Percutaneous anatomical reconstruction of the lateral ligament of the ankle using semitendinosus autograft

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Background
Injury to the lateral ligaments of the ankle is one of the most common sports-related injuries. Although these injures generally resolve with nonoperative treatment, reconstruction of the lateral ligaments of the ankle is occasionally necessary. The percutaneous techniques are minimally invasive and minimize the postoperative morbidity. The purpose of our study was to evaluate the outcome of percutaneous lateral ligament reconstruction with an autograft.

Materials and methods
This study included 25 patients (19 male patients and six female patients) suffering from chronic tear of the lateral ligament of the ankle treated by reconstruction of the lateral ligament by autograft semitendinosus tendon. The age of these patients ranged between 23 and 49 years, with an average age of 34.24 years. The time to operation ranged between 13 and 26 weeks, with an average 18.16 weeks. The average preoperative visual analogue score was 8.16; the average preoperative American Orthopedic Foot and Ankle Society (AOFAS) score was 41.96; the average anterior drawer test was 10.56 mm; the average preoperative talocalcaneal angle was 17.64°; and the average preoperative talar tilt angle was 11.26°.

Results
The follow-up period ranged between 8 and 40 months, with an average of 24.64 months. The average postoperative visual analogue score was 2.32, the average postoperative AOFAS was 86.24, the average anterior drawer test was 4.92 mm, the average postoperative talar tilt angle was 3.41° in the standard stress radiograph of the subtalar joint, and the average postoperative talocalcaneal angle was 3.37°. Concerning patient satisfaction, 22 patients (88%) were satisfied with excellent or good results.

Conclusion
The proposed technique of reconstruction of the lateral ligament of the ankle using autograft semitendinosus tendon is minimally invasive, effective, and reliable. Long-term follow-up is needed.

Keywords:
American Orthopedic Foot and Ankle Society, lateral ligament reconstruction, semitendinosus tendon

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Introduction

Ankle instability is a common problem that is routinely treated conservatively with a 90% success rate. Nevertheless, some patients presenting with recurrent lateral instability require surgical correction. The primary static restraints to inversion injury of the ankle are the anterior talofibular and the calcaneofibular ligaments. Hence, anatomic reconstruction restores ankle stability to close to normal. Few anatomical and minor invasive procedures have been reported for surgical reconstruction of the lateral ligaments to treat lateral instability of the ankle. Furthermore, there are no standards according to which ligaments should be reconstructed [1].

The work-up for any athlete requires care to evaluate the differential diagnosis of associated injuries such as osteochondral injury to the talus, dislocating or dysfunctional peroneal tendon injuries, and combinations of ligamentous injuries. It is important to clearly define the ligaments involved with an ankle injury [2]. A combination of injuries to the anterior talofibular ligament and the calcaneofibular ligament is important in the final determination of the procedure to be performed. The presence of associated syndesmosis, medial deltoid ligamentous injuries, or subtalar instability is also critical in determining appropriate treatment and will be discussed in other articles in this issue [3].

The use of patient's medical history, physical examination, fluoroscopic stress radiographs, plain films, and MRI can help in determining a clear diagnosis [3,4].

The purpose of our study was to evaluate the clinical and radiological outcomes of percutaneous lateral ligament reconstruction with an autograft in treating chronic lateral ligament instability of the ankle.

Materials and methods

Twenty-five patients were included; all were unilateral. There were 19 men and six women; the age ranged between 23 and 49 years with an average age of 34.24 years, the time to operation ranged between 13 and 26 weeks with an average of 18.16 weeks, the mechanism of injury was sport related in 10 cases, work related in five cases, and due to fall at home in 10 cases. The preoperative visual analogue score (VAS) ranged between 7 and 9 with an average of 8.16, and the preoperative American Orthopedic Foot and Ankle Society (AOFAS) score ranged between 37 and 49 with an average of 41.96. The average anterior drawer test was 10.56 mm, and the preoperative talar tilt angle ranged between 14 and 22.2° with an average of 17.64°. The preoperative talocalcaneal angle ranged between 9.9 and 12.7° with an average of 11.26° (Table 1).

