Effectiveness and Prognostic Factors of Radiotherapy for Painful Plantar Heel Spurs

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Background and Purpose: The efficacy of radiation treatment (RT) for plantar heel pain has been reported repeatedly. Yet, the results referring to the pain relief rate, to long-term effects and prognostic factors are not consistent. In this paper, the effectiveness (pain relief rate and long-term results) and prognostic factors of RT for plantar heel pain have been investigated.
Patients and Methods: From January 2000 to October 2000, 62 patients (73 heels) with painful plantar heel spurs and a minimum pain history of 3 months were treated and evaluated in a prospective study. Mean age was 54 years (range 28–84 years). All patients were treated with a total dose of 5 Gy in seven fractions (= one series), given twice a week at a single-dose sequence of 0.25-0.25-0.5-1.0-1.0-1.0-1.0 Gy (10-MV photons, source-skin distance [SSD] 100 cm, direct portal, field size 12 × 17 cm). The mean duration of heel pain before RT was 26 weeks (= 6.5 months; range 3–120 months). By means of a visual analog scale (VAS) the patients had to self-assess the quantity of their heel pain once before, three times during and four times after RT at a long-term median follow-up of 28 and 40 months. Additionally, the patients had to assess their mechanical heel stress extent during RT. Effectiveness was estimated according to the patients' judgment of pain reduction.
Results: A significant reduction of heel pain extent measured by VAS has been observed already during the RT series (before RT: 6.3 ± 1.5 vs. 3.8 ± 2.1 at the end of RT; $p < 0.001$). 6 weeks after RT (FU 1) pain reduction (> 20%) was achieved in 60 heels (82.3%; n = 73), in 64 heels (91.4%; n = 70) after a mean follow-up of 28 months (FU 2), and in 61 heels (89.7%; n = 68) after a mean follow-up of 40 months (FU 3), respectively. Sufficient pain relief (> 80% compared to initial extent) was observed in 18/73 heels (24.6%) at FU 1 (FU 2: 42/70; 60.0%; FU 3: 37/68; 54.4%), including 13/73 heels (17.8%) with complete pain relief (FU 2: 39/70; 55.7%; FU 3: 36/68; 52.9%). Partial improvement (50–80% pain reduction) was observed in 27/73 heels (37.0%) at FU 1 (FU 2: 14/70; 20.0%; FU 3: 15/68; 22.1%), and minor partial improvement (20–50% pain reduction) in 15/73 heels (20.5%) at FU 1 (FU 2: 8/70; 11.4%; FU 3: 9/68; 13.2%), respectively. No change was seen in 13/73 heels (17.8%) at FU 1 (FU 2: 6/70; 8.6%; FU 3: 7/68; 10.3%). Older patients ($p = 0.04$) and patients who avoided heel stress during the period of RT ($p < 0.01$) demonstrated a better short-term response (FU 1); both effects were lost 28 and 40 months after RT. Moreover, significant differences in the extent of heel pain reduction by RT were observed in dependence on previous pain duration (at FU 2–3).
Conclusion: The results confirm the high efficacy of RT in painful plantar spur and add new aspects to formerly published data concerning the time course of changes in heel pain reduction. Pain relief can be expected during and shortly after RT. In addition, the initial success can be transformed into effective long-term results > 2 years after RT; however, further improvement is not to be expected. As a new prognostic factor, the reduction of mechanical heel stress during RT may ameliorate the short-term results, whereas short heel pain history improves the long-term results. Especially for older patients, RT should be taken into consideration as primary treatment.

Key Words: Painful plantar heel spur · Low-dose radiotherapy · Benign disease · Analgesic therapy · Prognostic factors · Long-term results

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Effektivität und prognostische Faktoren bei der Radiotherapie schmerzhafter plantarer Fersensporne

Hintergrund und Ziel: Die Effektivität der Radiotherapie (RT) bei der Behandlung des plantaren Fersensporns wurde wiederholt beschrieben. Die Daten bezüglich der Schmerzlinderung, der Langzeitergebnisse und der prognostischen Faktoren variieren jedoch. In dieser Arbeit wurden die Effektivität der RT (Schmerzreduktionsrate und Langzeitergebnisse) und prognostische Faktoren bei der Behandlung plantarer Fersensporne untersucht.
Patienten und Methodik: In einer prospektiven Studie wurden von Januar bis Oktober 2000 62 Patienten (73 Fersen) mit einem schmerzhaften plantaren Fersensporn und einer minimalen Schmerzanamnese von 3 Monaten behandelt und ausgewertet. Das mediane Alter lag bei 54 Jahren (Bereich: 28–84 Jahre). Alle Patienten wurden mit einer Gesamtdosis von 5 Gy in sieben Fraktionen, mit zwei Fraktionen pro Woche und einer Einzeldosissequenz von 0,25-0,25-0,5-1,0-1,0-1,0-1,0 Gy (10-MV-Photonen, Abstand

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zwischen Strahlenquelle und Haut [SSD, „source-skin distance"] 100 cm, Stehfeld, Feldgröße 12 × 17 cm = eine Serie) bestrahlt. Die mediane Schmerzdauer vor RT betrug 26 Wochen (= 6,5 Monate; Bereich: 3–120 Monate). Eine quantitative Selbsteinschätzung der Fersenschmerzen mittels einer visuellen Analogskala (VAS) erfolgte vor, dreimal während und viermal nach Abschluss der RT mit einer medianen Nachbeobachtung von 28 und 40 Monaten. Zusätzlich wurde die mechanische Fersenbelastung während der RT erfasst. Die Effektivität der RT wurde nach den subjektiven Schmerzangaben der Patienten abgeschätzt.

