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ORIGINAL ARTICLE

The effectiveness of conventional radiofrequency ablation for chronic plantar heel pain due to heel spur

Topuk dikenine bağlı kronik plantar topuk ağrısında konvansiyonel radyofrekans ablasyonunun etkinliği

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Summary

Objectives: The purpose of this study was to investigate the effectiveness of conventional radiofrequency (CRF) ablation treatment on chronic plantar heel pain due to heel spur.

Methods: A total of 20 patients with heel spur who did not respond to conservative treatments were recruited for the study. Under fluoroscopy guidance, CRF was performed to three points at the top, above, and below the heel spur in the longitudinal plane of the foot. Pain intensity, the pressure pain threshold (PPT), and functional status were assessed using a visual analog scale (VAS), pressure algometers, and the Foot Function Index (FFI). All measurements were taken before the procedure, as well as 1, 3, and 6 months following the procedure.

Results: CRF was applied to 20 patients – 16 (80%) females and 4 (20%) males. Their mean age was 51.40±8.10 years, the mean body mass index was 33.80±5.47 kg/m^2, the mean duration of symptoms was 18.30±9.02 months, and pes planus was present in 5 patients (25%). A statistically significant decrease was observed in VAS score and PPT and FFI measurements at the 1st, 3rd, and 6th month following CRF compared to before CRF (p<0.001).

Conclusion: CRF is an effective, safe, minimally invasive method to reduce pain severity in patients with chronic heel pain due to heel spur in the short (0–3 months) and intermediate term (3–6 months).

Keywords: Heel spur; plantar heel pain; radiofrequency thermocoagulation.

Özet

Amaç: Bu çalışmanın amacı, topuk dikenine bağlı kronik plantar topuk ağrısında Konvansiyonel Radyofrekans Ablasyon (CRF) tedavisinin etkinliğini araştırmaktır.

Gereç ve Yöntem: Çalışmaya, topuk dikenine bağlı topuk ağrısı olan konservatif tedavilere yanıt vermeyen toplam 20 hasta alındı. Ayağın longitudinal düzleminde topuk dikeninin tepe, üst ve altındaki üç noktaya floroskopi klavuzluğunda CRF uygulandı. Ağrı şiddeti; görsel analog skala (VAS), basınç ağrı eşiği (PPT); basınç algometre ve fonksiyonel durum; Ayak Fonksiyon İndeksi (FFI) kullanılarak değerlendirildi. Tüm ölçümler işlemden önce ve işlemden sonraki bir, üç ve altıncı aylarda yapıldı.

Bulgular: CRF, 16 (%80) kadın ve 4 (%20) erkek olmak üzere toplam 20 hastaya uygulandı. Ortalama yaşları 51.40±8.10 yıl, ortalama VKİ 33.80±5.47 kg/m^2, ortalama semptom süresi 18.30±9.02 aydı ve beş hastada (%25) pes planus mevcuttu. CRF'u takiben birinci, üçüncü ve altıncı ayda VAS skoru, PPT ve FFI ölçümlerinde, CRF öncesine göre istatistiksel olarak anlamlı azalma gözlendi (p<0,001).

Sonuç: CRF, kronik topuk dikeni ağrısı olan hastalarda ağrı şiddetini azaltmak için, kısa (0-3 ay) ve orta vadede (3-6 ay) güvenli, etkili ve minimal invaziv bir yöntemdir.

Anahtar sözcükler: Topuk dikeni; plantar topuk ağrısı; radyofrekans termokoagülasyon.

Introduction

All structures in the heel area, including the calcaneus, periosteum, bursa, plantar fascia, muscles, fat ankle, and nerves, may cause plantar heel pain. A painful heel spur was first described by Plettner with radiological findings of exostoses at the entrance point of the plantar part of the calcaneus.[1] The symptoms are characterized by pain under the heel, sometimes radiating to the lower leg, which is most severe in the morning and increases with prolonged standing and walking.[2]

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Chronic damage to the insertion point of the small foot muscles and plantar aponeurosis, caused by mechanical injury or foot deformities, plays an important role in the pathogenesis of heel spur.[3] The elasticity of the insertional cartilage decreases as a result of chronic damage; the clefts formed in the cartilage overtime are filled with mesangial cells in the scar tissue. With the development of new blood vessels, the scar gradually ossifies to form a bony spur.[4] Histologic findings have shown fragmentation and degeneration of the fascia and indicate that heel spur is the result of a chronic degenerative process or fasciosis rather than the result of an inflammatory process.[5]

