Strahlenther Onkol 2014 · 190:298–303
DOI 10.1007/s00066-013-0462-7
Received: 1 June 2013
Accepted: 11 September 2013
Published online: 24 January 2014

M.G. Hautmann[1] · U. Neumaier[2] · O. Kölbl[1]
[1] Department of Radiotherapy, University of Regensburg
[2] Private Clinic for Radiotherapy, MVZ Neumaier & Kollegen, Regensburg

Re-irradiation for painful heel spur syndrome

Retrospective analysis of 101 heels

Painful heel spur syndrome is a common disease with a lifetime prevalence of approximately 10% in the general population [1, 2, 3, 4, 5]. Heel spur syndrome is considered to be the most common painful foot syndrome apart from toenail problems. Altogether approximately 15% of all foot syndromes are heel spur syndromes [6]. There are several different etiologies of painful heel spur syndrome [7]. The most common etiology is the plantar heel spur coexisting with plantar fasciitis [8, 9, 10]. Furthermore, there is the dorsal heel spur which is also known as Haglund's exostosis mostly combined with retrocalcaneal bursitis. There is also tendinitis of the Achilles tendon, Achilles tendinopathy or Achillodynia [7, 11, 12, 13, 14, 15, 16]. Several therapeutic options for treatment of heel spur syndrome are available but none with a high level of evidence [4]. Besides ice, heat, ultrasound treatment, soft spot heel pads and insoles for correcting an abnormal pronation, many patients receive drug therapy [2]. The drug therapy can be systemic, for example with nonsteroidal anti-inflammatory drugs (NSAID) or can consist of local injections of anesthetics or steroids [6, 17, 18]. For Achilles tendinitis physiotherapy with stretching and deep friction is often used [15, 19]. There are data for the treatment of heel spur syndrome with extracorporeal shock wave therapy and data for surgical treatment of heel spur syndrome [2, 6, 20, 21]. Besides these treatment options, radiotherapy for painful heel spur syndrome, just as radiotherapy for several other bone and joint disorders, has a long history [2, 22, 23, 24, 25, 26]. There have been several studies including some randomized trials with over 4,000 patients in total, which demonstrate the effectiveness of this treatment [2, 4, 5, 26, 27, 28, 29, 30, 31, 32]. In Germany over 3,500 patients receive radiation therapy for painful heel spur syndrome per year [16, 32]. Many authors mentioned that they applied a second or third series of radiotherapy [2, 5, 27, 28, 33, 34] which was given mostly because of recurrent pain or partial or no response after the initial radiation series [5, 27, 33, 35]. In some institutions two series of radiation are included in the primary treatment concept [28]. Although data exist that patients have lower response rates depending on a second series, no study exists which systematically analyzed the results of re-irradiation [16]. The aim of this study was to document the results of re-irradiation for painful heel spur syndrome and to give indications for the ideal time for application. Additionally, it should help to identify those patients who could benefit from re-irradiation.

Patients and methods

The retrospective analysis was performed on patients from two German radiotherapy institutions. All patients who underwent more than one series of radiotherapy for painful heel spur syndrome on the same extremity were identified and patient data from the regular follow-up were analyzed. Patients were additionally questioned about the current status and regular clinical examinations. The etiology of the pain was identified, the reason for re-irradiation was assessed and the time between initial radiotherapy and re-irradiation was documented. Possible risk factors for the result of radiation were registered and correlated with the response. Pain was documented using the numeric rating scale (NRS). Evaluation of the NRS was carried out before and directly after each radiation therapy as well as for the follow-up at 6 weeks, 12 weeks and 6, 12 and 24 months after treatment. Descriptive statistics were carried out. For the NRS the median, range and interquartile range (IQR) were calculated for all time periods. To analyze significant differences in the chronological sequence of the NRS, the paired Wilcoxen test for dependent variables was used. The Mann-Whitney U-test for independent variables was used for subgroup analyses and the Fisher-Yates test for testing of binomial variables. It was postulated that $p<0.05$ was significant. Statistical calculations were done with IBM SPSS Statistics 19.0. A total of 83 patients could be identified, questioned and clinically examined and a total of 101 heels were treated due to the fact that some patients were irradiated on both heels. The median age of the patients was 56 years with a range of 34-82 years and an IQR of 48-63 years. Of the patients 58 were female and 25 male, 55 patients were treated on the right heel and 46 on the left heel. The median follow-up time was 18 months. Etiologically the pain was caused by plantar fasciitis in 73 cases (72.3%), Haglund's exostosis in 16 cases (15.8%) and Achilles tendinitis in 12 cases (11.9%) (**Tab. 1**).