Preoperative treatment included

Preoperative investigations

Radiography of both ankles was performed in the anteroposterior and lateral views, with stress varus, and MRI of the affected ankle was performed. Standard stress radiographs of the subtalar joint were performed to measure the talocalcaneal angle.

Below knee cast for 2 weeks followed by physical therapy program for at least 6 weeks in the form of massage, ultrasound, and strengthening exercises for the peronei and proprioceptive balance were performed for all patients presented with pain.

Inclusion criteria

Chronic ankle instability after at least 13 weeks of conservative treatment was included.

Exclusion criteria

(1) Bilateral injury.
(2) The presence of associated syndesmosis injury.
(3) Medial deltoid ligamentous injuries.
(4) Subtalar instability.
(5) Previous surgery for lateral ligament injury.
(6) Associated cavus or cavovarus deformity in the ipsilateral foot.

Operative technique

Spinal or general endotracheal anesthesia was used and high tourniquet was applied over the ipsilateral thigh.

Graft harvesting and preparation

The pes anserinus can be palpated on the medial border of the tibia, 4 cm below the joint line. Palpate

Table 1 Preoperative data of all patients

ID	Age (years)	Sex	Mechanism of injury	Time to operation (weeks)	VAS	Anterior drawer test	AOFAS	Talar tilt angle	Talocalcaneal angle
1	28	M	Sport-related	13	7	11	42	18.2	11.7
2	24	M	Sport-related	22	8	10	40	14.5	12.3
3	32	F	Fall at home	17	9	12	39	16.5	11.9
4	41	M	Work-related	14	9	10	38	22	10.9
5	29	M	Sport-related	14	8	8	42	15.8	11.6
6	36	M	Fall at home	18	7	11	41	18.2	11.3
7	47	M	Work-related	20	9	10	42	14.8	12
8	43	M	Fall at home	24	8	10	39	15.5	11.8
9	26	F	Fall at home	14	9	12	48	19.2	9.9
10	44	M	Work-related	18	8	9	47	15.5	10
11	29	M	Sport-related	22	8	8	42	17.5	11
12	49	M	Fall at home	19	8	11	49	22.0	10.2
13	28	M	Sport-related	14	9	13	44	20.8	9.9
14	35	F	Fall at home	18	8	9	48	22.2	10.2
15	41	M	Work-related	14	8	10	37	15	12.7
16	38	M	Fall at home	16	7	11	42	22.2	11
17	27	M	Sport-related	18	8	11	37	16	11.8
18	23	M	Sport-related	26	9	12	39	15.5	12.3
19	33	M	Work-related	16	9	13	40	14	9.9
20	27	M	Sport-related	22	7	11	42	14.5	10.6
21	40	F	Fall at home	17	8	8	39	18.2	11
22	36	M	Sport-related	25	9	11	47	15.5	12.5
23	28	M	Fall at home	18	8	10	44	17.5	9.9
24	40	F	Sport-related	19	9	11	42	22.0	12.7
25	32	F	Fall at home	16	7	12	39	18	12.6

AOFAS, American orthopedic foot and ankle society; F, Female; M, Male; VAS, Visual analogue score.

the tibial tubercle and then place the longitudinal incision distal and medial to this site, in line with the upper edge of the palpated gracilis and semitendinosus tendons. After soft tissues are released from around the semitendenosis tendon, the tendon is harvested using a commercially available stripper, and a tendon measuring 15–22 cm is commonly harvested. The tendon ends are prepared using a locking whip stitch and cigar-rolled at the musculotendinous end to make a cylindrical structure at each end. The graft is kept in a moistened sponge and protected in a biopsy cup with a screw-on cap. This allows for maintenance of sterility, even if the cup is accidentally mishandled and dropped.