The main goal of treatment for a heel spur is pain relief and restoration of function. Orthopedic shoes, insoles, nonsteroidal anti-inflammatory agents, local anesthetic and corticosteroid injections, iontophoresis, microwave, radiation therapy, and ultrasound are common treatments.[6] Operative interventions are suggested for chronic plantar heel pain resistant to conservative options. However, surgery can be associated with prolonged healing and, in one study, did not prove superior to conservative treatment.[7]

There are two types of radiofrequency thermocoagulation (RT): Conventional radiofrequency (CRF) ablation and pulsed radiofrequency (PRF). In CRF, a 420 kHz high-frequency alternating current of 90–125 mA is applied for 60–90 s, generating a temperature of 60–80°C. This temperature causes local tissue damage and selective thermocoagulation of pain-carrying nerve fibers (A-delta and C fibers). The needle generates a 5–15 mm electric field and reliably produces an affected area of 8–10 mm. The target tissue temperature can be maintained in the range of 60–90°C, and the thermal lesion size created by this procedure is limited.[8] In PRF, a 420 kHz high-frequency alternating current of 200 mA is applied in short bursts, two per second, followed by a quiet phase for 240–480 s. In the quiet phase, the temperature is kept below 45°C, which is the neurodestruction threshold. This creates an electromagnetic field rather than thermal destruction and is thought to cause cellular changes that disrupt synaptic transmission, pain transmission, and signaling.[9]

We hypothesized that CRF could be effective in heel spur pain, which has similar pathophysiology to chronic pain syndromes. This study aimed to investigate the effectiveness of CRF treatment on chronic plantar heel pain due to heel spur.

Material and Methods

This prospective cohort study received approval from the Local Ethics Committee (Health Sciences University of the Bursa Yüksek Ihtisas Research and Training Hospital Clinical Research Ethics Committee, Decision Number 2011-KAEK-25 2018/10-15). After being given information about the study, participants provided their written informed consent. The study was carried out in accordance with the principles of the Declaration of Helsinki.

The study was conducted by one pain specialist and two physical medicine and rehabilitation doctors. Patients with chronic plantar heel pain due to heel spur were recruited from the first physical medicine and rehabilitation doctor at the Health Sciences University Yüksek Ihtisas Research and Training Hospital in Bursa from December 2018 to December 2019. The diagnosis of the calcaneal spur was based on the patient's clinical history, a physical examination, and lateral ankle X-rays findings. The patient data recorded by the first physical medicine and rehabilitation doctor were as follows:

1) The duration of symptoms (months)
2) Body mass index (BMI) (kg/m^2)
3) The presence of pes planus (weight-bearing lateral radiographs of all patients were taken, and the calcaneal pitch was measured. Patients in whom the angle formed between the plantar plane of the foot and the lower surface of the calcaneus bone was <20° were considered to have pes planus).
4) Pain intensity (when taking the first step in the morning was assessed by a 10 cm visual analog scale [VAS], in which 0=no pain and 10=severe pain).
5) Pressure pain threshold (PPT) (pressure algometers (Baseline® Dolorimeters, New York, USA, 2015) was used, measurements were taken from the sole of the foot and always taken by the same person, at the same room temperature, using the same test equipment. The measurements were taken with a 1 cm 2-disk head apparatus connect-

ed to the pressure device calibrated to Newton/cm^2 in the power unit. The applied pressure was increased at a rate of 1 N/sec until the patient felt pain. The patient terminated the procedure with a stop command. The value seen on the screen was saved. Each measurement was repeated 3 times, and the values were averaged; this value was recorded as the PPT (Fig. 1).

6) Foot Function Index (FFI) (the pain complaints of the patients during different activities, the difficulty levels of different activities, and activity limitations related to these were evaluated).[10]

Patients with chronic plantar heel pain due to heel spurs who did not respond to conservative treatments were referred to a pain specialist by the first physical medicine and rehabilitation doctor. The procedure was applied to the patients who were recommended CRF after examining the pain specialist and who received consent. The characteristics of the patients recommended CRF were as follows:

1) Patients over 18 years of age with pain on clinical evaluation (moderate or severe or every day for more than 3 months)
2) Patients who have not responded to conservative treatment methods (such as physical therapy and rehabilitation practices, and oral analgesic and anti-inflammatory drugs).
3) Patients whose pain decreased after local anesthesia and steroid injection, but the pain-free period lasted less than a month. (RFA treatment is an irreversible treatment method. It should be applied to patients who have a previous diagnostic injection to the target point and have a decrease in pain. For this reason, we did not apply RFA treatment to patients who did not receive injections before).

