Ligament reconstruction for ankle instability

A 5-year prospective RSA follow-up of 30 cases

Richard Löfvenberg, Johan Kärrholm and Olof Ahlgren

30 ankles in 27 patients operated on for chronic lateral instability with tensioning of the lateral ligaments and capsular tissue were examined using RSA preoperatively, at 20 and 60 months. 28 ankles were considered excellent or improved by the patients. Mechanical stability (talar adduction and translation) was increased without compromising the passive range of motions.

Department of Orthopedics, Umeå University Hospital, S-901 85 Umeå, Sweden. Tel +46 90-1010 00. Fax -13 74 55
Submitted 93-08-10. Accepted 94-02-18

Three-dimensional determination of the talocrural joint motions has mostly been performed in cadaver or amputation specimens (Rasmussen and Tovborg-Jensen 1981, Kjærsgaard-Andersen et al. 1989). The introduction of roentgen stereophotogrammetric analysis (RSA) enabled in vivo investigations. In previous studies we have used RSA to measure the talar and subtalar motions during a modified anterior drawer and adduction test in patients with chronic lateral instability of the ankle (Löfvenberg et al. 1989, 1992, Löfvenberg and Kärrholm 1993).

In this prospective study we evaluated reconstruction of the lateral ankle ligaments with reference to patient satisfaction and stability.

Patients and methods

Between 1984 and 1988, 68 patients were operated on at our department because of chronic lateral instability of the ankle (CLI). This condition was defined as frequent sprains, difficulty in walking and running on uneven ground, often pain and giving-way (Broström 1966, Brand et al. 1977, Javors and Violet 1985). 27 of these patients, 21 men and 6 women, mean age 30 (16–54) years, agreed to participate in a prospective RSA study of the stability and kinematics of the ankle. They had had their symptoms for 8 (1–25) years, were informed about the purpose of the study and approved the implantation of bone markers. 14 had unilateral and 13 bilateral problems. 10 previously operated ankles in patients with bilateral instability were excluded leaving 30 ankles to be studied. Minor lateral osteophytes were found in 3 ankles, fragments at the tip of the lateral malleolus in 5 ankles, and none had narrowing of the joint space.

Examinations

RSA examinations were done preoperatively 20 (12–35) months and 60 (42–83) months after surgery (Table 1). The non-symptomatic ankle in patients with unilateral instability was examined only preoperatively. The patient satisfaction (as regards pain, instability, working ability, sports) was recorded using a questionnaire filled out by the patient preoperatively and at the last follow-up.

At the RSA examinations local anesthetic (Citanest®) was injected into the lateral part of the talocrural joint. The patients were examined in the supine position, with the knee slightly flexed and the ankle in different positions, according to Table 1. The ankle was placed in the neutral position (90°) and maximum dorsal flexion was obtained by using an adjustable plastic splint. Maximum passive plantar flexion and adduction were performed manually by the examiner. During the manual adduction test,

Table 1. Ankles examined with RSA.

	Preoperatively	20 months	60 months
Neutral	26	26	27
Dorsal	21	21	21
Plantar	21	21	21
Adduction	25	25	27
Adduction 5 Nm	–	–	27
Drawer test 40 N	22	22	22
Drawer test 160 N	18	18	18

One ankle was excluded from all examinations because of poor position of the tantalum markers. 3 ankles were not included in the second follow-up. Some ankles were not examined in all the tests preoperatively and in a few cases the radiographs could not be analyzed because the tantalum balls were not clearly visible.

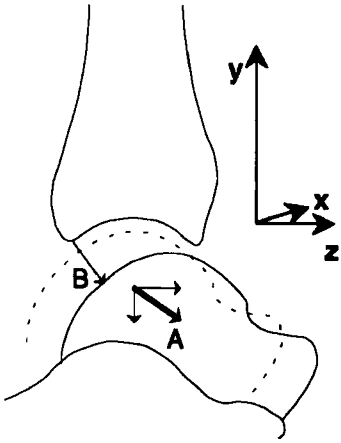

Figure 1. Total talar translation (A) (thick arrow), i.e., the vectorial sum of the translations along the 3 coordinate axes. Anterior talar translation measured as the absolute distance (B) between the posterior lip of the tibia and trochlea tali, thereby including joint cartilage in the measurement.

