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ORIGINAL PAPER

Results of lateral ankle ligament repair surgery in one hundred and nineteen patients: do surgical method and arthroscopy timing matter?

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Abstract
Purpose Ankle sprains are the most common athletic injury. One of five chronic lateral ankle instability patients will require surgery, making operative outcomes crucial. The purpose of this study is to determine if operative method influences failure and complication rates in chronic lateral ankle ligament repair surgery.
Methods We retrospectively reviewed 119 cases (118 patients) of lateral ankle ligament surgery between 2006 and 2016. Patient charts and operative reports were examined for demographics, use and timing of ankle arthroscopy, ligament fixation method, type of surgical incision, presence of calcaneofibular ligament repair, and operative technique. Impact of operative methods on failure (one-year minimum follow-up) and complication outcomes was explored using Chi-square test of independence (or Fisher's exact test). Statistical significance was set at p less than .05.
Results Mean age at surgery was 40 (*range, 18-73*) years. Mean follow-up was 51 (*range, 12-260*) weeks. Failure rate was 8.4% (10/89 cases) while complication rate was 17.6% (21/119). Failure rate did not differ significantly between any data subgroups ($p > .05$). Single stage arthroscopy was associated with a significantly lower complication rate (11%, 4/37) than double-stage arthroscopy (47%, 9/19) ($p < .01$) as was suture anchor ligament fixation (9%, 6/67) compared to direct suture ligament fixation (29%, 15/52) ($p < .01$).
Conclusion Failure rate was not impacted by any of the studied variables. Use of suture anchors and concurrent ankle arthroscopy may be favourable options to achieve fewer complications in chronic lateral ankle instability repair surgery.

Keywords Ankle instability · Ankle sprain · Arthroscopy · Broström-Gould · Clinical outcome · Suture anchors

Introduction

Chronic lateral ankle instability corrective surgery is generally accepted as a rewarding procedure for most patients, with current literature reporting success rates of 90-95% [1–3]. The operative approach for this reconstructive surgery has continuously evolved, with certain approaches being preferred in cases with poor ligament stock or for revisions [3]. Two broad operative approaches are the anatomic repair/reconstruction (Broström, Broström-Gould, Karlsson) and the non-anatomic reconstruction (Watson-Jones, Chrisman-Snook, Evans, modified Evans, Elmslie) [3, 4]. The original anatomical repair which involves direct reattachment of the anterior talofibular ligament (ATFL) to itself or the fibula periosteum was described by Broström in 1966, reporting an 80% success rate [5]. However, following concerns for return to activity in highly active dancers and athletes, the Gould modification was devised, incorporating the inferior extensor retinaculum into the repair for added strength and stability [1]. Recently, arthroscopic repair has also been undertaken, however, outcomes with this approach are mixed and do not allow its broad recommendation [3]. Of all approaches, the Broström-Gould reconstruction still remains the gold standard [1, 3, 4].

Regardless of the technique, certain operative nuances remain without consensus agreement. For example, although the use of arthroscopy has been encouraged in the literature as evidence-based (and its use has risen over the past decade),

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less than half of surgeons routinely perform ankle arthroscopy for chronic lateral ankle instability [6]. Likewise, various other operative methods such as timing of ankle arthroscopy (concurrent versus spaced/double-staged), type of surgical incision (Ollier incision versus longitudinal incision), and method of ligament fixation (suture anchor versus direct suture) lack consensus based on clinical outcome studies. However, biomechanical studies have assessed the properties of different ligament reattachment methods [7, 8]. Most decisions on these operative methods are driven by surgeon preference and comfort level. The purpose of this study is to examine the impact of these variations in operative method on failure and complication rates for chronic lateral ankle instability surgery.

