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Achillodynia and Patellar Tendinopathy. Results of Radial Shockwave Therapy in Patients with Unsuccessfully Treated Tendinoses.

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Abstract

This is the first prospective pilot study performed to evaluate the effect of radial shockwave therapy in patients with unsuccessfully pretreated Achilles tendinosis or patellar tendinosis (jumper's knee). Forty Achilles tendons (Achilles tendinosis) and 45 patellar tendons (jumper's knee) were treated 3 – 5 times by radial shockwave therapy in a one-week interval setting. Results show significant effects regarding pain at rest, tenderness, load-induced pain, pain threshold and on the pain-free running time as little as one week after the end of the treatment. At the one-year follow-up, results are even better. Radial shockwave therapy therefore seems to be an effective treatment modality for these running and jumping induced degenerative tendon lesions. Controlled and randomised trials are mandatory to provide further evidence of this effect.

Key words

Extracorporeal shockwave therapy – radial shockwave therapy – achilles tendinosis – patellar tendinosis - jumper's knee – treatment results

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Introduction

Achillodynia and patellar tendinopathy are sport-induced degenerative tendon injuries whose natural course is primarily chronic and progressive and whose treatment is traditionally regarded as problematic. No generally accepted treatment strategies exist. Particularly with infiltration treatment with corticosteroid substances, which accentuate degenerative processes and reduce reparative processes, there is a potential risk of an iatrogenic tendon rupture. At histology, patellar tendinopathy, a typical insertion tendinopathy (or more accurately, an origin tendinopathy), exhibits mucoid degeneration foci, fibrinoid necroses, microruptures, and regeneration foci at the central tendon-bone junction between the patellar ligament and the bony patella apex [14].

By contrast, achillodynia is characterised by degenerative damage to the Achilles tendon in its free course, usually two to seven centimetres above its calcaneal insertion [12].

Patellar tendinopathy is the most common insertion tendinopathy. Becker and Krahl [3] found that 37.8% of all tendinopathies in athletes involved the knee, whereas the upper extremity was preferentially affected in the general patient population. In our own sport-specific population (Institute for Sports Medicine of Frankfurt am Main), this diagnosis was established in some 7.4% of patients overall. In basketball players as young as 14 – 18 years old, the prevalence of patellar tendinopathy is 7%. With increasing age, the frequency rises [6]. Martens et al. [21] found that 2/3 of patients with patellar tendon problems were volleyball or football players. Orava and Leppilahti [22] view insertion tendinopathies affecting the patellar ligament, at 44%, as the most common cause in the differential diagnosis of patients with “anterior knee pain”. One-third of all sports patients with patellar tendinopathy complain that they are out of action for over 6 months [5].

In jumper’s knee, the pathology is concentrated on the patellar apex in 79% of cases. In 16%, the base of the patella is affected, in 3% the tibial tuberosity and in 2% the patellar ligament as a whole [22].

At 29%, knee problems are also predominant in runners. However, patellar tendinitis accounts for only 7% of such problems [11]. In a prospective study of sports students, 13.8% developed patellar tendinopathy in a two-year period [32].

Repetitive jumping, particularly vertically, appears to be an important aetiological factor in the onset of patellar tendinopathy.

In connection with the Melbourne Olympic Games as long ago as 1956, Arndt [2] reported on “the Olympics disease of track and field athletes”, meaning “painful and inflammatory conditions in the region of the Achilles tendon” as well as Achilles tendon ruptures. In recent times, there has been a resurgence of interest in the problem of Achilles tendon injuries in sports orthopaedics. In the German national track and field athletics squad (DLV) at the 2000 Olympic Games in Sydney, a total of 21 out of 70 athletes sustained relevant Achilles tendon injuries. Of these, 4 athletes have since had to undergo surgery. By two years later, 10 had still not regained full load-bearing capacity.

