint laxity whose diagnosis of collagen disorder had been previously made, isolated subtalar instability and high-performance athletes.

Additional surgery was required in 50% of patients during the same operation. Eight patients had osteochondral lesions that were treated using microfracture; 6 underwent arthroscopic resection of anterior soft tissue impingement; 3 patients had hindfoot varus that was corrected with Dwyer calcaneal osteotomy; one patient had peroneal tendinopathy and was treated with tenoscopy debridement. The other patient presented a partial lesion of the deep portion of the deltoid ligament that was treated by direct repair (table 1). The senior author performed all surgical procedures.

An independent observer used the American Orthopaedic Foot and Ankle Society (AOFAS) ankle questionnaire to evaluate all patients before and after surgery and during follow-ups. All patients signed the informed consent form. The Ethics and Research Committee of our institution approved this study.

STATISTICAL ANALYSIS

Variables were analyzed using the relevant descriptive measures: means, standard deviations (SDs), medians, and minimum and maximum values for the quantitative variables and absolute (n) and relative (%) frequencies for categorical variables. The paired t-test was used to evaluate the variations in AOFAS questionnaire scores between pre and post-operative evaluations. The mean age of the study groups was compared using the Student t-test, and gender distribution was analyzed using Fisher's exact test. Analysis of variance (ANOVA) with repeated measures, with Group fixed factor (with and without OCL) and pre- and post-operative repetitions (Time), was used to analyze the AOFAS ques-

tionnaire scores over the course of the study. Fisher's exact test was used to compare groups regarding the occurrence of failures as evaluated using the post-operative AOFAS questionnaire.
In all statistical tests, a significance level of 0.05 (α = 5%) was adopted. All statistical analyses were performed using SPSS software version 18.0.

SURGICAL TECHNIQUE

The same surgical protocol was used for all patients. No traction device was used. After exsanguination, a tourniquet was inflated to 300 mmHg. An arthroscopic camera with an optic of 2.7 mm/30 degrees was used, and the surgery was performed through two portals: the anteromedial and the anterolateral. With the arthroscope in the anteromedial portal, the superficial fibular nerve was identified under transillumination, and the anterolateral portal was located with an 18-gauge needle lateral to the extensor digitorum longus tendon. [10,11]
The joint was first carefully inspected in order to identify associated injuries, If such injuries were found, they were subjected to simultaneous surgical treatment. After the initial management of intra-articular injuries, the ankle lateral groove was debrided, and the lower portion of the anterior tibiofibular ligament was partially resected for adequate visualization of the anterior distal portion of the fibula. After debridement, the anterior region of the lateral malleolus was roughened to achieve proper integration of the tissue positioned there.
One 5.0 metal corkscrew anchor with two #2 FiberWire sutures (Arthrex, Naples, USA) was introduced into the anterior aspect of the fibula through the anterolateral portal, 1 cm from the apex of the lateral malleolus just in the center of the ATFL and CFL common foot print. With the arthroscope placed at the anteromedial portal, we introduced a curved suture-passer with a litinol lace inside through the lateral portal (SutureLasso, Arthrex, Naples, USA) (figure 1). Under direct vision, the sharp end of the suture-passer is positioned 1.5-2.0 cm anterior and distal to the tip of the fibula and is forced through the articular capsule, fibrous tissue containing ligament remains, superior border of the inferior extensor retinaculum (IER) and the skin. The litinol loop is then left in place while the suture-passer is removed. The first end of the sutures attached to the fibular anchor is then introduced in the litinol lace and the suture is then driven from inside to outside the joint (figure 2). One by one are passed using the same manouver taking care to keep at least 5 mm between each suture and to avoid the anatomical structures in the region (figure 3). In a recent paper, a “safe zone” was defined to reduce the risks on passing these sutures during this procedure.[3]
Two small incisions (approximately 5 mm) were made between the exit points of two of the four sutures. With the aid of a small probe the two extremities of the same suture are paired so that the knots can be done (figure 4). With the ankle in a neutral position and slightly everted, two Duncan arthroscopic knots were made[25]. A knot pusher was used to provide more tension to the knots and to push

the soft tissue against the anterior face of the fibula (figure 5). At the end of the procedure an arthroscopic overview can assure the effectiveness of the sutures and the stability of the joint through the anterior drawer test.

POSTOPERATIVE REHABILITATION

We found no need to amend our open Broström-Gould rehabilitation to suit our Inside-Out Arthroscopic postoperative protocol. After surgery, patients were kept in a non-weight-bearing cast, for two weeks. Load progression was started at the end of the second week, protected by a walking boot for another four weeks. If either an osteochondral lesion was treated or calcaneus osteotomy performed, weight-bearing was first allowed after 6 weeks.[19,24]

Rehabilitation was initiated four weeks after surgery, advancing from gentle active-assisted range of motion of the ankle and peroneal strengthening exercises. Proprioceptive training, active ankle extension and eversion resistance exercises were encouraged after week 4, or after week 6 if either microfracture or osteotomy were included. Walking, jogging and straight running were commenced by week 8 approximately. Intermittent use of ankle brace was maintained for daily activities up to 3 months after surgery, especially on uneven ground. Cutting and sport-specific skills were implemented by week 12 after which running, swimming and cycling were gradually permitted. High-level sports were allowed at months 4 to 6 months. Since our cohort was mostly compounded by non-professional athletes, faster rehabilitation program relied basically on patient's aptitude.

