RESEARCH ARTICLE

Does Sectioning and Then Repairing of the Calcaneofibular Ligament at Subtalar Approach Lead to Residual Lateral Ankle Instability?

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Abstract

Background: The calcaneofibular ligament is cut to increase vision in surgical field in minimally invasive surgery of displaced intraarticular calcaneus fractures with subtalar incision. We aimed to investigate whether this causes talar tilt instability in ankle stress radiographs due to the calcaneofibular ligament deficiency in postoperative period.

Methods: The files of 38 patients who were operated with the diagnosis of displaced calcaneus fracture between 2013 and 2018 were examined retrospectively. All the cases underwent with subtalar approach and the calcaneofibular ligament was repaired after the operation. The age, sex, injury mechanism, follow-up length, type of fracture by the Sanders classification, preoperative and postoperative Bohler's and Gissane's angle measurements, talar tilt measurements of intact and fractured side, postoperative calcaneal length, calcaneal height and calcaneal width of the cases were recorded. The obtained data were evaluated statistically.

Results: 31 (81.6%) of the cases were men, seven (18.4%) were women. The average age was 31.92±7.95 years. The average follow-up time was 15.82±3.33 months. The preoperative Bohler's angle was 14.16±3.67 degree, while the postoperative Bohler's angle was 31.53±4.60 degree (*P<0.05*). The average talar tilt was 0.96±0.87 degrees on the intact side and 1.19±1.12 degrees on the fractured side (*P:0.001*). Although the talar tilt values were statistically higher on the fractured side than the intact side, no radiological instability finding was found in any case. The average postoperative Gissane's angles were 126.45±6.69 degrees. The calcaneal length (*P:0.665*), calcaneal width (*P:0.212*) and calcaneal height (*P:0.341*) were statistically similar between the postoperative fractured foot and intact foot.

Conclusion: Sectioning of the calcaneofibular ligament in the surgical treatment with subtalar approach does not cause lateral ankle instability in stress radiographs but may cause laxity. Possible postoperative lateral ankle injuries can be prevented by ankle proprioception exercises.

Level of evidence: III

Keywords: Ankle instability, Calcaneal fracture, Calcaneofibular ligament, Sinus tarsi approach, Subtalar approach

Introduction

Calcaneus fractures account for 2% of all adult fractures and more than 60% of tarsal fractures (1). Approximately 75% of fractures are related to the joint and have high morbidity (2). The studies showed that stable fixation and anatomical reduction of displaced intraarticular calcaneus fractures play a role in better

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functional healing (3). However, the optimal operative approach for the treatment of displaced intraarticular calcaneal fractures is still controversial (4).

Expanded lateral approach is one of the common approaches used in surgery for intraarticular calcaneus fractures. However, minimally invasive sinus tarsi approach has been developed to reduce the risk of wound complications associated with calcaneus fractures (4). The calcaneofibular ligament (CFL) is cut to view the subtalar joint during the sinus tarsi approach (5-8). The repair of the CFL postoperatively is up to the surgeon's choice (6).

CFL is one of the three ligaments that forming the ankle lateral ligament complex (9). It is an important structure for the rotatory stabilization of the hindfoot (10). The CFL is relaxed in plantar flexion and stretched in dorsiflexion, and thus stabilizes the ankle and prevents talar tilt as the ankle moves from neutral into dorsiflexion (11).

We hypothesized that sectioning of the CFL and its subsequent repair may lead to chronic instability and result in ankle lateral ligament complex deficiency. Surgical operation performed to prevent subtalar arthritis and pain may cause iatrogenic tibiotalar arthritis and pain in other words. Our publication is the first article in the literature investigating the effect of CFL repair at the sinus tarsi approach as far as we know.

Materials and Methods

Patients who admitted to the emergency department of our hospital and were diagnosed with displaced intraarticular calcaneus fracture (DIACF) between 2013 and 2018 were evaluated retrospectively. Thirty-eight patients who were operated with subtalar approach were included in the study. Patients older than 18 years old with Sanders type 2 or type 3 fractures were included in the study. Exclusion criteria included the patients younger than 18 years old, who had an additional injury like peripheral vascular disease or a diabetic foot neuropathy, bilateral calcaneal fractures, pathologic fractures, open fractures, who had history of fracture around the ankle joint or history of ankle instability, Sanders Type 4 fractures and who had a Beighton Horan (12) hypermobility score of ≥5.

