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Effectiveness of radiofrequency ablation for treatment of plantar fasciitis

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Abstract

Plantar fasciitis is the most common cause of heel pain. Pain can be persistent in some patients and interrupt daily activities and sportive activities. There are a lot of treatment options available for plantar fasciitis. We hypothesized that patients with chronic persistent plantar fasciitis can be successfully treated with radiofrequency nerve ablation (RFNA).

Two hundred sixty-one patients with plantar fasciitis (378 feet) treated with RFNA from February 2017 to January 2019 were retrospectively assessed. All the patients had plantar heel pain for at least 6 months. Based on their body mass index (BMI), the enrolled patients were divided into obese (BMI $\geq$ 30 kg/m^2) and non-obese (BMI $<$ 30 kg/m^2) groups. The patients were asked to complete a questionnaire just before and after the procedure and during the final follow-up. The BNS Radiofrequency Lesion Generator was used during a single session. The patients' information, including their visual analogue scale (VAS) score and American Orthopaedic Foot and Ankle Society (AOFAS) score, was assessed. During their final follow-up, the patients were asked to rate the success of their treatment by choosing one of the following options: completely successful, very successful, moderately successful, marginally successful, or not successful.

The VAS and AOFAS scores of all the patients were evaluated pre-procedure, in the first month after procedure, and during the final follow-up (8–24 months). There was a statistically significant difference between the pre-procedure and postprocedure VAS scores ($P < .001$), there was no statistically significant difference between the VAS scores in the first month postprocedure and during the final follow-up.

There was a statistically significant difference between the pre-procedure and postprocedure AOFAS scores ($P < .001$), there was no statistically significant difference between the AOFAS scores in the first month postprocedure and during the final follow-up.

RFNA can be used as an alternative method to surgical procedures for treating plantar fasciitis because it is safe and effective. The advantages of RFNA are that patients can quickly return to their work and resume weight-bearing activities.

Abbreviations: AOFAS = American Orthopaedic Foot and Ankle Society, BMI = body mass index, ESWT = extracorporeal shockwave therapy, PRP = platelet-rich plasma, RFNA = radiofrequency nerve ablation, USG = ultrasonography, VAS = visual analogue scale.

Keywords: AOFAS, hell pain, plantar fasciitis, radiofrequency ablation, VAS

1. Introduction

The causes of heel pain include chronic plantar fascia rupture, heel spur fracture, nerve impingement, and chronic strain on the proximal plantar fascia.[1–3] Although the etiology of heel pain in patients with plantar fasciitis is being discussed, inflammation at the point where the plantar fascia attaches to the anteromedial tubercle is the accepted cause.[3]

Plantar fasciitis is a condition involving the inflammation of the plantar fascia; it is the most common cause of heel pain and may cause disabilities.[4] It is more common in people with a sedentary lifestyle and in people who jog.[5]

Plantar fasciitis accounts for approximately 11% to 15% of foot symptoms.[6] The incidence of bilateral plantar fasciitis is 20% to 30%.[7,8] Although the severity of pain may decrease with daily activities, the pain can be persistent in some patients and interrupt daily activities. Although it is initially diffuse and migratory, it is focused in the medial calcaneal tuberosity over time.[9]

While surgical and non-surgical treatment options exist for the treatment of plantar fasciitis, they have not been proven to be very effective.[6,8]

Successful results can be obtained on using traditional plantar fascia release procedures for treating plantar facia pain. However, these are associated with complications, such as

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All study participants provided informed consent, and the study design was approved by the appropriate ethics review board.

The authors have no conflicts of interest to disclose.

The datasets generated during and/or analyzed during the current study are not publicly available, but are available from the corresponding author on reasonable request.

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wound infection, postoperative lateral foot pain syndrome, deep vein thrombosis, midfoot syndrome, and metatarsal stress fractures.[10,11]

Non-surgical options are more commonly used for the treatment of plantar fasciitis[6–8,12]; these include stretching exercises, braces and orthoses, non-steroidal anti-inflammatory drugs, steroidal injections, botulinum toxin injections, transcutaneous electrical nerve stimulation, platelet-rich plasma (PRP) injections, radiofrequency nerve ablation (RFNA), and extracorporeal shockwave therapy (ESWT).[6,7,12–20]

Despite the treatment options available, not all patients are able to recover. RFNA, a non-surgical treatment option, has a high success rate for treating chronic plantar heel pain.[6,19]

In the present study, we hypothesized that patients with chronic persistent plantar fasciitis can be successfully treated with RFNA. To test this hypothesis, we retrospectively analyzed patients with chronic persistent plantar fasciitis treated with RFNA.