Materials and methods

All procedures were performed in accordance with the 1964 declaration of Helsinki and its later amendments or comparable ethical standards. Institutional review board approval was obtained prior to study initiation. Three hundred eighty-two cases of lateral ankle ligament reconstruction surgery between June 2006 and November 2016 were retrospectively reviewed for inclusion in this study. Medical charts were reviewed for demographics (age, body mass index, smoking and diabetic status, and generalized ligament laxity) clinical and operative notes as well as radiology reports. We excluded cases with patients less than 18 years of age, cases of gross trauma, ipsilateral subtalar or triple arthrodesis, ligament repairs associated with total ankle replacement, revisions and cases with inaccessible electronic medical records. Cases with less than one year of follow-up were excluded from failure rate analyses under the assumption that failures would take a longer time to develop (greater time lag to occurrence) than complications. All cases had undergone at least six months of conservative management with no improvement. Operative notes were reviewed for incision type (Ollier versus longitudinal), ligament fixation method (suture anchor versus direct suture), performance of ankle arthroscopy prior to ligament repair, timing of ankle arthroscopy (concurrent versus double-staged), performance of calcaneofibular ligament (CFL) repair, and type of anatomical repair (Broström versus Broström-Gould). Clinical notes were reviewed up to the most recent follow-up, and information related to complications and failure of operation was recorded. Failure was defined as the need for re-operation secondary to continued chronic lateral ankle instability.

Statistics

All statistics were computed using SPSS 24.0 Statistics Software (IBM, Chicago, IL). Data regarding smoking status, diabetic status, and generalized joint laxity were missing for 11 cases. Ten data points were missing for the body mass index (BMI) variable. One data point was missing for the CFL repair variable. Missing data points were omitted listwise for each statistical procedure. Simple descriptive statistics (means, standard deviation, and frequencies) were obtained for demographic variables including age, body mass index, and other target variables. Data sub-groups were created using ligament fixation method (suture anchor versus direct suture), arthroscopy status (arthroscopy versus no arthroscopy), timing of arthroscopy prior to surgery (concurrent/single stage versus separated/double stage), CFL repair (performed versus not performed), type of skin incision (Ollier versus longitudinal versus mixed), and type of anatomical repair (Broström versus Broström-Gould) as grouping variables. Chi-square test of independence was used to compare failure and complication rates across the levels of each grouping variable. Binary logistic regression was performed to evaluate the effect of any associated surgical procedures on outcomes measured. P values < .05 were considered statistically significant.

Results

Demographics and associated procedures

One hundred nineteen cases (65 left-sided, 54 right-sided) in 118 patients were included after application of selection criteria. There were 85 females and 33 males. Of the 119 cases, 89 had a minimum follow-up of 1 year. The mean age at surgery was 40 (*range, 18-73*) years and the mean body mass index (BMI) at surgery was 31.9 (*range, 20-51.6*) kg/m^2. The mean follow-up was 51 (*range, 12-260*) weeks (Table 1). There were 17 smokers, nine diabetics, and six patients with generalized ligament laxity. Sixty-two cases (52%, 62/119) had associated peroneal debridement or repair, 57 cases (48%, 57/119) had associated arthroscopic ankle joint debridement, 20 cases (17%, 20/119) had an associated lateral

Table 1 Demographic variables for all cases (N = 119 cases)

Variable	Statistic
Mean age, years (range)	40 (18-73)
Female gender, number of cases (%)	86 (72.2%)
Mean body mass index, kg/m^2 (range)	31.9 (20-51.6)
Left side operated, number (%)	65 (54.6%)
Mean follow-up, weeks (range)	51 (12-260)
Associated procedures, number (%)	98 (82.4%)
Peroneal debridement	62 (52.1%)
Ankle joint debridement (arthroscopic)	57 (48.9%)
Lateral sliding calcaneal osteotomy	20 (16.8%)
Osteochondral lesion Microfracture	13 (10.9%)
Medial plantar soft tissue release	3 (2.5%)

Table 2 Crosstabulations for operative method variables versus failure and complication rates with respective *p* values for the Chi-square test or Fischer test

