ORIGINAL ARTICLE

Dorsal calcaneocuboid ligament versus lateral ankle ligament repair: a case-control study

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Objective: Anatomic reconstruction is the treatment of choice for lateral ankle ligament instability. A similar technique has recently been described for stabilisation of a chronic unstable calcaneocuboid joint as an alternative to the previously proposed tenodesis and arthrodesis procedures.

Methods: Five consecutive young females experiencing recurrent giving way of six calcaneocuboid joints were treated operatively during a 4 year period using anatomic ligament repair reinforced by a periosteal flap. Results were compared to five patients who underwent anatomic lateral ankle ligament repair in a case-control design. Outcome was measured using the Foot and Ankle Outcome Score, physical examination, and stress radiographic and MRI (calcaneocuboid group) investigation. Functional neuromuscular performance was evaluated by isokinetic torque measurements, posturometry, single-leg drop jumps, and single-leg long jumps.

Results: Outcome scores at follow up (5–61 months after surgery) revealed excellent results for both groups. No relevant difference was found between the affected legs and the non-affected legs or between groups with respect to the outcome measures. MRI exhibited ligament-like structures at the repaired dorsal calcaneocuboid joints in five out of six joints.

Conclusions: Results of anatomic repair of unstable lateral ankle and isolated calcaneocuboid joint instability equally lead to excellent results.

Lateral ankle ligament instability is a frequent well known condition. Diagnostic principles and evidence based treatment is established and generally accepted.^{1,2} Incidence is rated to be one sprain per 10 000 persons each day and 20–40% of patients are reported to develop persistent problems following this injury.³ Differential diagnosis in these cases includes additional injuries affecting different structures⁴; isolated dorsal calcaneocuboid ligament lesions may possibly be one cause.⁵ Rare epidemiologic data regarding the frequency of this injury reveal that about 5.5% of all inversion injuries involve the dorsal calcaneocuboid ligament and about one third of such patients develop a chronically unstable calcaneocuboid joint.⁵ One can therefore calculate that approximately one chronically unstable calcaneocuboid joint per 500 000 people develops each day.

In principle, lesions of the dorsal calcaneocuboid ligament and lateral ankle ligaments seem to result from a similar mechanism, indicating that both joints are functionally connected.^{6,7} Calcaneocuboid joint injuries have been graded with respect to radiographic and stress radiographic findings.⁸ Arthrodesis,⁹ plantaris¹⁰ or peroneus brevis⁸ tenodesis, and periosteal augmented repair¹¹ have been suggested for treatment of chronically unstable cases.

This report compares the outcome of operatively treated calcaneocuboid and lateral ankle ligament lesions in order to highlight the need to further differentiate the term “ankle sprain” because of different therapeutic consequences.

METHODS

Patients

The series comprised five consecutive patients who were surgically treated for chronically unstable calcaneocuboid joints using augmented periosteal flap repair (calcaneocuboid joint repair group).¹¹ Diagnosis was based on results from individual case histories, physical examination, and calcaneocuboid stress radiographs^{5,9,11} (table 1).

Surgical files were screened retrospectively for patients who had undergone lateral ankle ligament repair¹² because of chronic lateral ankle instability during the same period. Five patients who met these criteria (lateral ankle repair group) were matched to the calcaneocuboid joint repair group with respect to sex, age, and sporting activity level. Both groups were compared in a case-control study.

Follow-up examination

The study was approved by the local ethics committee and written consent was obtained from all patients. Anthropometric data, the course of postoperative rehabilitation, and the individual level of activity¹³ were assessed.

Physical examination consisted of investigation of the axial alignment and hypermobility testing of the lower extremities. Talar tilt and anterior talar drawer tests as well as lateral calcaneocuboid instability tests¹¹ were estimated in degrees or millimetres. Range of motion was determined for all ankles using a goniometer. A reduction of more than 5° as compared with the contralateral ankle was considered to be a limited range of motion.² Tenderness at the lateral ankle and calcaneocuboid joint was determined. The circumference around the transverse tarsal joint and around the anterior part of the ankles and the heels was measured.