Ergebnisse: Während der RT-Serie kann bereits eine signifikante Schmerzreduktion im Bereich der Ferse, mittels VAS erhoben, erreicht werden (vor RT: 6,3 ± 1,5 vs. 3,8 ± 2,1 am Ende der RT; $p < 0{,}001$; Abbildung 1). 6 Wochen nach der RT (FU 1) wurde eine Schmerzreduktion (> 20%) bei 60 Fersen (82,3%; n = 73), nach einer Nachbeobachtungszeit von 28 Monaten (FU 2) bei 64 Fersen (91,4%; n = 70) und nach 40 Monaten (FU 3) bei 61 Fersen (89,7%; n = 68) festgestellt. Eine ausreichende Schmerzlinderung (> 80%) wurde bei 18/73 Fersen (24,6%) zum Zeitpunkt FU 1 beobachtet (FU 2: 42/70; 60,0%; FU 3: 37/68; 54,4%); davon konnte bei 13/73 Fersen (17,8%) eine komplette Schmerzfreiheit erreicht werden (FU 2: 39/70; 55,7%; FU 3: 36/68; 52,9%). Eine teilweise Besserung der Schmerzen (50–80% Schmerzreduktion) wurde bei 27/73 Fersen (37,0%) während FU 1 (FU 2: 14/70; 20,0%; FU 3: 15/68; 22,1%) und eine geringe Linderung (20–50%) bei 15/73 Fersen (20,5%; FU 2: 8/70; 11,4%; FU 3: 9/68; 13,2%) berichtet. Keine Linderung wurde bei 13/73 Fersen (17,8%) während FU 1 beobachtet (FU 2: 6/70; 8,6%; FU 3: 7/68; 10,3%; Abbildungen 2a bis 2d). Ältere Patienten zeigten eine bessere kurzfristige Schmerzlinderung (FU 1; $p = 0{,}04$; Abbildung 3). Patienten, die während der RT eine Belastung der Ferse vermieden, zeigten ebenfalls 6 Wochen nach RT signifikant bessere Behandlungsergebnisse ($p < 0{,}01$; Abbildung 4); beide Effekte waren 28 und 40 Monate nach RT nicht mehr nachweisbar. Ein signifikanter Unterschied im Ausmaß der Schmerzreduktion wurde in Abhängigkeit von der Dauer der Schmerzanamnese festgestellt (FU 2–3; Abbildung 5).

Schlussfolgerung: Die Resultate bestätigen die hohe Effektivität der RT bei der Behandlung des schmerzhaften plantaren Fersensporns und ergänzen die bisher publizierten Ergebnisse zum dynamischen Schmerzverlauf nach RT. Schmerzlinderung kann bereits während und kurz nach der RT erwartet werden. Der initiale Therapieerfolg kann durch weitere Schmerzreduktion nach > 2 Jahren in effektive Langzeitresultate übertragen werden; eine weitere Schmerzreduktion ist danach nicht mehr zu erwarten. Eine Reduktion der mechanischen Fersenbelastung unter der RT kann, als neuer prognostischer Faktor, die Kurzzeitergebnisse verbessern, während eine kurze Schmerzanamnese die Langzeitergebnisse verbessern kann. Insbesondere für ältere Patienten sollte die Strahlentherapie als Therapie der ersten Wahl genutzt werden.

Schlüsselwörter: Schmerzhafter plantarer Fersensporn · Radiotherapie · Gutartige Erkrankung · Schmerztherapie · Prognostische Faktoren · Langzeitergebnisse

Introduction

The painful plantar heel spur is part of the heterogeneous group of degenerative benign diseases concerning the osseous and tendinous structures of spurs. Due to microtraumatic changes and mechanical stress in the insertion of the plantar aponeurosis corresponding to increasing pressure and tractive force of the calcaneus, the osseous heel spur starts to grow toward the trajectories of the spongiosa in the base of the plantar aponeurosis [6, 23]. Form and size of plantar heel spurs do not correlate with the intensity of plantar heel pain [20].

Using anti-inflammatory effects, radiotherapy (RT) of the painful plantar heel spur has been reported to be clinically effective at low costs [28]. During the last decades, several authors repeatedly postulated the effectiveness of RT as measured by the analgesic effect. However, the published quantitative data are variable. The reported rate of complete pain reduction varies between 12 and 75% [15, 30, 31]. Schäfer et al. [20] described a low rate of complete pain reduction after RT (13%), whereas Mücke et al. [15], Seegenschmiedt et al. [28] and Keim [9] described a complete pain reduction of 75%, 72%, and 71%, respectively, in their cohorts. Also the published rate of insufficient pain remissions and the number of therapy failures differ considerably from 5–35% [12, 27].

