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## CLINICAL REPORT

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# Pulsed Radiofrequency Application in the Treatment of Chronic Pain

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■ **Abstract:** The efficacy of pulsed radiofrequency (PRF) in the treatment of painful lumbosacral spondylosis has been reported. This case series reviews 22 consecutive patients presenting to clinic who had been previously treated with PRF with good results. Patients being prescribed opioids were excluded. During the PRF application, tissue temperature was limited to 43°C. A minimum of 200 mA of current was delivered in each case. The minimum current (at 50 Hz) necessary to stimulate the involved nerve was recorded. The duration of time from PRF treatment until the patient requested a subsequent application was documented. The effective duration of PRF in patients treated for lumbosacral spondylosis ranged from 5 to 18 months (mean  $\pm$  SD:  $9 \pm 3.7$  months;  $n = 16$ ). PRF applications to dorsal root ganglia were effective from 2 to 12 months ( $7 \pm 3.8$  months;  $n = 8$ ). Similar results were observed when PRF was applied to cervical medial branch nerves, one suprascapular nerve, and one stellate ganglion. The mean (50 Hz) sensory stimulation thresholds obtained before treatment ranged from 0.08 V to 0.14 V. In this select population of patients not receiving controlled substances, who had a favorable response to a previous PRF application, the duration of pain relief supports the use of PRF as an effective pain treatment. ■

**Key Words:** pulsed radiofrequency, medial branch nerves, dorsal root ganglia, suprascapular nerve

### INTRODUCTION

Various degrees of efficacy of conventional radiofrequency (RF) treatments with high, neurodestructive temperatures using continuous high-frequency electric current (CRF) have been reported in the treatment of neuraxial spine disorders.<sup>1-4</sup> Marked temperature elevations around the electrode presumably interrupt pain transmission by coagulation of nervous tissue. However, it has been strongly suggested that thermocoagulation is not the mechanism involved in pain relief, as it has been noted that the duration of pain relief far outlasted the length of denervation when CRF was used on dorsal root ganglia (DRG).<sup>5</sup> This finding led to the hypothesis that the electromagnetic field developed by the RF current might account for the beneficial clinical effect. If, in fact, the heat generated with CRF treatments is not therapeutic, it then represents an undesirable, potentially neurodestructive incidental consequence.<sup>6,7</sup> Thus, an alternative delivery of RF current that maintains tissue temperature below that causing tissue destruction (43°C), pulsed radiofrequency (PRF), was developed.<sup>8</sup> The delivery of current using intermittent pulses creates a satisfactory electromagnetic field while, at the same time, allows the friction-generated heat to be dissipated between the pulsed current deliveries.

A recent study described one group's early experience with PRF.<sup>9</sup> Since that time, it has been suspected that alterations in the technique of delivery have resulted in

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Submitted: August 24, 2006; Revision accepted: November 14, 2006

a substantial improvement in patient responses. In the current case series, patients returning to clinic following PRF treatments using several modifications to the previously described technique were retrospectively reviewed.

## MATERIALS AND METHODS

### Patient Selection

Consecutive patients returning to the pain medicine clinic over a 2-week contiguous period who were previously treated with PRF were included. Patients treated suffered from mechanical pain (sacroiliac and shoulder joint treated), radiculopathic pain (DRG and ventral rami treated), and sympathetically maintained pain (stellate ganglion treated). All patients included in the analysis received PRF treatments within the previous 19 months and were noted to have a favorable outcome at 6 weeks following PRF treatment. Following this initial clinic evaluation post PRF treatment, patients had been instructed, as per our customary practice, to return in 6 to 8 months or when the return of discomfort was of such intensity that a repeat PRF application was desired.

All patients were treated in a Pain Management Clinic from August 2003 through December 2004. Patients regularly consuming controlled substances prescribed by our clinic were excluded.