The characteristics of the patients not recommended CRF were as follows:

1) Patients experiencing pain for causes other than heel spurs, such as foot deformity, suspected nerve compression, or any systemic disease that may cause foot pain.
2) Patients who have been treated with physical therapy and local anesthetic and steroid injections to the heel spur in the past 3 months.
3) Patients with a current skin or soft-tissue infection near the injection site.

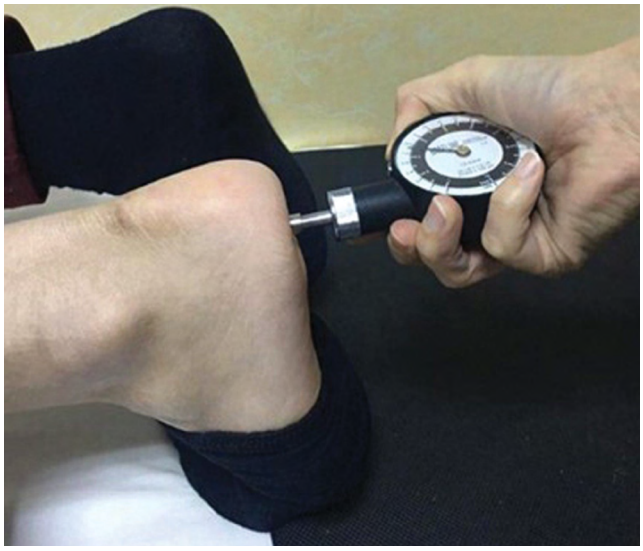

Figure 1. Use of a pressure algometer to measure pressure pain threshold in patients.

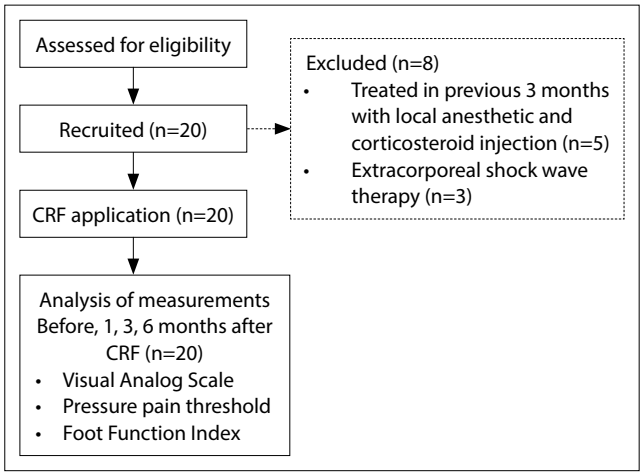

Figure 2. Design of the study.
CRF: Conventional radiofrequency ablation.

The pain specialist recorded post-operative complications and side effects (post-injection pain, soft-tissue infection, nerve injury from needle penetration, etc.) of the patients. The patients were asked not to receive any other medical treatment or physiotherapy during the course of the study. Measurements (pain intensity, PPT, and FFI) 1, 3, and 6 months after another physical medicine and rehabilitation doctor made the procedure. The study design is shown in Figure 2.

Interventions

Patients were placed in a prone position on a translucent X-ray table, and the patient's foot was supported by placing a small pillow under the ankle. Povidone-iodine 10% was applied to the heel as an antiseptic measure. The heel spur was detected in the lateral view of the calcaneus under fluoroscopic guidance. No sedation was given. Anesthesia was provided by ap-

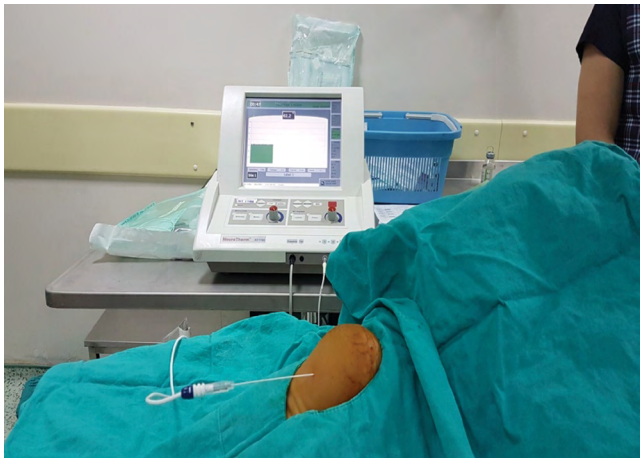

Figure 3. Conventional radiofrequency ablation application to calcaneal spur.