Tab. 1 Demographic data

Criteria	Number	%
Patients (n)	83	
Heels (n)	101	
Gender (n)		
– Male	25	30.1
– Female	58	69.9
Age (years)		
– Median	56	
– First quartile	48	
– Third quartile	63	
Sites (n)		
– Right	55	54.5
– Left	46	45.5
Etiology (n)		
– Plantar fasciitis	73	72.3
– Haglund's exostosis	16	15.8
– Achilles tendinitis	12	11.9
Initial radiation (n)		
Single dose		
– 0.5 Gy	23	22.8
– 1.0 Gy	77	76.2
Total dose		
– 3.0 Gy	23	22.8
– 5.0 Gy	3	3.0
– 6.0 Gy	75	74.2
Interval to re-irradiation (weeks)		
– Median	10	
– First quartile	8	
– Third quartile	16	
Pretreatment besides radiation (%)		98.9
Number of modalities (n)		
– Median	2	

Radiotherapy was carried out with a linear accelerator using 6 MV photons in opposing fields. Dose calculation was carried out for the isocenter. Initially heels were treated with a single dose of 0.5 Gy (23 heels, 22.8%) to a total dose of 3.0 Gy or with a single dose of 1.0 Gy (77 heels, 76.2%) or 1.2 Gy (1 heel) to a total dose of 6.0 Gy (75 heels, 74.3%) or 5.0 Gy (3 heels, 3.0%). In the majority of cases treatment time was 2 weeks (median 12 days, IQR 12–14 days). Re-irradiation was given a median of 10 weeks after the initial radiation (range 4 weeks to 63 months, IQR 8–16 weeks). The reason for re-irradiation was no response after the initial radiation in 36 cases (35.6%), partial response in 40 cases (39.6%) and recurrent pain in 25 cases (24.8%). A total of 16 (15.8%) heels were re-irradiated with a single dose of 0.5 Gy to a total dose of 3.0 Gy and 84 (83.2%) heels with a single dose of 1.0 Gy to a total dose of 6.0 Gy (82 heels, 81.2%) or 5.0 Gy (2 heels, 2.0%). In one case the patient received one dose of 0.5 Gy and then five times 1.0 Gy to a total dose of 5.5 Gy. Treatment time was mostly 2 or 3 weeks (2 or 3 times per week), 74 heels (73.3%) were re-irradiated over 2 weeks and 20 heels (19.8%) were re-irradiated over 3 weeks. Acute or long-term side effects did not occur in this sample.

Results

The median pain score before the initial irradiation was 8 on the NRS (IQR 7–9), before the re-irradiation the median was 6 (IQR 5–8) and on the last day of the re-irradiation the median was 5 (IQR 2–6). The median NRS 6 weeks after re-irradiation was 2 (IQR 1–4), after 12 weeks 1 (IQR 0–3), after 6 months 0 (IQR 0–2) and after 12 and 24 months 0 (IQR 0–1) (**Fig. 1**).

The percentage of patients being free of pain (NRS 0) or scoring 1 on the NRS increased with time (**Fig. 2**).

In the follow-up 6 weeks after re-irradiation 65 out of 99 heels (65.7%) had pain reduction of 3 grades or more on the NRS, after 12 weeks 44 out of 59 heels (74.6%), after 6 months 72 out of 87 heels (82.8%), after 12 months 75 out of 87 heels (86.2%) and after 24 months 56 out of 59 heels (94.9%). Pain reduction compared with the pain level before re-irradiation was significant with $p<0.0001$ for the whole follow-up. There were no significant differences in the remaining pain level and absence of pain for gender and age (patients older or younger than 58 years) for the whole follow-up [36]. Male and female patients older or younger than 58 years had a significant reduction in pain ($p<0.001$ for all categories and the whole follow-up period). Patients were analyzed separately for the etiology of the heel spur syndrome. All patients, those with plantar fasciitis, Haglund's exostosis and Achilles tendinitis showed positive responses to re-irradiation with $p<0.001$ for the whole follow-up for plantar fasciitis and $p<0.05$ for Haglund's exostosis and for Achilles tendinitis. Comparing the subgroups for absence of pain and remaining NRS level, there were no significant differences in the response rates.

