

# Better Functional Results of Conservative Treatment in Fresh Lateral Ligament Injuries of the Ankle with Additional Deep Oscillation

## Bessere funktionelle Ergebnisse der konservativen Behandlung bei frischen Außenbandrupturen des oberen Sprunggelenks mit Tiefenoszillation

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### Key words

- injury of the lateral ankle ligament
- deep oscillation
- physical therapy
- rehabilitation

### Schlüsselwörter

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### Bibliography

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### Abstract

**Background and Aim:** 25% of all injuries of musculoskeletal injuries involve the ankle. 85% concern the lateral ligament structures, 10% the anterior syndesmosis and 5% the medial ligament structures, accompanied by edema and hematoma in the respective regions. Very good results were already achieved with deep oscillation therapy for several indications, including trauma. The aim of this study was the evaluation of conservative treatment with the Aircast® brace for fresh exterior ligament injuries with an additional electro-mechanical treatment, i.e. deep oscillation, and optimisation of this novel combination of treatments.

**Methods:** 43 patients were treated for acute ligament injuries of the fibular ankle with distortion or laceration of the medial ligament, hematoma and contusion. They received a complex functional conservative treatment with the Aircast® brace with additional deep oscillation therapy. 25 of these injuries of the ankle occurred during sports and 18 during everyday activities. A questionnaire, a clinical and radiological examination of the upper ankle joint were used for evaluation. At the beginning and end of treatment, symptoms were assessed subjectively by the patients with the numerical rating scale (NRS) and by the physician with a modified 4-step rating scale. The study compares the effect of additional deep oscillation with a control group of 25 patients receiving standard treatment.

**Results:** 30 (70%) of the 43 patients were female and 13 (30%) male. The average age was 26 years. 14 (33%) patients had a very good, 22 (51%) good, 3 (7%) satisfactory, and 4 (9%), insufficient outcome. Thus, 39 (91%) were satisfied and 4 (9%) dissatisfied. The subjective assessment of symptoms (NRS) improved significantly ( $p < 0.001$ ) from 9.1 (baseline) to 2.1 points after treatment. Objective assessment by the attend-

### Zusammenfassung

**Hintergrund und Zielstellung:** 25% aller Verletzungen des Bewegungsapparates betreffen das obere Sprunggelenk. 85% betreffen die lateralen Bandstrukturen, 10% die vordere Syndesmosse und 5% die medialen Bandstrukturen einhergehend mit Ödemen und Hämatomen in den entsprechenden Regionen. Mit der Tiefenoszillationstherapie wurden bereits bei verschiedenen Indikationen einschließlich Traumata sehr gute Ergebnisse erzielt.

Ziel dieser Arbeit war die Auswertung der konservativen Behandlung durch die Aircast® Orthese bei frischen Außenbandsverletzungen mit Optimierung einer zusätzlichen elektromechanischen Therapie, der Tiefenoszillation.

**Methoden:** 43 Patienten wurden wegen akuten fibularen Bandverletzungen des oberen Sprunggelenks mit Innenbanddistorsion, Zerrung, Hämatom und Prellung behandelt. Sie erhielten komplexe konservative funktionelle Behandlung mit der Aircast® Orthese und zusätzliche Tiefenoszillation. 25 dieser Verletzungen des oberen Sprunggelenks traten beim Sport und 18 im Alltag auf. Ausgewertet wurde mit einem Fragebogen, einer klinischen und radiologischen Untersuchung des oberen Sprunggelenks. Zu Beginn und am Ende der Behandlung wurden die Beschwerden durch die Patienten subjektiv mit der numerischen Beurteilungsskala und durch den Arzt mit einer modifizierten 4-stufigen Beurteilungsskala beurteilt.

Die Studie vergleicht den Effekt der zusätzlichen Tiefenoszillation mit einer Kontrollgruppe von 25 Patienten.

**Ergebnisse:** Von 43 Patienten waren 30 (70%) weiblichen und 13 (30%) männlichen Geschlechts. Das durchschnittliche Alter betrug zum Zeitpunkt der Behandlung 26 Jahre. 14 (33%) Patienten hatten ein sehr gutes, 22 (51%) ein gutes, 3 (7%) ein befriedigendes und 4 (9%) ein unzureichendes Behandlungsergebnis. Somit waren 39

ing physician based on various clinical parameters was good or very good in 80% of the cases.

