Clinical outcome after anatomical reconstruction of the lateral ankle ligaments using the Duquennoy technique in chronic lateral instability of the ankle

A LONG-TERM FOLLOW-UP STUDY

S. P. J. Muijs,
P. D. S. Dijkstra,
C. F. A. Bos

From Leiden University Medical Center, Leiden, The Netherlands

We performed a retrospective study to assess the long-term outcome of non-augmented anatomical direct repair of the lateral ankle ligaments, as originally described by Duquennoy et al, for the treatment of chronic lateral instability of the ankle. This procedure aims to restore stability by the re-insertion and tightening of the original talofibular and calcaneofibular ligaments without division of the ligament. We examined the outcome in terms of the post-operative quality of life, the function of the joint and the development of osteoarthritis.

Between 1985 and 2002, 23 patients (11 males, 12 females) with a mean age of 32 years (15 to 58) who had undergone this procedure completed the Short-Form 36 assessment of quality of life and the Olerud and Molander Ankle score for the subjective evaluation of symptoms. Clinical re-evaluation, including examination of the ankle and the completion of the American Orthopaedic Foot and Ankle Society questionnaire was performed on 21 patients after a mean follow-up of 13 years (3 to 22.2). At the final follow-up radiographs of both ankles were taken to assess the development of osteoarthritis.

The mean total Short-Form 36 and Olerud and Molander Ankle scores in 23 patients at final follow-up were 79.6 points (37 to 100) and 81.6 points (40 to 100), respectively. The mean total post-operative American Orthopaedic Foot and Ankle Society score in 21 patients was 89.7 points (72 to 100). We found a significant post-operative reduction in talar tilt and anterior drawer sign (chi-squared test, p <0.001). The functional outcome of the procedure was excellent in ten patients (48%), good in seven (33%) and fair in four (19%). The results in terms of ankle function and stability did not deteriorate with time and there was little restriction in movement.

This procedure is simple and effective with a very low rate of complications.

Inversion injury of the ankle accounts for 25% of all injuries to the musculoskeletal system.[1] In the Netherlands, approximately 425 000 patients are involved annually. It is estimated that 20% to 40% of patients who rupture one or more lateral ankle ligament have residual pain and instability after initial non-surgical treatment.[2] Chronic ankle instability combines mechanical (anterior and inversion laxity) and functional (proprioceptive and strength) deficiencies.[3] The goal of surgical treatment is to regain stability by mechanical and/or functional means.

More than 80 surgical procedures have been described as treatment for chronic lateral ligament instability of the ankle.[2,4-17] The procedures can be divided into non-anatomical and anatomical reconstructions. In the former usually one of the peroneal tendons, generally the tendon of peroneus brevis, is used to regain lateral ankle stability.[6,8,14] In anatomical reconstruction, the original anatomical position of the insertions and origins of the ligaments is restored, either using endogenous tissue,[16] synthetic graft[18] or by direct repair.[2,13,19]

It is generally accepted that the range of movement of the ankle after a non-anatomical reconstruction is restricted,[6,20-22] with mechanical studies showing that normal hindfoot kinematics are not restored. Altered kinematics of the hindfoot can lead to osteoarthritis (OA).[23-25]

In a biomechanical study, Schmidt et al[26] reported that anatomical reconstruction, and direct repair of the ligaments in particular, did not cause restriction of movement, but restored the hindfoot kinematics and decreased the risk of OA. The limitation of movement after non-anatomical reconstruc-

■ S. P. J. Muijs, MD, PhD Candidate
■ P. D. S. Dijkstra, MD, PhD, Orthopaedic Surgeon
■ C. F. A. Bos, MD, PhD, Orthopaedic Surgeon
Department of Orthopaedic Surgery
Leiden University Medical Center, Albinusdreef 2, P. O. Box 9600, 2300 RC Leiden, The Netherlands.