Patients were analyzed separately based on the reason for re-irradiation. For the 36 heels with no response after the initial radiation the median NRS was 8 (IQR 6–9) before re-irradiation, 6 (IQR 5–7.5) directly after re-irradiation, 3 (IQR 1.75–6) at the time of the 6-week follow-up, 3.5 (IQR 1–6) at the 12-week follow-up and 1 (IQR 0–3) at 6, 12 and 24 months follow-up. There was a significant response for the whole follow-up ($p=0.002$ after 12 weeks and $p<0.0005$ for all other times). For the non-responders re-irradiation was carried out a median 10 weeks after the initial radiation (IQR 8–13 weeks). The heels with no pain reduction irradiated 12 weeks or later after the initial series (n=11) showed a significant response 6 weeks, 6 months and 12 months after re-irradiation ($p<0.05$). Non-responders after the initial radiation had a significantly higher remaining NRS for the whole follow-up except after 12 months. For the whole time period the rate of patients being free of pain for this subgroup was significantly lower than for the whole sample ($p<0.01$ after 6 weeks and 12 weeks and $p<0.05$ after 6 months, 12 months and 24 months). The 40 patients with partial response after the initial radiation had a median NRS of 5 (IQR 4–6) before re-irradiation, 3 (IQR 1–5) directly after re-irradiation, 1 (IQR 0–3) after 6 weeks and 0 (IQR 0–1) after 12 weeks, 6, 12 and 24 months after re-irradiation. There was a significant response with $p<0.0005$ for the whole follow-up. Patients with partial response after the initial radiation series had a significantly lower NRS level, compared with the other patients, for the whole time except 24 months ($p<0.01$ for 6 weeks and for 12 weeks and <0.012 for 6 months and for 12 months). Initial NRS levels (before the first radiation) showed no significant differences to those of other patients. There were also significantly more patients with absence of pain in this subgroup for the whole follow-up period except after 6 weeks ($p<0.05$). For those 25 patients with recurrent pain, the median NRS was 6 (IQR 4–7) before re-irradiation, 4 (IQR 2–5) directly after re-irradia-

tion and 2 (IQR 0–4) 6 weeks after re-irradiation, 0.5 (IQR 0–2) after 12 weeks and 0 (IQR 0–3) after 6, 12 and 24 months. Pain reduction was significant with p=0.001 after 12 weeks and p<0.0005 for all other times. The patients with recurrent pain did not have a significantly higher number with absence of pain or lower NRS levels compared with the rest of the sample for the whole follow-up (**Fig. 3**).

There were no significant differences in pain reduction and absence of pain if heels were irradiated two or three times weekly or if re-irradiation took place 6–8 weeks or 10–14 weeks after the initial series. Heels of all these categories had a significant pain reduction for the whole follow-up (p<0.0005). Patients re-irradiated with a single 0.5 Gy dose to a total dose of 3 Gy had a significant response to treatment with p<0.001 after 6 and 12 weeks as well as after 24 months and p<0.0005 after 6 and 12 months. Patients re-irradiated with a single 1.0 Gy dose to a total dose of 6 Gy also had a significant response with p<0.0005 for the whole follow-up. There were no significant differences in pain reduction with six times 0.5 Gy compared with six times 1.0 Gy (p>0.05 for the whole follow-up). For the 24 months follow-up a lower NRS level for patients treated with a single dose of 0.5 Gy to a total dose of 3.0 Gy (p=0.022) was found. For the whole follow-up period except the 6 weeks follow-up, there were significantly more patients free of pain in those who were treated with six times 0.5 Gy (p=0.062 after 6 weeks, p<0.05 after 12 weeks, 6 and 12 months and p<0.0005 after 24 months). Of the patients four were re-irradiated a second time (third radiation series), in the case of two patients because of recurrent pain, one patient showed no response and one patient a partial response to the first two radiation series. All four patients had a decrease in pain (lower NRS level) for the whole follow-up.

Discussion

This study is the first where re-irradiation of painful heel spur syndrome was systematically examined. Other authors noted re-irradiation and some information was presented, for example descriptive statistics but most authors just mentioned

Strahlenther Onkol 2014 · 190:298–303 DOI 10.1007/s00066-013-0462-7

M.G. Hautmann · U. Neumaier · O. Kölbl

Re-irradiation for painful heel spur syndrome. Retrospective analysis of 101 heels

Abstract

Purpose. Painful heel spur syndrome is a common disease with a lifetime prevalence of approximately 10%. One of the most effective treatment options is radiotherapy. Many authors recommend a second or third series of radiation for recurrent pain and partial or no response to the initial treatment. As the results of re-irradiation have not been systematically analyzed the aim of this study was to document the results of repeated radiation treatment and to identify patients who could benefit from this treatment.

Material and methods. The analysis was performed on patients from 2 German radiotherapy institutions and included 101 re-irradiated heels. Pain was documented with the numeric rating scale (NRS) and carried out before and directly after each radiation therapy as well as for the follow-up period of 24 months. The median age of the patients was 56 years with 30.1% male and 69.9% female patients. Pain was caused by plantar fasciitis in 72.3%, Haglund's exostosis in 15.8% and Achilles tendinitis in 11.9%. Repeated radiation was indicated because the initial radiotherapy resulted in no response in 35.6% of patients, partial response in 39.6% and recurrent pain in 24.8%.