In pathological anatomy terms, we understand achillodynia to be a combination of paratendinosis and tendinosis of the Achilles tendon. These components vary in severity according to the individual [24]. The free course of the tendon, usually two to seven centimetres proximal to its calcaneal insertion, is affected. Achillodynia is characterised by load-induced local pain and is always

accompanied by tenderness and usually by swelling of the Achilles tendon [17]. In the literature, the diagnosis of "achillodynia" is generally used incorrectly, being applied to all heel pain. Achillodynia is a typical sports injury induced by running stresses. James et al. [11] found achillodynia in 11% of cases of pain syndromes in runners. Only rarely are endogenous causes (usually hyperuricaemia) involved in the aetiology. Repetitive microtrauma and deficient regeneration of the tendon, or inflammatory changes in the paratenon, set in motion the process of Achilles tendon degeneration, which has often been present in a clinically latent form for years [12]. Lower extremity abnormalities and previous injuries lead to increased pronation in the stance phase of running, causing the Achilles tendon to be exposed to greater torsional stress [30].

The efficiency of extracorporeal shockwave therapy in various chronic insertion tendinopathies is sufficiently proven in the literature by means of controlled, randomised, prospective studies [15,27,28]. Today, the standard indications in the supporting apparatus and locomotor system are plantar fasciitis, radiohumeral epicondylitis and frozen shoulder [10]. A comparison of the treatment results with focussed and radial (unfocussed) extracorporeal shockwaves showed no differences in plantar fasciitis [28] or in frozen shoulder [9].

In theory, therefore, the radial shockwave, which hits a relatively large target volume, should also be able to achieve regenerative therapeutic effects in achillodynia and patellar tendinopathy.

Objective of the study

This study constitutes the first prospective pilot study of the effect of radial extracorporeal shockwaves in chronic achillodynia and chronic patellar tendinopathy.

Patients, materials, and methods

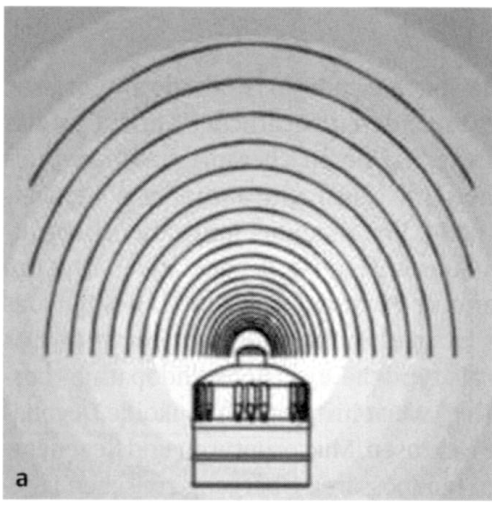
The inclusion criteria selected for admission to the study, for both achillodynia and patellar tendinopathy, were a prior symptomatic period of at least 6 months. The onset and persistence of the symptoms also had to be associated with competitive sports activity (Table 1). At least two standard conservative treatments, such as customised orthotics, physical and remedial therapy, strapping, local infiltration and X-ray treatment had to have been received and to have failed to produce significant success (Table 1).

Table 1. Distribution of type of sport among the study patients

Type of sport	Achillodynia	Patellar tendinopathy
Jogging	8	3
Middle-distance running	5	1
Long-distance running	5	0
Football	4	6
Triple jump/Long jump	4	2
Handball	4	1
Tennis	3	6
Triathlon	2	1
Cycling	2	0
Volleyball	1	8
Decathlon	1	1
Gymnastics	1	0
Basketball	0	11
Ballet/dance	0	3
Weight-lifting	0	1
High jump	0	1
n	40	45

Achillodynia was defined as a load-induced, tender (when pinched) injury to the Achilles tendon in its free course [18]. The tendon had to be thickened. Patellar tendinopathy was defined as a load-dependent tender injury to the patellar ligament at its origin at the patella apex. The exclusion criteria were a systemic predisposition such as hyperuricaemia, positive HLA B 27 and positive rheumatoid factors, as shown by laboratory tests. Distal Achilles insertion tendinopathies with or without dorsal heel spur and sub-Achilles bursitis were not included in the study. The achillodynia-mimicking heel pain syndromes [17] and intra-articular ankle and knee joint injuries, but particularly concomitant chondropathological damage and instability, led to exclusion from the study.