Data on the influence of treatment parameters and patient-associated factors on the extent of plantar pain relief are sparse. Seegenschmiedt et al. showed a higher rate of complete and partial remissions after a total dose of 5 Gy in comparison to a total dose of 3 Gy, whereas no further improvement was achieved by increasing the dose to 12 Gy [27]. Presumably, older patients gain a higher advantage from RT than younger ones [5]. Several authors postulated that the duration of plantar heel spur pain may be a prognostic factor. Mücke et al. found an interval of > 6 months until the initiation of RT to be a negative prognostic factor for clinical improvement [15]. Systematic data on persistence of the treatment effects have not been published.

In this article we report the results of RT in a prospective series and analyze the significance of prognostic factors suggested in the literature.

Patients and Methods

From January 2000 to October 2000, 62 patients (49 female, 13 male) with refractory painful heel spurs were treated to a standard RT and evaluation protocol in our department. Eleven patients had a bilateral plantar heel spur. Accordingly, 73 plantar heels (58 female, 15 male) were irradiated. Mean age

was 54 years (range 28–84 years). 40 left and 33 right heels were treated. Inclusion criteria were a radiologically proven plantar heel spur, plantar heel pain with a minimum pain history of 12 weeks, age ≥ 25 years, and written consent of the patient. Exclusion criteria were previous foot injuries, peripheral arterial vessel disease, rheumatic illness, pregnancy, and severe psychotic illness.

All patients were treated according to a standard protocol, using high-voltage photons (10 MV, Linear accelerator Saturne I; CGR, Buc, France; source-skin distance [SSD] 100 cm and one lateral field, sized 12 × 17 cm). The total dose applied was 5 Gy, in seven fractions, twice a week, at a dose sequence of 0.25-0.25-0.5-1.0-1.0-1.0-1.0 Gy.

Three heels (4.1%) had previously experienced no other treatment, 70 heels (95.9%) had received at least one other treatment, such as insole support (n = 59; 81%), local injections (n = 57; 79%), systemic nonsteroidal antiphlogistics (n = 21; 29%), physiotherapy (n = 9; 12%), and others (n = 13; 18%). The mean interval between initial heel pain and start of RT was 26 weeks (= 6.5 months; range 3–120 months). In 43 heels pain history was between 3–6 months, in eleven heels between 6–12 months, and 19 heels had a pain history of > 12 months. Patients were divided into these three groups with regard to their duration of pain anamnesis.

18 heels (24.7%) received a second series of RT according to the standard protocol (3–6 months after the first RT series) because of insufficient pain reduction during the period of follow-up. The analysis included all RT.

Plantar heel pain was evaluated during the RT series (in the 1st, 2nd and 3rd week), shortly after RT (immediately and 6 weeks after RT [FU 1]), and during the long-term follow-up in August 2002 (median 28 months after RT [FU 2]) and in August 2003 (median 40 months after RT [FU 3]), including a quantitative self-assessment of heel pain. Quantitative assessment included duration of heel pain before RT, prior treatment, and intensity of pain, specified by a visual analog scale (VAS; from 0 [no pain] to 10 [maximal pain]). Additionally, patients were asked to estimate their subjective mechanical heel stress during the 3.5 weeks of RT. The extent of the latter was documented using the VAS (range from 0 [indicating no stress] to 10 [indicating maximal heel stress]). Effectiveness was estimated according to patients' judgment of pain reduction.

For this purpose, patients were asked to complete a questionnaire. Moreover, patients underwent physical examination before, at the end and 6 weeks after RT. Statistical analysis was performed using a commercial SPSS package (version 11.0).

Results

A significant decrease of pain was observed during RT: pain intensity was reduced from 6.3 ± 1.5 on the VAS (mean ± SD) before RT to 6.2 ± 1.8 after 1 week of RT, 5.5 ± 2.0 after 2 weeks, 4.7 ± 2.4 after 3 weeks, and 3.8 ± 2.1 by the end of RT ($p < 0.001$). During the first follow-up visit, 6 weeks after RT (FU 1), a value of 3.0 ± 2.5 on the VAS was measured, indicating a further significant pain reduction ($p < 0.004$). An increasing pain relief to the value of 1.6 ± 2.2 on the VAS was observed until the second follow-up, 28 months after RT (FU 2; $p < 0.001$). 40 months after RT (FU 3) no further pain relief was measured (VAS 1.8 ± 2.3) in comparison to FU 2 ($p = 0.40$; Figure 1).

A high number of patients reported pain relief shortly after irradiation. In 60 heels (82.3%; n = 73) pain was reduced (relative pain reduction > 20% compared to initial extent). No change was reported in 13/73 heels (17.8%) at FU 1. Complete pain relief was achieved in 13/73 heels (17.8%). Sufficient pain relief (> 80% of initial pain extent) was recognized in 18/73 heels (24.6%), partial improvement (50–80% pain reduction) in 27/73 heels (37.0%), and minor partial improvement (20–50% pain reduction) in 15/73 heels (20.5%; Figures 2a and 2b).