Technique of reconstruction of the lateral ligament [5]

Semitendinosis autograft tendons were used in all cases. We measured the necessary tendon length by laying the graft on the skin through an imaginary course, including the depth of the fixation under fluoroscopy control. After measuring the thickness of the graft, the size of the bony tunnel and the diameter and the length of the biodegradable screw were determined. We first inserted a guide pin into the center of the talar neck and perpendicular to its axis under fluoroscopy. After making a drill hole through small incision on the lateral side of the talus, the talar end of the prepared autograft was inserted and fixed by an interference biodegradable screw. Through two small incisions anterior and posterior to the lateral maleolus, the second fibular tunnel was made 1 cm above the tip of the fibula using a 4.5 mm drill bit from the anterosuperior to the posteroinferior direction. The calcaneal end of the graft was delivered through the fibular tunnel to the anterior margin of the peroneal tendon sheath. Finally, through a small incision on the lateral side of the calcaneus, we inserted a calcaneal guide pin from lateral to medial direction, inferior to peroneal tendon (near to the site of calcaneofibular ligament). After drilling the tunnel, we passed the graft superficial to the peroneal tendon, then from the lateral end of the tunnel to the medial side and fixed by an interference biodegradable screw with the ankle in dorsiflexion and eversion for optimal tensioning of the graft with triple tenodesis technique.

Postoperative program

The reconstructed ankle is placed in a well-padded short leg cast for 4 weeks. Partial weight bearing was permitted 2 weeks postoperatively. Full weight bearing and active range of motion initiated after 4 weeks. After ~6 weeks, the rehabilitation phase is initiated. The rehabilitation phase focuses on the following:

(1) Improving ankle motion.
(2) Strengthening the muscles around the ankle.
(3) Regaining of the ankle proprioception.
(4) Improving gait.

By 3 months, athletes frequently are able to return to sport-specific activities wearing a functional ankle brace.

Statistical analysis

For statistical analysis, preoperative and follow-up VAS, AOFAS scores, and radiographic values were compared using Student's paired *t*-test by means of a SPSS program (SPPS Inc., Chicago Illinois, USA). Correlations were investigated by Pearson's analysis. For all comparisons, a *P* value of less than 0.05 was considered significant.

Results

The study included 25 patients; all were with unilateral affection and all patients were available for follow-up. The follow-up period ranged between 8 and 40 months with an average of 24.64 months. The postoperative VAS ranged between 1 and 5 with an average of 2.32 and a mean improvement of VAS of 5.84 points. The average postoperative anterior drawer test was 4.92 mm with an average improvement of 5.64 mm. The postoperative AOFAS ranged between 68 and 92 with an average of 86.24 and a mean improvement of 44.28 points. The postoperative talar tilt angle ranged between 2.7 and 4.2° with an average of 3.41° and a mean improvement of 14.23°. The postoperative talocalcaneal angle ranged between 2.7 and 4.3° with an average of 3.37 and average improvement of 7.89°. The average time to return to preinjury level of activity was 16.36 weeks (Tables 2 and 3; Figs 1 and 2).

Regarding patient satisfaction, in our study 22 patients (88%) were satisfied with excellent and good results and three patients (12%) were unsatisfied with fair results. One of them was a 24-year-old male patient who suffered from twisting injury 5 months postoperatively and complaint of pain and tenderness distal to lateral malleolus, despite of conservative treatment. No specific lesion was found on MRI. He refused surgical exploration. Of the other two patients, one was 26-year-old female patient and another was male patient of 49 years of age; both of them had postoperative limited range of motion mainly dorsiflexion and complaint of mild occasional pain with activities on uneven ground.

There were no reported intraoperative complications during graft harvesting, tunnel preparation, or graft fixation. Furthermore, there were no reported early postoperative complications.

Table 2 Postoperative data of all patients

ID	Follow-up (months)	VAS	Anterior drawer test	AOFAS	Talar tilt angle	Talocalcaneal angle	Time to return to preinjury activity (weeks)
1	12	4	5	88	3.7	3.5	18
2	24	3	6	69	4.9	4.2	19
3	20	3	5	86	3	4.1	16
4	36	3	4	88	3.3	3.8	16
5	28	2	6	87	3.6	2.7	19
6	10	2	5	90	4.2	3.2	15
7	38	1	4	88	3.2	2.7	14
8	40	2	6	84	4	4.1	16
9	32	5	4	68	2.8	2.8	16
10	24	1	5	88	3.6	3.3	15
11	16	4	6	92	3.8	2.9	18
12	12	2	4	90	3.4	4.3	16
13	8	2	6	90	3.3	2.9	19
14	24	1	5	90	2.7	2.7	14
15	36	4	3	88	2.8	3.1	18
16	32	2	4	88	3.3	2.7	19
17	28	2	6	84	3.6	3.3	16
18	10	2	5	68	4.2	3.9	13
19	38	2	5	88	3.2	4.2	19
20	40	3	6	92	3.2	2.8	14
21	33	1	4	90	2.8	3.7	14
22	25	2	6	90	3	3.1	16
23	22	2	5	90	3.6	2.8	16
24	14	2	3	92	3	3.2	15
25	14	1	5	88	3.2	4.3	18

AOFAS, American orthopedic foot and ankle society; VAS, Visual analogue score.