All consecutive patients who attended the orthopaedics out-patient department of the Institute for Sports Medicine of Frankfurt am Main from September 1998 to October 2000 and who fulfilled the inclusion criteria (and to whom none of the exclusion criteria applied) were enrolled in the study.



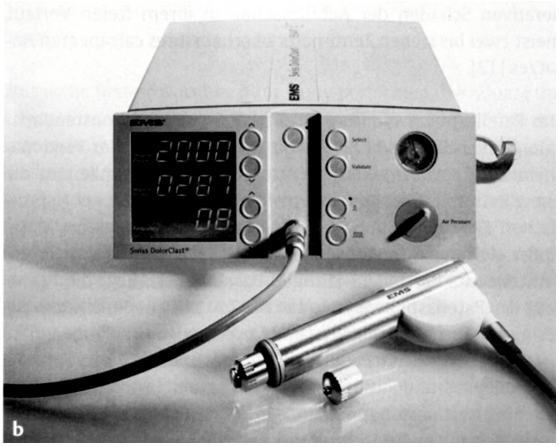


Fig. 1 (a) Principle behind radial shockwaves. The energy is highest as it leaves the tip of the applicator, and decreases peripherally as the distance is squared. This means that a relatively larger tissue volume is treated. (b) The radial extracorporeal shockwave therapy device (Swiss DolorClast®, EMS Medical GmbH, Constance) allows gentle biofeedback-controlled shockwave therapy to be administered.

The treatment with radial extracorporeal shockwaves was administered with the Swiss DolorClast® (EMS Medical GmbH, Constance, Figs. 1a and b). By means of this technology, a projectile in a handpiece is accelerated by a pressurised air source and strikes the metal applicator with a 15 mm diameter. The energy generated is transmitted to the patient's skin as a shockwave through a contact gel (standard commercially available ultrasound gel). This then disperses radially from the application site into the tissue that is to be treated (Fig. 1a). The energy generated depends considerably on the working pressure to which the device has been set, and was increased from 2 to 4 bars (0.06 and 0.18 mJ/mm^2 respectively), according to the patient's response to the shockwave-induced pain. The contact pressure setting of "moderate" was selected for this study. No analgesia of the treatment area was

administered. The treatment (Figs. 2 and 3) took place in 5 sessions at weekly intervals. At each treatment session, 2000 pulses were applied. The treatment frequency was 5 pulses/sec. In the case of both patellar tendinopathy and achillodynia, the pathologically changed area was covered in a meandering pattern (for achillodynia) or a circular pattern (patellar tendinopathy), starting at the clinically assessed maximum pain level.

In all cases, an examination was carried out before treatment, after the admission examination and following a treatment-free interval of at least two weeks. Follow-up examinations took place 1, 4, 12, 26 and 52 weeks after completion of the treatment.

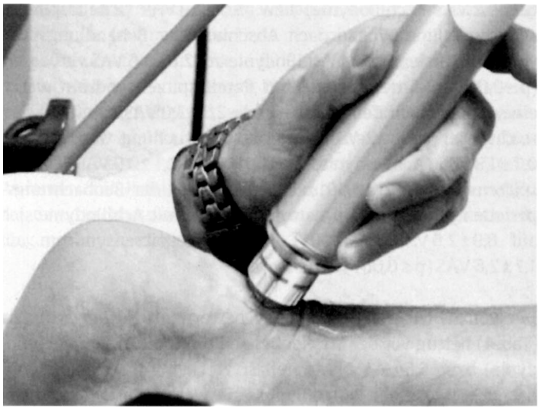


Fig. 2 Radial extracorporeal shockwave treatment technique in achillodynia. The pain focus is covered in a meandering pattern during treatment.