2. Patients and methods

In the present study, 261 patients with plantar fasciitis (378 feet) treated with RFNA from February 2017 to January 2019 were retrospectively assessed. Our institutional ethics committee for studies on human subjects approved the study protocol. Informed consent was obtained from all the patients. Patients with bilateral heel pain were also included in the study, and each heel was analyzed separately. All the patients had plantar heel pain for at least 6 months and were resistant to multiple conservative treatments. The complete inclusion and exclusion criteria are presented in Table 1. All the patients were evaluated using x-rays, and the presence of a calcaneal spur was assessed. Based on their body mass index (BMI), the enrolled patients were divided into obese ($BMI \geq 30\,kg/m^2$) and non-obese ($BMI < 30\,kg/m^2$) groups. The patients who met the criteria were asked to complete a visual analogue scale (VAS) score and American Orthopaedic Foot and Ankle Society (AOFAS) score questionnaire just before and after the procedure and during the final follow-up. The questionnaires were filled as per the standard procedure and were retrospectively analyzed. The patients' data were retrospectively abstracted from their charts. The patients' information, including their VAS score and AOFAS score, was assessed. During their final follow-up, the patients were asked to rate the success of their treatment by choosing one of the following options: completely successful, very successful, moderately successful, marginally successful, or not successful.

Figure 1. Application of RFNA. RFNA = radiofrequency nerve ablation.

2.1. RFNA procedure

The BNS Radiofrequency Lesion Generator (Beijing Neo Science Co., Ltd., China) was used during a single session. After the patient was in a prone position, the painful area was detected by palpation and marked with a marker pen. Once the area was numb, a sterile hypodermic needle (cannula) with a stylet was inserted through the skin and was advanced into the plantar aspect of the calcaneus to reach the painful area. The stylet was withdrawn, and the electrode was inserted through the cannula into the painful area (Fig. 1). After inserting the probe, the stimulated nerve was confirmed to be the sensory nerve and not the motor nerve. This was accomplished by reducing the voltage setting to 0 V, switching to 2 Hz, and increasing the motor stimulation setting to a maximum of 2.5 V. If involuntary contractions appeared on the toes when the motor stimulation was gradually increased, the motor nerve was stimulated and the probe was repositioned. Similarly, in the case of involuntary fasciculations on the foot, the electrode was pulled and repositioned. RFNA was performed using heat under the lesion

Table 1

The complete inclusion and exclusion criteria.

Inclusion criteria	Exclusion criteria
1. Having plantar medial heel pain over 6 months	1. Having undergone a prior surgery in the heel area/region
2. Having undergone at least 2 of the conservative treatment options mentioned below at least 3 months ago:	2. Having a history of trauma or fracture of the calcaneus
• Stretching exercises and ice treatment	3. Having peripheral vascular ischemia
• Extracorporeal shockwave therapy	4. Having peripheral neuropathy and radiculopathy proven by electromyography or physical examination
• Physical therapy	5. Having calcaneal lesions, including benign tumors
• Steroid injections	6. Having an open wound or infection in the heel area/region
• Oral anti-inflammatory drugs and heel pads	7. Having severe fat pad atrophy, calcaneal bursitis, and skin abnormalities around the heel
• Night splints	8. Being pregnant
3. Having benefited from local anesthetic trial injections	9. Having severe arthritic changes

mode at 80°C for 240 seconds. The procedure was performed by a single physician. After the procedure, the small puncture wound at the inlet was covered with a dry dressing.