Correspondence should be sent to Dr P. D. S. Dijkstra; e-mail: p.d.s.dijkstra@lumc.nl

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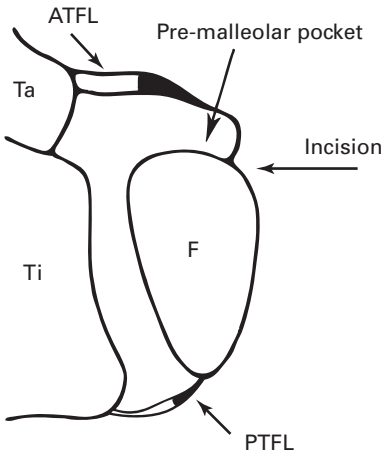

Fig. 1a

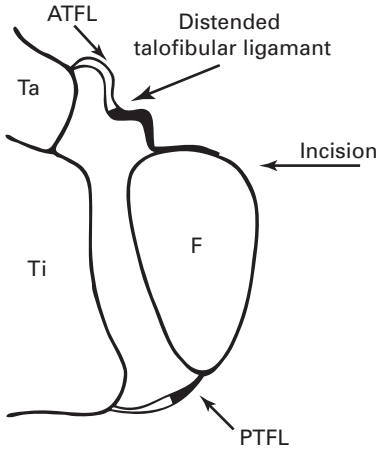

Fig. 1b

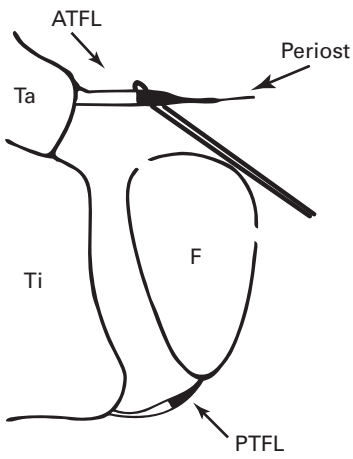

Fig. 1c

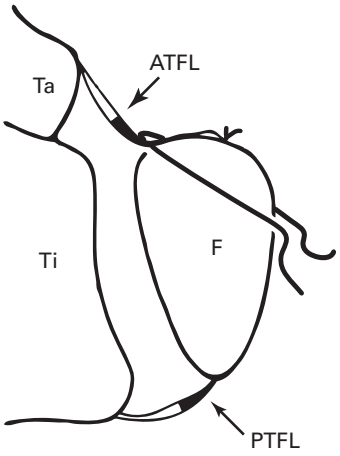

Fig. 1d

Diagrams of the transverse section on the level of the lateral malleolus showing a) the incision of the pre-malleolar pocket, formed by the talofibular ligament and periosteum which immediately opens the lateral aspect of the ankle, b) true ligamental distension with all ligamentous and periosteal elements dislodged to open the articulation, c) the sutures placed through the original ligamentous tissue at an intra-articular point to allow adjustable tightening and d) the sutures tightening and re-attaching the ligament (Ta, talus; F, fibula; Ti, tibia; ATFL, anterior talofibular ligament; PTFL, posterior talofibular ligament; Periost, periosteum).

tion has led several authors to recommend an anatomical procedure.[2,16] It has been suggested that if adequate ligament tissue is available, direct repair of the ligaments should be undertaken.[20]

In the Leiden University Medical Center, the non-augmented direct repair method as described by Bouretz and Duquennoy,[4] Duquennoy, Létendard and Loock[27] and Duquennoy et al[28,29] has been used since the early 1980s. To our knowledge, this procedure has not been previously described in the English literature and little is known about its long-term effects. Our aim therefore was to determine the outcome in terms of quality of life, function of the ankle and the development of OA.

Patients and Methods

We identified 23 patients (11 males and 12 females), who had undergone an anatomical reconstruction of the lateral ankle ligaments, as described by Duquennoy et al[27-29] between April 1985 and December 2002. The variables studied were clinical data, the time of procedure, complications, the development of OA, and objective and subjective function of the ankle. The mean age of the patients at operation was 32 years (15 to 58).

Operative technique. The patient is placed in the supine position with a bolster under the ipsilateral hip. A thigh tourniquet is used. The lateral malleolus is approached by a curvilinear (J-shaped) incision. Care is taken not to damage the sural nerve or the lateral branch of the superficial peroneal nerve. After incising the periosteum the bone is exposed.