plying 2% lidocaine under the skin. A 10 cm long 22G radiofrequency cannula with a 5 mm active tip (NeuroTherm®, Radionics, Burlington, MA, USA) was passed, until the tip reached the heel spur and was placed on three points – at the top, above, and below the heel spur in the longitudinal plane of the foot. A radiofrequency thermocouple electrode (NeuroTherm®, Radionics, Burlington, MA, USA) was passed through the radiofrequency cannula. A 10 cm long, 23 Fr radiofrequency cannula with a 5 mm active tip was used for the technique. Then, sensory stimulation with 50 Hz and motor stimulation with 2 volts at a stimulation intensity between 0.4 and 0.8 volts (V) was investigated. The sensation of swelling and fullness at the tip of the cannula was investigated for sensory stimulation and the sensation of kick and movement for motor stimulation. Tissue impedance was confirmed to be <600 Ohms. After the location of the cannula tip was confirmed, 2% lidocaine was applied as it is a painful procedure, and a radiofrequency generator was activated in the RT program at 80°C and applied for 90 s (Fig. 3, 4).

Statistical Analyses

In this study, pre-treatment descriptive statistics were expressed as the mean and standard deviation for continuous variables and frequencies and percentages for categorical variables. The change in VAS score, PPT, and foot activity index overtime was evaluated using the Friedman test. The Dunn test was used to compare the groups to see from which measurement the difference originated. The significance level was set as $p<0.05$. Spearman's Rho test was used to measure the strength of the relationship between the two variables. Correlation is significant at the Spearman's rho (ρ)<0.05. The data analysis was performed using

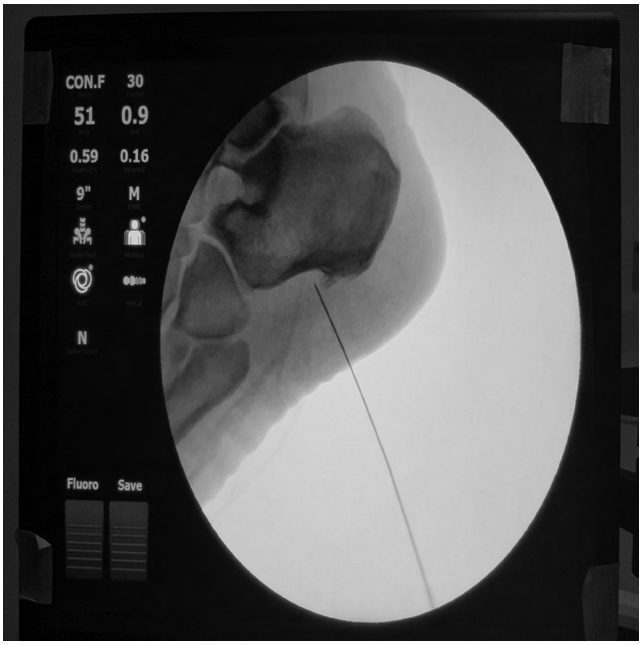

Figure 4. Fluoroscopic-guided conventional radiofrequency ablation: A 10 cm – long 22 G radiofrequency cannula with a 5 mm active tip's view around the calcaneal spur.

the Statistical Package for the Social Sciences software, version 25.0 (IBM Corporation, Armonk, NY, US).

Results

A total of 28 patients diagnosed with chronic plantar heel pain due to heel spur were assessed for eligibility and recruited for the study. Eight patients who had been treated in the previous 3 months (three patients with extracorporeal shock wave therapy and five patients with local anesthetic and corticosteroid injection) were excluded due to exclusion criteria. CRF was performed on 20 patients. The demographic and clinical data of patients before CRF administration are summarized in Table 1.