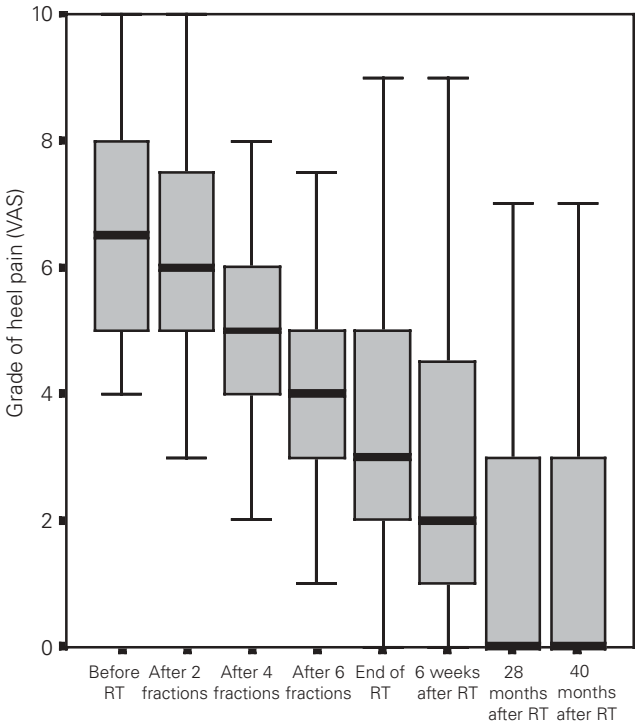

Figure 1. Boxplots showing median, standard deviation, and 25% and 75% percentiles of grade of heel pain demonstrated by patients' subjective evaluation with a visual analog scale (VAS) from 0 (no pain) to 10 (maximal pain) before, during (two to six fractions), and after radiation treatment (RT; at the end of RT and 6 weeks, 28 months, and 40 months after RT; before RT vs. end of RT and 6 weeks after RT vs. 28 months after RT; $p < 0.001$; end of RT vs. 6 weeks after RT; $p < 0.01$).

Abbildung 1. Die Boxplots zeigen den Median, die Standardabweichung und die 25%- und 75%-Perzentilen der subjektiven Schmerzausprägung im Bereich der Ferse, angegeben auf einer visuellen Analogskala (VAS) von 0 (kein Schmerz) bis 10 (maximaler Schmerz) vor, während (nach zwei bis sechs Fraktionen) und nach Radiotherapie (RT; bei Beendigung der RT und 6 Wochen, 28 Monate sowie 40 Monate nach RT; vor RT vs. Ende der RT und 6 Wochen nach RT vs. 28 Monate nach RT; $p < 0{,}001$; Ende der RT vs. 6 Wochen nach RT; $p < 0{,}01$).