Results. A significant response to re-irradiation could be found. For the whole sample the median NRS pain score was 6 before re-irradiation, 2 after 6 weeks and 0 after 12 and 24 months. Of the patients 73.6% were free of pain 24 months after re-irradiation. All subgroups, notably those with no response, partial response and recurrent pain had a significant reduction of pain.

Conclusion. Re-irradiation of painful heel spur syndrome is an effective and safe treatment. All subgroups showed a good response to re-irradiation for at least 24 months.

Keywords

Heel spur · Plantar fasciitis · Calcaneodynia · Radiotherapy · Re-irradiation

Rebestrahlung bei schmerzhaftem Fersenspornsyndrom. Retrospektive Analyse von 101 Fersen

Zusammenfassung

Hintergrund. Der schmerzhafte Fersensporn ist eine der häufigsten Erkrankungen unter den Fußsyndromen. Die Lebenszeitprävalenz liegt bei etwa 10%. Eine der wirkungsvollsten Therapieoptionen stellt die Strahlentherapie dar. Dabei beschreiben viele Autoren die Durchführung einer Rebestrahlung bei rezidivierten Schmerzen bzw. unzureichendem oder keinem Ansprechen auf die initiale Bestrahlungsserie, eine strukturierte Auswertung der Rebestrahlung existiert allerdings nicht. Ziel dieser Arbeit ist die strukturierte Auswertung der Rebestrahlung beim schmerzhaften Fersenspornsyndrom.

Material und Methode. Ausgewertet wurden Patienten aus zwei strahlentherapeutischen Institutionen. Insgesamt konnten 101 Fersen analysiert werden. Die Schmerzintensität wurde mit Hilfe der numerischen Rating-Skala (NRS) quantifiziert und zu den Zeitpunkten vor Bestrahlungsbeginn, direkt nach Radiatio, 6 und 12 Wochen, 6, 12 und 24 Monate nach Bestrahlung erfasst.

30,1% der Patienten waren männlich, 69,9% weiblich bei einem medianen Alter von 56 Jahren. Bei 72,3% lag eine Plantarfasziitis, bei 15,8% eine Haglund-Exostose und bei 11,9% eine Tendinitis der Achillessehne vor. Grund der Rebestrahlung war in 35,6% kein Ansprechen und in 39,6% ein unzureichendes Ansprechen auf die erste Bestrahlungsserie sowie in 24,8% rezidivierte Schmerzen.

Ergebnisse. Es zeigte sich für das Gesamtkollektiv eine signifikante Schmerzreduktion. Die mediane Schmerzintensität war 6 vor der Rebestrahlung, 2 nach 6 Wochen und 0 nach 12 und 24 Monaten. 73,6% der Patienten waren 24 Monate nach Rebestrahlung schmerzfrei. Alle Subgruppen, insbesondere Patienten ohne und Patienten mit unzureichendem Ansprechen auf die initiale Bestrahlung bzw. Patienten mit rezidivierten Schmerzen hatten eine signifikante Schmerzreduktion.

Schlussfolgerung. Zusammenfassend zeigt diese Arbeit, dass die Rebestrahlung beim schmerzhaften Fersenspornsyndrom eine effektive Therapie darstellt und dass alle Patientengruppen von der Therapie profitieren.

Schlüsselwörter

Fersensporn · Plantarfasziitis · Kalkaneodynie · Strahlentherapie · Rebestrahlung