Patient relevant outcome was assessed by the Foot and Ankle Outcome Score, which is a valid and reliable evaluation instrument related to ankle ligament reconstruction, including sporting and recreational function.¹⁴

Ankle¹⁵ and calcaneocuboid stress radiographs^{9,11,16} were taken bilaterally and analysed.

MRI investigation was performed for all repaired calcaneocuboid ligaments (1.5 T unit, Sonata, Siemens, Erlangen, Germany).

Single-limb posturometry is a validated test which has been shown to differentiate between functionally unstable and stable ankles.¹⁷ The stance plate of a Posturomed system (Haider Bioswing, Pullenreuth, Germany) was unexpectedly

Table 1 Diagnostic criteria for isolated calcaneocuboid ligament instability

	Mandatory	Optional
History	Inversion-plantarflexion injury Recurrent (fear of) giving way†	Haematoma covering the calcaneocuboid joint* Calcaneocuboid joint swelling and load induced pain Walking on uneven ground is painful
Physical examination	Pain on palpation at the calcaneocuboid joint Lateral ankle ligament injury excluded‡	
Dorsoplantar stress x ray	Lateral calcaneocuboid angle >10°→unstable joint No fractures or bone avulsions	No or mild degenerative signs (spurs)

*Acute injury; †chronic injury; ‡there is one report of combined instability of the lateral ankle and the calcaneocuboid joint.⁷

moved 25 mm in a lateral to medial direction while the patient (standing upright on one leg with open eyes looking directly ahead) tried to stabilise their position. The path of the centre of gravity was recorded for 20 s. Each patient's best of three tests for each leg was used for further calculation.

Isokinetic testing has been shown to be a reproducible instrument for quantification of the muscular status of the ankle.¹⁸ Measurements (Biodex System 3 PRO, Biodex Medical Systems, New York, USA) were taken using a standard concentric/concentric dorsal/plantarflexion ankle protocol at 30°/s. From this, peak torque values were calculated for each ankle.

Functional motor performance was examined by single-leg drop jump and single-leg long jump tests. Drop jumps were executed from a height of 24 cm with the hands on the hips. The time between take off and landing was registered (contact mat, Biovision, Wehrheim, Germany) and jumping height was calculated. Long jumps were executed from a standing position with the tested foot positioned at the starting line. Landing had to occur on the same foot and the covered distance was measured. Patients were allowed to practise both jumping techniques. The best of three trials for each leg was considered for further calculation.

In a pilot study, the reliability of both the single-leg drop jump and the single-leg long jump was tested. For this, both legs of 11 rhythmic gymnasts (11–16 years old) were evaluated in a test-retest design (1 week interval). Pearson's product moment correlation coefficients, Cronbach's α , and intraclass correlation coefficients for single-leg drop jumps and single-leg long jumps were all ≥ 0.95 .

Statistical analysis

Results were compared between the injured and non-injured sides, between treatment groups, and to preoperative values. The anthropometric data and outcome score measurements of both groups ($n = 5$ in each group) were compared using paired Student's t test. Injured ($n = 6$ in the calcaneocuboid joint repair group and $n = 5$ in the lateral ankle repair group) and non-injured joints ($n = 14$ and $n = 15$, respectively) were compared using unpaired t test. Significance was set at $p < 0.05$. As one patient had bilateral operations, only four patients remained in the calcaneocuboid joint repair group for individual side to side comparisons using clinical rating, radiographs, and functional motor performance. Consequently, descriptive analysis was performed for these parameters.