Table 3 Results of the study

	Preoperative	Postoperative
Average VAS (points)	8.16	2.32
Average talar tilt angle (deg.)	17.64	3.41
Average talocalcaneal angle (deg.)	11.26	3.37
Average anterior drawer test (mm)	10.56	4.92
Average AOFAS (points)	41.96	86.24

AOFAS, American orthopedic foot and ankle society; VAS, Visual analogue score.

Discussion

Acute lateral ankle ligament injuries are common. If left untreated, they can result in chronic instability. Nonsurgical measures, including functional rehabilitation, are the management methods of choice for acute injuries, with surgical intervention reserved for high-demand athletes [6].

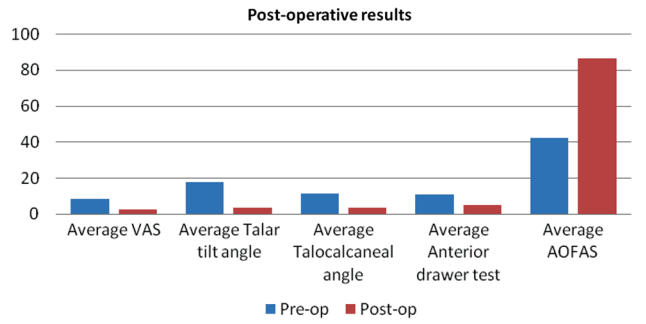
Chronic lateral ankle instability is multifactorial [7]. Failed nonsurgical management after appropriate rehabilitation is an indication for surgery. Of the many surgical options available, anatomic repair of the anterior talofibular and calcaneofibular ligaments is recommended when the quality of the ruptured ligaments permits. Anatomic reconstruction with autograft or allograft should be performed when the ruptured ligaments are attenuated [8].

Paterson *et al.* [9] reported the surgical technique and result of reconstruction of the anterior talofibular ligament using a semitendinosus free graft in 26 patients with an average follow-up of 24 months. Eighty-one percent of patients reported complete resolution or substantial improvement in instability, swelling, and sharp pain. Episodes of functional instability persisted in five patients postoperatively. Short-term results suggest that this ligament reconstruction provides good results without sacrifice of peroneal function and has minimal donor site morbidity.

Coughlin *et al.* [10] treated 28 patients (29 ankles) with chronic ankle instability with a direct anterior talofibular ligament repair and free gracilis tendon graft augmentation. The average follow-up was 23 months. Good or excellent outcome was noted on patient subjective self-assessment, pain scores, AOFAS, and Karlsson scores. The talar tilt was reduced from a mean of 13–3° ($P < 0.0001$), and the anterior drawer was reduced from a mean of 10–5 mm ($P < 0.0001$) by the lateral ankle ligamentous reconstruction.

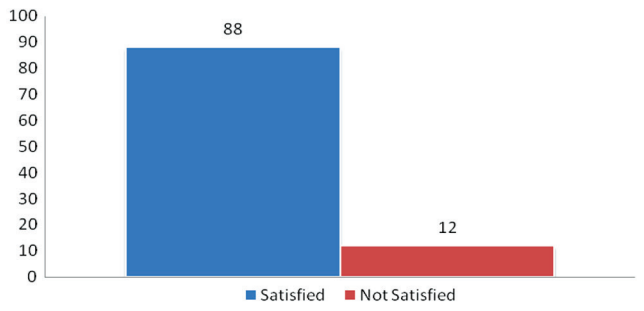
Takao *et al.* [1] described an interference fixation technique using single limbs of the gracilis tendon for 21 patients with lateral instability of the ankle. In 17 patients who received only the anterior talofibular

Figure 1



Results of the study. AOFAS, american orthopedic foot and ankle society; VAS, Visual analogue score.