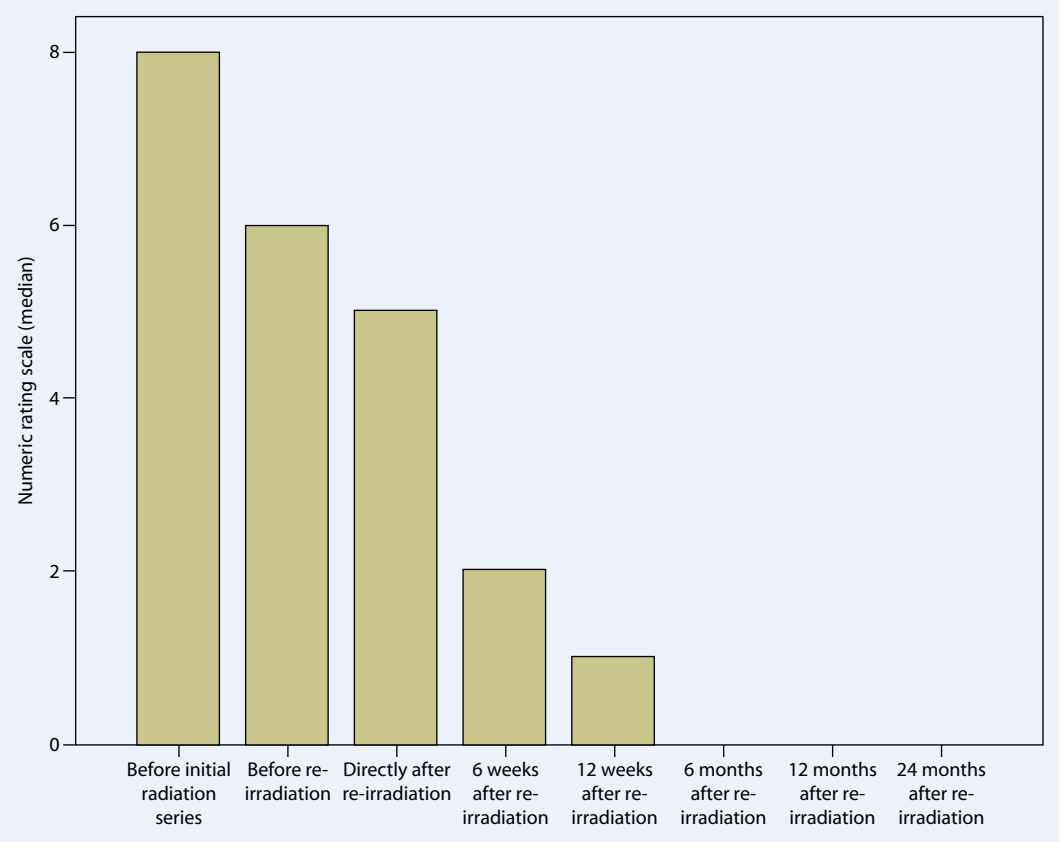

Fig. 1 ◀ Median pain on the numeric rating scale (NRS) of patients during the follow-up period

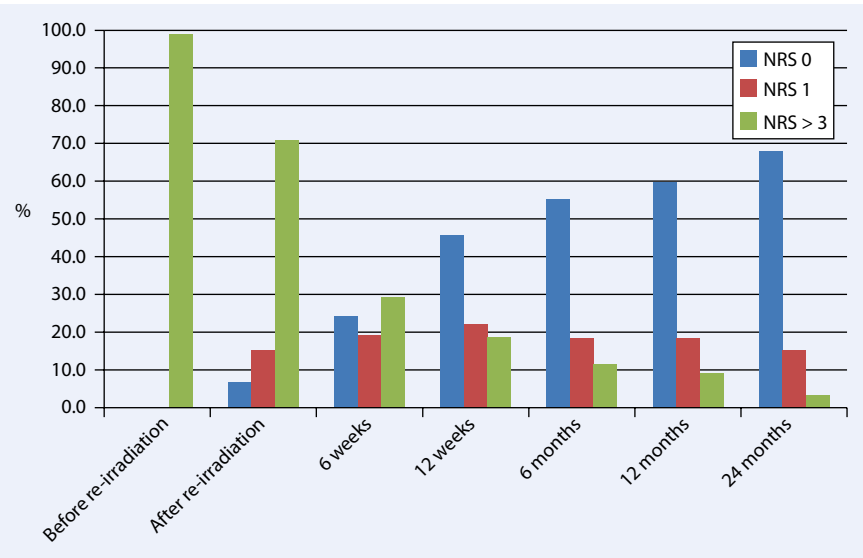

Fig. 2 ▲ Percentage of heels free of pain (NRS 0), scoring 1 on the numeric rating scale (NRS) or scoring pain more than 3 on the NRS

that patients were re-irradiated. No specific subgroup analysis has been carried out until now. The study samples were also small or unstructured. For samples where generally two series of radiation separated by 6 weeks were used for painful heel spur syndrome, no specific analysis was done for the second series alone [8, 16]. The current study sample of only re-irradiated patients seems to be comparable to samples of primary irradiated patients, e.g. the median age of 56 years is similar to that of the samples of Glatzel et al. [35] (average age 55 years), Schneider et al. [34] (average age 54 years), Mücke et al. [27] (median age 58 years) and Heyd et al. [5] (median age 58.5 years). The proportion of male to female patients with 25 male and 58 female patients and the proportion of right to left heels (approximately 1:1) is also representative [28, 33, 34, 36]. There is no published sample where the exact distribution of the etiology of heel pain is mentioned. The radiation technique and dose concept used conform to the recommended concepts of the German cooperative group on radiotherapy for benign diseases. Most of the published study samples were treated in the same way [4, 16, 32]. Re-irradiation has proven beneficial to the patients in the sample studied here. Most of the patients had a response to re-irradiation and more than two thirds of patients were free of pain or had a low pain score of 1 in the NRS 12 weeks after re-irradiation. This effect lasted for at least 2 years as of the last follow-up examination. In this sample of re-irradiated patients a complete response (NRS 0) was achieved in 59.8% after 12 months and another 18.4% of patients scored pain level 1 on the NRS. The response rate to radio-