2.2. Statistical analysis

Descriptive analyses were performed to provide information on the general characteristics of the study population. The Kolmogorov–Smirnov test was used to evaluate whether the distribution of numerical variables was normal. The Mann–Whitney *U* test was used to compare numerical variables between the 2 groups, while the Friedman test was used to compare numerical variables among the 3 time points. A chi-square test was used to compare categorical variables between the groups. The numerical variables are presented as the medians and interquartile ranges, while the categorical variables are presented the counts and percentages. A multiple logistic regression model was applied to determine the risk factors. A P value $< .05$ was considered statistically significant. Analyses were performed using SPSS statistical software (IBM SPSS Statistics, Version 23.0. Armonk, NY: IBM Corp.).

3. Results

RFNA was performed in 261 patients (378 feet) for treating plantar fasciitis, and the patients were retrospectively assessed. Of these, 89 (34%) patients were male and 172 (66%) were female. The median age of the patients was 48 years (range 27–76 years). In total, 117 (31%) patients were treated bilaterally. The average follow-up period was 15 months (range 8–24 months). The VAS and AOFAS scores of all the patients were evaluated pre-procedure, in the first month after procedure, and during the final follow-up (8–24 months). The median VAS score of the patients was 8 (range 8–9) pre-procedure, 0 (range 0–7) in the first month postprocedure, and 0 (range 0–7) during the final follow-up (Table 2). While there was a statistically significant difference between the pre-procedure and postprocedure VAS scores ($P < .001$), there was no statistically significant difference between the VAS scores in the first month postprocedure and during the final follow-up.

The median AOFAS score of the patients was 41 (range 35–54) pre-procedure, 98 (range 60–100) in the first month postprocedure, and 98 (range 55–100) during the final follow-up (Table 2). While there was a statistically significant difference between the pre-procedure and postprocedure AOFAS scores ($P < .001$), there was no statistically significant difference between the AOFAS scores in the first month postprocedure and during the final follow-up.

There was no complete improvement in the symptoms of 16 patients (24 feet). No adverse events were noted in any patient. The non-obese group had better VAS and AOFAS scores and better functional recovery in the postprocedure period than the obese group ($P < .001$, Table 3).

We also evaluated the success of RFNA in the presence of heel spurs and found that heel spurs did not affect the clinical outcomes (Table 4).

Table 2

Comparison results of the among 3 times.

Variables	Preop	Postop	Last follow up	Test statistics	*P*
VAS	8 [1]*	0 [1]	0 [1]	719.3	<.001
AOFAS	41 [6]*	98 [2]	98 [2]	717	<.001

Data were shown as median [interquartile range].

AOFAS = American Orthopaedic Foot and Ankle Society, VAS = visual analogue scale.

* Preop measurements are statistically different from others.

4. Discussion

Patients with plantar fasciitis usually experience pain in the midsection of the heel, especially in the morning (after the first weight-bearing steps) or after long periods of rest.[21] Approximately 11% to 15% of cases of chronic heel pain require treatment,[22,23] and 90% to 95% of successful results are achieved with standard conservative treatments.[24]

Although the etiology of plantar heel pain is not fully known,[17] BMI and calcaneal spurs are associated with its etiology.[25] The role of calcaneal spurs in the pathogenesis of chronic heel pain is not fully known.[17] While most patients with calcaneal spurs are asymptomatic, most patients with plantar heel pain do not have any spur.[14,26] However, a relationship between calcaneal spurs and chronic heel pain has been reported.[27] Spur formation has been observed in 31% to 50% of patients with plantar fasciitis.[14,26] In the present study, we observed spur formation in 45% of the patients. However, we did not note a statistically significant difference between the functional outcomes of patients with and without calcaneal spur formation.

Previous studies have reported a relationship between pain in patients with plantar fasciitis and BMI.[14,15] In many studies, patients have been found to be overweight.[14,15,28] In the study conducted by Wu et al,[15] significant pain reduction and functional improvement were noted in the non-obese group in the early postprocedure period; however, no difference was detected between the obese and non-obese groups after 6 months. Morton et al[29] observed better results in the postprocedure period in patients with low BMI. Similarly, in the present study, non-obese patients showed better functional improvement and a greater decrease in VAS scores than obese patients.

Judy et al[30] found that local steroid injections compared with placebo or no treatment may slightly reduce heel pain up to 1 month but not subsequently. Also it has been reported that steroid injection may cause rupture of the plantar fascia and atrophy of the heel pad in these patients.[4] In our study, pain relief in the early period was better than the results of steroid administration in the literature, and at the same time, side effects of steroid administration were avoided.