	Fail surgery ($N = 89$)			Complication ($N = 119$)		
	Yes	No	*p* value	Yes	No	*p* value
Ankle scope						
Yes	6 (13.3%)	39 (86.7%)		13 (23.2%)	43 (76.8%)	
No	4 (9.1%)	40 (90.9%)	*0.739*	8 (12.7%)	55 (87.3%)	*0.133*
Scope staging						
Single	5 (16.1%)	26 (83.9%)		4 (10.8%)	33 (89.2%)	
Double	1 (7.1%)	13 (92.9%)	*0.648*	9 (47.4%)	10 (52.6%)	***0.006***
Incision						
Ollier	3 (11.5%)	23 (88.5%)		7 (20%)	28 (80%)	
Longitudinal	6 (12.5%)	42 (87.5%)		9 (14.1%)	55 (85.9%)	
Mixed	1 (6.7%)	14 (93.3%)	*0.821*	5 (25%)	15 (75%)	*0.486*
Broström-Gould						
Yes	10 (12.3%)	71 (87.7%)		18 (17%)	88 (83%)	
No	0 (0%)	8 (100%)	*0.590*	3 (23.1%)	10 (76.9%)	*0.699*
CFL[a] repair						
Yes	10 (15.2%)	56 (84.8%)		17 (19.1%)	72 (80.9%)	
No	0 (0%)	22 (100%)	*0.061*	3 (10.3%)	26 (89.7%)	*0.395*
Suture anchor						
Yes	6 (12.8%)	41 (87.2%)		6 (9%)	61 (91%)	
No	4 (9.5%)	38 (90.5%)	*0.743*	15 (28.8%)	37 (71.2%)	***0.005***

[a] CFL = Calcaneofibular ligament

sliding calcaneal osteotomy for hindfoot varus alignment, 13 cases (11%, 13/119) had osteochondral lesion microfracture, and three cases (3%, 3/119) had an associated medial plantar soft tissue release for excessive first ray plantarflexion. None of the associated surgical procedures was found to successfully predict the probability of failure or complication ($p > .05$).

Post-operative outcomes

Eighty-nine percent (79/89) of cases with a minimum followup of one year did not require reoperation. Group comparisons summarized in Table 2 revealed that none of the tested variables including the use of arthroscopy, scope staging, incision type, use of the Broström-Gould technique, repair of the CFL, and ligament fixation technique significantly impacted failure rates ($p > .05$). Multivariable binary logistic regression showed that none of the associated procedures significantly predicted the probability for failure ($p > .19$). Of note, the impact of CFL repair (or not) on failure rate indicated a potentially important relationship with marginal significance obtained. Cases with the CFL repaired had a 15% (10/66 cases) failure rate compared to zero failures (0/22) in patients without repair of the CFL ($p = .061$). Post-hoc power analysis revealed 75% power for this comparison at an alpha level of 5%.

Eighteen percent (21/119) of all cases developed at least one complication. Neuritis (10%, 12/119 cases) and self-reported feeling of ankle tightness (4.2%, 5/119) were most common. Superficial skin complication (3.4%, 4/119 cases) was third most common while self-reported pain (2%, 2/119) was the least common complication. Nerves affected by neuritis included the sural (seven cases), superficial peroneal (seven cases), and deep peroneal (one case) nerves. Neuritis was resolved in three out of 12 cases (two self-resolved, one after nerve block). One case of ankle tightness (1/5) resolved after physical therapy. One case of skin complications required surgical debridement for poor would healing while the other three resolved after a short course of antibiotics for superficial skin infection. The number of cases in each complication group that had positive diabetic status or positive smoking status is presented in Table 3. Complication rates across each operative method variable are presented in Table 2 while a breakdown of complications for each surgical variable is presented in Table 4. Multivariable binary logistic regression revealed that none of the associated surgical procedures significantly predicted the probability of developing a complication ($p > .07$). Of note, cases with single-stage (concurrent) arthroscopy had a significantly lower rate of complications (11%, 4/37) compared to cases with double-stage arthroscopy (47%, 9/19) ($p < .01$) while cases with suture anchor ligament fixation had significantly lower complication rates (9%, 6/67 cases) compared to cases with direct suture ligament fixation (29%, 15/52 cases) ($p < .01$). Use of ankle arthroscopy was associated with a 23% (13/56 cases) complication rate compared to