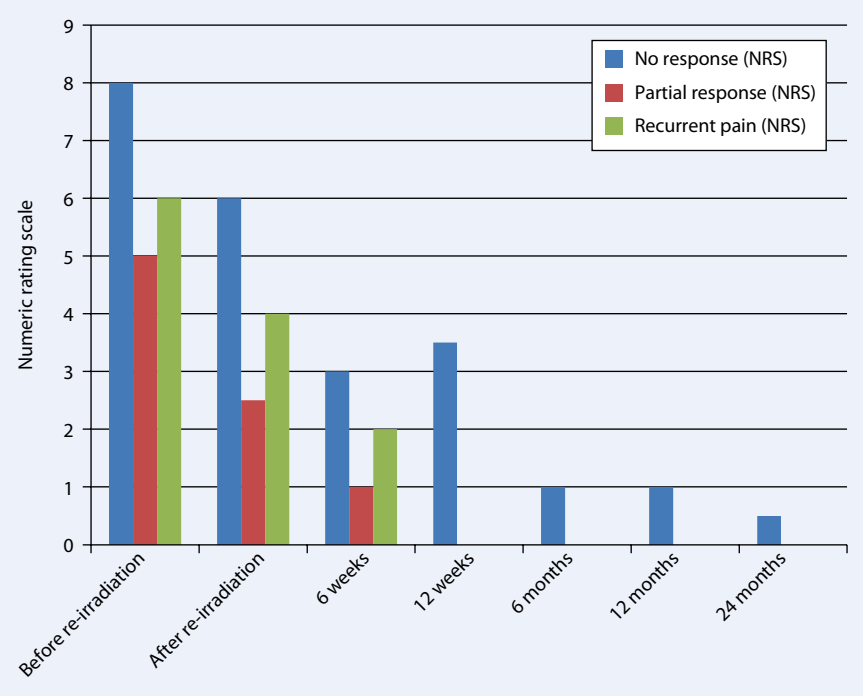

Fig. 3 ▲ Median pain on the numeric rating scale (NRS) depending on the reason for re-irradiation. Patients with no response after the initial series are coloured *blue*, patients with partial response *red* and patients with recurrent pain *green*

therapy of heel spur syndrome in primary samples varied between 65 % and 100%. Complete response could be achieved for 12-100%, a partial response for 0-65% and with no response in 0–35% [2, 5]. Analysis of the unstructured data for re-irradiation published so far revealed that 31 out of 41 (75.6%) [5] and 77 out of 97 (79.4%) [32] of re-irradiated patients showed further improvement from re-irradiation after 6 weeks. For this sample a longer follow-up period was not given. Miszczyk et al. [32] found a further improvement in 89% (85 out of 96 patients) of the re-irradiated patients after a median follow-up time of 18 months. In 47% of the cases (45 heels) patients were free of pain, in 20% (19 heels) patients had a reduction of pain of more than 50% and in 22% of the cases (21 heels) patients had a reduction in pain of less than 50% [33]. In the sample of Schneider et al. [34] a relative pain reduction of >20% was achieved in 13.1% of the re-irradiated patients after 6 weeks and 36.7% after a median of 28 months. In the samples published by Mücke et al. [27] 88 patients were re-irradiated and 38 (32.2%) patients were free of pain or showed marked improvement after a median follow-up of 26 months [36]. In the sample of Glatzel et al. [35]41.7% (10 out of 24 heels) were free of pain after a median follow-up time of 30 months but no other specifications were given. Although no specific subgroup analysis was carried out these data support the results of this study that patients benefit from re-irradiation. For samples where generally two series of irradiation separated by 6 weeks were used for painful heel spur syndrome, each one with a total dose of 6.0 Gy, no better results were found compared with a single series of 5.0 Gy in total [8]. For reasons of radiation protection a general application of two series of radiotherapy for heel spur syndrome has to be carefully evaluated as to the risks involved. In most of the published samples the majority of patients could be treated with sufficient results with just one series of radiotherapy [4, 16, 30, 31]. The data from this study suggest that patients with no or partial response or recurrent pain have good results even if re-irradiation is done later than 6 weeks after the first radiation series. In summary a general application of two series of radiotherapy should not be recommended. As recommended for the initial series of radiation, a single dose of 0.5–1.0 Gy and a total dose of 3.0–6.0 Gy, two or three times weekly, should be used for re-irradiation of painful heel spur syndrome [4, 16, 32, 36]. As no randomized trial was performed, a definitive suggestion for the exact dose concept could not be made based on this analysis. A single dose of 0.5 Gy over 2–3 weeks seems to be recommendable, particularly as there seems to be a trend for a better response with six times 0.5 Gy compared to six times 1.0 Gy in this study. Furthermore, other authors could show similar response rates for a single dose of 0.5 Gy for primary irradiated patients [32, 28]. For reasons of radiation protection a total dose of 3.0 Gy seems to be adequate [32]. It needs to be further examined whether better results can be achieved with a total dose of 3.0 Gy, as in this analysis or recommended by Heyd et al. [32] or 5.0 Gy, as recommended by some other authors [27, 28, 36].