PRP injections have been shown to be more effective in relieving pain and improving functional outcomes than steroid injections during the 3-month follow-up.[31,32] With the RFNA method we applied, it was seen that pain relief was possible in an average of 15 months of follow-up and additional interventions such as bloodletting in the PRP procedure were not needed. More than 70% of improvement has been reported in patients after partial or full plantar fascia release. However, some complications, such as iatrogenic pes planus, cuboid compression syndrome, and calcaneal stress fracture, have been reported after plantar fascia release.[33] In our practice, more success was achieved than the success achieved in surgery, and the side effects of surgery were avoided. At the same time, earlier onset and mobilization were achieved compared to the surgical procedure. The fact that it can be easily applied bilaterally also offers an advantage over surgical methods.

Table 3

Comparison results of the characteristics and other features between 2 groups.

Variables		Obesity			
	No (n = 273)	Yes (n = 105)		Test statistics	*P*
Gender	Male	108 (%39.6)	22 (%21)	11.637	<.001
	Female	165 (%60.4)	83 (%79)		
Side	Right	129 (%47.2)	49 (%46.6)	1.256	.534
	Left	144 (%52.8)	56 (%53.4)		
Age	47 [17]	48 [14]	0.569	0.569	
ESWT	No	151 (%55.3)	53 (%50.5)	0.714	.398
	Yes	122 (%44.7)	52 (%49.5)		
Steroid	No	87 (%31.9)	29 (%27.6)	0.644	.422
	Yes	186 (%68.1)	76 (%72.4)		
ESWT+steroid	No	191 (%70)	64 (%61)	2.805	.094
	Yes	82 (%30)	41 (%39)		
BMI	24 [5]	34 [3]	14.998	<0.001	
Symptom duration (mos)	12 [13]	10 [9]	0.792	0.428	
Follow up duration (mos)	15 [7]	15 [9]	1.181	0.238	
Preop VAS score	8 [1]	8 [1]	2.423	0.015	
Postop VAS score	0 [1]	1 [1]	4.795	<0.001	
Last follow up VAS score	0 [1]	1 [3]	5.288	<0.001	
Preop AOFAS score	42 [6]	40 [4]	2.797	0.005	
Postop AOFAS score	98 [2]	96 [2]	5.168	<0.001	
Last follow up AOFAS score	98 [2]	96 [13]	5.921	<0.001	
Success	Not successful	11 (%4)	13 (%12.4)	47.147	<.001
	Marginally successful	2 (%0.7)	9 (%8.6)		
	Moderately successful	10 (%3.7)	16 (%15.2)		
	Very successful	93 (%34.1)	30 (%28.6)		
	Completely successful	157 (%57.5)	37 (%35.2)		
Heel spur	No	153 (%56)	53 (%50.5)	0.948	.330
	Yes	120 (%44)	52 (%49.5)		

Data were shown as median [interquartile range] and count (percentage).

AOFAS = American Orthopaedic Foot and Ankle Society, BMI = body mass index, ESWT = extracorporeal shockwave therapy, VAS = visual analogue scale.

Table 4

Comparison results of the characteristics and other features between 2 groups.