RESULTS

All patients were female. With the exception of body height ($p = 0.04$), anthropometric data between groups did not differ. At surgery, patients in the calcaneocuboid joint repair group were 13.7 (10–18) years old and patients in the lateral ankle repair group were 16.0 (14–19) years old ($p = 0.33$). Follow-up investigations were carried out 26.6

(9–59) months (calcaneocuboid joint repair group) and 24.2 (5–61) months (lateral ankle repair group) after surgery ($p = 0.89$). There was no specific side dominance, although take off leg was injured in all patients. The period from initial injury to first clinical presentation was 3.0 (0–10) months for the calcaneocuboid joint repair group and 8.6 (0–35) months for the lateral ankle repair group. A forceful plantarflexion-inversion mechanism while playing sport initiated the injury in all patients, resulting in recurrent instability or fear of giving way preoperatively. One gymnast underwent repair of the contralateral calcaneocuboid joint 15 months following initial surgery. There was no history of or actual lesion or previous surgery of any other joint of the same lower leg, and no signs of generalised joint laxity or generalised neuromuscular disorder in any of the subjects. There were no postoperative complications. Early functional postoperative treatment was implemented for both groups.^{5, 11}

Physical examination at follow up revealed no axial misalignment or limitation of range of motion. All ankles and calcaneocuboid joints were clinically stable. There was no swelling or pain on palpation in the affected feet.

As a consequence of the calcaneocuboid ligament lesion, ankle specific sporting abilities¹³ were considerably reduced. However, at follow up, preinjury levels had been regained (table 2) and patient relevant outcome was good or excellent in all cases (table 2).

Preoperative and follow-up radiographs of one patient demonstrated minimal calcaneocuboid bone spurs bilaterally. In the lateral ankle repair group, a similar finding was visible at one calcaneocuboid joint postoperatively. One uninjured and two injured ankles had minimal spurs preoperatively and at follow up.

Table 2 Results of operative interventions for the calcaneocuboid joint repair group (CC) and the lateral ankle repair group (Ankle)

	CC	Ankle	p
Ankle Activity Score*			
Preinjury	7.8 $\pm$ 1.9 (5–10)	7.4 $\pm$ 1.7 (6–10)	0.59
Post-injury preoperative	2.7 $\pm$ 1.3 (1–4)	3.4 $\pm$ 1.2 (1–4)	0.47
Follow up	7.6 $\pm$ 1.9 (5–10)	7.0 $\pm$ 1.8 (5–10)	0.43
Foot and Ankle Outcome† Score			
Pain	97.6 $\pm$ 3.0	86.6 $\pm$ 12.6	0.20
Symptoms	91.4 $\pm$ 7.4	74.8 $\pm$ 10.7	0.11
Activities of daily life	98.8 $\pm$ 1.5	90.6 $\pm$ 11.0	0.28
Sport and recreational activity	94.0 $\pm$ 5.8	79.0 $\pm$ 23.5	0.31
Quality of life	82.4 $\pm$ 15.6	71.6 $\pm$ 16.6	0.52

*Worst result = 0, best result = 10; †worst result = 0, best result = 100. Retrospectively calculated Ankle Activity Score,¹³ and Foot and Ankle Outcome Score¹⁴ measured at follow up. Mean $\pm$ standard deviation (range).

Table 3 Follow-up values for stress radiographic evaluation of the lateral calcaneocuboid and lateral ankle joints under investigation

Radiograph evaluation at follow up	n	Mean $\pm$ SD (range)	p
CCI ($^{\circ}$) affected joints	6	9.5 $\pm$ 3.5 (7–11)	0.81
CCI ($^{\circ}$) non-affected joints	14	8.9 $\pm$ 5.3 (0–16)	
Anterior talar drawer (mm) affected joints	5	7.0 $\pm$ 4.2 (3–15)	
Anterior talar drawer (mm) non-affected joints	15	5.5 $\pm$ 1.7 (3–8)	0.29
Talar tilt ($^{\circ}$) affected joints	5	4.0 $\pm$ 3.3 (0–9)	
Talar tilt ($^{\circ}$) non-affected joints	15	2.8 $\pm$ 2.5 (0–9)	

Mean $\pm$ standard deviation (range). CCI, calcaneocuboid stress radiographic instability.