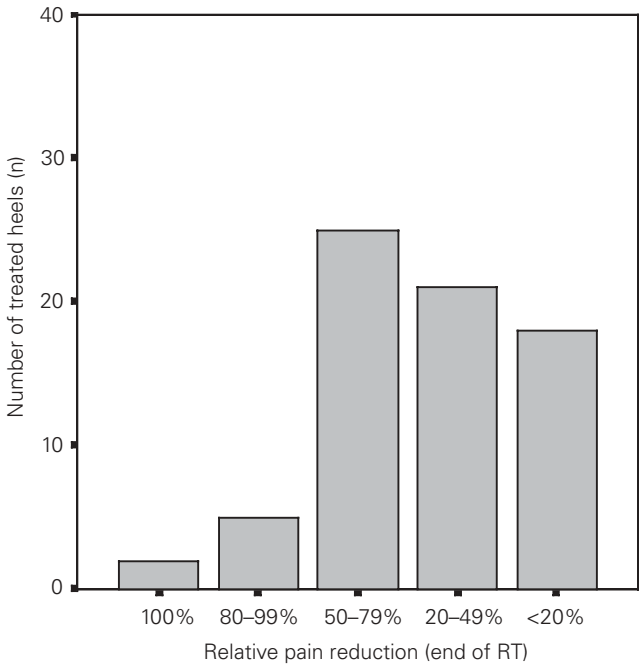

Figure 2a – Abbildung 2a

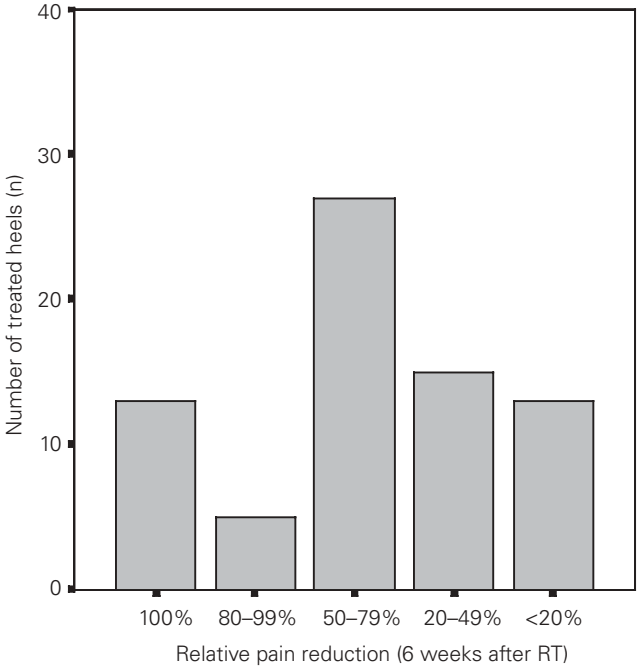

Figure 2b – Abbildung 2b

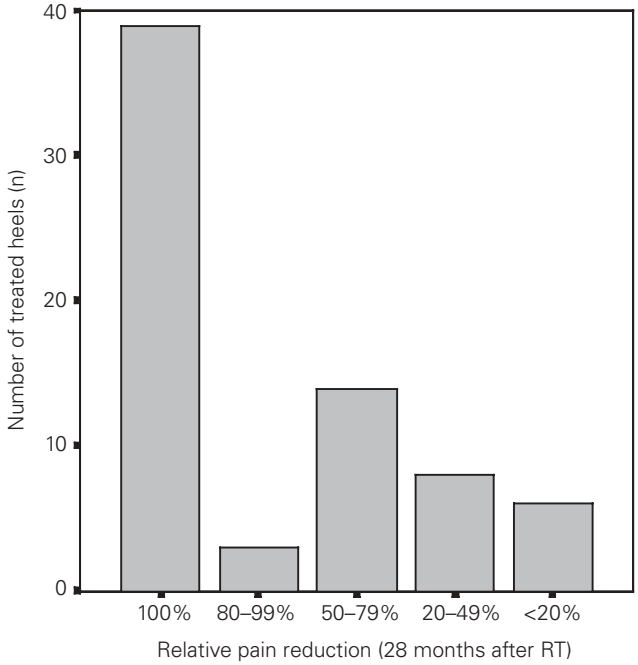

Figure 2c – Abbildung 2c

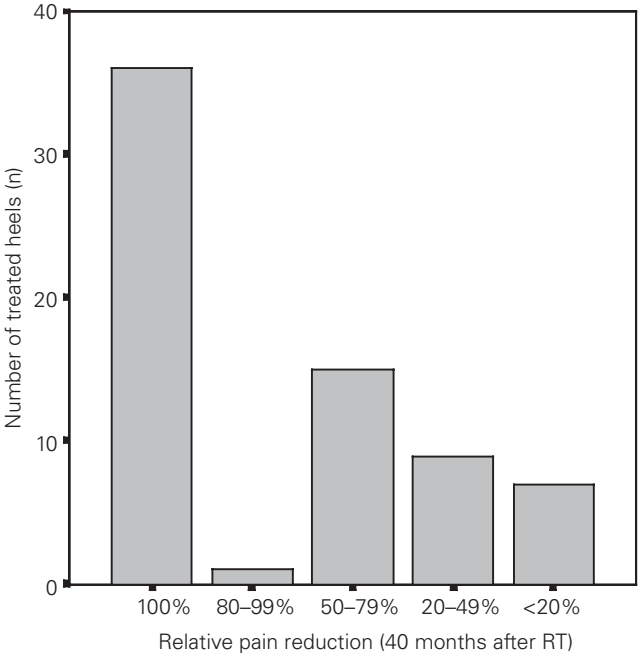

Figure 2d – Abbildung 2d

Figures 2a to 2d. Bar graphs showing number of treated heels with distinct relative pain reduction at four different times: a) at the end of RT (n = 73) as well as b) 6 weeks (n = 73), c) 28 months (n = 70), and d) 40 months after RT (n = 68).

Abbildungen 2a bis 2d. Das Balkendiagramm zeigt die Anzahl der behandelten Fersen mit bestimmter relativer Schmerzreduktion zu vier verschiedenen Zeitpunkten: a) bei Beendigung der RT (n = 73) sowie b) 6 Wochen (n = 73), c) 28 Monate (n = 70) und d) 40 Monate nach RT (n = 68).

The evaluation at FU 2 revealed a plantar pain reduction in 64 heels (91.4%; n = 70), complete pain relief in 39/70 heels (55.7%), sufficient pain reduction in 42/70 heels (60.0%), partial improvement in 14/70 heels (20.0%), minor improvement in 8/70 heels (11.4%), and no improvement in 6/70 heels (8.6%; Figure 2c). Within the 28 months of follow-up (FU 2) pain progression was observed in nine cases (12.9%), which included four cases (5.5%) with complete pain reduction after 6 weeks. However, 49 patients (67.1%) reported a further pain reduction.

Pain extent at FU 3 differed in 25 heels (36.8%) in comparison to FU 2. We found a decreased level of pain in twelve heels (17.6%) and an increasing pain extent in 13 heels (19.1%); the mean difference on the VAS was 0.6 ± 0.8 (± SD). Four patients (5.9%) showed a real pain recurrence, whereas in another four patients (5.9%) a complete pain remission was reported at FU 3. No significant difference in the extent of heel pain at FU 2 versus FU 3 was found. 61/68 heels (89.7%) showed a pain reduction at FU 3, complete pain relief was achieved in 36/68 heels (52.9%), sufficient pain reduction in 37/68 heels (54.4%), partial improvement in 15/68 heels (22.1%), minor improvement in 9/68 heels (13.2%), and no improvement in 7/68 heels (10.3%; Figure 2d).