Table 3 Demonstrating the comorbidities present for each complication type

	N feet[a]	Number of diabetics[b]	Number of smokers[b]
Neuritis (sural, peroneal)	12	1	2
Subjective ankle tightness	5	1	0
Skin complication (superficial)	4	1	1
Pain	2	0	0

[a] Total (23) does not correspond to number of patients with at least one complication (21) because two patients had skin complication along with neuritis

[b] Missing comorbidities data in one of the neuritis patients, one of the skin complication patients, and two of the ankle tightness complication patients

cases that did not have ankle arthroscopy (13%, 8/63 cases) but this did not reach statistical significance (p = .13).

Discussion

Ankle sprains are a very common injury, especially in athletes. Up to 70% of high-performance athletes who have a first ankle sprain will have a repeat ankle sprain [9]. This feedforward cycle of repetitive ankle sprains can lead to chronic lateral ankle mechanical instability which will require operative management in at least 20% of cases [1, 4, 10]. The Broström-Gould technique is considered the gold standard by most of the orthopaedic community; however, various other techniques have been described for lateral ankle ligament reconstruction surgery along with their indications [1, 11]. The anatomical techniques (Broström, Broström-Gould, Karlsson) are used in cases where there is still enough remnant quality ligament for reattachment—although anatomic reconstructive techniques have surfaced, incorporating autografts and allografts along with some native ligament tissue [3]. Non-anatomic approaches (which rely heavily on grafts) include the Chrisman-Snook, Evans, Modified Evans, Elmslie, and Watson-Jones [1, 4]. Current literature suggests that regardless of the operative approach (anatomic versus nonanatomic), success rates will range from 85-95% [1–4]. Our study reports an 89% (79/89 cases) success rate, which is consistent with current literature. While a subtle distinction of our study, we would like to point out the difference in mean body mass index (BMI) of cohorts in the majority of lateral ankle instability surgery outcomes studies (<30 kg/m^2) in comparison to the mean BMI (31.86 kg/m^2) of our cohort [2, 10–12]. The majority of these studies report on moderately to highly athletic cohorts, theoretically limiting the generalizability of their findings. Thus, this study reports acceptable success rates of first time anatomical lateral ligament repair even in patients with high BMI.

Table 4 Enumeration of type of complication present for each level of examined surgical variables

Surgical variable	Level of variable	Neuritis	Ankle tightness	Skin complication	Pain
Ankle scope	Yes	8	4	2	1
	No	4	1	2	1
Scope staging	Single	3	1	0	1
	Double	5	3	2	0
Incision	Ollier	4	2	1	1
	Longitudinal	5	2	2	1
	Mixed	3	1	1	0
Broström-Gould	Yes	9	5	4	2
	No	3	0	0	0
CFL[a] repair	Yes	11	4	3	0
	No	1	1	0	2
Suture anchor	Yes	3	2	1	0
	No	9	3	3	2

[a] CFL = Calcaneofibular ligament. Note: Numbers may not add up to reported complication rates in Table 2 since one patient may have presented with multiple complications