**Conclusions:** The study shows that the conservative functional treatment described here with an Aircast® brace with the integration of deep oscillation is a very good treatment for fresh lateral ligament injuries. Based on this study, an additional positive effect of deep oscillation is observed in terms of reduction of edema and hematoma, detumescence, pain and inflammation. Also, the high patient satisfaction supports this conclusion. The treatment is gentle and thus, unlike other electrical and mechanical therapies, not contraindicated in the acute phase. It is effective, easy to apply and patients perceive it consistently as positive.

## Introduction

Every day 1 in 10000 people injure their ankle joint. This corresponds to about a quarter of the traumas of the musculoskeletal system [1] and 16–21% of sports injuries [2]. The majority of those affected is male (m/f=70/30) and occurs most often between the age of 23 and 32. Most lesions involve the ligaments of the ankle. Specifically, 85% the lateral ligaments, 10% the anterior syndesmosis and 5% the medial ligament structures [1]. The lateral ankle ligament complex consists of 3 major ligaments: the anterior talofibular ligament (ATFL), the posterior talofibular ligament (PTFL) and the calcaneo-fibular ligament (CFL). The medial ankle ligament complex is formed by the deltoid ligament [3].

Injuries of the lateral collateral ligaments are caused by rotational forces. Ruptures of these results mainly from plantarflexion, supination, and inversion. Twisting the ankle is the typical accident.

An isolated lesion of the deltoid ligament is rare since significantly more force is required in comparison to fibular ligament injuries. The 3 major lateral ligaments may rupture in various combinations or just one of them [4–6].

The treatment of fresh lateral ligament injuries of the ankle joint has changed significantly in recent years. This affects both the range of conservative and surgical treatment, as well as rehabilitation and the associated therapeutic measures. First aid and an early initiation of therapy are most important in conservative therapy.

Regardless of the extent of the injury, the quality of the emergency treatment is decisive for the healing process. During emergency treatment, local cooling, propping up, elastic and functional bandages and ankle joint braces all serve the purpose of reducing pain, swelling and tissue bleeding [7–9].

Conservative functional treatment in fresh lateral ligament injuries have major benefits in terms of quick recovery of the full mobility of the ankle [10–13].

Conservative therapies for acute fibular ligament injuries are discussed controversially in literature. Functional treatment with the Aircast orthosis had better results compared to plaster casts [10,11,14]. The main afferent influences such as pain,

(91%) zufrieden und 4 (9%) unzufrieden. Die subjektive Einschätzung der Beschwerdesymptomatik (NRS-Skala) verbesserte sich signifikant ( $p < 0,001$ ) von 9,1 (baseline) auf 2,1 Punkte nach der Behandlung. Die objektive Bewertung durch den behandelnden Arzt anhand verschiedener klinischer Parameter war gut oder sehr gut in 80% der Fälle.

**Schlussfolgerungen:** Die Studie zeigt, dass die hier beschriebene komplexe konservative funktionelle Behandlung durch die Aircast® Orthese mit Integration der Tiefenoszillation eine sehr gute Methode für die Behandlung frischer Außenbandsverletzungen ist. Beruhend auf dieser Studie zeigt sich ein zusätzlicher positiver Effekt der Tiefenoszillation in Bezug auf Ödem- und Hämatomminderung, Abschwellung, Schmerzlinderung, Entzündungshemmung. Auch die hohe Zufriedenheit der Patienten mit der Therapie spricht dafür. Durch ihre schonende Wirkweise stellt die Behandlung mit Tiefenoszillation im Gegensatz zu anderen elektrischen und mechanischen Therapien keine Kontraindikation in der Akutphase dar, ist einfach anwendbar und wird durch Patienten durchgehend positiv wahrgenommen.

swelling and effusion are more important in post-treatment [15,16]. These findings should consequently be reflected in the acute care and in rehabilitation which led to changes in treatment in recent years.

A key point of the therapy in ankle injuries is treatment planning and preparation of an overall concept. This includes prescription of physical therapy measures with appropriate application, dose, and serial design based on the damage and functional deficits of the ankle [7,17,18].