For the sport-specific assessment, the pain-free running distance, as recorded in the case history and expressed in minutes, was selected. The question of the load-induced pain intensity, measured on the standard visual analogue scale (VAS), was also checked in order to be able to evaluate non-sports-related stresses. A score of 10 indicated the maximum subjectively perceived pain intensity in relation to the test parameter, and 0 the minimum.

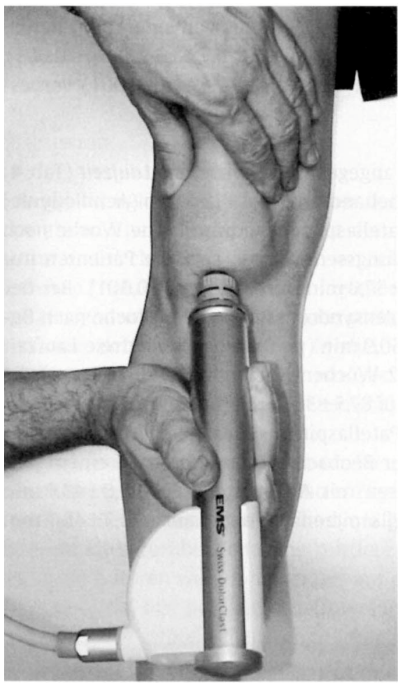


Fig. 3 Radial extracorporeal shockwave treatment technique in patellar tendinopathy. The pain focus is covered in a circular pattern during treatment.

The “Dolormeter” was introduced as a semi-objective measuring instrument [16,29] that allows a standardised application of defined forces (Fig. 4). Both the tenderness threshold (in Newtons) and the subjective pain response (VAS) to a defined pressure of 30 Newtons using a metal stamp with a 10 mm diameter were evaluated. The data obtained were subjected to statistical analysis (comparison of mean values; Microsoft Excel 2000).

Fig. 4 The “Dolormeter”. As an assessment instrument, it allows a standardised pressure to be applied to a circular surface with a diameter of 10 mm.

Results

The patients in the study groups had a mean age of 35.8 ± 10.5 years (achillodynia) and 24.2 ± 9.8 (patellar tendinopathy). The athletes with achillodynia were 178.5 ± 7.5 cm tall and weighed 75.9 ± 12. 6 kg. The group of athletes with patellar tendinopathy were 179.1 ± 8.9 cm tall, and had a weight of 73.7 ± 13.7 kg.

All patients in the study groups were athletes. Runners predominated in the achillodynia group. Patients with patellar tendinopathy were mainly involved in jumping (Table 1). The study involved 40 patients with chronic achillodynia and 45 patients with chronic patellar tendinopathy. After one year, it was still possible to follow up 33 (82.5%) patients with chronic achillodynia and 40 (88.9%) patients with patellar tendinopathy (Table 3).

Table 2 Prior treatments received by the study patients (multiple mentions were possible)

Prior treatment	Achillodynia	Patellar tendinopathy
Physiotherapy	31	26
Massage	15	13
Electrotherapy	30	30
Medication (oral)	14	12
Ointments	8	9
Strapping	11	21
Infiltration (without cortisone)	22	13
Infiltration (with cortisone)	8	2
Orthotics	7	7
Immobilisation	6	7
Acupuncture	4	1
X-ray treatment	1	0
Surgery	5	2

Table 3. Development of the number of patients (n) over the course of the treatment and the follow-up period

	Before treat-ment	After treatment				
		1 week	4 weeks	12 weeks	26 weeks	52 weeks
Achillo-dynia	40	40	39	33	33	33
Patellar tendino-pathy	45	45	45	42	40	40