RESULTS

In the present study, 26 patients were evaluated with a mean follow-up of 27 months (range, 21-36 months). Prior to the procedure, patients had an average AOFAS score of 58 (42 to 70). Afterwards, the mean value was 90 (77 to 100). The questionnaire criteria that showed the most improvement were pain and function. All patients reporting moderate and daily pain became asymptomatic after surgery. The average improvement in overall score was 58%.

The ankles of all patients were judged to be stable. Stress radiographs in the final evaluation showed no mechanical laxity. There were no wound complications during the follow-up. One patient had hyperesthesia in the anterolateral ankle region, which spontaneously improved during follow-up with no treatment.

There were no significant differences between the groups with and without OCL regarding patient characteristics: mean age ($p = 0.7115$) and distribution by gender ($p = 0.6279$). No significant effect was found on the AOFAS Ankle scores for the interaction between time and group ($p = 0.5399$), indicating that the 2 groups had similar behaviors between evaluations. The Time factor showed a significant effect, with a significant variation between pre and post-operative evaluations ($p < 0.0001$). The Group factor showed no significant effect ($p = 0.6928$).

A significant variation was found between the pre- and post-operative evaluations ($p < 0.0001$). The AOFAS scores of all patients increased, varying between 19 and 53 points and with a mean of 32.2 (SD = 10.6) points. In percentage terms, the increase in score ranged from 28.6% to 126.2% and averaged 57.9% (SD = 25.5%).

Failure, displayed by regular-poor AOFAS Ankle Score, was observed in 4 of the 26 patients (15.4%). Regardless of these 4 patient, we still attain a excellent mean value in the AOFAS Ankle Score after a fair 27 months of follow-up, which is comparable to other studies.[20, 21, 27]

There was no statistically significant difference between the groups with and without OCL regarding failures (AOFAS Score <70), as evaluated by the post-operative questionnaire ($p = 1.0000$). To date, we had no revision surgery due to another ankle ligament injury.

DISCUSSION

Over fifty procedures to treat ankle instability have been described. The open modified Brostrom-Gould anatomic repair has been widely accepted as the standard technique, but since the first report in 1987, arthroscopic ankle stabilization has been emerging as a viable alternative to open techniques.[16,21]

Advances in arthroscopic technique have facilitated the diagnosis and treatment of lesions that would not previously have been possible to treat.[10,11] In 2005, Okuda et al.[26] verified that osteochondral talar lesions do not interfere with clinical and radiographic results of ankle ligament reconstruction, even without undergoing any specific treatment; however, other authors have shown that osteochondral lesions are associated with worse outcomes, confirming the importance of making a correct diagnosis of these conditions.[18]

Corte-Real et al.[5] addressed intra-articular lesions associated with ligamentous instability in 23/28 patients (14 anterolateral impingements and 8 osteochondral talar lesions), guided by the "Broström-Gould arthroscopically assisted" technique. Nery et al.[24] treated 10 chondral talar lesions (9 postero-medial, 1 lateral) in 38 patients with chronic instability, using the same technique. In the same study, the authors obtained good/excellent AOFAS scores for 36 patients after 9,8 years on average. The same reasons to favour arthroscopic procedures encourage the use of the Inside-Out Technique as an alternative procedure for lateral ankle instability.

In a previous description of an arthroscopic ankle ligament reconstruction technique, Acevedo reported successful results for both the "Outside-In" and "Inside-Out" approaches.[2] After 10.9 months of follow-up, all 23 patients reported overall improvement of instability symptoms. No surgical revision was required up to the time that publication. The anterior drawer test was negative in all patients. The present study corroborates this promising results. Although, the technique used in our study is essentially a capsular-ligament plication, incorporating the ATFL and anterolateral capsule, with IER strengthening as described before.[1,2,5] This technique does not include CFL repair, however. Some authors have demonstrated that CFL repair was not necessary.[23] As the IER runs from the medial malleolus into the calcaneus, its fibers provide additional stability to the ankle and subtalar because these fibers run parallel to the CFL. The author suggests that suturing the IER to the periosteum of the fibula one can replace the CFL force vector.

In 2013, Cottom et al.[8] showed the results of the "All Inside" arthroscopic technique in 40 patients with a mean 12-month follow-up. The mean AOFAS and visual pain scale scores improved significantly after the operation. As in the present study, only one patient had developed transient neural damage of the intermediate dorsal cutaneous nerve. Clinical evaluation showed excellent laxity restoration and a negative anterior drawer test.