Variables		Heel spur			
		No (n = 206)	Yes (n = 172)	Test statistics	*P*
Gender	Male	73 (%35.4)	57 (%33.1)	0.219	.640
	Female	133 (%64.6)	115 (%66.9)		
Side	Right	87 (%42.2)	90 (%52.3)	7.025	.030
	Left	119 (%57.8)	82 (%47.7)		
Age	45 [15]	51.5 [20]	3.440	<0.001	
ESWT	No	114 (%55.3)	90 (%52.3)	0.343	.558
	Yes	92 (%44.7)	82 (%47.7)		
Steroid	No	58 (%28.2)	58 (%33.7)	1.365	.243
	Yes	148 (%71.8)	114 (%66.3)		
ESWT+steroid	No	142 (%68.9)	113 (%65.7)	0.447	.504
	Yes	64 (%31.1)	59 (%34.3)		
BMI	30 [8]	32 [7]	1.574	0.115	
Obesity	No	153 (%74.3)	120 (%69.8)	0.948	.330
	Yes	53 (%25.7)	52 (%30.2)		
Symptom duration (mos)	12 [15]	12 [9]	0.248	0.804	
Follow up duration (mos)	15 [7]	15 [7]	0.489	0.625	
Preop VAS	8 [1]	8 [1]	0.890	0.374	
Postop VAS	0 [1]	0 [1]	0.768	0.443	
Last follow up VAS score	1 [1]	0 [1]	0.759	0.448	
Preop AOFAS score	41 [6]	41 [5]	0.617	0.537	
Postop AOFAS score	98 [2]	98 [2]	1.053	0.292	
Last follow up AOFAS score	96 [2]	98 [2]	0.998	0.318	
Success	Not successful	9 (%4.4)	15 (%8.7)	6.037	.196
	Marginally successful	7 (%3.4)	4 (%2.3)		
	Moderately successful	15 (%7.3)	11 (%6.4)		
	Very successful	75 (%36.4)	48 (%27.9)		
	Completely successful	100 (%48.5)	94 (%54.7)		

Data were shown as median [interquartile range] and count (percentage).

AOFAS = American Orthopaedic Foot and Ankle Society, BMI= body mass index, ESWT = extracorporeal shockwave therapy, VAS = visual analogue scale.

One of the methods applied in the treatment of plantar fasciitis is ESWT, which uses high or low-energy shock waves to treat the interface between the calcaneus and the plantar fascia. Although the exact mechanism of this method in reducing pain is not known, several mechanisms have been suggested. The air spaces that develop within the tissues are believed to be a result of ESWT application, thereby physically separating the plantar fascia from the calcaneus and causing transdermal release. It has not been clearly demonstrated that the decrease in pain after ESWT application may be the result of injury to the calcaneal nerve, and whether this effect is temporary or permanent. Although it is not known exactly how it shows its effect, the ESWT method has remained controversial due to the inconsistency of its results.[34] It has been suggested that the critical step in achieving good results with this device is the location of the central cone of the shock wave, and therefore the success of this method is highly operator dependent. At the same time, it was stated that different devices spread the shock wave differently and could affect the success of the procedure.[35] Wang et al[36] reported an 82.7% success rate and Weil et al[37] found satisfactory results in 82% of the patients treated with ESWT. Rompe et al[38] reviewed 2100 patients from 17 studies and concluded that 60% of those patients who underwent multiple treatments and 50% of those who had a single treatment had total resolution of heel pain. We achieved a success rate of 93% with the single RFNA treatment.

RFNA is based on the principle of dissipating heat from an active electrode.[15] It is used for treating different diseases, such as essential tremor, trigeminal neuralgia, cardiac arrhythmia, lumbar disk herniation, neuroma, coronary vascular disease, cervical pain syndrome, verrucae, and ingrown toenails.[19,39]

RFNA is known to activate angiogenesis in the ischemic heart and increase the release of factors, such as vascular endothelial growth factor and fibroblastic growth factor, in the ischemic area.[40] RFNA, which increases the biological recovery response, plays a role in reducing pain and increasing functional recovery.[41]

Liden et al[35] retrospectively examined 22 patients (31 feet) with plantar fasciitis who underwent RFNA of the medial calcaneal nerve area; they stated that RFNA can be used an alternative to corticosteroid and surgical methods for treating plantar fasciitis. In our study, the success of this procedure was demonstrated on 261 patients (378 feet).

The advantages of RFNA are that the plantar fascia is left intact, the patient is able to resume normal activities a day after the procedure, and the pain relief is long lasting.[19] Another advantage is immediate weight bearing. Moreover, no wound healing is necessary, no surgical shoes or heavy postoperative bandages are needed, and the procedure can be performed easily and quickly.[42]