No risk factors for treatment failure of re-irradiated patients could be found in this patient sample. All patients, male and female of all age categories, left and right heels, those with plantar fasciitis, Haglund's exostosis and Achilles tendinitis showed positive responses to re-irradiation without significant differences among the subgroups. There were also no significant differences for the patients re-irradiated over a 2 or 3-week period. Independent of the reason for re-irradiation (e.g. no response, partial response to initial radiation or recurrent pain) patients had a significant pain reduction. Those patients with no response to initial radiation retained a higher level of pain during the follow-up period. In addition, they had a lower chance to become free of pain. Nevertheless, also these patients had a significant pain reduction with re-irradiation. Patients with partial response to the initial radiation had the best chance to achieve absence of pain. Only some authors mentioned a third or fourth radiation series for heel spur syndrome [33]. The sample sizes examined, including that in this study are too small for reliable statistical analyses. As all patients showed a response to the second re-irradiation, it seems to be ethically justified to irradiate patients a third time although there is no evidence to support this. A third series is

justified even more if there are no other treatment options.

Conclusion

Re-irradiation of painful heel spur syndrome is an effective and safe form of treatment. All subgroups, notably those with no response, partial response and recurrent pain showed a good response to re-irradiation for at least 24 months. A single dose of 0.5 Gy and a total dose of 3.0 Gy seem to be recommendable. To define the exact dose concept further investigations are necessary.

Corresponding address

M.G. Hautmannm, M.D.
Department of Radiotherapy, University of Regensburg
94042 Regensburg
Germany
matthias.hautmann@ukr.de

Compliance with ethical guidelines

Conflict of interest. G. Hautmann, U. Neumaier, and O. Kölbl state that there are no conflicts of interest.

The accompanying manuscript does not include studies on humans or animals.