Deep oscillation is an electro-mechanic therapy procedure in which a pulsating electrostatic field is built up between the hand-applicator and the tissue which is to be treated. The electrostatic pulses lead to attraction and static friction, while the elasticity of the tissue counteracts this mechanism during the interval between pulses. When moving the hand applicator the underlying tissue section is attracted by the force of the electrostatic field against the compression pressure of the hand applicator along the movement trajectory and released again. Fast repetition of this process brings about rhythmic distortions [19]. This leads to a resonating fluctuation of the treated tissue segment affecting all tissue components like skin, connective tissue, subcutaneous fatty tissue, muscles, blood and lymph vessels.

Deep oscillation has been investigated for various indications with regard to the above mentioned and other parameters and successfully applied for various sports injuries [8,20–22].

Ankle injuries were treated in 2 studies using deep oscillation and good results in terms of pain and swelling were achieved [8,21]. But both studies were conducted with few patients with ankle injuries, without a control group and randomization. This fragmented approach was the reason for this follow-up.

The aim of this study was the evaluation of conservative treatment with the Aircast® brace for fresh exterior ligament injuries with an additional electro-mechanical treatment, i.e. deep oscillation, and optimalisation of this novel combination of treatments.

**Table 1** Classification of lateral ankle ligament injuries to the upper ankle joint.

Grade	Hallmarks
I	Strain or sprain of the joint capsule of the ATFL, no instability, minimal swelling and hematoma. No side difference on X-rays.
II	Partial rupture and partial tears of the ATFL + CFL. Signs of a slight but well-compensated instability.
III	Complete rupture and sheets of ATFL + CFL. Joint clinically and radiologically massively unstable (15° upon varus stress).
Ankle luxation	Rupture of all 3 ligaments, cartilage lesion and syndesmosis lesion.

## Patients and Treatment

Fresh, clinically and radiologically proven first-time injuries of the outer ligaments of the first to third degree were included in the study. Furthermore, patients had to be willing to be randomly assigned to either the treatment or control group, to undergo a 6-week treatment with early functional therapy and appear for follow-up.

If a third-degree lesion with rupture of all 3 of the lateral ligaments, a bony injury of the ankle joint with surgical treatment, recurrence or a concomitant injury was present, patients were excluded from the study. Other comorbidities, radiographic degenerative disease of the ankle joint or from the planned therapy treatments deviating requests also led to exclusion.

After completion of diagnostics and examination of inclusion and exclusion criteria, the patient was asked for his consent to participate in this study. An information sheet about the course of the study was handed out and each patient randomly (random tables) assigned to either the experimental or control group.

Thereafter, data on sports, injured side, age and gender was collected. The mechanism of injury was also described. This included when, where and how the accident happened and the period up to the first examination by a physician.

### Experimental group

The study included 43 patients who were treated in the sports medicine service for amateur sports in our institution for acute fibular ligament injuries of the upper ankle joint with inner ligament distorsion, laceration, hematoma, and contusion after trauma.

### Control group

The study compares the influence of deep oscillation therapy in rehabilitation following ligament injuries of the upper outer joint jump with a control group of 25 patients without additional deep oscillation receiving placebo therapy without current flow instead.

### Investigations

The clinical and radiological assessment as well as the follow-up was performed by the same examiner for all participating patients. Both groups received the same diagnostic procedures bilaterally.

### Case history

During Anamnesis the accident mechanism (in- and eversion trauma), the beginning of the swelling, if a snap was heard during the accident and previous trauma were asked about.

### Clinical examination

All clinically relevant band structures of the outer ankle, the anterior syndesmosis, the deltoid ligament and the stability of the ankle mortise were investigated. Instability was examined by the drawer test (translational movement of the Talus) and varus stress.

Location and extent of swelling with bruising and tenderness to palpation in the trajectory of the ligament were also recorded. The swelling of the ankle joint was measured at the smallest circumference of the lower leg, ankle and instep of the navicular bone.

### Radiological examination

The ankle joint was examined radiographically in 2 planes (anteroposterior at 25° internal rotation and lateral) when patients had received analgesics. An ultrasound examination was also performed.

The classification of patients according to diagnoses based on the above diagnostic measures is shown in [Table 1](#).