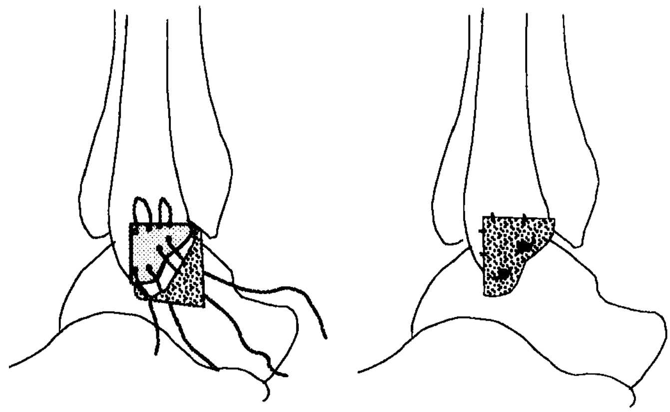

Figure 2. Surgical technique. Sutures are placed (left) in the periosteal, ligament and capsular flap, threaded through the bore canals in the fibula and back again and then tightened (right). Additional adaptation sutures are placed in the periost.

the ankles assumed the position which gave the least resistance. This resulted in a plantar-flexed and slightly internally rotated position of the talus (Table 2).

At the 5-year follow-up the adduction test was also performed under constrained conditions, with a predetermined torque of 5 Nm. At this examination the lower leg was placed in another plastic splint connected to a shoe by a hinge designed to allow motions in the frontal plane. The shoe was supplied with an arched sole and a cord was fastened to its lateral side. The cord ran through a pulley to a weight on the medial side of the examination table (Löfvenberg et al. 1992, Löfvenberg and Kärrholm 1993).

The anterior drawer tests were performed at 10° of plantar flexion, with the sole of the foot placed on a platform positioned inside the calibration cage (Löfvenberg et al. 1989). Three exposures were done: one without a load (starting point) and two with posteriorly directed loads (40 and 160 N). The loads were applied for 2 (at 40 N) and 4 minutes (at 160 N) to the tibia 20 cm proximal to the medial malleolus.

Talar rotations and translations were measured in relation to the neutral position (90°), using the bone markers in the distal tibia as the fixed reference segment. Talar translations were represented by the motions of a fictive point at the center of the talus. This fictive point was plotted on the AP and lateral views of the talus in the neutral position of the ankle. Its position at the subsequent exposures was mathematically calculated by using the known positions of the tantalum markers in the talus (Kärrholm et al. 1988, Löfvenberg et al. 1989).

The evaluation of the RSA radiographs has been described by Kärrholm et al. (1988). The total talar translation, i.e., the vectorial sum of the anterior, proximal–distal and medial–lateral displacement (Figure 1) of the talar center, was calculated. The reproducibility of the testing procedure has been reported by Löfvenberg et al. (1989) and Löfvenberg and Kärrholm (1993).

The operation

A soft-tissue flap including the periosteum, the fibrous tissue corresponding to the insertion of the anterior talo-fibular and calcaneo-fibular ligament, and capsular tissue was created starting approximately 2 cm proximal to the distal tip of the fibula according to Ahlgren and Larsson (1989). The entire ligaments were not explored. The fibula was decorticated, corresponding to the periosteal part of the flap. 3 or 4 canals were drilled from the distal tip of the fibula into the decorticated area. The periosteal-capsular-ligamentous flap was tightened with the foot in pronation and secured with resorbable or non-resorbable sutures to the fibula through the canals (Figure 2).

The average duration of the operation was 1 hour. The patients stayed in the hospital for 4 (1–8) days. A below-knee walking cast was used for 6 weeks. Full weight bearing was allowed for the last 4 weeks, after which physiotherapy was initiated. Full activity without any restriction was allowed at 3 months. In

Table 2. Talar rotation around the cardinal axes from passive dorsal to passive plantar flexion

Talar rotation (degrees)		Preoperatively (A)		20 months (B)		60 months (C)		P-value		
n 22	Axis	Median	Range	Median	Range	Median	Range	A–B	A–C	B–C
Dorsal–plantar flexion	x	58	(33–77)	54	(24–78)	53	(34–74)	0.3	0.4	0.02
Internal +/External –	y	6.2	(–1.7–21)	5.2	(–4.6–24)	7.7	(–2.7–23)	0.5	0.8	0.2
Adduction +/Abduction –	z	3.7	(–18–21)	2.3	(–13 –19)	5.2	(–15–20)	0.1	0.8	0.3

Table 3. Talar rotation around the cardinal axes during manual adduction test

Talar rotation (degrees)	Preoperatively (A)		20 months (B)		60 months (C)		P-value		
n 25	Median	Range	Median	Range	Median	Range	A–B	A–C	B–C
Plantar flexion	27	(2.1–49)	21	(4.2–38)	21	(5.2–35)	0.03	0.03	0.8
Internal + / External–	3.4	(–8.2–15)	1.4	(–9.9–15)	1.5	(–9.8–15)	0.4	0.7	0.5
Adduction+/Abduction–	7.8	(–1.5–19)	5.2	(–2.8–15)	6.1	(–2.8–18)	0.002	0.002	0.2

physically demanding situations, the patients were advised to use external support during the first year.