Either a pre-malleolar pocket is encountered (Fig 1a), in which case the joint capsule is immediately opened, or an attenuated true ligament without a pocket is found (Fig. 1b). In the latter case all the ligamentous and peri-

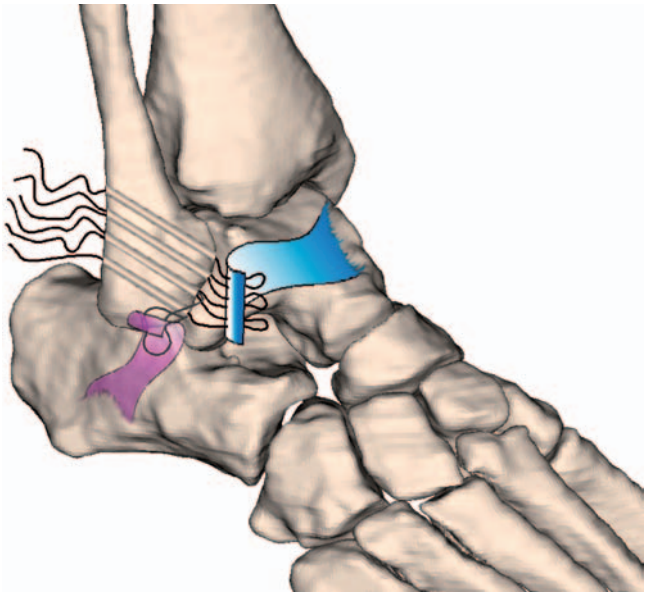

Fig. 2

Diagram showing the reattachment of the talofibular (blue) and calcaneofibular ligaments (purple). It is essential that the drill holes in the fibula are directed from a proximal-posterior direction to a distal-anterior direction. The angle of the drill holes allows adjustable ligamentous tensioning during tightening of the sutures. The procedure as originally described by Duquennoy et al[27-29] can be supplemented by the tightening of the calcaneofibular ligament in subtalar instability due to laxity of the ligament. The two distal drill holes are used for the reinsertion of the talofibular ligament.

osteal elements are carefully elevated to reach the anterior edge of the lateral malleolus at the osteocartilaginous junction.

A capsular periosteal flap, with its origin on the anterodistal portion of the talus, is detached from the distal fibula. Three to four U-shaped sutures, covering the whole width of the ligamentous tissue, are placed approximately 1.5 cm distal to the free edge of the detached capsular periosteal flap. Care is taken to pass the sutures through the original ligamentous tissue (Fig. 1c). The point at which the sutures pass through the ligamentous tissue lies intra-articularly, in such a way that the sutures can be used to tighten the ligament while it is reinserted (Figs 1c and d).

The osseous reinsertion is prepared by drilling four or five holes in the distal fibula with a drill of 2 mm in diameter. The anterior ends of these holes emerge at the osteocartilaginous junction at the anterior edge of the lateral malleolus, which is roughened to promote ligamentous reattachment. It is essential that the drill holes are directed from a proximal-posterior direction to distal-anterior direction. In this way their direction ensures that there can be as precise an adjustment as possible of the ligamentous tension during tightening of the sutures (Fig. 2). Using a suture passer, the sutures are placed through the drill holes. The tightening of the sutures is performed with the ankle in the anatomical neutral position. The sutures through the drill holes do not necessarily have to be fully tightened to the bone in order to allow adhesion of the periosteum to the bone. In this way the procedure facilitates adjustable ligamentous tension. If the sutures are always tightened to the bone, the point at which the suture penetrates the ligament will determine the reinsertion tension, possibly leading to restricted movement. Following the reinsertion procedure the range of movement of the ankle is tested, after which the wound is closed without drainage. The foot is immobilised in a neutral or slightly everted position in a below-knee cast for four weeks. No weight-bearing is allowed during immobilisation. After removal of the cast, mobilisation occurs with partial weightbearing (30kg) for two weeks. Crutches are advised, after which weightbearing can be increased gradually within a period of two weeks.