Using arthroscopic technique to repair the lateral ankle ligamentous might jeopardize some structures in the anterolateral aspect of the ankle. Corte Real et al[5]. showed low incidence of complains related to the intermediate branch of the superficial fibular nerve, with only one persistent injury in 28 patients. Acevedo [1] published recently 5 cases in 73 patients, two resolving spontaneously, one resolved after removal of sutures and the rest two had only mild neuritic symptoms. The present series had only one case that resolved spontaneously. An anatomic study by Drakos et al[9]. designing a “safe zone” before starting the procedure can minimize inadvertent entrapment of these nerves as structures at risk. This zone is located between the peroneal tendons, the distal fibula, and the intermediate branch of the superficial fibular nerve.[15]

There was a significant improvement in AOFAS scores in the patients included in the present study, with an average increase of 32 points after the procedure and a final value of 91 points, with 85% good or excellent results. The evaluation of patients with osteochondral talar lesions (OCD) treated with microfracture showed no significant difference in terms of the AOFAS score compared with patients with no cartilage lesions. In a series of 55 patients, all with chronic ankle instability, intra-articular lesions were noted during arthroscopy in 93% of these ankles; however, this finding was not related to inferior outcome[21]. In this context, we could possibly refute the idea that having a variety of pathologies in our case series makes it difficult to appreciate how important is the Inside-Out Technique in the treatment process. Osteochondral lesions treatment yielded no better outcomes than stabilization alone in our study. [9,23] In contrast to the results of the present study, a series of 87 ankles showed that chondral lesions, even if treated using microfracture, were associated with worse clinical outcomes and lower AOFAS score after ligament repair.[18] This data also reinforce the importance of ankle stabiliation in the scope of arthroscopic ankle treatment, since OCDs treated in isolation could likely provide even worse outcomes.

The literature has recently been presenting biomechanical studies that compare traditional open and arthroscopic procedures for ankle ligament reconstruction. Giza et al. in [14] evaluated ankles found no differences between the techniques in terms of strength and rigidity15.Very similar results were achieved in Lee et al.'s study of 11 pairs of cadaver extremities using the "All-Inside" and open techniques.[23] Drakos et al. studied 10 cadavers in a similar comparative analysis.[9] There were no significant differences in anterior translation and talar tilt between the open and arthroscopic techniques. These findings suggest that the quality of repair and the restoration of joint biomechanics support the use of the arthroscopic technique for lateral ankle stabilization. Most recent, a RCT[27] compared All-Inside Arthroscopic and Open Modified Broström procedure. Conclusions drawn were that there was no difference between groups in the clinical (AOFAS, VAS and Karlsson scores) or radiologic (TT and AD) outcomes after 1 year of follow-up. Other than that, Arthroscopic ankle instability treatment is justified especially when the intra-articular lesions can be successfully treated by the same method. This conclusion is based not only on the diagnosis and treatment of these lesions, which possibly affect results and patient satisfaction, but also the equivalent joint stabilization achieved using the arthroscopic "*Inside-Out*" technique.

Incited by good results of many case series, new variants of the “All-Inside” arthroscopic technique with different types of augmentation have been published short time ago. Cottom et al brought out a study with additional proximal suture anchor augmentation which has shown to safely afford an earlier weightbearing program after surgery, with no adverse effects in terms of pain, functional and clinical outcomes.[6] Same authors conducted a cadaveric study in which they demonstrated superiority of additional proximal suture anchor augmentation over other two techniques (single-row of 2-suture anchor and double-row of 4-suture anchor) in terms of load to failure.[7] Similar results were found with an internal brace augmentation for “All-Inside” techniques in a comparative study. Patients who received an internal brace augmentation had a successful and accelerated rehabilitation with quicker return to sports, without the need of early protection.[28].

There are limitations to this study. This is a relatively small cohort, and the study design did not allow us to provide a comparative analysis of other established procedures. The score used is not validated and instability is poorly assessed by AOFAS tool. Despite of achieving a significant improvement in scores, we can still attribute this to pain relief after other procedures. Subjective satisfaction was not evaluated, which provides reasonable clue for encouraging patients to undergo surgery. We also acknowledge that accurate measurements on radiographic tests would be of value and their correlation with AOFAS score might have been beneficial for a better understanding between stability and function of operated ankles. The follow-up period is 27 months on average and therefore the results might still be claimed to be somewhat preliminary.

CONCLUSION

The arthroscopic *"Inside-Out"* technique to treat chronic lateral ankle instability showed good functional results with low morbidity. Therefore we believe that this technique is a viable option in the surgical approach to this common pathology. Comparative and randomized clinical trials are needed to compare this technique to open procedures and other arthroscopic techniques.