The *pain at rest* subjectively assessed by the patients (Table 4) was 1.7 ± 2.5 VAS (achillodynia) and 1.6 ± 2.4 VAS (patellar tendinopathy) before the study treatment. One week after the end of the course of treatment, the patients with achillodynia had improved to 0.4 ± 1.0 VAS ($p \leq 0.001$). In the group with patellar tendinopathy, 0.8 ± 1.7 VAS ($p \leq 0.05$) was achieved one week after the end of treatment. At the 12-week follow-up examination, the results were 0.1 ± 0.3 VAS (achillodynia, $p \leq 0.001$) and 0.3 ± 0.7 VAS (patellar tendinopathy, $p \leq 0.001$). At the end of the observation period after one year, the achillodynia patients had improved to 0.1 ± 0.3 VAS ($p \leq 0.001$) and the patellar tendinopathy patients to 0.3 ± 0.7 VAS ($p \leq 0.001$).

The *pain threshold* determined with the Dolormeter (Table 4) was 14.1 ± 6.6 N (achillodynia) and 15.1 ± 7.4 N (patellar tendinopathy) before the study treatment. One week after the end of the course of treatment, the patients with achillodynia had improved to 27.5 ± 10.9 N ($p \leq 0.001$). In the group with patellar tendinopathy, 28.7 ± 14.0 N ($p \leq 0.05$) was achieved one week after the end of treatment. At the 12-week follow-up examination, the results were 38.4 ± 11.8 N (achillodynia, $p \leq 0.001$) and 32.9 ± 15.6 N (patellar tendinopathy, $p \leq 0.001$). At the end of the observation period after one year, the achillodynia patients had improved to 41.9

± 11.6 N ($p \leq 0.001$) and the patellar tendinopathy patients to 35.3 ± 15.0 N ($p \leq 0.001$).

The *tenderness* determined by means of the Dolormeter and VAS (Table 4) at 30 N pressure was 6.7 ± 3.2 VAS (achillodynia) and 5.5 ± 2.9 VAS (patellar tendinopathy) before the study treatment. One week after the end of the course of treatment, the patients with achillodynia had improved to 2.6 ± 3.6 VAS ($p \leq 0.001$). In the group with patellar tendinopathy, 2.3 ± 3.0 VAS ($p \leq 0.001$) was achieved one week after the end of treatment. At the 12-week follow-up examination, the results were 0.7 ± 1.8 VAS (achillodynia, $p \leq 0.001$) and 2.1 ± 2.9 VAS (patellar tendinopathy, $p \leq 0.001$). At the end of the observation period after one year, the achillodynia patients had improved to 0.9 ± 2.6 VAS ($p \leq 0.001$) and the patellar tendinopathy patients to 1.7 ± 2.6 VAS ($p \leq 0.001$).

The *load-induced pain* subjectively assessed by the patients (Table 4) was 7.8 ± 1.7 VAS (achillodynia) and 5.5 ± 2.3 VAS (patellar tendinopathy) before the study treatment. One week after the end of the course of treatment, the patients with achillodynia had improved to 2.2 ± 2.5 VAS ($p \leq 0.001$). In the group with patellar tendinopathy, 2.8 ± 3.0 VAS ($p \leq 0.001$) was achieved one week after the end of treatment. At the 12-week follow-up examination, the results were 0.5 ± 1.1 VAS (achillodynia, $p \leq 0.001$) and 2.3 ± 2.8 VAS (patellar tendinopathy, $p \leq 0.001$). At the end of the observation period after one year, the achillodynia patients had improved to 0.7 ± 1.6 VAS ($p \leq 0.001$) and the patellar tendinopathy patients to 1.9 ± 2.5 VAS ($p \leq 0.001$).