All the surgical operations were performed by two senior orthopedic surgeons with more than ten years of experience in foot and ankle surgery. The operations were performed in lateral decubitus position under tourniquet control with spinal anesthesia. The skin incision starting from the tip of the lateral malleolus was ended in 4th metatarsal base. In cases where the incision was insufficient for exposing subtalar joint, the incision was expanded approximately two cm proximally from the tip of the lateral malleolus along the posterior edge of the distal fibula. The peroneal tendons and sural nerve were identified and secured. The CFL was sharply cut 5 mm above its attachment to the calcaneus. The subtalar joint was exposed. The collapsed bone fragments in the subtalar joint were removed with the help of an elevator and the joint was reduced. The fractured fragments were reattached using 2.0-mm kirschner wires. The heel varus deformity was corrected. The fracture was fixed after anatomic restoration was achieved by direct observation and fluoroscopy images. Minimally invasive calcaneus plates (Acumed® MINI-Calc plates) were used for all the cases. Autologous bone grafting was performed with iliac bone autograft if there was a bone defect due to impaction. The proximal and distal ends of the CFL were repaired primary with a 3/0 non-absorbable suture. The subcutaneous soft tissues and the skin were sutured, and all the cases were placed in a short leg plaster splint in equinus position.

The splint was removed after the two-week. Non-weight bearing ankle motion exercises was started. The patients were encouraged to make partial weight-bearing exercises within their tolerance range between 6-8 the weeks and patients made full weight-bearing exercises after 12 weeks.

The Bohler's angle (normal: 25-40 degrees), Gissane's angle (normal: 120-145), calcaneal length, and calcaneal height were measured using the computerized tomography images taken in the postoperative 12th month (2,4). Talar tilt stress radiography measurements and anterior drawer stress radiography measurements were performed as described by Hashimato et al (13). Talar tilt angles were measured when the knees were in extension and the ankles were in the neutral position, evaluating the angle between the talar dome and the tibial plafond. All the stress tests were conducted by the same senior orthopedic surgeon who did not perform the operations. We examined the force applied by this surgeon during the stress testing against the maximum force and found that the surgeon applied a force of approximately 143 N based on the measurement we conducted using the spring balance (13). The difference of five degrees in talar tilt angles and five-mm difference of anterior drawer distance test based on the measurement taken from the intact side and the operated side was evaluated as ankle instability (14). The stress radiographs were taken at the postoperative 12th month [Figure 1].

The monitoring software, INFINITT PACS (Picture Archiving and Communication Systems) version

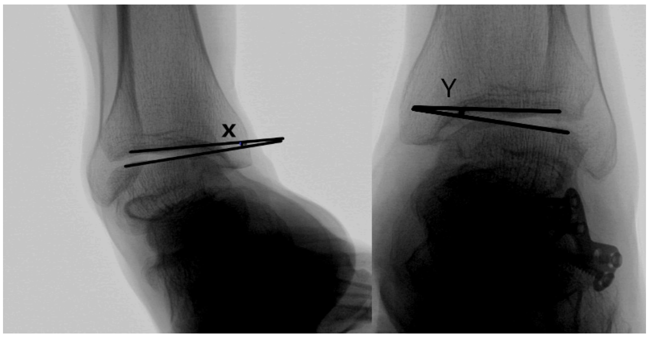

Figure 1. The talar tilt angles (X) on the intact side and the stress talar tilt angles (Y) on the fractured side were measured using the stress radiographs. A difference of 5 degrees and above between X and Y was evaluated as instability.

3.0.11.4(BN13), which was available in our hospital, was used for the pre-operative and post-operative radiographs and computed tomography measurements. The surgeon who did not perform the surgery took the measurements for two times every two weeks, and then the averages were calculated.

The age, sex, injury mechanism, follow-up length, type of fracture according to the Sanders classification, presence of recurrent ankle sprain during the follow-up period, preoperative and postoperative Bohler's and Gissane's angles, talar tilt measurements of uninjured and fractured side, postoperative calcaneal length, calcaneal height and calcaneal width of the cases were recorded. The obtained data were evaluated statistically.

IBM SPSS Statistics 24 (IBM SPSS, Turkey) program was used for the statistical analyses.