### Additional MRI examinations

Patients who complained of pain and lack of load bearing capacity after a week of treatment were examined by MRI. 5 patients with a lesions of the lateral ligament of the third degree, and 11 patients with a suspected lesion of the medial ligament of the second or third degree received an additional MRI. In all patients a complete tear, of the lateral and medial ligaments respectively, were excluded.

### Subjective assessment

For the subjective assessment of pain, we chose a 10 point numerical rating scale (NRS) [23,24]. The values obtained were grouped into 3 pain-categories: “none or little” (0–3), “moderate” (4–7), “severe” (8–10).

### Objective assessment

The objective assessment of the outcome was performed by the attending physician based on a 4-point assessment scale modified based on Good et al. [25] with the categories “very good”, “good”, “satisfactory” and “unsatisfactory results”. This was based on the evaluation of the pain, healing process of hematomas and edemas, condition of the tissue and treatment of reactive tissue inflammation ([Table 2](#)).

### Standard treatment

The conservative therapy for injuries of the lateral ankle ligaments was carried out in an ankle orthosis (Aircast brace), which was worn continuously for a period of 6 weeks until full weight bearing was possible. The orthosis had to be worn constantly during the night for the 6 weeks. The brace was only removed for personal hygiene and physical or physiotherapy treatment. This is vital because the axial load is absent when lying down and the primary mechanical stabilization is lost. The ligaments are potentially threatened. All patients received a similar treatment regimen. In addition to standard therapy (incl. ice-treatment, physiotherapy, electrotherapy, ointments, tape bandage, etc.) and medicinal therapy (peripherally effective analgesics: NSARs; centrally effective analgesics for more acute pain, e.g. Tramadol, Valoron N).

**Table 2** Modified 4-step rating scale.

Category	Criteria
very good	No pain, no instability, free mobility, ability to walk (gait) without crutches, no swelling, no edema and hematoma
good	mild pain, no instability, no restriction of movement, ability to walk (gait) without crutches, no clinically significant reduction in performance, slight swelling and edema, no hematoma
satisfying	Stress pain, slight instability, ability to walk (gait) with crutches or with stick, slight limitation of motion of the ankle joint, moderate swelling, edema and bruising of the ankle joint
insufficient	Constant pain, instability of the ankle joint, significant movement limitations of the ankle joint, inability to walk, remaining joint effusion, significant swelling, edema and bruising of the ankle joint

**Table 3** Demographic and epidemiologic data per group. There were no significant differences between the 2 groups.

Group		Experimental	Control
gender	male	30	14
	female	13	11
age (years)		26	27
days absent from work		8	9
activity	sports	25	15
	daily life	18	10
indication	lateral grade I + II	21	12
	lateral grade III	5	3
	lateral grade I + II	7	4
	medial strain		
	lateral grade I sprain, bruising, hematoma	10	6

### Deep oscillation therapy

A treatment programme performed once daily – starting directly after emergency procedures (i.e. on the day of the accident). Depending on the injury, the treatment was 25 min at long with predetermined frequencies over a total period of 6 weeks. A trained therapist followed lines of lymphatic drainage with a standardized motion pattern. The therapy device used was the DEEP OSCILLATION® Evident from the company PHYSIOMED (Schnaittach, Germany).

Patients in the control group underwent the same procedure with the hand applicator therapy, but without current flow as a placebo therapy.

### Follow-up

The follow-up was performed after 6 weeks at the end of treatment. The ankle orthosis (Aircast) was removed and then all patients were investigated again as described above. Satisfaction with the course of treatment and functional results was reported by the patients. The time absent from work was recorded.

### Statistics

Nonparametric testing methods (Wilcoxon) were used because the assumptions underlying the parametric methods (T tests) were not met (i.e. normality and/or constancy of variance). All tests were performed at  $\alpha=0.05$ .

## Results



### Demographics

Summarizes the demographic and epidemiologic data per group is shown in **Table 3**. There were no significant differences between the 2 groups.

### Clinical examination

#### Stability

The drawer test was evaluated in 39 patients (91%) of the experimental group as stable and 4 (9%) as unstable (grade 1). In the control group, however, there were 18 (72%) stable and 7 (28%) unstable (grade 1).

Varus stress was evaluated in 40 patients (93%) of the experimental group as stable 3 (7%) as unstable (grade 1). Of the control group 23 patients (92%) were found to be stable and one (8%) unstable (grade 1).