Statistics

Wilcoxon matched-pairs signed-ranks test, Spearman's rank correlation test and the Pearson chi-square test were used. Values are presented as median and range, unless otherwise stated.

Results

Range of motion

The talar rotations from maximum passive dorsal to plantar flexion were not impaired by the operation (Table 2). From the dorsiflexed position to the plantar-flexed position the preoperartive adduction and internal rotation of the talus had not changed after surgery.

Manual adduction test

In patients with unilateral problems, an increased talar tilt was recorded preoperatively on the symptomatic side (5.5°; –1.2°–16.6°) compared to the non-symptomatic side (1.8°; -3.2°–10.3°; P 0.009). There was no correlation between the obtained talar plantar flexion and adduction (r 0.20).

After surgery, talar adduction was reduced, internal rotation was not altered, and plantar flexion was decreased (Table 3).

At the 5-year follow-up the stability of the operated ankles in patients with unilateral symptoms did not differ from the non-symptomatic side.

Adduction test with a predetermined torque (5 Nm)

When the adduction test was performed with a predetermined torque (5 Nm, n 27) under more constrained conditions, the talus was less plantar flexed (12°) and displayed an external rotation (3.5°) which was separated from the internal rotation (1.5°) during the manual testing procedure ($P < 0.001$). The correlation between the constrained (4.5°) and non-constrained (5.7°) testing procedures regarding the talar rotation around the AP axis was 0.75 ($P < 0.001$). There was no difference in talar rotations around the AP axis between the 2 testing procedures.

Anterior drawer test

In the anterior drawer tests the talus displaced medially, distally and anteriorly.

Before surgery the total talar translations were 1.4 (0.1–9.1) mm, using 40 N and 5.3 (0.7–10) mm at the greater load in the ankles with symptoms (Table 4). The difference between the two loads was substantial, not only at the initial examination (4.1 mm, P 0.008) but also at the follow-up (Figure 3).

In the patients with unilateral symptoms, the side with instability had increased laxity at the preoperative examination (5.1 [0.7–7.7] mm) compared to the opposite side (2.6 [0.3–6.4] mm) when tested at 160 N ($P < 0.03$, n 11), but not at 40 N.

At the first follow-up, the total talar translations decreased at both loads and a still smaller laxity was recorded at the 5-year follow-up, using the 160 N load (Figure 3). No significant difference was noted in talar translation when comparing the ankles without symptoms (the initial examination) in patients

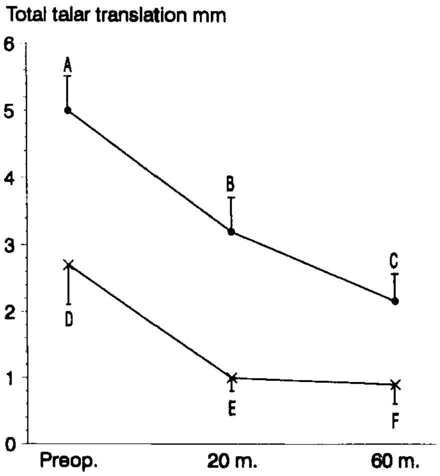

Figure 3. Total talar translation in mm during posterior load with 40 N (×; n 22) and 160 N (●; n 18) of the tibia preoperatively, at 20 and 60 months postoperatively (mean, SEM). A–B P 0.007, A–C P < 0.001, B–C P 0.01. D–E P 0.01, and D–F P 0.001.

having unilateral problems with their corresponding operated ankles at the 5-year follow-up. The talar rotations during the anterior drawer tests were small with no difference between the primary and the follow-up investigations.

Subjective results

Before surgery, all patients had symptoms of instability. 23 experienced pain and 10 had swollen ankles. At the 5-year follow-up the subjective feeling of instability had disappeared in 16 ankles and was reduced in 13. In 1 patient the symptom of instability remained unchanged. 20 ankles were free of pain at follow-up, in 5 ankles the pain was reduced, and in 5 it was unaffected. None of the ankles was swollen.