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Fig. 1 Suture-passer guided distally through anterolateral portal and ligament layers

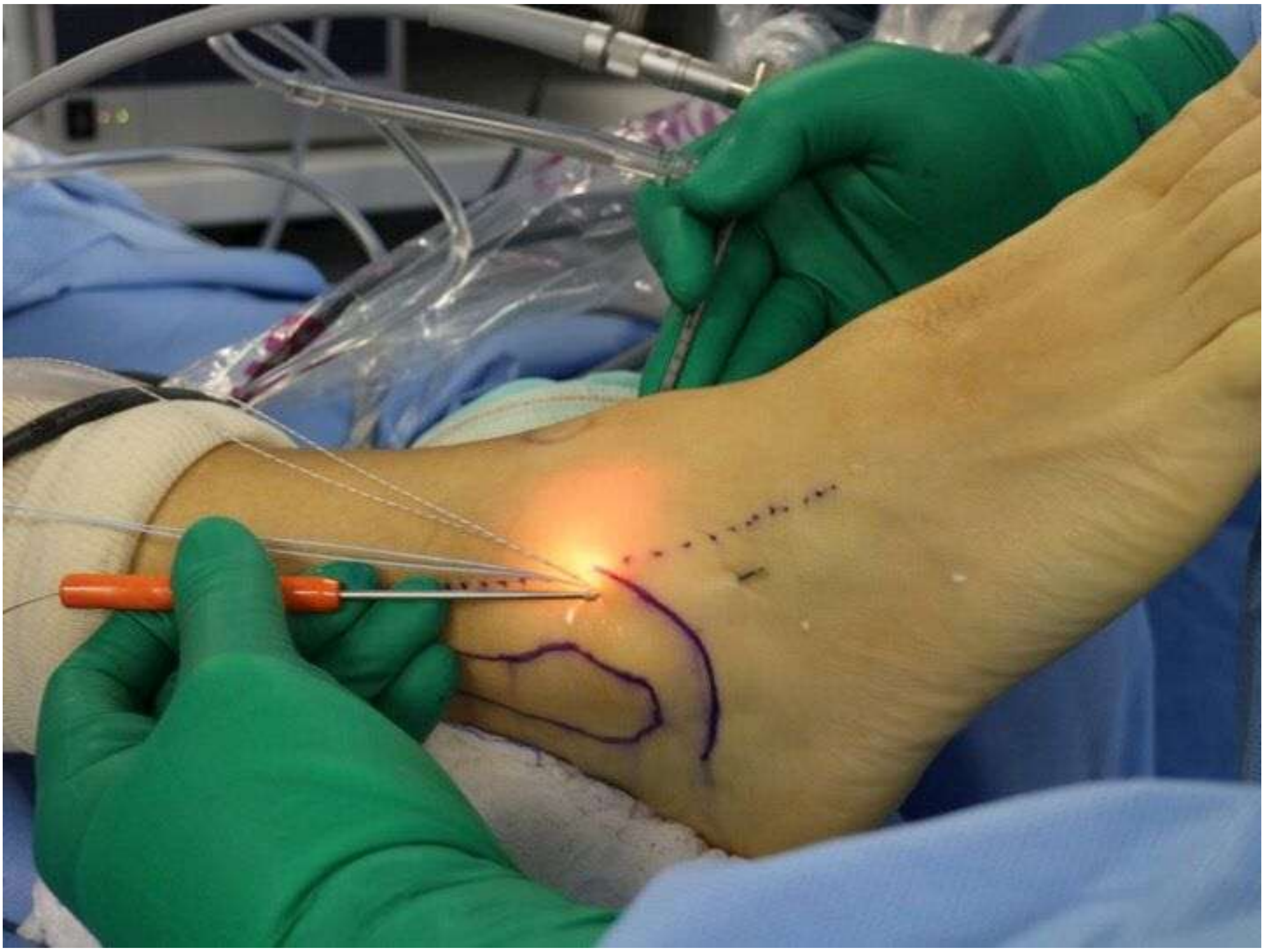

Fig. 2 Litinol loop pulling outwards the first suture, after suture-passer is removed