The mean VAS scores 1, 3, and 6 months following CRF were 4.15±1.95, 4.10±1.83, and 4.30±1.68. The mean PPT 1, 3, and 6 months following CRF was 8.05±4.17, 8.00±3.93, and 7.90±4.02. The mean FFI pain 1, 3, and 6 months following CRF was 34.55±26.09, 34.35±25.77, and 34.55±26.09, respectively. The mean FFI function 1, 3, and 6 months following CRF was 32.35±21.17, 31.95±20.57, and 32.35±21.17. The mean FFI activity limitation 1, 3, and 6 months following CRF was 8.85±7.15, 8.85±7.15, and 8.80±7.16. A statistically significant decrease was observed in the VAS score as well as PPT and FFI measurements 1, 3, and 6 months following CRF compared to before CRF ($p<0.001$) (Table 2).

Table 1. Demographic and baseline characteristics of the patients

Characteristics	Patients (n=20)
Age (year)*	51.40±8.10 (35–68)
Gender#	
Female	n=16 (80%)
Male	n=4 (20%)
BMI (kg/m²)*	33.80±5.47 (25–46)
Presence of pes planus#	
With	n=5 (25%)
Without	n=15 (75%)
Duration of symptoms (month)*	18.30±9.02 (6–36)
VAS*	8.35±1.13 (6–10)
PPT*	16.00±4.12 (8–22)
Foot activity index*	
Pain	75.85±11.56 (52–90)
Function	74.75±10.06 (55–90)
Activity limitation	18.85±7.67 (3–31)

*: Mean±standard deviation (minimum/maximum); #: n (%); BMI: Body mass index; VAS: Visual analog scale; PPT: Pressure pain threshold.

The effect of the age, BMI, duration of symptom, and presence of pes planus outcomes in visual analog scale scores, PPT, and foot activity index 6 months after CRF was evaluated. A statistically significant relationship was found only between PPT and duration of symptoms (Spearman's rho [ρ]<0.05). There is a high negative correlation between these two variables. It was observed that the PPT measurement decreased as the duration of symptom is prolonged. No statistically significant relationship was found in age, BMI, and presence of pes planus between the visual analog scale scores, PPT, and foot activity index (Spearman's rho [ρ]>0.05) (Table 3).

During the CRF treatment, no patient had any side effects from injections. In three patients, the pain became more severe in the 1st week after the injection; these patients were recommended only to apply cold and not to step on the foot. No additional analgesic medication was given.

Table 2. Outcome measures of foot pain and function in patients with plantar heel pain due to heel spur treated with conventional radiofrequency ablation

	Before treatment	1-month post-treatment	3-month post-treatment	6-month post-treatment	p
VAS score*	8.35±1.13 (6–10)	4.15±1.95 (0–8)	4.10±1.83 (1–8)	4.30±1.68 (2–8)	<0.001
PPT*	16.00±4.12 (8–22)	8.05±4.17 (2–16)	8.00±3.93 (2–16)	7.90±4.02 (1–16)	<0.001
Foot activity index*					<0.001
Pain	75.85±11.56 (52–90)	34.55±26.09 (8–82)	34.35±25.77 (8–82)	34.55±26.09 (8–82)	
Function	74.75± 10.06 (55–90)	32.35±21.17 (9–64)	31.95±20.57 (9–64)	32.35±21.17 (9–64)	
Activity limitation	18.85± 7.67 (3–31)	8.85±7.15 (3–22)	8.85±7.15 (3–22)	8.80±7.16 (3–22)	

*: Mean±standard deviation (minimum/maximum); VAS: Visual analog scale; PPT: Pressure pain threshold.

Table 3. The effect of the age, body mass index, duration of symptom, and presence of pes planus changes in VAS scores, PPT, and foot activity index 6 months after CRF

	Spearman's rho test	Visual analog scale score	PPT	Foot activity index
Age	Correlation coefficient	–0.092	–0.161	–0.267
	Sig. (two tailed)	0.700	**0.499**	0.256
Body mass index	Correlation coefficient	0.034	–0.051	0.253
	Sig. (two tailed)	0.888	**0.830**	0.281
Duration of symptoms	Correlation coefficient	–0.162	–0.604	0.253
	Sig. (two tailed)	0.494	**0.005**	0.281
Presence of pes planus	Correlation coefficient	0.143	0.098	–0.182
	Sig. (two tailed)	0.548	**0.680**	0.443

PPT: Pressure pain threshold; CRF: Conventional radiofrequency; VAS: Visual analog scale.