At the 5-year follow-up 16 patients (17 ankles) rated the overall result as excellent; 9 patients (11 ankles) improved, and 2 ankles were considered not improved. There was no sex difference.

24 patients could resume their former occupation. In 2 of the 3 patients who did not resume their vocations, this was because of persistent ankle symptoms. 17 patients could take up their previous sport. 7 of the remaining 10 could not, due to ankle symptoms.

Ankle joint laxity and clinical results (Table 4)

Preoperatively, there was no difference in talar stability between the excellent and the improved groups. In the excellent group there was a reduction in talar adduction postoperatively, which was not noted in the improved group. The total talar translation was reduced 1 mm/2.6 mm (40 N/160 N) in the excellent group and 1.3 mm/1.8 mm in the improved group.

In the 2 patients who reported that they were not improved, the adduction was reduced from 12° to

Table 4. Ankle joint laxity-stability, i.e., total rotation around z-axis in degrees and total talar translation in mm, in relation to the clinical results

		Preoperatively (A)		20 months (B)		60 months (C)		*P*-value		
	n	Median	Range	Median	Range	Median	Range	A–B	A–C	B–C
Rotation (adduction test), n 25										
Excellent	14	4.7	(–1.5–17)	2.7	(–2.8–15)	4.0	(–2.8–18)	0.03	0.01	0.8
Improved	9	8.1	(1.8–19)	6.2	(–1.7–13)	8.6	(–1.9–15)	0.09	0.1	0.1
Unchanged	2	11.6		5.9		7				
		14.3		11.8		13				
Translation at 40 N, n 22										
Excellent	11	1.5	(0.7–9.1)	0.5	(0.2–1.5)	0.6	(0.0–1.4)	0.01	0.007	0.9
Improved	9	2.3	(0.4–5.7)	0.9	(0.2–3.5)	0.5	(0.2–7.4)	0.2	0.05	0.5
Unchanged	2	0.1		0.5		0.1				
		0.6		0.3		0.8				
Translation at 160 N, n 18										
Excellent	11	4.4	(2.3–10.1)	3,0	(0.2–6.9)	1.8	(0.7–5.0)	0.02	0.003	0.1
Improved	5	5.8	(5.4 –7.7)	3.7	(0.9 –7.5)	1.2	(0.6 – 5.4)	0.2	0.08	0.5
Unchanged	2	0.7		1.1		0.1				
		4.1		2.1		0.8				
Translation at 40 N and 160 N										
40 N	22	1.4	(0.1 –9.1)	0.5	(0.2–3.5)	0.5	(0.0–7.4)	0.01	0.001	0.6
160 N	18	5.3	(0.7–10.1)	3.0	(0.2–7.5)	1.4	(0.1 –5.4)	0.007	0.0002	0.01

7.0° and 14° to 13°, respectively. The talar translation was changed from 0.1/0.7 mm to 0.1/0.1 mm in one patient and from 0.6/4.1 mm to 0.8/0.8 mm in the other.

Discussion

Chronic lateral instability occurs in 10–20 percent of patients after acute ligament rupture in spite of adequate treatment (Broström 1966, Balduini and Tetzlaff 1982). There are some reports on the efficacy of conservative treatment and the prevention of recurrent sprains (Garrick and Requa 1973, Glick et al. 1976, Larsen 1984, Tropp et al. 1985, Firer 1990, Löfvenberg et al. 1993) but no overall results in patients with chronic lateral instability of the ankle have been reported (Peters et al. 1991). The results of surgery are more frequently reported and include more than 50 procedures (Peters et al. 1991, Karlsson and Lansinger 1992). The clinical outcome in many of these studies is comparable to our results, with good or excellent in 80–90 percent of the cases, although there are only a few studies with a 5-year follow-up or more (Cass et al. 1985, Snook et al. 1985, Karlsson et al. 1988, Korkala et al. 1991).

In more recent literature (Karlsson et al. 1988, Ahlgren and Larsson 1989, Peters et al. 1991) reconstruction of the lateral ligament complex using remnants of the ligaments and local tissue or direct suture is advocated. The authors argue that, if tendons are not incorporated in the repair, the joint kinematics will not be negatively influenced (Broström 1966, Peters et al. 1991). It has also been reported that these procedures will minimize postoperative stiffness although the postoperative range of motion is not usually described. In our study these statements were confirmed. Kristiansen (1981) reported reduced extension/flexion in 3 of 18 ankles 3 years after Evans' tenodesis, but without stating the preoperative range of motions. The ROM commonly receives little, if any, attention in studies on tendon reconstructions.