Most surgeons use ultrasonography (USG) or fluoroscopy during the procedure to accurately place the electrode.[15,19,39] However, some studies have reported successful results without the use of USG or fluoroscopy.[43,44,45] We did not use USG or fluoroscopy to locate the electrode. We initially used a low voltage and repositioned the probes to the heel in the case of any involuntary foot or toe contraction in order to prevent possible neurological injuries. None of our patients experienced complications. Although 16 of our patients (24 feet) did not recover sufficiently, but their functional outcomes were better than those in the pre-operative period. RFNA is a minimally invasive method, and adverse effects are generally caused by incorrect probe insertion. RFNA involves the use of radiofrequency energy. Consequently, the myelin sheath on the nerves is disrupted by the generation of heat in a small area. The high temperature results in the formation of myelin sheath gaps and impairs nerve conduction. Hence, there is a concern about neuroma formation following RFNA. Motor nerve ablation is one of the major complications associated with RFNA. Discriminatory motor and sensory nerve stimulators make it difficult to injure a motor nerve while attempting to ablate a sensory nerve.[33] If the necessary steps are taken before nerve stimulation, motor nerve damage is unlikely. Nevertheless, if motor nerve ablation occurs, the abductor hallucis muscle will be highly affected and minimal functional loss may occur but may theoretically contribute to a slight increase in bunion deformity.[46]

Erken et al[22] suggested RFNA to be an effective alternative treatment option for patients with resistant plantar fasciitis who do not respond to other conservative treatments. In their study, the mean follow-up period was 2 years and the stylus temperature was increased to a maximum of 90°. Similarly, Landsman et al[33] showed that RFNA is an effective method for treating plantar fasciitis.

The success rate of procedures performed using the medial approach has been reported to be 87.5% to 93.3%.[1–3,8,9] Sollitto et al[39] achieved a 92% complete recovery rate using the plantar approach. Similarly, we placed the probe using the plantar approach and achieved a 93% success rate.

Another advantage of RFNA is that it has immediate effects. Erken et al[22] reported significantly lower VAS scores in the first month after RFNA. They also reported that this effect persisted for 2 years. Moreover, Cozzarelli et al[42] found the 5-, 10-, and 12-year success rates of the treatment to be 89%. In the present study, a significant decrease in VAS scores was observed in the first month after RFNA; this effect was persistent during the final follow-up.

5. Limitations

This study has some limitations. First, it is a retrospective study. Second, our follow-up time is short. Third, we did not use USG or fluoroscopy when performing RFNA. Fourth, we did not investigate the effect of multiple factors such as the presence of ankle equines, activity level, and average time standing per day, all of which may affect outcomes.

6. Conclusion

In conclusion, RFNA can be used as an alternative method to other procedures for treating plantar fasciitis because it is safe and effective. Complications of surgical procedures are avoided. It can eliminate the need for multiple applications in the ESWT method. The side effects of the steroid in the steroid injection are avoided and there is no need for extra procedures such as bloodletting in the PRP application. The advantages of RFNA are that patients can quickly return to their work and resume weight-bearing activities.