Patients who suffered from bilateral painful heel spurs (n = 11) showed significant differences in the extent of heel pain, the duration of pain history, and the rate of pain relief between the right and the left heel. In three of these patients pain duration before RT was equal in both feet, in six patients the pain extent before RT was equal, and in four of these patients pain reduction after RT was identical. However, in ten patients differences in regard to the latter variables were observed; only one patient showed equal values in all aforementioned variables.

Patients who required a second RT series due to insufficient pain reduction after the first series (18 heels), demonstrated a significantly diminished pain relief at all three follow-up visits (FU 1: 13.1% ± 7.4% vs. 66.9% ± 3.5%; FU 2: 36.7% ± 9.0% vs. 86.7% ± 4.1%; FU 3: 29.5% ± 7.7% vs. 86.4% ± 3.9%; $p < 0.001$). No influence of previously achieved therapy options could be determined.

Older patients showed a better short-term response 6 weeks after RT (Pearson's correlation coefficient = -0.241; $p = 0.04$; Figure 3). Besides, patients avoiding heel stress during the period of RT demonstrated also a significantly better treatment result 6 weeks after RT (Pearson's correlation coefficient = -0.467; $p < 0.01$), albeit both effects were lost 28 and 40 months after RT (Figure 4).

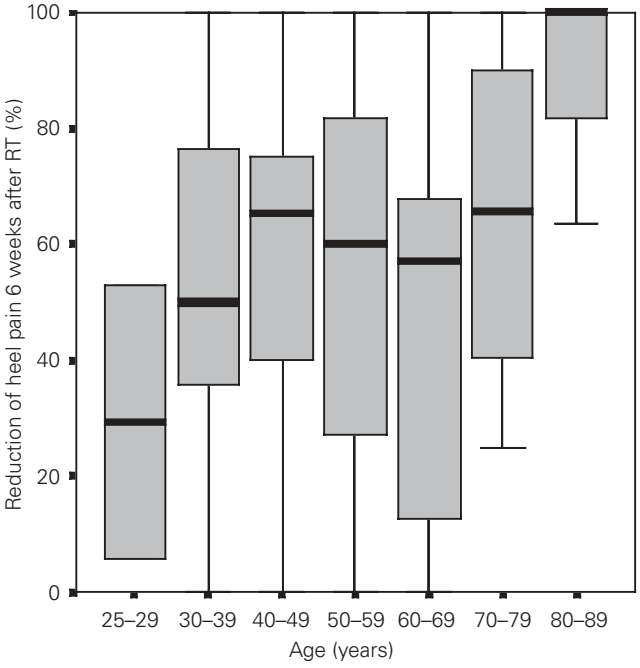

Figure 3. Boxplots showing median, standard deviation, and 25% and 75% percentiles of relative heel pain reduction 6 weeks after RT, depending on the patients' age ($p < 0.05$).

Abbildung 3. Die Boxplots zeigen den Median, die Standardabweichung und die 25%- und 75%-Perzentilen der relativen Fersenschmerzreduktion 6 Wochen nach RT in Abhängigkeit vom Alter der Patienten ($p < 0,05$).

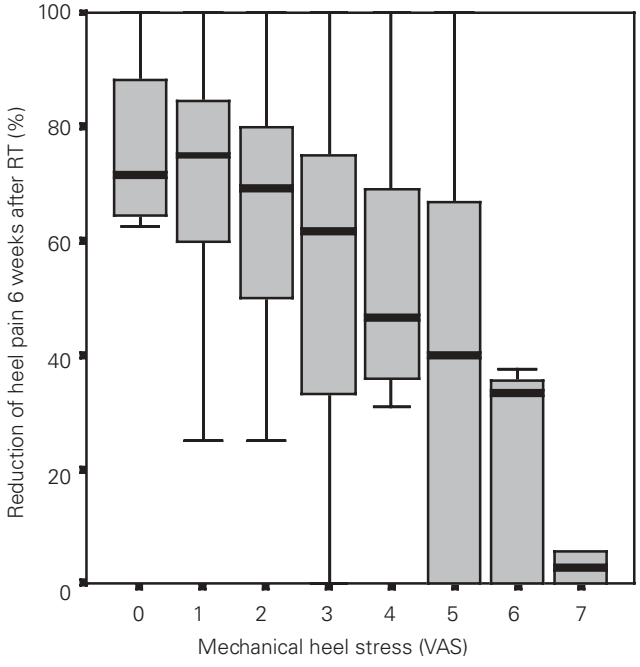

Figure 4. Boxplots showing median, standard deviation, and 25% and 75% percentiles of relative heel pain reduction 6 weeks after RT, depending on the patients' subjective grade of mechanical heel stress during RT ($p < 0.01$).