In most studies the anterior talar translation is measured as the shortest distance between the tangent of the talar trochlea and the inferoposterior corner of the distal tibia, corresponding to a combination of anterior and distal translations (Kristiansen 1981, Korkala et al. 1991, Karlsson and Lansinger 1992). Unlike most other researchers, we have measured the actual translation, i.e., the distance between a starting position of the ankle before loading and the position obtained during the loading procedure. In some previous techniques (Karlsson 1989) the measurement included the width of the joint cartilage and this recording was done on only one loaded radiograph (Figure 1). The joint cartilage has an average width of 3.1 mm (±0.6 mm) in normal ankles as well as in ankles with long-standing instability (Löfvenberg et al. 1993). By the gravitational forces acting on the tibia in our testing situation, there might have been an anterior translation of the talus relative to the tibia, even in the starting position.

The technique of measurement in our recordings and the lack of information about correction for magnification in previous studies could explain wht the talar translations in our study are smaller than in others. Karlsson (1989) used the Telos apparatus with the lateral or medial malleolus facing downwards and applied a load of 150 N. By using the pre–postoperative reduction in talar translation, differences in the technique of measurement can partly be compensated for. In our study the findings of decreasing talar translations between the 2- and 5-year follow-ups when tested at 160 N, but not at 40 N, might be due to several factors. The muscle strength could have increased due to a feeling of improved stability and increased activity. A more probable explanation might be a continuous stiffening of the ligaments and the lateral capsular tissue, which is easier to demonstrate at the higher loads.

The talar tilt reported by Karlsson (1989) in 57 patients with unilateral instability was equivalent to our findings in 13 patients with unilateral instability (2.6° in stable ankles; 8.4° in unstable ankles). To obtain a more standardized evaluation of the talar tilt we added a test using a defined torque in the later part of this study. An acceptable correlation was found, although the talar adduction tended to be greater in the manual test. This finding may support the use of an unconstrained testing procedure. Studies which compare the preoperative and postoperative mechanical stability on a long-term basis are rare (Keller et al. 1981, Karlsson et al. 1988). Milachowski and Wirth (1988) reported in a 4-year follow-up a reduction of the talar tilt from about 15° to 6°–8° using 3 different operative procedures, but did not compare the same groups of patients pre- and postoperatively and did not report how the instability was measured. The reduction of anterior talar translation in their material varied between 0.1 and 3.5 mm. In 21 patients they used a ligament advancement somewhat resembling our operation and obtained 9.1° reduction in talar tilt and 3.5 mm reduction in anterior subluxation. However, the residual tilting was 6.1° and the anterior subluxation 8 mm, indicating other testing procedures and/or a selection of patients with a more pronounced instability.

Some authors argue that subtalar instability might be an important component in CLI on the basis of their clinical impression, but without stating or actually measuring the skeletal motions (Sefton et al. 1979, Larsen 1990). In a previous study we did not find any instability in the talocalcaneal joint in patients scheduled for reconstructive surgery, indicating that the stabilization of the talocrural joint is a prerequisite for good results (Löfvenberg et al. 1992).

We conclude that tensioning of the lateral ligaments in patients with chronic lateral instability stabilized the ankle joint for at least 5 years and without compromising the passive range of motion. Because this stabilization was associated with patient satisfaction in a majority of the cases we recommend this surgical technique.

Acknowledgements

This study was supported by grants from Stina and Arne Lundbergs stiftelse, Samverkansnämnden för norra regionen, Swedish Medical Research Council B92-17X-07941-06B and from funds at the Medical Faculty of the University of Umeå.

References

Ahlgren O, Larsson S. Reconstruction for lateral ligament injuries of the ankle. J Bone Joint Surg (Br) 1989; 71 (2): 300–3.

Balduini F C, Tetzlaff J. Historical perspectives on injuries of the ligaments of the ankle. Clin Sports Med 1982; 1 (1): 3–12.

Brand R L, Black H M, Cox J S. The natural history of inadequately treated ankle sprain. Am J Sports Med 1977 ; 5 (6): 248–9.

Broström L. Sprained ankles. VI. Surgical treatment of "chronic" ligament ruptures. Acta Chir Scand 1966; 132 (5): 551–65.

Cass J R, Morrey B F, Katoh Y, Chao E Y. Ankle instability: comparison of primary repair and delayed reconstruction after long-term follow-up study. Clin Orthop 1985; 198: 110–7.