There were no instabilities greater than grade 1 found in both groups for both tests.

#### Mobility

In the treatment group, there were 36 freely movable joints, 3 joints were restricted in one direction, 4 in 3 directions. In the control group 9 joints were freely movable, 8 were restricted in one direction, 4 in 2 directions, 2 in 3 directions and 1 in all 4 directions. Dorsiflexion was seldomly restricted. 2 cases in the treatment group, 3 cases in the control group. None of these restrictions was found to be clinically relevant (more than 10°) compared to healthy side. 2 patients in the treatment and 3 in the control group were restricted in pronation. In each of the groups 1 patient had a relevant restriction of movement of more than 10°. Movement restrictions in plantar flexion and supination were found more often. At least a third of the patients in both groups had a slight restriction of 0–10° in these 2 directions. Restrictions of movement of over 10° were not found in plantar flexion.

#### Swelling

**Table 4** shows the the descriptive statistics of the measured circumferences for each location.

Possible relations between the circumferences of the different body parts were examined with Spearman Rank Correlation Coefficient ( $r_s$ ) and scatter plots. There are strong correlation between the measured circumferences (correlation between circumferences at discharge  $r_s > 0.90$ , at admission  $r_s = 0.45$ ).

The circumference at admission and discharge is not significantly different between the sexes in for all 3 locations. There is a significant decrease in circumference between admission and discharge for both groups at all 3 locations (Wilcoxon signed rank test). At discharge there is a significant difference between the 2 groups at all 3 locations (Wilcoxon rank-sum test). At admission this is only true for the circumference of the lower leg. The detumescence (i.e. the difference in circumference between admission and discharge) is significantly larger in the treatment group compared to the control group (Wilcoxon rank-sum test: p-values < 0.018) (**Fig. 1a–c**).

**Table 4** Descriptive statistics of the measured circumferences for each location.

location: lower leg				
	group	mean	Median	std dev
admission	control	1.9	2.0	0.6
	treatment	1.6	1.8	0.4
discharge	control	0.8	0.8	0.5
	treatment	0.2	0.0	0.4
location: ankle				
	group	mean	Median	std dev
admission	control	1.7	1.8	0.4
	treatment	1.7	1.5	0.4
discharge	control	0.8	0.8	0.6
	treatment	0.2	0.0	0.4
location: instep above navicular bone				
	group	mean	Median	std dev
admission	control	1.6	1.5	0.4
	treatment	1.6	1.5	0.6
discharge	control	0.7	0.8	0.5
	treatment	0.2	0.0	0.4

### Complications

There were no obvious complications in both groups. In each of the 2 groups 2 patients reported to have twisted the same ankle until the first follow-up. However, there was no new or increase in pain or swelling. The therapy was not interrupted, so that the patient received no unscheduled medical check up. These incidents occurred when wearing the orthosis and walking on uneven surfaces.

### Subjective assessment

#### Numerical rating scale

In the treatment group the pain improved from  $9 \pm 2$  to  $2 \pm 2$  points and in the control group from  $8 \pm 2$  to  $5 \pm 3$  points. Both improved significantly (Wilcoxon Signed Rank Test,  $p < 0.001$ ). On admission, the groups did not differ (Mann-Whitney rank sum test,  $p = 0.053$ ). At discharge patients of the treatment group had significantly less pain (Mann-Whitney rank sum test,  $p < 0.001$ ) (● Fig. 2).