Certain method preferences exist in lateral ligament repair/reconstruction surgery without a firm grounding in clinical evidence. For example, the decision on whether to routinely perform ankle arthroscopy prior to ligament repair or to routinely perform CFL repair usually hinges on the surgeons' training, preference and expertise. Arthroscopy in particular has been increasingly recommended due to recent recognition of the high co-occurrence of intra-articular pathology such as osteochondral lesions and osteophytes with chronic lateral ankle instability [1, 8, 13–15]. Nonetheless, a 2015 national database study by Werner et al., which examined trends of arthroscopy use in lateral ankle ligament surgery in the United States, found that under half of all cases in 2011 were preceded by diagnostic ankle arthroscopy [6]. However, they reported a rise in the use of ankle arthroscopy prior to lateral ankle ligament repair from 37.2% in 2007 to 43.7% in 2011. In line with these findings, our study revealed a 47% rate (56/119 cases) of ankle arthroscopy prior to ligament repair. The use of arthroscopy in our study did not impact failure rate, but was associated with higher complication rates (although not statistically significant). Specifically, we found that cases that had ankle arthroscopy prior to their ligament repair had a 23% (13/56) complication rate compared to cases without prior ankle arthroscopy, which had a 13% (8/63) complication rate (p = .13). Given these findings, we would be in favor of an approach that uses clinical and imaging indications to guide the decision to perform or not perform arthroscopy prior to lateral ligament repair surgery. Particularly, the presence of pain between episodes of ankle sprains should be an indication for ankle arthroscopy regardless of MRI findings which have been shown to underdiagnose intra-articular pathologies, especially osteochondral lesions [8]. In addition, we recommend prospective studies aimed at examining complication rates with and without ankle arthroscopy in lateral ankle ligament repair or reconstruction.

Within the decision to perform ankle arthroscopy is another decision of when to perform arthroscopy—at the same time as the ligament repair/reconstruction (concurrent or single-stage), or at least one week prior to the ligament repair/reconstruction (double-stage). The primary concern with the concurrent approach is the fluid extravasation that is believed to render the soft tissue less workable, and hence more prone to inadequate ligament tightening and strengthening. However, recent reports of "all-inside" arthroscopic lateral ligament reconstructions reporting good-excellent repair/reconstruction outcomes run counter to this idea [3, 16]. Though, these "all-inside" procedures have been shown to harbor numerous complications [3, 16]. To the best of our knowledge, no studies have directly examined the timing of arthroscopy as an investigative tool prior to lateral ankle ligament reconstruction. Werner et al.'s national database study showed an increase in concurrent ankle arthroscopy for lateral ligament repair procedures from 90.6% in 2007 to 99.2% in 2011; however, no comparative data was offered on clinical outcomes of the concurrent approach versus the double-stage approach [6]. As such, this study represents the first to report significant findings related to the timing of ankle arthroscopy. We believe that our finding of a double-stage approach being associated with a significantly increased rate of complications (47%, 9/19 cases) compared to a single stage approach (11%, 4/37 cases) (see Table 2) is most likely related to repeated surgical incision. Any residual inflammatory response from the first procedure may predispose the tissue to higher irritability, making it more prone to injury during a repeat incision. As shown in Table 4, complications arising from double staged arthroscopy were related to nerve irritation (neuritis) as well as tightness, which may be a reflection of increased scarring and incision site contraction. Asides from avoiding the risks of direct tissue injury, the single-stage approach circumvents the patient inconvenience of repeated travel to the operative facility as well as repeated exposure to regional and general anesthesia. Lastly, because single-stage procedures are reimbursed as a bundle (versus separate payments for the scope procedure and then the ligament repair procedure in a double-stage approach), the single-stage approach lowers the financial burden on the healthcare industry. As the senior author (AS) performed 81% (30/37 cases) of all single-stage repairs, he recommends keeping arthroscopy time under one hour and use of gravity pump in these procedures to obtain optimal results.

The use of suture anchors in lateral ankle ligament reconstruction has risen dramatically over the past few years [7, 11, 17]. Some recent studies are even experimenting with new approaches to suture anchor use in lateral ankle ligament reconstruction, mimicking approaches used in shoulder arthroscopic surgery [11]. Cho et al. found no significant difference in clinical outcomes measured by the Karlsson and Sefton scales between lateral ankle reconstruction patients who had ligament fixation with suture anchors and those who had ligament fixation by transosseous suture [18]. Likewise, biomechanical studies have found no significant differences in load to failure of reconstructions using suture anchors compared to those using direct suture technique [7]. In line with these studies, our findings indicate no significant differences in failure rates regardless of ligament reattachment technique. To the best of our knowledge however, no studies have explicitly compared complication rates across the different ligament reattachment techniques. Thus, our finding of suture anchors being associated with a significantly lower complication rate (9%, 6/67 cases) compared to direct suture reattachment (28.8%, 15/52) ($p < .01$) is an important finding. Perhaps, this is related to the lesser need for extensive surgical dissection when suture anchors are used as opposed to direct suturing. Specifically, direct suture reattachment involves greater periosteal stripping and bone roughening, creating more surgical motion and activity that potentially risks postoperative complications. Distal fibula drilling for placement of intraosseous sutures is also another step that may increase the risk for injury and postoperative complication in the direct suture group. As a recommendation, the senior author (AS) suggests the use of intraoperative fluoroscopy to confirm suture anchor placement, in order to avoid the complication of suture anchor migration into the ankle joint.