Abbildung 4. Die Boxplots zeigen den Median, die Standardabweichung und die 25%- und 75%-Perzentilen der relativen Fersenschmerzreduktion 6 Wochen nach RT in Abhängigkeit von der subjektiven mechanischen Fersenbelastung der Patienten während der RT ($p < 0,01$).

Significant differences in the extent of heel pain reduction by RT were observed in correlation to previous pain duration. 28 months after RT, patients with a plantar heel pain history of 3–6 months demonstrated a relative pain reduction of 84.4% ± 4.1% (mean ± SE), whereas patients with a longer pain history (> 6 months) reported only a reduction of 57.9% ± 9.2%. 71.4% of the patients with a pain history < 6 months and 42.9% with a longer pain history, respectively, showed a sufficient pain relief ($p < 0.01$; Figure 5). The effect was constantly observed at FU 3 ($p = 0.02$). Using the upper limit of 12 months pain history before RT, differences in heel pain reduction were observed at FU 2 ($p = 0.03$) and FU 3 ($p = 0.02$). The duration of pain history had no effect on heel pain reduction at FU 1, neither using upper limit of 6 months ($p = 0.24$) nor 12 months ($p = 0.15$).

Discussion

In Germany, RT is a well-accepted and common indication to treat osteoarthritis and periarthritis, and although it is an acknowledged treatment for painful heel spurs [26], no results of randomized trials evaluating RT against a control population are available [4]. However, results of previous clinical studies indicate a high efficacy of RT for painful heel syndrome [2, 3, 5, 7, 10, 12, 14–17, 19, 20, 22, 23, 28, 31].

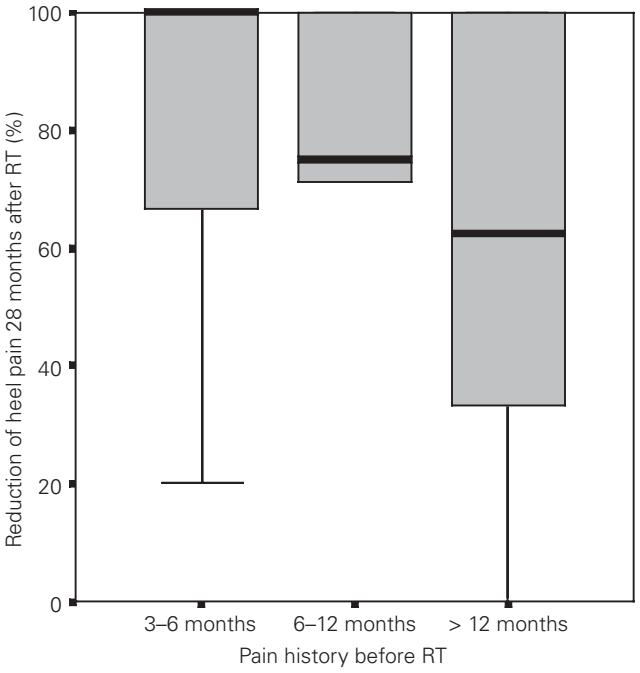

Figure 5. Boxplots showing median, standard deviation, and 25% and 75% percentiles of relative heel pain reduction 6 weeks, 28 months, and 40 months after RT, depending on heel pain history before RT (3–6 months vs. > 6 months; $p < 0.01$; 3–12 months vs. > 12 months; $p = 0.03$).

Abbildung 5. Die Boxplots zeigen den Median, die Standardabweichung und die 25%- und 75%-Perzentilen der relativen Fersenschmerzreduktion 6 Wochen, 28 Monate und 40 Monate nach RT in Abhängigkeit von der Schmerzdauer vor RT (3–6 Monate vs. > 6 Monate; $p < 0,01$; 3–12 Monate vs. > 12 Monate; $p = 0,03$).

Further indications of low-dose RT besides osteoarthritic diseases were published, and positive effects on other inflammatory diseases such as chronic otitis media, hyperproliferative or fibrosing diseases such as Ledderhose's, Dupuytren's or Peyronie's disease were demonstrated [1, 13, 24, 25].

The complex pathophysiological mechanisms involved in these effects are not completely elucidated. The synovial membrane may be the critical target of RT for osteoarthritis [29]. The empirically based anti-inflammatory RT of benign diseases appears to act through specific modulation of different pathways of inflammatory reactions such as the nitric oxide (NO) pathway in stimulated macrophages with reduction of NO production and iNOS expression [8]. In addition, the effect is influenced by different cellular components and mechanisms of inflammation such as adhesion of peripheral blood mononuclear cells and endothelial cells. Low-dose RT shows interacting effects like downregulation of tumor necrosis factor-(TNF-)α, increased expression of interleukin-(IL-)10 and induction of transforming growth factor-(TGF-)β_1, increased apoptosis, and reduction of expression of selectin [18].