References

1. DeMaio M, Paine R, Mangine RE et al (1993) Plantar fasciitis. Orthopedics 16:1153–1163
2. Brady LW, Brady LW, Heilmann H et al (2008) Radiotherapy for non-malignant disorders. Springer eBooks. Springer, Berlin Heidelberg New York Tokio
3. Karagounis P, Tsironi M, Prionas G et al (2011) Treatment of plantar fasciitis in recreational athletes: two different therapeutic protocols. Foot Ankle Spec 4:226–234
4. Niewald M, Seegenschmiedt MH, Micke O et al (2012) Randomized, multicenter trial on the effect of radiation therapy on plantar fasciitis (painful heel spur) comparing a standard dose with a very low dose: mature results after 12 months' follow-up. Int J Radiat Oncol Biol Phys 84:e455–e462
5. Heyd R, Tselis N, Ackermann H et al (2006) Functional outcome after megavoltage irradiation for heel spurs. Strahlenther Onkol 182:733–739
6. Buchbinder R (2004) Clinical practice. Plantar fasciitis. N Engl J Med 350:2159–2166
7. Sofka CM, Adler RS, Positano R et al (2006) Haglund's syndrome: diagnosis and treatment using sonography. HSS J 2:27–29
8. Seegenschmiedt MH, Keilholz L, Stecken A et al (1996) Radiotherapy of plantar heel spurs: indications, technique, clinical results at different dose concepts. Strahlenther Onkol 172:376–383
9. Yi TI, Lee GE, Seo IS et al (2011) Clinical characteristics of the causes of plantar heel pain. Ann Rehabil Med 35:507–513
10. Johal KS, Milner SA (2012) Plantar fasciitis and the calcaneal spur: fact or fiction? Foot Ankle Surg 18:39–41
11. Weber C, Wedegärtner U, Maas LC et al (2011) MR-Tomografie der Achillessehne: Evaluation von Kriterien zur Differenzierung von asymptomatischen und symptomatischen Sehnen (MR imaging of the Achilles tendon: evaluation of criteria for the differentiation of asymptomatic and symptomatic tendons). Rofo 183:631–640
12. Steffensen JC, Evensen A (1958) Bursitis retrocalcanea achilli. Acta Orthop Scand 27:229–236
13. Pyasta RT, Panush RS (1999) Common painful foot syndromes. Bull Rheum Dis 48:1–4
14. Barrett SJ, O'Malley R (1999) Plantar fasciitis and other causes of heel pain. Am Fam Physician 59:2200–2206
15. Scott A, Huisman E, Khan K (2011) Conservative treatment of chronic Achilles tendinopathy. CMAJ 183:1159–1165
16. Micke O, Seegenschmiedt MH (2004) Radiotherapy in painful heel spurs (plantar fasciitis)—results of a national patterns of care study. Int J Radiat Oncol Biol Phys 58:828–843
17. Crawford F, Thomson C (2003) Interventions for treating plantar heel pain. Cochrane Database Syst Rev 3:CD000416
18. Ball EM, McKeeman HM, Patterson C et al (2012) Steroid injection for inferior heel pain: a randomised controlled trial. Ann Rheum Dis 72:996–1002
19. Joseph M, Taft K, Moscwa M et al (2011) Deep friction massage for the treatment of tendinopathy: a systematic review of a classic treatment in the face of a new paradigm of understanding. J Sport Rehabil 21:343–353
20. Chang K, Chen S, Chen W et al (2012) Comparative effectiveness of focused shock wave therapy of different intensity levels and radial shock wave therapy for treating plantar fasciitis: a systematic review and network meta-analysis. Arch Phys Med Rehabil 93:1259–1268
21. Komatsu F, Takao M, Innami K et al (2011) Endoscopic surgery for plantar fasciitis: application of a deep-fascial approach. Arthroscopy 27:1105–1109
22. Ott OJ, Hertel S, Gaipl US et al (2012) Benign painful elbow syndrome. First results of a single center prospective randomized radiotherapy dose optimization trial. Strahlenther Onkol 188:873–877
23. Arenas M, Sabater S, Hernández V et al (2012) Anti-inflammatory effects of low-dose radiotherapy. Indications, dose, and radiobiological mechanisms involved. Strahlenther Onkol 188:975–981
24. Seegenschmiedt MH, Micke O (2012) Strahlentherapie nichtmaligner Erkrankungen. Vergangenheit, Gegenwart und Zukunft (Radiotherapy of non-malignant diseases. Past, present and future). Strahlenther Onkol 188(Suppl 3):272–290
25. Ott OJ, Hertel S, Gaipl US et al (2012) Benign painful shoulder syndrome: initial results of a single-center prospective randomized radiotherapy dose-optimization trial. Strahlenther Onkol 188:1108–1113
26. Mitrov G, Harbov I (1967) Unsere Erfahrungen mit der Strahlenbehandlung von nichttumorartigen Erkrankungen (Our experiences with radiation treatment of non-tumorous diseases). Radiobiol Radiother (Berl) 8:419–422
27. Mücke R, Schönekaes K, Micke O et al (2003) Low-dose radiotherapy for painful heel spur. Retrospective study of 117 patients. Strahlenther Onkol 179:774–778
28. Seegenschmiedt MH, Keilholz L, Katalinic A et al (1996) Heel spur: radiation therapy for refractory pain—results with three treatment concepts. Radiology 200:271–276
29. Niewald M, Seegenschmiedt MH, Micke O et al (2008) Randomized multicenter trial on the effect of radiotherapy for plantar fasciitis (painful heel spur) using very low doses—a study protocol. Radiat Oncol 3:27
30. Ott OJ, Jeremias C, Gaipl US et al (2013) Radiotherapy for calcaneodynia. Results of a single center prospective randomized dose optimization trial. Strahlenther Onkol 189:329–334
31. Ott OJ, Jeremias C, Gaipl US et al (2013) Radiotherapy for achillodynia. Results of a single-center prospective randomized dose-optimization trial. Strahlenther Onkol 189:142–146
32. Heyd R, Tselis N, Ackermann H et al (2007) Radiation therapy for painful heel spurs: results of a prospective randomized study. Strahlenther Onkol 183:3–9
33. Miszczyk L, Jochymek B, Wozniak G (2007) Retrospective evaluation of radiotherapy in plantar fasciitis. Br J Radiol 80:829–834
34. Schneider O, Stückle CA, Bosch E et al (2004) Effectiveness and prognostic factors of radiotherapy for painful plantar heel spurs. Strahlenther Onkol 180:502–509
35. Glatzel M, Bäsecke S, Krauss A et al (2001) Radiotherapy of painful plantar heel spur. Benign News 2:18–19
36. Muecke R, Micke O, Reichl B et al (2007) Demographic, clinical and treatment related predictors for event-free probability following low-dose radiotherapy for painful heel spurs — a retrospective multicenter study of 502 patients. Acta Oncol 46:239–246