In the power analysis for the study, the required minimum sample size was determined to be 34 in total, with 0.05 type-I error, 0.50 standardized effect size, double-sided hypothesis and 0.80 working power. When evaluating the study data, the conformity of the parameters with normal distribution was determined by Shapiro Wilks test. When evaluating the study data, descriptive statistical methods (mean, standard deviation, frequency), as well as the paired t test were used for the inter-measurement comparisons of the parameters that showed normal distribution in the comparison of quantitative data. The Wilcoxon test was used to compare the data that did not show normal distribution. The significance was evaluated at *P<0.05* level.

Results

31 (81.6%) of the cases were men, seven (18.4%) were women. The average age was 31.92±7.95 years. The average follow-up time was 15.82±3.33 months. 23 (60.5%) of the injuries were due to falling from height, seven (18.4%) due to a traffic accident and eight (21.1%) due to a work-related accident. According to the Sanders classification, 16 (42.1%) cases were classified as type 2 and 22 (57.9%) as type 3. The preoperative Bohler's angle was 14.16±3.67 degree, while the postoperative Bohler's angle was 31.53±4.60 degree (*P<0.05*). The average talar tilt was 0.96±0.87 degrees on the intact side and 1.19±1.12 degree on the fractured side (*P=0.001*) [Table 1]. Although the talar tilt values were statistically higher on the fractured side than the intact side, no radiological instability finding was found in any case (in all cases, the difference in talar tilt angles between the fractured side and the intact side was less than 5 degrees). The average anterior drawer test was 4,61±0,56 mm on the intact side and 4,93±0,67 mm on the fractured side and there were no radiological signs of instability in the anterior drawer test. None of the patients had a history of recurrent ankle sprain during the follow-up period.

The average postoperative Gissane's angles were 126.45±6.69 degrees (distribution: 108.40-139,60 degrees). The calcaneal length (*P=0.665*), calcaneal width (*P=0.212*) and calcaneal height (*P=0.341*) were statistically similar between postoperative fractured foot and intact foot [Table 2].

Table 1. The tilt values on intact and fractured sides and the Bohler's angles on the fractured side of the cases (preoperative and postoperative)

	N	Mean	Std. Deviation	Min	Max	test	*P*
Talar tilt on intact foot	38	0.96	0.87	.2	3.00	z=-4.35	0.001
Talar tilt on the fractured foot	38	1.19	1.12	0.05	4.96		
Bohler (preoperative)	38	14.16	3.67	7.00	21.00	z=-5.377	0.001
Bohler (postoperative)	38	31.53	4.60	25.00	40.00		

The Z value was obtained from the Wilcoxon test, and the t value from the Paired t-test.

Table 2. Calcaneal length/width/height in intact foot and fractured foot (postoperative)

Paired Samples Statistics								
		Mean	N	Std. Deviation	95% Confidence Interval of the Difference: Lower	95% Confidence Interval of the Difference: Upper	t	Sig (p)
Calcaneal length	Fractured side	78.5263	38	6.03475	-.59333	.38280	-.437	.665
	Intact side	78.6316	38	6.14431				
Calcaneal width	Fractured side	48.5263	38	4.48865	-.61459	.14091	-1,270	.212
	Intact side	48.7632	38	4.66403				
Calcaneal height	Fractured side	47.8421	38	3.26758	-.73465	.26097	-.964	.341
	Intact side	48.0789	38	3.20794				

Discussion

Minimally invasive sinus tarsi approach reduces wound complications in the surgical treatment of displaced intraarticular calcaneus fractures. The CFL is cut during the surgical operation (4-6). A study observed an increase in the total rotation range of the tibial talocalcaneal joint complex and the talocalcaneal joint after sectioning of the CFL in amputation cases (10). We aimed to seek an answer to the question whether the sectioning then repairing of the CFL causes lateral ankle instability in stress radiographs. However, our results showed that this did not cause radiological instability in any case. The only knowledge in the literature on this subject was the study by Wang et al (14). In this study, the extensile lateral approach was used to treat DIACFs and the CFL was not repaired. They claimed that sectioning of the CFL does not cause instability. However, the results showed that there was no statistical difference in comparative stress radiographs between the intact foot and the fractured side (14). The remarkable point of our study was that although no case had a radiological instability finding, the stress test results were significantly higher in the operated ankle than the intact side. We think that this can be interpreted as sectioning of the CFL during the operation and its subsequent repair may cause laxity rather than instability.