Follow-up MRI investigation of the calcaneocuboid joints which had been operated on demonstrated ligament-like structures in all cases. Two of these structures were graded as normal, two were thicker than normal, and one was thinner than a normal dorsal calcaneocuboid ligament, while in one case an inhomogeneous structure was detected (fig 2A,B).

Preoperative calcaneocuboid and ankle stress radiograph values had improved significantly at follow up in the respective groups (fig 1). However, no difference was found in follow-up values for talar tilt ($p = 0.43$), anterior talar drawer ($p = 0.29$), and the lateral calcaneocuboid instability test ($p = 0.81$) when the uninjured and injured joints were compared with respect to the relevant diagnoses (table 3).

Posturometry at follow up showed that postural sway was lower in both the affected (-29.9%) and the non-affected (-18.3%) legs of the lateral ankle repair group (table 4). No difference could be detected between the injured and the contralateral non-injured legs in isokinetic testing, single-leg drop jumps, or single-leg long jumps (table 4). However, these values were 1.8–22.4% higher in the lateral ankle repair group but were not statistically significant (table 4).

DISCUSSION

Freeman *et al.*¹⁹ introduced the term functional ankle instability for recurrent giving way of the mechanically stable ankle. Frequently unrecognised in the past, isolated calcaneocuboid instability may be one mechanical reason for this condition which has been previously attributed to a merely proprioceptive deficit.

Combined lesions of the talo-navicular²⁰ or the cuneonavicular²¹ joints, therefore leading to a more serious transverse tarsal joint instability, have been reported. Isolated calcaneocuboid instability is rare and reports are anecdotal.^{7–11 16} The principles of diagnostic procedures,

Figure 1 Results of the calcaneocuboid stress radiographic investigations. The preoperative mean value was $20.7^{\circ} \pm 3.2^{\circ}$ (range 17–25). Stability was significantly ($p = 0.001$) improved to $9.5^{\circ} \pm 3.5^{\circ}$ (range 7–11) at follow up 2.3 years later. Paired Student's *t* test. 95% confidence interval.

treatment, and post-treatment have been established.^{5 8 11} This investigation presents the largest series so far of surgically treated isolated calcaneocuboid instabilities. In contrast to reports in the literature, the calcaneocuboid injuries in our study occurred exclusively in young females during sporting activity. Preoperatively, patients in both groups complained of persistent giving way and/or fear of giving way, associated with pain and sporting inability.

Anatomic reconstruction^{12 22} and functional post-treatment is the gold standard for management of lateral ankle instability.^{1 2} A similar procedure may protect the calcaneocuboid joint^{5 11} from risks associated with fusion or tenodesis (reduced mobility of the lateral foot column, transfer arthritis, graft absorption).

Ligamentisation of the calcaneocuboid repair was demonstrated by MRI in five of the six joints in the calcaneocuboid repair group. However, MRI morphology was not associated with outcome as evaluated by clinical, functional, and stress radiographic investigations.

The rationale for choosing lateral ankle ligament repair patients as a control group is substantiated by the fact that lesions of the dorsal calcaneocuboid ligament seem to be relevant in the differential diagnosis of anterolateral ankle instability. In addition, the surgical techniques and post-treatment are similar.

Patient relevant (Foot and Ankle Outcome Score) and mechanical (physical and stress radiographic examination)

Table 4 Results of functional testing for calcaneocuboid joint repair group (CC) and lateral ankle repair group (Ankle) comparing the affected and unaffected sides