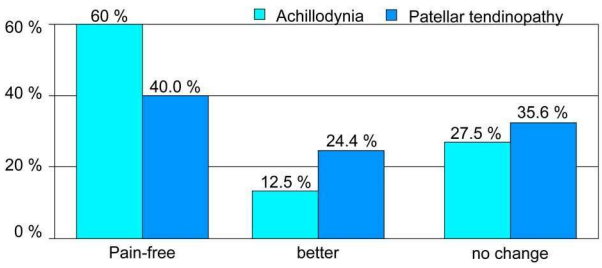
Table 4. Results of radial extracorporeal shockwave therapy in achillodynia and patellar tendinopathy over the course of 5 sessions and a follow-up period of up to one year

	Before treatment	**After shockwave treatment**				
		1 week	**4 weeks**	**12 weeks**	**26 weeks**	**52 weeks**
Achillodynia						
Pain at rest (VAS)	1.7±2.5	0.4±1.0**	0.3±1.3**	0.1±0.3**	0.1±0.2**	0.1±0.3**
Pain threshold (VAS)	14.1±6.6	27.5±10.9**	31.2±13.4**	38.4±11.8**	43.3±9.1**	41.9±11.6**
Tenderness (30 N, VAS)	6.7±3.2	2.6±3.6**	1.8±3.4**	0.7±1.8**	0.5±1.8**	0.9±2.6**
Load-induced pain (VAS)	7.8±1.7	2.2±2.5**	1.3±2.2**	0.5±1.1**	0.4±1.0**	0.7±1.6**
Pain-free running time (min)	14.4±18.5	63.0±37.0**	75.4±38.1**	87.5±35.2**	96.7±34.7**	90.0±43.0**
Patellar tendinopathy						
Pain at rest (VAS)	1.6±2.4	0.8±1.7*	0.6±1.6**	0.3±0.7**	0.3±0.7**	0.3±0.7**
Pain threshold (VAS)	15.1±7.4	28.7±14.0**	30.6±14.5**	32.9±15.6**	34.6±15.5**	35.3±15.0**
Tenderness (30 N, VAS)	5.5±2.9	2.3±3.0**	2.2±3.0**	2.1±2.9**	1.9±2.9**	1.7±2.6**
Load-induced pain (VAS)	5.5±2.3	2.8±3.0**	2.5±2.9**	2.3±2.8**	1.9±2.4**	1.9±2.5**
Pain-free running time (min)	10.4±15.0	54.3±50.9**	57.0±48.9**	62.8±49.2**	71.2±49.1**	70.3±48.7**

The *pain-free running time* reported by the patients (Table 4) was 14.4 ± 18.5 min (achillodynia) and 10.4 ± 15.0 min (patellar tendinopathy) before the study treatment. One week after the end of the course of treatments, the patients with achillodynia had improved to 63.0 ± 37.0 min ($p \leq 0.001$). In the group with patellar tendinopathy, 54.3 ± 50.9 min ($p \leq 0.001$) pain-free running time was achieved one week after the end of treatment. At the 12-week follow-up examination, the results were 87.5 ± 35.2 min (achillodynia, $p \leq 0.001$) and 62.8 ± 49.2 min (patellar tendinopathy, $p \leq 0.001$). At the end of the observation period after one year, the achillodynia patients had improved to 90.0 ± 43.0 min ($p \leq 0.001$) and the patellar tendinopathy patients to 70.3 ± 48.7 min ($p \leq 0.001$).

Overall (Fig. 5), at the time of the last follow-up examination one year after the end of treatment with extracorporeal radial shockwaves, 60% of patients with achillodynia and 40% of patients with patellar tendinopathy had become pain-free. A further 12.5% (achillodynia) and 24.4% (patellar tendinopathy) of patients had improved. In 27.5% of achillodynia patients and 35.6% of patellar tendinopathy patients, the symptom picture was unchanged at the final examination in relation to the admission examination.

Fig. 5. Overall result of radial extracorporeal shockwave therapy in achillodynia and patellar tendinopathy one year after the end of treatment.