Author contributions

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References

[1] Barrett SJ, O'Malley R. Plantar fasciitis and other causes of heel pain. Am Fam Physician 1999;59:2200–6.
[2] Weber JM, Vidt LG, Gehl RS, Montgomery T. Calcaneal stress fractures. Clin Podiatr Med Surg 2005;22:45–54.
[3] Alshami AM, Souvlis T, Coppieters MW. A review of plantar heel pain of neural origin: differential diagnosis and management. Man Ther 2008;13:103–11.
[4] Thapa D, Ahuja V. Combination of diagnostic medial calcaneal nerve block followed by pulsed radiofrequency for plantar fascitis pain: a new modality. Indian J Anaesth 2014;58:183–5.
[5] Trojian T, Tucker AK. Plantar fasciitis. Am Fam Physician 2019;99: 744–50.
[6] Jain SK, Suprashant K, Kumar S, Yadav A, Kearns SR. Comparison of plantar fasciitis injected with platelet-rich plasma vs corticosteroids. Foot Ankle Int 2018;39:780–6.
[7] Cardenuto Ferreira R. Talalgia: plantar fasciitis. Rev Bras Ortop 2014; 49:213–7.
[8] Aqil A, Siddiqui MR, Solan M, Redfern DJ, Gulati V, Cobb JP. Extracorporeal shock wave therapy is effective in treating chronic plantar fasciitis: a meta-analysis of RCTs. Clin Orthop Relat Res 2013; 471:3645–52.
[9] Roxas M. Plantar fasciitis: diagnosis and therapeutic considerations. Altern Med Rev 2005;10:83–93.
[10] Sammarco GJ, Helfrey RB. Surgical treatment of recalcitrant plantar fasciitis. Foot Ankle Int 1996;17:520–6.
[11] Cheung JT, An KN, Zhang M. Consequences of partial and total plantar fascia release: a finite element study. Foot Ankle Int 2006;27:125–32.
[12] Yin MC, Ye J, Yao M, et al. Is extracorporeal shock wave therapy clinical efficacy for relief of chronic, recalcitrant plantar fasciitis? A systematic review and meta-analysis of randomized placebo or active-treatment controlled trials. Arch Phys Med Rehabil 2014;95:1585–93.
[13] Chuckpaiwong B, Berkson EM, Theodore GH. Extracorporeal shock wave for chronic proximal plantar fasciitis: 225 patients with results and outcome predictors. J Foot Ankle Surg 2009;48:148–55.
[14] Yucel I, Yazici B, Degirmenci E, Erdogmus B, Dogan S. Comparison of ultrasound-, palpation-, and scintigraphy-guided steroid injections in the treatment of plantar fasciitis. Arch Orthop Trauma Surg 2009;129: 695–701.
[15] Wu PT, Lee JS, Wu KC, et al. Ultrasound-guided percutaneous radiofrequency lesioning when treating recalcitrant plantar fasciitis: clinical results. Ultraschall Med 2016;37:56–62.
[16] Babcock MS, Foster L, Pasquina P, Jabbari B. Treatment of pain attributed to plantar fasciitis with botulinum toxin a: a short-term, randomized, placebo-controlled, double-blind study. Am J Phys Med Rehabil 2005;84:649–54.
[17] Yalcin E, Keskin Akca A, Selcuk B, Kurtaran A, Akyuz M. Effects of extracorporal shock wave therapy on symptomatic heel spurs: a correlation between clinical outcome and radiologic changes. Rheumatol Int 2012;32:343–7.
[18] Atkins KL, Chin KF, Noorani AM, Nairn DS. Image intensifier-guided injection of corticosteroid and local anesthetic agent for the treatment of recalcitrant plantar fasciitis. Foot Ankle Spec 2010;3:172–6.
[19] Cione JA, Cozzarelli J, Mullin CJ. A retrospective study of radio-frequency thermal lesioning for the treatment of neuritis of the medial calcaneal nerve and its terminal branches in chronic heel pain. J Foot Ankle Surg 2009;48:142–7.
[20] Ordahan B, Karahan AY, Kaydok E. The effect of high-intensity versus low level laser therapy in the management of plantar fasciitis: a randomized clinical trial. Lasers Med Sci 2018;33:1363–9.
[21] Tracey I. Imaging pain. Br J Anaesth 2008;101:32–9.
[22] Erken HY, Ayanoglu S, Akmaz I, Erler K, Kiral A. Prospective study of percutaneous radiofrequency nerve ablation for chronic plantar fasciitis. Foot Ankle Int 2014;35:95–103.
[23] Michel R. Use of pulsed radio frequency energy in the effective treatment of recalcitrant plantar fasciitis: six case histories. Foot 2012;22:48–52.
[24] Gill LH. Plantar fasciitis: diagnosis and conservative management. J Am Acad Orthop Surg 1997;5:109–17.