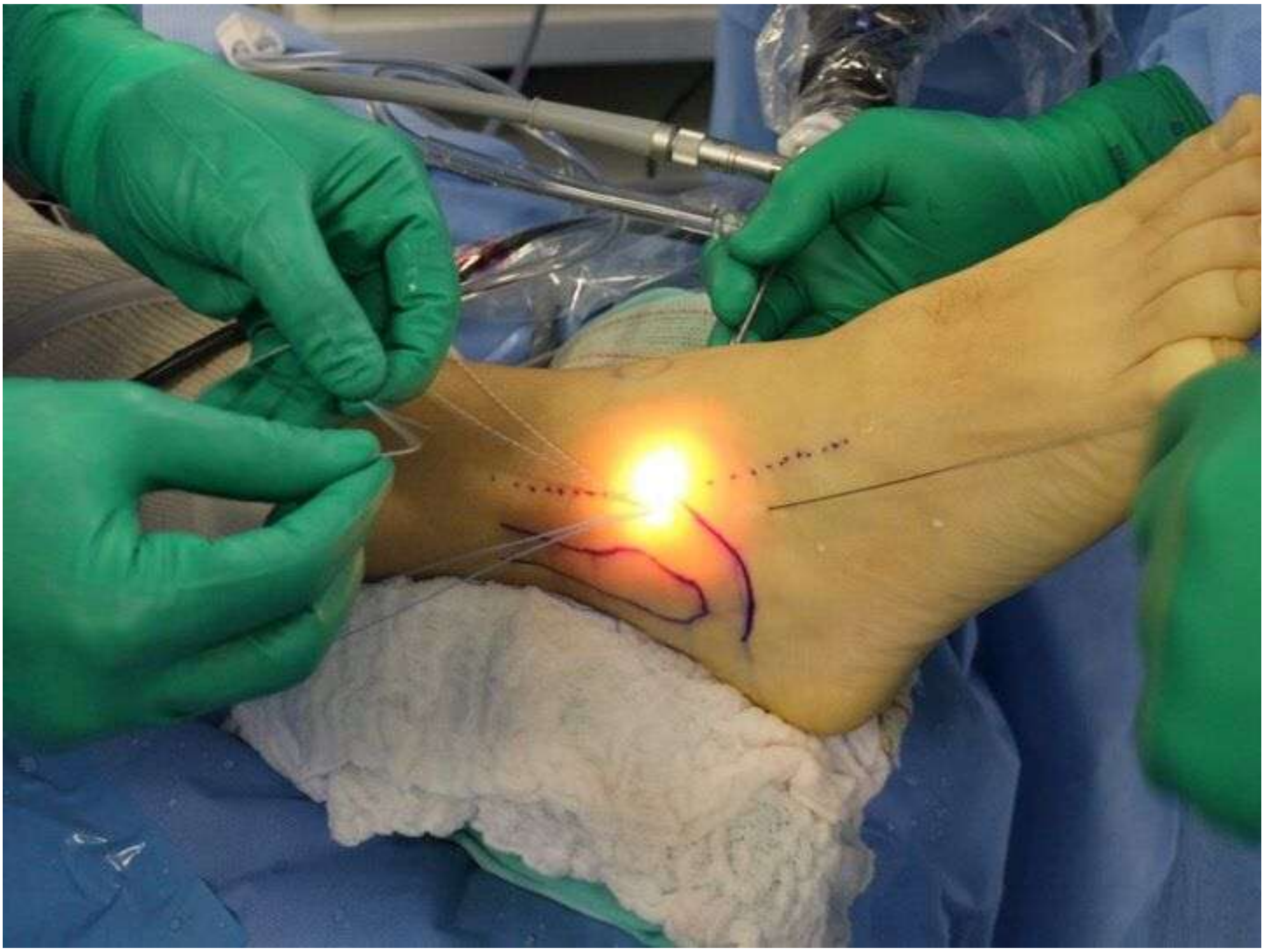

Fig. 3 The last suture is driven to outside the joint in the same way

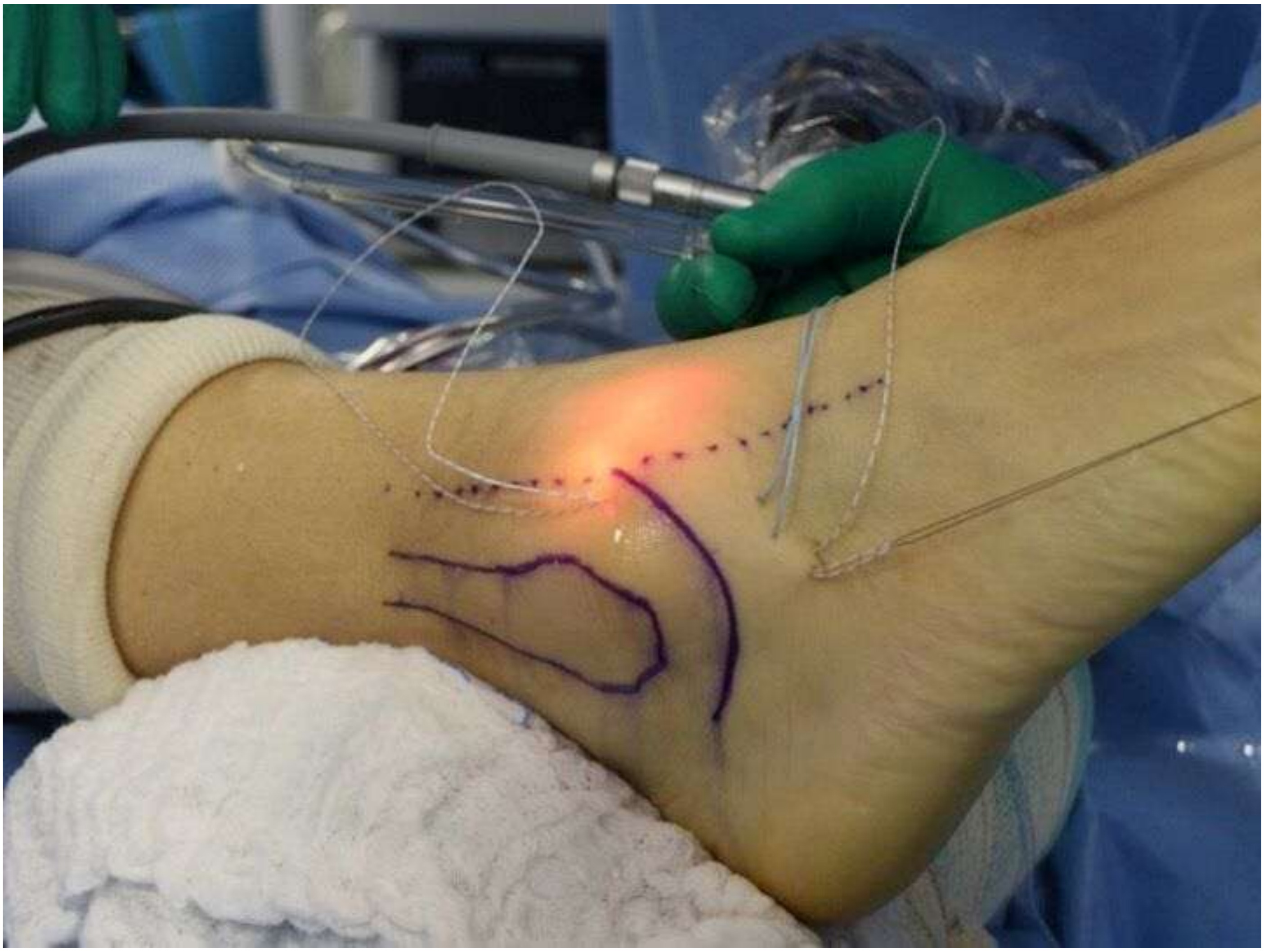

Fig. 4 Once these sutures are paired with a small incision and probe