The published studies reported that the normal range of talar tilt testing is 0 to 23 degrees for uninjured ankle. It has been claimed that this wide range can be explained by several variables, including the techniques used and the calculation of measurement results (15,16). In our study, the talar tilt values were within this range for each fractured and intact ankle.

Despite the healing and remodeling process after tendon and ligament injuries, the mechanical characteristics of the final composition and organization of the healed tissue remain insufficient compared to that of the natural tissue (17). The mechanical characteristics of the healed ligament are not enough to provide tensile forces required to achieve the original performance level (17). The mechanical characteristics of the healed MCL after the injury of the medial collateral ligament (MCL) of the knee remain statistically insufficient compared to the intact MCL (18,19). The laxity occurred after the surgical treatment of DIACFs may be probably caused by the fact that the mechanical characteristics of the healed CFL remain insufficient compared to the intact CFL.

Mechanical instability of the ankle may be due to specific conditions such as arthrokinematics changes, synovial irritation or degenerative changes (20). Lee et al. suggested that the amount of joint effusion and the capsule and soft tissue tension may affect the stress test radiographs of the ankle (21). The appearance of laxity in stress radiographs may be probably caused by the soft tissue and synovial tissue alterations around the joint after the fracture and the surgical operations.

A cadaver study suggested that the ankle joint instability (talar tilt) is positive only when it has caused an additional rupture of the anterior talofibular ligament (ATFL) during a stress loading (22). In a study by Okuda et al., they performed only ATFL reconstruction in both groups; one with ATFL rupture, and the other one with ATFL + CFL. There was a significant difference in the preoperative talar tilt measurement results between the two groups, while there was no significant difference in the postoperative talar tilt measurement results. However, the average postoperative talar tilt values were higher for group with ATFL + CFL. They suggested that the reconstruction of the calcaneofibular ligament along with the AFTL is not required in patients with chronic combined lateral ligament instability (23). An isolated CFL damage alone may not be enough to cause a talar tilt instability. Therefore, sectioning of this ligament in subtalar incision may probably result in laxity without creating instability.

The CFL is also a restrictor of the subtalar joint since it crosses both the tibiotalar joint and the subtalar joint (24,25). Another suitable explanation in the stress test is that the stability of the talus relative to the tibia is assessed while applying the force to directly to the calcaneus rather than the talus. The rotation or inversion between the talus and the tibia does not represent the whole stability between the calcaneus and the tibia (26). This is the most important shortcoming of the study. Both the CFL and the subtalar joint capsule are cut during the operation. The subtalar joint may be probably affected by sectioning of the CFL. In such a case, since the force applied to the calcaneus in stress radiography will also cause an opening of the subtalar joint, this may have caused that the talar tilt measurement values were found lower. This may be a complex situation that can be revealed by magnetic resonance or computerized tomography images taken comparatively with the intact ankle while applying stress.

Other shortcomings of the study were the retrospective nature of the study, the limited number of cases, the lack of further evaluation of the subtalar instability via Broden radiography, and the lack of using a device to apply the standard force in the stress testing (Telos Stress Device, Marburg, Germany-). Nevertheless, a study reported that the results obtained from the manual anterior drawer test and talar tilt test of the normal ankle were statistically similar with those obtained using a device (Telos Medical Equipment) (15). The follow-up time is also much shorter than the time required for the development of tibiotalar joint arthrosis. The fact that whether this laxity has an effect on tibiotalar joint arthrosis, pain and functional outcomes in the long term is not known, is the shortcoming of this study. We believe that more information on the effect of sectioning of the CFL during the operation on laxity and the necessity to repair this ligament after the operation can be obtained by a prospective and comparative study including cases where the CFL is not repaired after the operation.

Consequently, sectioning of the CFL in surgical treatment of DIACFs by subtalar approach does not cause lateral ankle instability in stress radiographs but may cause laxity. Suture repair of the CFL after the operation and the long length of fixation and weight-bearing restriction in the fracture treatment may allow ligament healing enough to prevent instability. The long-term effects of this on the tibiotalar joint are unclear. However, it can be revealed by new and long-term follow-up studies. Possible postoperative lateral ankle injuries can be prevented by ankle proprioception exercises.

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