[25] Irving DB, Cook JL, Menz HB. Factors associated with chronic plantar heel pain: a systematic review. Sci Med Sport 2006;9:11–22.
[26] Riddle DL, Pulisic M, Sparrow K. Impact of demographic and impairment-related variables on disability associated with plantar fasciitis. Foot Ankle Int 2004;25:311–7.
[27] McMillan AM, Landorf KB, Barrettl JT, Menz BH, Bird AR. Diagnostic imaging for chronic plantar hell pain: a systematic review and meta-analysis. J Foot Ankle Res 2009;2:32.
[28] Reb CW, Schick FA, Karanjia HN, Daniel JN. High prevalence of obesity and female gender among patients with concomitant tibialis posterior tendonitis and plantar fasciitis. Foot Ankle Spec 2015;8:364–8.
[29] Morton TN, Zimmerman JP, Lee M, Schaber JD. A review of 105 consecutive uniport endoscopic plantar fascial release procedures for the treatment of chronic plantar fasciitis. J Foot Ankle Surg 2013;52:48–52.
[30] David JA, Sankarapandian V, Christopher PRH, Chatterjee A, Macaden AS. Injected corticosteroids for treating plantar heel pain in adults. Cochrane Database Syst Rev 2017;6:CD009348.
[31] Singh P, Madanipour S, Bhamra JS, Gill I. A systematic review and metaanalysis of platelet-rich plasma versus corticosteroid injections for plantar fasciopathy. Int Orthop 2017;41:1169–81.
[32] Zhang H, Xiao T. Comment on Singh et al.: a systematic review and metaanalysis of platelet-rich plasma versus corticosteroid injections for plantar fasciopathy. Int Orthop 2018;42:219–20.
[33] Landsman AS, Catanese DJ, Wiener SN, Richie DHJr, Hanft JR. A prospective, randomized, double blinded study with crossover to determine the efficacy of radio-frequency nerve ablation for the treatment of heel pain. J Am Podiatr Med Assoc 2013;103:8–15.
[34] Jan D, Rompe JD, Furia J, Weil L, Maffulli N. Shock wave therapy for chronic plantar fasciopathy. Br Med Bull 2007;81-82:183–208.
[35] Liden B, Simmons M, Landsman AS. A retrospective analysis of 22 patients treated with percutaneous radiofrequency nerve ablation for prolonged moderate to severe heel pain associated with plantar fasciitis. J Foot Ankle Surg 2009;48:642–7.
[36] Wang CJ, Wang FS, Yang KD, Weng LH, Ko JY. Long-term results of extracorporeal shockwave treatment for plantar fasciitis. Am J Sports Med 2006;34:592–6.
[37] Weil LSJr, Roukis TS, Weil LS, Borrelli AH. Extracorporeal shock wave therapy for the treatment of chronic plantar fasciitis: indications, protocol, intermediate results, and a comparison of results to fasciotomy. J Foot Ankle Surg 2002;41:166–72.
[38] Rompe JD, Furia J, Weil L, Maffulli N. Shock wave therapy for chronic plantar fasciopathy. Br Med Bull 2007;81-82:183–208.
[39] Sollitto RJ, Plotkin EL, Klein PG, Mullin P. Early clinical results of the use of radiofrequency lesioning in the treatment of plantar fasciitis. J Foot Ankle Surg 1997;36:215–9.
[40] Dietz U, Horstick G, Manke T, et al. Myocardial angiogenesis resulting in functional communications with the left cavity induced by intra-myocardial high-frequency ablation: histomorphology of immediate and long-term effects in pigs. Cardiology 2003;99:32–8.
[41] Tay KS, Ng YC, Singh IR, Chong KW. Open technique is more effective than percutaneous technique for TOPAZ radiofrequency coblation for plantar fasciitis. Foot Ankle Surg 2012;18:287–92.
[42] Cozzarelli J, Sollitto RJ, Thapar J, Caponigro J. A 12-year long-term retrospective analysis of the use of radiofrequency nerve ablation for the treatment of neurogenic heel pain. Foot Ankle Spec 2010;4: 338–46.
[43] Ozan F, Koyuncu Ö, Gürbüz K, Oncel ES, Altay T. Radiofrequency thermal lesioning and extracorporeal shockwave therapy. A comparison of two methods in the treatment of plantar fasciitis. Foot Ankle Spec 2016;10:204–9.
[44] Hormozi J, Lee S, Hong DK. Minimal invasive percutaneous bipolar radiofrequency for plantar fasciotomy: a retrospective study. J Foot Ankle Surg 2011;50:283–6.
[45] Sorensen MD, Hyer CF, Philbin TM. Percutaneous bipolar radio-frequency microdebridement for recalcitrant proximal plantar fasciosis. J Foot Ankle Surg 2011;50:165–70.
[46] Landsman A. Radiofrequency nerve ablation for the treatment of heel pain. Tech Foot Ankle 2011;10:76–81.