Firer P. Effectiveness of taping for the prevention of ankle ligament sprains. Br J Sports Med 1990; 24 (1): 47–50.

Garrick J G, Requa R K. Role of external support in the prevention of ankle sprains. Med Sci Sports 1973; 5 (3): 200–3.

Glick J M, Gordon R B, Nishimoto D. The prevention and treatment of ankle injuries. Am J Sports Med 1976; 4 (4): 136–41.

Javors J R, Violet J T. Correction of chronic lateral ligament instability of the ankle by use of the Broström procedure. A report of 15 cases. Clin Orthop 1985; 198: 201–7.

Karlsson J. Chronic lateral instability of the ankle joint. A clinical, radiological and experimental study. Thesis, Gothenburg University Hospital, Gothenburg, Sweden 1989.

Karlsson J, Lansinger O. Lateral instability of the ankle joint. Clin Orthop 1992; 276: 253–61.

Karlsson J, Bergsten T, Lansinger O, Peterson L. Reconstruction of the lateral ligaments of the ankle for chronic lateral instability. J Bone Joint Surg (Am) 1988; 70 (4): 581–8.

Keller E, Meeder P J, Weller S. Ergebnisse einer modifizierten Watson-Jones-Plastik zur Behandlung der chronischen fibularen Bandinsuffizienz. Aktuel Traumatol 1981; 11 (5): 179–84.

Kjærsgaard-Andersen P, Söjbjerg J O, Wethelund J O, Helmig P, Madsen F. Watson-Jones tenodesis for ankle instability. A mechanical analysis in amputation specimens. Acta Orthop Scand 1989; 60 (4): 477–80.

Korkala O, Tanskanen P, Mäkijärvi J, Sorvali T, Ylikoski M, Haapala J. Long-term results of the Evan's procedure for lateral instability of the ankle. J Bone Joint Surg (Br) 1991; 73 (1): 96–9.

Kristiansen B. Evans' repair of lateral instability of the ankle joint. Acta Orthop Scand 1981; 52 (6): 679–82.

Kärrholm J, Selvik G, Elmqvist L G, Hansson L I, Jonsson H. Three-dimensional instability of the anterior cruciate deficient knee. J Bone Joint Surg (Br) 1988; 70 (5): 777–83.

Larsen E. Taping the ankle for chronic instability. Acta Orthop Scand 1984; 55 (5): 551–3.

Larsen E. Static or dynamic repair of chronic lateral ankle instability. A prospective randomized study. Clin Orthop 1990; 257: 184–92.

Löfvenberg R, Kärrholm J. The influence of an ankle orthosis on the talar and calcaneal motions in chronic lateral instability of the ankle. A stereophotogrammetric analysis. Am J Sports Med 1993; 21 (2): 224–30.

Löfvenberg R, Kärrholm J, Selvik G, Hansson L I, Ahlgren O. Chronic lateral instability of the ankle. Roentgen stereophotogrammetry of talar position. Acta Orthop Scand 1989; 60 (1): 34–9.

Löfvenberg R, Kärrholm J, Lundberg A. Subtalar stability in chronic lateral instability of the ankle. Foot 1992; 2 (1): 32–43.

Löfvenberg R, Kärrholm J, Lund B. 20 year follow-up of non-operated patients with chronic lateral instabibility of the ankle. Foot Ankle 1994; 15 (4): 165–9.

Milachowski K A, Wirth C J. The results of reconstruction of the lateral ligaments of the ankle. Int Orthop 1988; 12 (1): 51–5.

Peters J W, Trevino S G, Renstrom P A. Chronic lateral ankle instability. Foot Ankle 1991; 12 (3): 182–91.

Rasmussen O, Tovborg-Jensen I. Anterolateral rotational instability in the ankle joint. An experimental study of anterolateral rotational instability, talar tilt, and anterior drawer sign in relation to injuries to the lateral ligaments. Acta Orthop Scand 1981; 52 (1): 99–102.

Sefton G K, George J, Fitton J M, McMullen H. Reconstruction of the anterior talofibular ligament for the treatment of the unstable ankle. J Bone Joint Surg (Br) 1979; 61 B (3): 352–4.

Snook G A, Chrisman O D, Wilson T C. Long-term results of the Chrisman-Snook operation for reconstruction of the lateral ligaments of the ankle. J Bone Joint Surg (Am) 1985; 67 (1): 1–7.

Tropp H, Askling C, Gillquist J. Prevention of ankle sprains. Am J Sports Med 1985; 13 (4): 259–62.