	CC	Ankle	Mean value difference (%)
Single-leg drop jump (m), affected side	0.15 $\pm$ 0.03 (0.12–0.19)	0.17 $\pm$ 0.03 (0.14–0.23)	13.3
Single-leg drop jump (m), opposite side	0.16 $\pm$ 0.02 (0.13–0.19)	0.17 $\pm$ 0.03 (0.13–0.21)	6.3
Single-leg long jump (m), affected side	1.78 $\pm$ 0.19 (1.40–1.96)	1.95 $\pm$ 0.15 (1.80–2.20)	9.6
Single-leg long jump (m), opposite side	1.72 $\pm$ 0.23 (1.38–2.01)	1.96 $\pm$ 0.14 (1.70–2.09)	14.0
Isokinetic plantarflexion 30° (Nm), affected side	41.0 $\pm$ 19.9 (16.00–75.50)	50.2 $\pm$ 14.1 (34.40–73.90)	22.4
Isokinetic plantarflexion 30° (Nm), opposite side	43.3 $\pm$ 17.5 (27.80–61.10)	44.1 $\pm$ 11.5 (28.10–57.20)	1.8
Isokinetic dorsiflexion 30° (Nm), affected side	11.2 $\pm$ 2.5 (8.50–15.10)	14.0 $\pm$ 2.8 (10.80–18.60)	25
Isokinetic dorsiflexion 30° (Nm), opposite side	12.3 $\pm$ 1.7 (10.20–14.40)	13.5 $\pm$ 3.3 (10.20–18.10)	9.8
Posturometry, length of path (mm), affected side	197.7 $\pm$ 17.2 (172.0–223.0)	138.6 $\pm$ 9.9 (130.0–155.0)	-29.9
Posturometry, length of path (mm), opposite side	195.5 $\pm$ 125.7 (65.0–365.0)	159.8 $\pm$ 62.2 (94.0–278.0)	-18.3

Numbers for the affected side are six in the CC group and five in the ankle group. Numbers for the opposite side are four in the CC group and five in the ankle group. Mean $\pm$ standard deviation (range).

Figure 2 MRI of reconstructed dorsal calcaneocuboid ligaments at follow-up investigation. A ligament-like structure is visible adjacent to the implanted anchor (*) 15 months after surgery, patient 2 (A). The reconstructed structure resembles a normal ligament 59 months after surgery, patient 3 (B). Reconstructed dorsal calcaneocuboid ligament is indicated between arrows.

data were gathered at follow up and neuromuscular control was measured. No relevant differences between the injured and the uninjured sides could be detected (tables 3 and 4). Considering the fact that all injuries were to the dominant leg, one might argue that functional tests would show superior capacity on this side. However, the literature does not support this assumption, stating that regardless of whether the dominant or non-dominant leg is investigated, the uninvolved leg can be used as a reference.^{23, 24} Follow-up stress radiographic investigation demonstrated normal values as compared to standards known from the literature for calcaneocuboid joints¹⁶ and lateral ankles.^{2, 15} If not random, the observed systematic group differences in favour of the lateral ankle repair group regarding jumping ability, isokinetic performance, and posturometry (table 4) need substantiation by further research. Furthermore, these findings are not mirrored by the results of patient relevant outcome score evaluation (table 2). Restoration of sporting activity levels (table 2) is in accordance with previously published material for anatomical ankle ligament reconstruction.²

In summary, the results of this study indicate that both interventions lead to excellent results, with mechanical and functional capacity being restored. In the calcaneocuboid instability group, no deterioration was detected in a longer term follow-up 29–77 months postoperatively.⁵ However, conclusions drawn from this study are limited due to the low numbers of patients. Further prospective research including more patients and longer follow-up periods is recommended to confirm these conclusions.

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What is already known on this topic

- Isolated calcaneocuboid ligament lesions are frequently overlooked
- The injury mechanism is similar for isolated calcaneocuboid and lateral ankle ligament lesions
- Giving way of mechanically stable ankles is often attributed to a proprioceptive deficit

What this study adds

- Calcaneocuboid instability is an important differential diagnosis in giving way of the foot
- A forceful plantarflexion-inversion mechanism during sport initiated the injury in all patients
- A newly developed periosteal augmented repair procedure for isolated calcaneocuboid instability restores mechanical and functional capacity

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