#### Feeling of instability

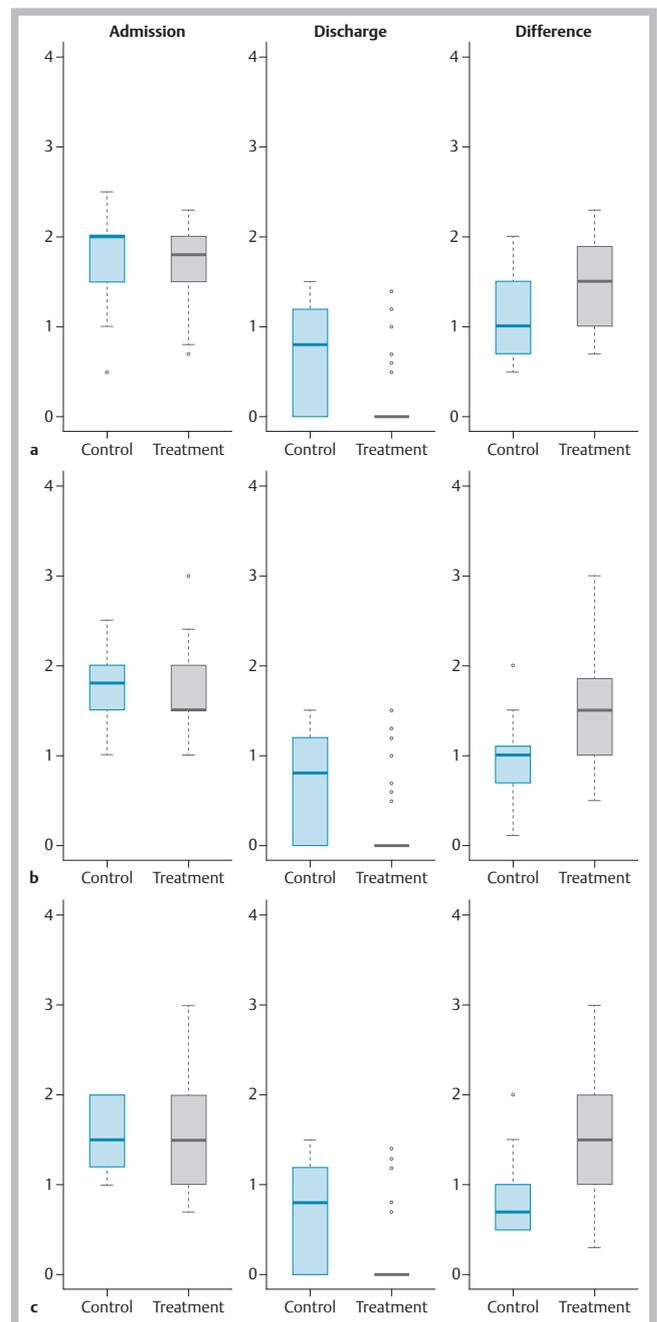
2 patients in the treatment and 3 in the control group reported a feeling of instability when walking without being able to state from why they felt that way.

#### Fear of recurrence

4 patients in the treatment and 7 of the control group were afraid of spraining their ankle again. Usually when the ankle was strained more and in situations similar to the first accident.

### Objective assessment

In the treatment group 14 (33%) patients had a very good, 22 (51%) a good, 3 (7%) a satisfactory and 4 (9%) an unsatisfactory outcome. Thus, 39 (91%) were satisfied and 4 (9%) dissatisfied. In the control group 3 (12%) patients had a very good, 6 (24%) a good, 9 (36%) a satisfying and 7 (28%) an unsatisfactory outcome. Thus were 18 (72%) satisfied and 7 (28%) dissatisfied (● Fig. 3).



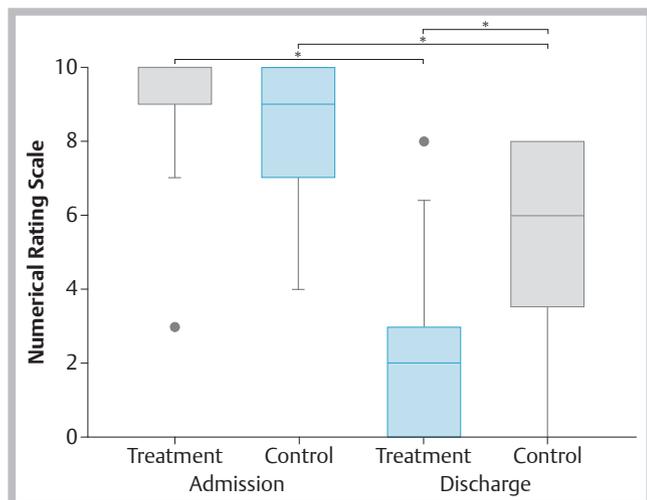
**Fig. 1** a–c Box plots of the increase in circumference of the affected leg at the indicated location compared to the contralateral side in centimeters at admission and discharge as well as the detumescence (difference) for both groups.