manouver, first knot can be tighted

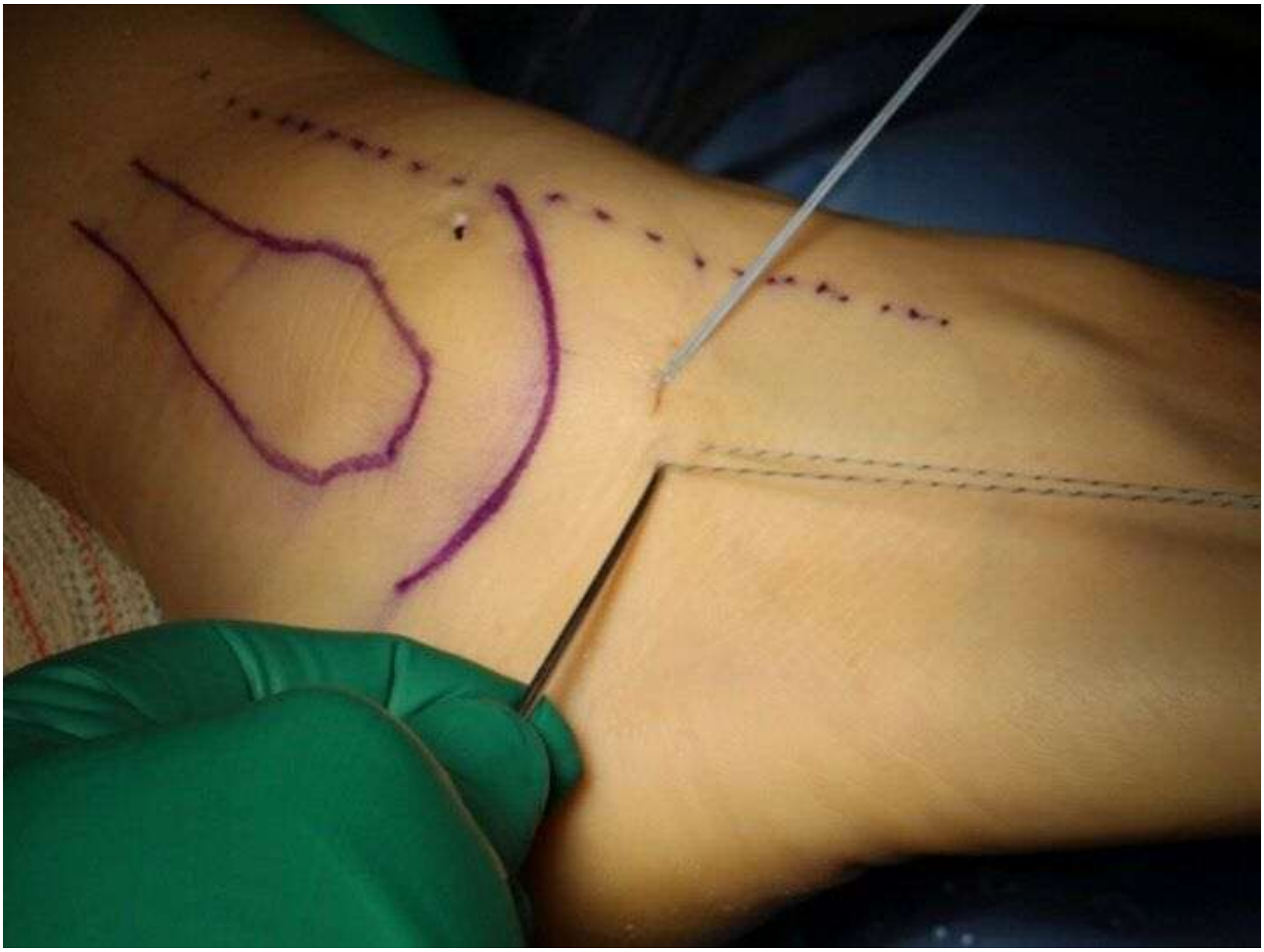

Fig. 5 A knot pusher is loaded with one suture of Duncan knot and conducted to the fibula, carrying itself ligament and retinaculum layers.