Discussion

Chronic plantar heel pain is often accompanied by heel spurs,[11] but it is known that heel spurs may not present any clinical sign in some cases; it is possible to detect heel spur in 15% of asymptomatic patients.[12] However, the disease is often painful and troublesome. The rate of heel spurs causing heel pain is 30–89%.[11] Wearing the wrong footwear, standing for long hours, walking long distances, and practicing sports that put much strain on the feet are predisposing factors in the formation of heel spurs. The previous studies have indicated that foot deformities, obesity, advanced age, and female gender are important factors in developing heel spurs.[13]

Although heel spurs are common in advanced age, it would not be correct to say that they affect only the elderly. In this study, the mean age was found to be 51.40±8.10 years. First of all, overweight and obese people are at risk for developing heel spurs. Overweight contributes to degenerative changes in the lower extremity joints, especially in the feet. Most of the patients in this study were overweight females with a mean BMI of 33.80±5.47 kg/m^2.

Many studies have reported that pes planus may play a role in developing heel spurs.[14] Pes planus may develop with increasing age and body weight, which causes increased stress in the plantar fascia and short flexor muscles. In this study, 25% of the patients were found to have pes planus. In conclusion, most of the patients in this study were middle-aged, overweight women in accordance with the literature.

The treatment of heel spur pain is mainly conservative. In cases resistant to treatment, a local steroid injection is applied and reduces the inflammation and swelling of the soft tissue around the plantar fascia.[15] Some studies have reported that short-term pain relief following corticosteroid injection is no greater than with placebo or no treatment.[16] Other studies have reported good results with corticosteroid injection in terms of pain relief and functional improvement in the short term (up to 2 months) but not in the intermediate term (2–6 months) and that the treatment loses its effectiveness overtime.[17] This study aimed to investigate what can be done to treat patients with a good but short-term response to corticosteroid injection. For this reason, we chose patients who had an inadequate response to conservative treatments and had received a steroid injection previously with a pain-free period lasting <1 month. A major finding of this study was that the clinical outcomes achieved with CRF treatment did not decline over time. We consider this an important finding, as it indicates that CRF is a good treatment option for pain relief and functionality improvement not only in the short term but also in the intermediate term. The local steroid injection is applied with imaging or palpation. Studies have shown that ultrasound-guided injection is not superior to injection determined by palpation.[18] We performed CRF with fluoroscopy guidance to correctly localize the heel spur and avoid unwanted side effects.

In the treatment of chronic pain syndromes, RT has been used for a long time and has been shown to improve pain when applied to various neural tissues, including the dorsal root ganglion,[19] the cranial nerves,[20] the medial branches of the spinal nerves,[21] and other peripheral nerves.[22] Studies have also investigated the effect of applying RF to non-neural tissues such as vertebral discs[23] and joints.[24,25] The mechanism of CRF in heel spur pain can be described as follows: An RF electrode produces an electrical field, breaking down the covalent bonds maintaining the three-dimensional structure of the plantar fascia around the heel spur, and reducing the thickness of the plantar fascia, thus ablating the nociceptors that enable the formation and transmission of pain.

Studies have also reported that nerve neurotomy is performed to treat chronic heel pain. A recently published study containing a small number of patient groups showed that RF neurotomy of the posterior tibial nerve (PTN) provided clinical improvement.[26] However, it is unknown whether branches of the PTN to the muscles of the foot and damage to nerve tissue in the long term can cause muscle weakness.

Among the limitations of this study, we should mention the following. We evaluated only the short-term and mid-term results; therefore, the long-term effects of CRF are not well understood yet. Furthermore, our study included relatively small sample size, and the absence of a control group may have prevented us from understanding the natural course of the disease. Finally, there is no consensus on the

optimal dose, frequency, and duration of CRF. Different results may be obtained using different CRF treatment parameters. However, there are a few prospective studies on CRF use to treat heel spur pain in the literature. Therefore, we hope our study will trigger large-scale, long-term, prospective, randomized, placebo-controlled studies.

Conclusion

Regarding the results of our study, fluoroscopy-guided CRF was an effective, safe, minimally invasive method to reduce pain severity and improve disability in patients with chronic heel spur pain in the short term (0–3 months) and the intermediate term (3–6 months). Therefore, CRF is an effective treatment option for treating heel spur pain before operative management.

Ethics Committee Approval: The Bursa Yüksek İhtisas Training and Research Hospital Ethics Committee granted approval for this study (date: 24.10.2018, number: 2011-KAEK-25 2018/10-15).

Conflict-of-interest issues regarding the authorship or article: None declared.

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