### Discussion

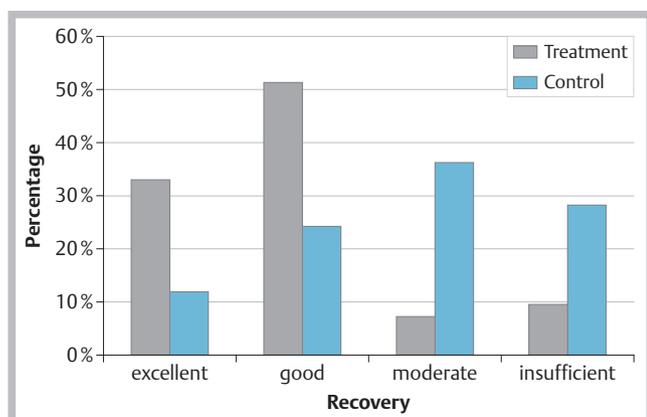
In the present study, the conservative treatment of fresh lateral ligament injuries of the ankle by Aircast® brace was improved significantly by additional deep oscillation therapy.

Subjective estimates of pain with a NRS improved significantly ( $p < 0.001$ ) from a pre-rehabilitation value of  $9 \pm 2$  points to a post-rehabilitation value of  $2 \pm 2$  points.

91% of the patients were satisfied. This is a remarkable result compared with the control group where only 72% were satisfied. The correlation of subjective feelings of instability and both clinical and radiological instability has been confirmed many times [11, 12, 26–28].



**Fig. 2** Box plots of the NRS scores per group at admission and discharge. Bars with asterisks indicate significantly different samples.



**Fig. 3** Bar plot of the frequency distribution of each group per category of the modified 4-step rating scale.

With reference to the drawer test and varus stress we observed a good to very good stability. The calculated gain in stability on radiological examinations shows comparable values [11]. The translational movability of the talus was found to be stable in 91% of patients in the experimental group, but only in 72% of the control group. Regarding varus stress both groups performed similarly with 93% and 91% remaining stable respectively. According to Kannus et al. the swelling correlates closely with functional instability [27]. This observation can not be confirmed. The concept of functional instability refers to the uncertainty of a patient in terms of the ability to stabilize the joint and avoid twisting the ankle [29]. We could not demonstrate any connection between swelling and this phenomenon. Deep oscillation already yielded positive results with regard to reduction of edema, swelling, pain, inflammation and increase in physical activity in other studies on ankle injuries [8,21]. In the present study, residual swelling averages at 0.2 cm at all 3 measured locations compared to the healthy side in the treatment group and 0.8 cm in the control group. Both treatments lead to less swelling, but the experimental group had significantly less than the control group at follow-up. Detumescence was found to be significantly greater in the group with deep oscillation.

In the context of swelling and pain, the importance of the interstitium is often undervalued in contrast to the superficial passive and active tissues. It is often neglected when it comes to therapy, even though it has key functions as a depot and in the supply and transport of nutritional and waste products [30]. The effects of deep oscillation therapy on the flow of lymph are explained by the fact that the interstitial septa and interstices are kept open [8,20,22]. The soft, mechanical “mixing” of the traumatized tissue and the surrounding tissue also promotes the further transport and distribution of interstitial liquid together with its contents (proteins, cell disintegration materials, neurotransmitters, inflammation mediators, etc.) and thus accelerates the early initiation of the wound healing process and pain-free self-mobilisation. This corresponds with the findings of this study.

The procedure was described by patients as pleasant and benefiting, even in the acute, post-traumatic application. There were no cases of non-compliance. The pain improved significantly. 84% of the patients achieved a good or very good result upon objective assessment by the physician.

It is prudent to consider that this study is prospective and a blind or double blind study may provide more substantial results as the chance of bias is smaller.

## Conclusion

In summary we can conclude that deep oscillation is an easy to use and effective adjuvant treatment option. Even before the study, we observed positive effects for other indications in relation to edema, pain, inflammation, and trophic state of the tissue [8,20–22]. These effects could also be confirmed in the treatment of patients with injuries of the ankle joint. In addition, more timely freedom from pain, mobility, load bearing capacity and hence ability to work were observed. The treatment is gentle and thus, unlike other electrical and mechanical therapies, not contraindicated in the acute phase. It is effective, easy to apply and patients perceive it consistently as positive.

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