Figure 2



Postoperative patient satisfaction.

ligament reconstruction, the mean talar tilt angle on standard stress radiography of the talocrural joint was 14.5 ± 1.7° before surgery and 2.6 ± 0.8° 2 years after surgery ($P < 0.0001$). In four patients who had both the anterior talofibular ligament and calcaneofibular ligament reconstructed, the mean talar tilt angle was 16.5 ± 1.5° before surgery and 3.0 ± 0.5° 2 years after surgery ($P = 0.0015$). The overall mean talocalcaneal angle on standard stress radiography of the subtalar joint was 11.3 ± 1.4° before surgery and 3.5 ± 0.8° 2 years after surgery ($P = 0.0060$).

Ibrahim *et al.* [11] treated 16 patients (11 male patients and five female patients) with lateral ankle instability using the gracilis autograft. Their age ranged from 18 to 29 giving a mean age of 25 years. During the final follow-up, the mean postoperative AOFAS score was 96 (range 80–100). The talar tilt angle was reduced from a mean of 12.4° and the anterior drawer was reduced from a mean of 11.4 mm by the ankle ligament reconstruction.

Richter *et al.* [12] reported open reconstruction of lateral ligament with hamstring tendon autograft in 20 patients with chronic lateral instability of the ankle. All patients were evaluated after a mean follow-up of 1.8 years. Clinical evaluation referred to the AOFAS score. Stress radiography was performed preoperatively and postoperatively; 19 of 20 patients reported good stability. The mean postoperative AOFAS score was 92 of 100 points (72–100). Stress radiography showed a significant reduction of both lateral ankle instability and talar tilt.

To date, there are few reports about percutaneous reconstruction of the lateral ligament of the ankle. The advantages of open techniques are dealing with simultaneous peroneal or calcaneal disorders. In patients without these lesions, no benefits are present for the open techniques [13]. Hence, we performed percutaneous autograft reconstruction, which allows better cosmesis, short operative time, less soft tissue dissection, early rehabilitation program, and no additional cost or complications for autograft.

Youn *et al.* [5] described percutaneous lateral ligament reconstruction with allograft for chronic lateral ankle instability on 15 ankles in 13 patients. The mean follow-up period was 18.1 months. The allografted tendon was secured by two biodegradable screws. Thirteen patients were satisfied with excellent or good results. Radiologically, the mean varus tilting angle was 15.5° preoperatively and 7.3 at the final follow-up. The anterior drawer distance was 10.1 mm preoperatively and 7.2 mm at the final follow-up.

Wang and Xu [14,15] treated 25 patients with semitendinosus autograft by percutaneous technique. The mean follow-up was 32.3 months (range 12–56), and the mean AOFAS improved from 71.1 to 95.1. Two patients reported residual instability on uneven ground. The satisfaction level was excellent in 20 patients and good in five patients. Significant improvement was observed in stress radiographs for the talar tilt angle with reduction from a mean of 14–3.8° and the mean anterior drawer test improved from 12.3 to 4.6 mm.

In our study, the proposed technique allows reconstruction of both the anterior talofibular and calcaneofibular ligaments in the same setting using the same autograft and with the use of biodegradable screws. After an average of 23.44 months, the average postoperative VAS was 2.38 and the average postoperative AOFAS was 86.22. The average postoperative talar tilt angle was 3.42° ($P < 0.015$) and the average anterior drawer test postoperatively was 5.05 mm ($P < 0.0001$). Hence, our results were comparable with the results of many authors at early follow-up.

Conclusion

Chronic ankle instability is a disabling problem especially in young people and athletes. Surgical treatment is usually indicated to provide pain relief and better function of the ankle. Several treatment options are available. The technique of anatomical percutaneous reconstruction using the semitendinosus autograft tendon and biodegradable screws is reliable and promising because of significant reduction of pain and negligible loss of ankle and hind foot motion. Finally, we recommend percutaneous autograft reconstruction as a good alternative because of its minimal invasiveness and easy and fast technique. Furthermore, there was no additional cost or complications for allograft. However, longer periods of follow-up are needed.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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