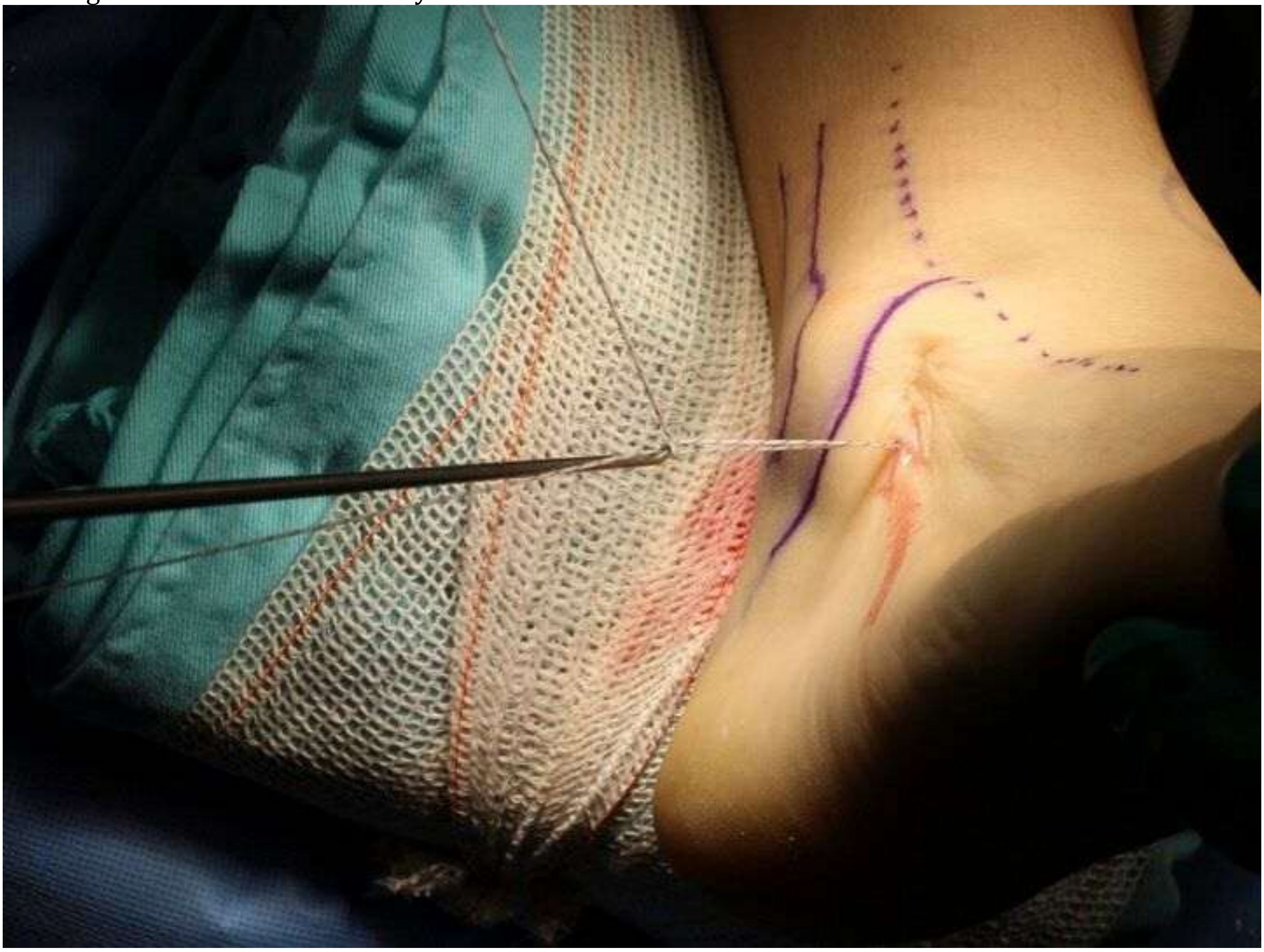

Chart 1 – Means +/- 1 SDs of pre- and post-operative AOFAS Ankle scores of groups with and without osteochondral lesion (OCL)