Evaluation. For the subjective evaluation of the outcome the patients filled in two questionnaires. We used the Short-Form 36 Health Survey (SF-36)[30-32] to assess quality of life, and the Olerud and Molander Ankle Score[33] for evaluating symptoms after ankle injury.

For the objective evaluation of the outcome, the American Orthopaedic Foot and Ankle Society (AOFAS) ankle-hindfoot scale,[34] completed by a member of the research team (PDSD), was used at the final follow-up. The results were graded as excellent (100 to 91 points), good (90 to 81 points), fair (80 to 71 points), and poor (< 70 points), as previously described by Becker et al.[22]

Each patient underwent a physical examination of both ankles including range of movement and assessment of talar tilt and the anterior drawer sign. The latter were scored on a scale ranging from 0 to 3, 0 indicating no talar tilt or a negative anterior drawer and 3, obvious tilting of the talus or an obvious anterior drawer sign. Because only a few patients had pre-operative stress radiographs and the correlation between the stress view and the subjective outcome was not clear, no stress radiographs were taken for scoring talar tilt and the anterior drawer sign at the final follow-up.[35,36] Since the clinical determination of a single range of movement of the ankle is not reliable, the combined movements of dorsiflexion, plantar flexion, inversion and eversion were measured by a goniometer.

The development of OA was assessed from weight-bearing anteroposterior and lateral radiographs of both ankles, which were obtained pre-operatively and at the final follow-up. These were scored by an independent observer, who was not an author, using the system described by Krips et al,[37] van Dijk, Tol and Verheyen[38] and van Dijk, Verhagen and Tol.[39]

Statistical analysis. Differences between the groups were compared using a two-tailed Student's *t*-test for normally distributed values. For comparison of categorical variables a chi-squared test was performed, otherwise the Wilcoxon signed rank test was used to compare variables.

The symmetry of the distribution was determined by measuring the value by which the data was skewed.

Table I. The mean (SD) post-operative short-form (SF)-36 sub-scores in 23 patients compared with the mean (SD) sub-scores of the average Dutch population[30]

SF-36 score domains	Our series	Dutch population
Physical functioning	80.2 (18.5)	83.0 (22.8)
Role physical	85.9 (31.8)	76.4 (36.3)
Bodily pain	74.9 (20.9)	74.9 (23.4)
General health	72.3 (21.5)	70.7 (20.7)
Vitality	66.5 (20.0)	68.6 (19.3)
Social functioning	84.9 (21.2)	84.0 (22.4)
Role emotional	91.3 (25.1)	82.3 (32.9)
Mental health	79.1 (17.0)	76.8 (17.4)

Table II. The mean (SD, range) Olerud-Molander ankle score for the 23 patients

Parameter	Score	Maximum score
Pain	21.0 (4.3)	25
Stiffness	7.8 (4.2)	10
Swelling	8.3 (3.2)	10
Stair climbing	8.9 (2.1)	10
Running	3.5 (2.4)	5
Jumping	3.0 (2.5)	5
Squatting	4.1 (1.9)	5
Supports	8.9 (2.6)	10
Work, activities of daily life	16.1 (8.1)	20
Total	81.6 (17.2)	100

The results are presented as the mean and range. A two-tailed p-value ≤ 0.05 was considered to be statistically significant. All the analyses were performed using SPSS version 11.0 software (SPSS Inc., Chicago, Illinois).

Results

Of the 23 patients, 21 were available for clinical assessment. The remaining two were not able or were unwilling to visit the hospital for clinical re-evaluation. The mean follow-up was 13 years (3 to 22.2). The mean operating time was 60 minutes (40 to 85).

There was one minor per-operative complication when a fracture occurred between two drill holes in the distal fibula. This was managed by drilling a separate hole several millimetres proximal to the original drill hole. One patient was treated post-operatively for a superficial infection. No further operations were required and no long-term complications were noted.