Discussion

No studies meeting the requirements of evidence-based medicine have been performed in relation to the conservative or surgical treatment of chronic degenerative injuries to the Achilles tendon (achillodynia) or patellar ligament (patellar tendinopathy) associated with running and jumping stresses [7,12,21,23]. To date, there have also been no concrete studies of the natural course of these symptom pictures [23].

Studies of the conservative treatment of achillodynia have reported excellent results in 41-67% of cases [1,4]. For the surgical treatment of achillodynia, Tallon et al. [31] cite a mean success rate of 77.4% in a review of the literature. The authors refer in particular to a poor methodological quality of the published studies. Moreover, studies with cruder methodological shortcomings yielded comparatively better results [31].

For the treatment of patellar tendinopathy, Cook and Khan [7] found 10 randomised studies of conservative treatment and no randomised studies of surgical treatment in their literature search. These authors conclude from their analysis that neither a specific conservative nor a specific surgical method can currently be recommended for the treatment of this sports injury.

At histology, achillodynia and patellar tendinopathy exhibit mucoid degeneration foci, fibrinoid necroses, microruptures and regeneration foci [12]. There is considerable dissent as to the nomenclature of these running- and jumping-associated chronic tendon injuries in the literature [19]. Even the precise cause of the pain that marks these sports injuries has not yet been established [13].

A degenerative microtraumatic origin is fundamentally assumed, since

inflammatory cells have never been described histologically to any relevant extent [12].

In diagnostic terms, achillodynia is confined to the free course of the tendon approximately 2 – 7 cm above its calcaneal insertion, and must be differentiated diagnostically from other Achilles pain syndromes (e.g. distal insertion tendinopathy, dorsal heel spur, sub-Achilles bursitis) and from peri-Achilles pain syndromes [18].

The efficiency of extracorporeal shockwave therapy in various chronic insertion tendinopathies is sufficiently proven in the literature on the basis of controlled, randomised and prospective studies [15,26,27]. The various treatment modalities (energy production, energy density, dose, and treatment frequency) are still the subject of scientific discussion.

Experience with the treatment of individual cases of achillodynia and patellar tendinopathy with focussed shockwaves has not been successful. The reason for this might lie in the fact that the effective focus of the focussed shockwave is very small. Accordingly, a prerequisite for its use is a small focus of pain, with a diameter not exceeding 5 – 10 mm. Extensive areas of pain should therefore not be one of the indications [8].

Achillodynia and patellar tendinopathy are sports-induced chronic injuries that differ from insertion tendinopathies such as plantar fasciitis insofar as the painful, pathologically changed part of the tendon is of a relatively large volume. Radial extracorporeal shockwaves take automatically account of this, because, in view of their physical properties, they treat a larger target volume.

To date, no clinical studies of the effect of extracorporeal shockwaves in achillodynia and patellar tendinopathy have been published (Medline search). Rompe et al [25] were able to demonstrate dose-dependent effects of extracorporeal shockwaves experimentally in the rabbit Achilles tendon. High energies (> 0.28 mJ/mm^2) therefore cause damage and necrosis.

In agreement with this, we were able to show here that a lower-energy shockwave that strikes a relatively larger target volume is able to achieve regenerative therapeutic effects in both achillodynia and patellar tendinopathy.

The results of this pilot study can be considered good in relation to the results of previous conservative and surgical treatment methods, particularly considering that at least two previous conservative methods of treatment had been unsuccessful. The success rate (freedom from pain or improvement) is 72.5% (achillodynia) and 67.4% (patellar tendinopathy) after one year, and is therefore hardly any different from the mean success rate cited by Tallon et al. [31] after surgery (77.4%).

The decisive limitation of this study is the lack of a control group. Therefore, the results cannot be regarded as sufficiently confirmed according to the criteria of evidence-based medicine. For this reason, further confirmation is needed in future by means of a controlled and randomised study.

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