Complication rates reported by most studies of chronic lateral ankle instability repair are below 10% [1, 11, 18]. However, they have been reported as high as 19% [19, 20]. In Xu et al.'s study, they report a minor complication rate of 8% in 100 patients who underwent the Broström-Gould ligament repair surgery [12]. We report a fairly significant complication rate of 18% (21/119 cases), which is in contrast with the majority of the reported complication rates. However, we note that our patient cohort had a higher mean BMI (31.86 kg/m^2) than other studies (<30 kg/m^2) [2, 10–12]. This high BMI potentially required more extensive surgical dissection, leading to the higher complication rates we report. In addition, our definition of complications included persistent post-operative pain (which was not included as a complication in other studies, lowering their measured complication rate). In line with previous literature, we report neuritis (seven sural, seven superficial peroneal, one deep peroneal) as the most common complication [1, 3, 12, 21]. Our reported findings suggest that the risk of complications such as neuritis and excessive ankle tightness should be discussed with patients as part of the pre-operative visit, allowing the patient to weigh this risk against the chance for a successful and uncomplicated outcome. Per our findings, use of concurrent arthroscopy (as opposed to a double stage arthroscopy approach) where arthroscopy is indicated, as well as suture anchors (as opposed to direct suture technique) can be effective at achieving lower complication rates.

While the anterior talofibular ligament (ATFL) is affected in 85-90% of all ankle sprains, the CFL is affected in 50-75% of cases [22]. Therefore, it goes without argument that all lateral ankle ligament reconstruction operations will involve repair of the ATFL, while the decision to repair the CFL is usually driven by whether it is injured or not. Therefore, our reported findings related to repair of the CFL most likely reflects the impact of injury mechanism and severity on failure and complication rates. Specifically, more severe injuries (affecting the CFL) may be more likely to fail compared to injuries that do not affect the CFL. While this finding did not reach statistical significance, we felt it was worthy of mention given the associated p value ($p = .06$). Given this marginal significance, we performed a post-hoc power analysis which showed that we achieved 75% power at a significance level of 5%. Thus, with a larger sample size, a true difference may have been detected.

Limitations to our study include those inherent to all retrospective studies such as the lack of control of possible extraneous variables such as decision for operative method. For example, surgeon decision to use or not use suture anchors may have been driven by implicit estimations of failure or complication risk. Also, errors associated with data extraction from numerous patient charts could be a weakness of this study. However, all data was confirmed by the lead author. Lastly, the lack of incorporation of associated co-pathologies can be considered a weakness of this study; however, the role of associated co-pathologies was not a primary focus for this study and is anticipated for future analyses.

In conclusion, use of ankle scope, timing of ankle arthroscopy, type of surgical incision, type of anatomical repair, decision to repair the CFL, and choice of ligament fixation method did not significantly impact failure rates in chronic lateral ankle ligament repair surgery. Complication rate was significantly impacted by timing of arthroscopy (in patients who underwent arthroscopy) and ligament fixation method but not by decision to perform ankle arthroscopy, type of incision, type of anatomical repair, and decision to repair the CFL. Concurrent arthroscopy (when arthroscopy is used) and use of suture anchors may be indicated for achieving lower complication rates in chronic lateral ankle instability surgery.

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Compliance with ethical standards

Conflict of interest On behalf of all authors, the corresponding author states that there is not conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. As this study was retrospective, formal consent was not required.

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