The mean total SF-36 score in 23 patients at final follow-up was 79.6 (37 to 100). The mean SF-36 sub-scores are presented in Table I. The patients scored higher on the 'role physical' domain than the average Dutch population (85.9 *vs* 76.4).[30]

The mean total Olerud-Molander ankle score in 23 patients at final follow-up was 81.6 points (40 to 100; Table II). The mean total AOFAS score in 21 patients at final follow-up was 89.7 points (72 to 100) (Table III). The results were classified as excellent in ten patients (48%), good in seven (33%) and fair in four (19%). Since the procedure was performed on both feet in one patient this individual was excluded for left-right comparison of the range of movement of the ankle and assessment of the development of OA. The ranges of movement of the subtalar (inversion and eversion) and ankle (plantar flexion and dorsiflexion) joints are detailed in Table IV.

At the final follow-up, there was no statistically significant difference (Wilcoxon signed rank test, $p = 0.07$) between the combined mean subtalar range of movement of the operated foot of 43° (30° to 65°) and that of the contralateral foot (mean 50° (20° to 80°)). The mean range of movement at the final follow-up was 78° (40° to 115°) and did not significantly differ (Wilcoxon signed rank test, $p = 0.196$) from that of the contralateral foot at a mean of 80° (28° to 130°). There was a modest but significant difference of 7° in the mean inversion between the operated ankle and the contralateral ankle (Wilcoxon signed rank test, $p = 0.037$).

The mean talar tilt at final follow-up was significantly lower than the mean pre-operative value (Wilcoxon signed rank test, $p < 0.001$) and did not differ significantly (Wilcoxon signed rank test, $p = 0.78$) from that of the contralateral foot. The mean score for the anterior drawer sign at final follow-up was significantly lower than the pre-operative score (Wilcoxon signed rank test, $p < 0.001$) and did not differ significantly (Wilcoxon signed rank test, $p = 0.32$) from that of the contralateral ankle.

Pre-operatively, 15 patients had no signs of degenerative change in the ankle and five had grade-I OA. Of these, at final follow-up, eight patients had no signs of degenerative change of the ankle and seven had grade-I OA. One patient with pre-existing grade-I OA progressed to grade-II (Table V). In eight patients, who pre-operatively had no signs of degenerative change there was no change present at a mean follow-up of more than 11 years (2.5 to 21.5). In four patients who had pre-existing grade-I OA, the grade remained unchanged at a mean follow-up of more than 14 years (9.3 to 20.4). In three patients, who pre-operatively had had no degenerative changes, grade-I OA had developed during a follow-up of 18, 19 and 21 years, respectively. The patient with pre-existing grade I OA developed grade-II OA at final follow-up at 12 years. The mean pre-operative OA grade (0.25 (0 to 1)) was significantly lower than that post-operatively (0.65 (0 to 2)) (Wilcoxon signed rank test, $p = 0.003$). Five of seven patients who had no OA pre-operatively developed grade-I changes in their contralateral ankle at final follow-up.

Discussion

Chronic lateral instability of the ankle is a disabling condition. Of the many types of operation which have been described none has been shown to be superior.

Table III. The mean (SD) American Orthopaedic Foot and Ankle Society ankle-hindfoot scale subscores

Parameter	Score	Maximum available score
Pain	35.2 (6.0)	40.0
Function		50.0
Activity limitations, support requirements	8.4 (1.8)	10.0
Maximum walking distance, blocks	4.9 (0.3)	5.0
Walking surfaces	4.2 (1.0)	5.0
Gait abnormality	8.0 (0.0)	8.0
Sagittal motion	8.0 (0.0)	8.0
Hindfoot motion	5.7 (0.9)	6.0
Ankle-hindfoot stability	7.2 (2.4)	8.0
Function total	46.4 (3.5)	
Alignment	7.9 (2.5)	10.0
Total	89.7 (8.2)	100.0

Table IV. Comparison between the mean range of movement in the surgically-treated and the contralateral ankles in 20 patients*

Movement	Surgically-treated ankle (°)	Contralateral ankle (°)	Difference (°)	p-value
Inversion	33 (20 to 50)	40 (15 to 60)	7	0.037
Eversion	10 (0 to 25)	10 (0 to 20)	0	0.705
Dorsiflexion	18 (5 to 30)	18 (5 to 50)	0	0.315
Plantar flexion	60 (20 to 90)	62 (10 to 100)	2	0.331