Our results confirm the formerly reported high efficacy of low-dose RT in painful plantar spur. Due to significant differences in the extent of heel pain and the duration of pain history between the right and the left heel of the eleven patients suffering from bilateral painful heel spurs, the individual heel was evaluated in itself and not to the single patient. In the literature, response rates from 65% to 100% and rates of complete remission of heel pain from 12% to 81% were observed [3, 5, 7, 10, 14, 15, 20, 21, 27, 31]. Orthovoltage and high-voltage RT were used. We used high-voltage RT (10 MV) and found a short-term response rate (6 weeks after RT) of 82% and a rate of complete pain relief of 18%. We confirmed the observation of other authors of increasing pain relief within weeks and months [11, 19, 28, 31]. We specified the time course of changes in heel pain reduction during and after RT, previously not published. Our data show a significant pain relief already during the RT series. The effect increased and heel pain decreased significantly until the follow-up visits 6 weeks and > 2 years (28 months) after RT, showing that initial success can be transformed into effective long-term results. We observed a delayed complete pain relief after 28 months in 56% and a response rate in 91% of the patients. Schäfer et al. [20] and Seegenschmiedt et al. [28] reported a delayed complete pain relief of 58% (at median 41.5 months) as well as 67% (12 Gy) and 72% (3 Gy/5 Gy; at median 3 years), respectively. Mücke et al. found exemption of heel pain in 75% 20 months after RT [15].

In addition, we observed no further plantar heel pain reduction in the following year. Yet, we also found no significant pain progression or recurrence. 37% of the patients reported slightly higher or lower pain extent during FU 2 to FU 3; the mean difference on the VAS in the patients concerned, however, was only 0.6 in both directions and referred mainly to changes in pain extent of patients with persistent and chronic

heel pain. Real pain recurrence was reported by 13% of the patients in the interval 6 weeks to 28 months after RT and by 5.9% in the interval 28–40 months after RT. By contrast, complete pain reduction was achieved in 67.1% and 5.9%, respectively. It remains unclear to what extent these findings correlate to formerly applied RT or just show the inherent course of the disease. The latter data specify the observation of Lindner & Freislederer who found no further change in the results after a follow-up of 4 years and that of Seegenschmiedt et al. who noticed 0–9% recurrences of heel pain after a median follow-up of 3.5 years [11, 28].

The problem of the optimal RT schedule is not definitely solved. Dose concepts in recent years used single doses ranging from of 0.3 [10] to 1.0 Gy [5, 7, 10, 20, 21, 26]. In the literature, total doses applied range from 3 to 12 Gy. We used a total dose of 5.0 Gy, because a total dose of 5.0 Gy given in 0.5-Gy fractions has been shown to be superior to a total dose of 3.0 Gy with 0.3-Gy fractions. The use of 12.0 Gy in 1.0-Gy fractions did not yield any better result. Yet, in a previous study we found the same effectiveness to reduce heel pain in one series of 10.0 Gy with 1.0-Gy fractions in comparison to 5.0 Gy with 0.5-Gy fractions [2].

On top of this, we used increasing single doses, from 0.25 to 1.0 Gy, to reduce the intensification of pain shortly after initiation of RT. This was supported by our own data previously found and had been published by Lindner & Freislederer before [11]. Our analysis of the time course of heel pain development during RT showed, due to our RT concept, increasing heel pain in only two cases (2.1%). A significant decrease of the heel pain grade started at a dose of 2.0 Gy in the 2nd week of RT. After the subsequent fractions, heel pain was reduced progressively until the end of the RT period (Figure 1).

Treatment failure after the first RT series was evaluated as a prognostic factor. If a second RT series was necessary (n = 18/73), the overall pain reduction was worse at all three follow-up visits in comparison to the rest ($p < 0.001$). Our data confirm the result of Mücke et al. [15]. By contrast, no influence on pain reduction was observed in regard to previously achieved therapy options.

For the endpoint sufficient pain relief, we found the patients' age to be a prognostic parameter for the short-term results 6 weeks after RT. Glatzel et al. [5] also reported age as a prognostic factor for pain relief. In our study, we could reveal another new prognostic parameter influencing the short-term results: mechanical heel stress during RT. Reduction of mechanical heel stress during RT may ameliorate the short-term results. Patients who avoided mechanical heel stress during the period of RT showed significantly better treatment results ($p < 0.01$). Both effects, age and stress, were linked in our study and might be explained by the fact that older patients found it easier to take care of their heels, as they were often retired. Nevertheless, these effects are only short-term ones and could not be observed in the follow-up evaluation 28 and 40 months after RT.

In accordance with several authors [5, 15, 28] and with some of our own previous data [22], we can confirm the duration of heel pain history as a prognostic factor concerning heel pain relief. Our current data show significant differences in the grade of heel pain reduction observed in different groups in regard to their heel pain duration before RT. After a disease record of > 6 months and > 12 months, the patients showed a decreased amount of heel pain reduction. These findings were observed as a trend 6 weeks after RT and showed a significant level at the long-term follow-up visits. Side effects were not observed.

Our results confirm the high efficacy of RT in painful plantar spur. Pain relief can be expected during RT and transformed into a long-term benefit. Results can be divided into short-term and long-term results with their own prognostic factors. Especially for older patients, RT should be taken into consideration as primary treatment due to its low costs and high efficacy. Reduction of mechanical heel stress during RT may improve the short-term treatment results, whereas a short pain history (< 6 months) might influence the long-term results positively.

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