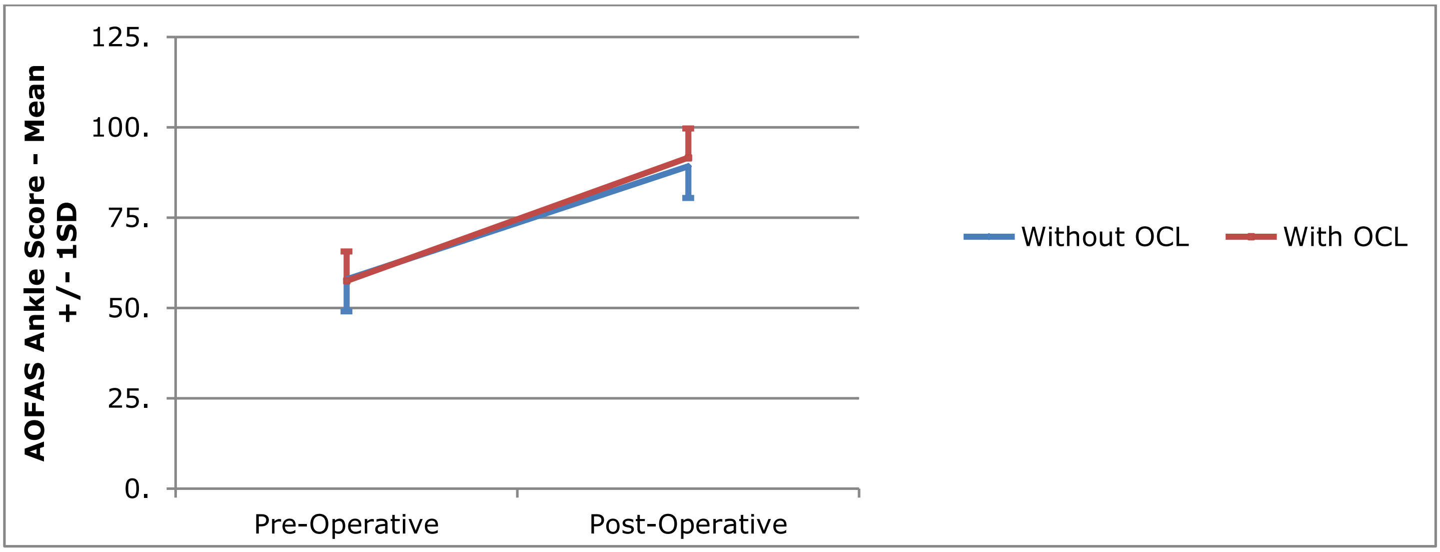

Table 1 Demographic Data, Additional Lesions and American Orthopaedic Foot & Ankle (AOFAS) scores

Patient	Age (year)	Sex	MR (aditional lesions)	Aditional Procedures	AOFAS pré	AOFAS pós
1	32	F		–	62	100
2	52	F		–	61	80
3	36	M		–	55	77
4	60	M	OCLT	Microfracture (MF)	50	100
5	60	M	OCLT	MF	55	77
6	41	M	Partial Deltóide Lesion	direct repair	59	80
7	30	M		–	61	100
8	45	M		–	58	100
9	46	M	Varus Hindfoot	calcaneal osteotomy	42	95
10	39	F	Peroneal Brevis Lesions	tenoscopic repair	45	77
11	41	M	OCLT	MF	50	100
12	19	M		–	61	100
13	28	F	anterior impingement/OCLT	arthroscopic ressection/ MF	70	90
14	32	M	OCLT	MF	66	90
15	42	M		-	60	84
16	44	M		-	64	100
17	35	M	anterior impingement	arthroscopic ressection	60	90
18	59	F		-	55	78
19	44	M	anterior impingement/ OCLT/Varus Hindfoot	arthroscopic ressection/ MF/ calcaneal osteotomy	64	86
20	50	M	anterior impingement	arthroscopic ressection	62	82
21	51	F		-	68	93

22	44	M	anterior impingement/ OCLT/Varus Hindfoot	arthroscopic ressection/ MF/ calcaneal osteotomy	50	90
23	27	M		-	62	90
24	47	M		-	60	90
25	30	M	anterior impingement/OCLT	arthroscopic ressection/ MF	55	100
26		M		-	48	90
Total	**41,36**	**20M/6F**		**26**	**57,81**	**89,96**

Table 1.2. Pre and post-operative AOFAS Ankle Score results for the 26 patients included in the sample

Evaluation	**AOFAS** (n = 26)				
	Mean	SD	Median	Minimum	Maximum
Pre-operative	57.8	7.0	60	42	70
Post-operative	90.0	8.5	90	77	100
p-value	p < 0.0001				
Variation (Post – Pre)	32.2	10.6	30	19	53
Variation %	57.9	25.5	50	28.6	126.2

Table 1.3. Distribution of AOFAS Ankle scores in the pre- and post-operative evaluations of the 26 patients included in the sample

AOFAS (n = 26)	**Pre**	**Post**
Excellent (90 – 100)	0 (0%)	17 (65.4%)
Good (80 – 89)	0 (0%)	5 (19.2%)
Regular (70 – 79)	1 (3.8%)	4 (15.4%)
Poor (< 70)	25 (96.2%)	0 (0%)