*a total of 21 patients were available for clinical re-evaluation of which one was operated on both ankles. This patient was excluded from operated *vs* contralateral comparison, leaving 20 patients

Table V. Pre- and post-operative grading for osteoarthritis in 20 patients according to the system of van Dijk et al[39]

Grade	Pre-operative	Post-operative
0	15	8
I	5	11
II	0	1
III	0	0

The most widely used non-augmented direct repairmethods are the Broström[2] procedure and its modifications as described by Karlsson et al[13] and Gould et al.[19] In these procedures, the ligament is initially divided in order to create a mid-substance repair or an osseous reinsertion. In contrast, in the procedure as described by Duquennoy et al[27-29] the original ligament is detached along with a periosteal flap, reefed and reinserted under adjustable tension. Since the ligament in patients with chronic instability is elongated and often scarred, we believe that it is better to shorten it without dividing it. The procedure can be supplemented by tightening the calcaneofibular ligament when it is lax. In this situation one U-shaped suture, covering the whole width of the calcaneofibular ligament is used and is placed through the two most distal drill holes of the four created for the reinsertion of the talofibular ligament (Fig. 2).

Our results indicate that the currently described technique only results in a modest, but in our series, statistically significant, decrease of inversion compared with the contralateral ankle and the post-operative inversion lies well within the normal range.[40] This finding is in agreement with the outcomes of other anatomical reconstructions. Schmidt et al[26] reported that the biomechanical properties after non-augmented direct-repair methods gave results similar to the physiological kinematics. Broström,[2] Karlsson et al[13] and Gould et al[19] found in short-term follow-up studies after a non-augmented direct repair procedure, that the mobility of the ankle was marginally reduced in a few cases. Additionally, several clinical and biomechanical studies have shown that non-anatomical reconstructions often restrict the range of movement of the ankle.[6,20-22,24,26,41] Krips et al[37] compared anatomical reconstruction with the Evans[8] tenodesis. They found that of 45 patients who had an Evans tenodesis, 15 (33%) had limited movement compared with six (11%) in the anatomical repair group.

In our study a significant reduction in talar tilt and the anterior drawer sign was achieved after anatomical reconstruction. The mean follow-up in our series of 13 years suggests that these results do not deteriorate with time.

The mean grade of OA pre-operatively was significantly lower than that at final follow-up. However, only seven of the 15 patients (47%) who had no sign of degenerative change pre-operatively developed grade-I OA during a

mean follow-up of more than 19 years, and five of these seven also developed grade-I OA in the contralateral ankle. In five patients with pre-existing grade-I OA, only one appeared to have grade-I changes after a follow-up of more than 12.5 years. This patient also had developed grade-I changes in the contralateral ankle. In a recent study by Ferkel and Chams,[42] in which an arthroscopic examination of the ankle was routinely conducted before reconstruction of the lateral ligaments, 95% of the patients were found to have pathological intra-articular changes before surgery.

The mean SF-36 score of the patients in our series was lower than that of the average Dutch population,[30] but we lack any pre-operative data concerning the quality of life for comparison. In a mid-term (64 months) follow-up study by Brodsky et al[43] evaluating the Broström-Gould procedure in 73 patients, the mean physical component summary score of the SF-36 was 50.9 points and the mean overall AOFAS score 95 points, compared with 76.6 and 89.7, respectively in our series. In their study the authors stressed the superiority of the SF-36 score over the AOFAS score for evaluating residual instability. In a study in which an augmented anatomical reconstruction had been done, Coughlin et al[16] described a mean post-operative AOFAS score of 98 points, even higher than that in our series but the SF-36 questionnaire was not used. The mean Olerud-Molander ankle score in our series was 81.6 points. This relatively low score was possibly confounded by comorbidities and the age of our patients. Since Olderud and Molander[33] found that grade-I OA was consistent with a mean score of approximately 72 points, the presence of osteoarthritis in either ankle in our series could have contributed to the relatively low score.

In conclusion, the procedure as originally described by Duquennoy et al[27-29] is simple and effective in the long term with a very low rate of complications.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

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