### Diagnostic Nerve Blocks

All procedures were performed by a single practitioner using 2% lidocaine placed with C-arm fluoroscopic guidance (Series 9800, OEC Medical Systems, Salt Lake City, UT, U.S.A.). Isohexol (0.1 mL) was injected to confirm cannula positioning. These diagnostic procedures were deemed warranted based upon supporting history and physical findings for the specific disorder that had failed conservative management and persisted in an unrelenting manner for at least 6 months. For example, patients with suspected cervical facet disease demonstrated neck pain with radiation to the trapezius region on the ipsilateral side that was exaggerated by facet loading. Patients with lumbosacral facet arthropathy similarly had axial pain with radiation upon facet loading that did not extend below the knee. Patients with sacroiliac disease presented with pain in the sacroiliac area that was exacerbated by provocative maneuvers (FABER maneuver—flexion abduction, external rotation). One patient had shoulder pain secondary to a rotator cuff tear with discomfort on abduction of the

shoulder. Radicular pain presented primarily with pain in the L5 and S1 dermatomal distributions extending below the knee. Imaging studies, history, and physical examinations were assimilated in all cases to support the diagnoses. For blockade of lumbosacral medial branch nerves, lateral branch nerves, or dorsal rami, 0.3 mL of local anesthetic was used, but for blockade of cervical medial branch nerves, 0.2 mL was used at each level. Typically, medial branches/dorsal rami innervating the lumbosacral L45 and L5–S1 facet joints were treated. In the cervical region, medial branches supplying the C34, C45, and C56 facets joints were treated. For sacroiliac denervations, in addition to blockade of the dorsal ramus of L5, lateral branch nerve blocks of S1–3 were carried out using 0.3 mL of lidocaine.

For lumbosacral medial branch/dorsal ramus nerve blocks, cannulae were placed at the L4 and L5 transverse process-articular pillar junction, the base of the articular pillar on the sacral ala, and at a midpoint of a line between the dorsal S1 foraminal opening and the L5–S1 facet joint. For suspected sacroiliac disease, in addition to cannulae placements at the sacral ala as described above, lateral branch nerve conduction was blocked by the deposition of lidocaine approximately 10 mm lateral to the first three dorsal sacral neuroforamina. Lumbosacral DRG and/or nerve root diagnostic blocks were performed using 0.5 mL of lidocaine injected into the neuroforamina corresponding to the suspected segmental levels of disease. Cervical medial branch nerve blocks were performed with cannula placement on the midpoint and lateral third position on the respective dorsal articular pillars. For the one stellate ganglion block in this series, 5 mL of 2% lidocaine was deposited at the anterior tubercle of C6 after the injection of isohexol validated distribution of solution over the C7–T1 anterior elements. The single suprascapular nerve block was performed for chronic shoulder pain using an image-guided placement of a cannula just below the dorsal aspect of the suprascapular notch and injecting 3 mL of lidocaine.

### Pulsed Radiofrequency Application

Following significant resolution of the discomfort following the diagnostic procedure, a PRF application was performed at a later date. With the exception of the single stellate ganglion application, a 20-gauge cannula with a 10 mm curved active tip was used (PMC20-100-10CS, Bayliss Medical Co., Inc., Montreal, Canada). In the case of the stellate ganglion, a 22-gauge straight Bayliss cannula with a 4 mm active tip was used

**Table 1. Duration of Effectiveness of PRF Applications**

	Duration of Relief Months $\pm$ SD	Mean Sensory Stimulation Threshold Volts $\pm$ SD
Lumbosacral medial branch, lateral branch nerves ( $n = 16$ )	$9 \pm 0.3.7$	$0.13 \pm 0.07$
Cervical medial branch nerve ( $n = 2$ )	$12 \pm 2.1$	$0.08 \pm 0.01$
Dorsal root ganglia ( $n = 8$ )	$7 \pm 3.8$	$0.14 \pm 0.14$
Stellate ganglion ( $n = 1$ )	19	0.16
Suprascapular nerve ( $n = 1$ )	6	0.14

$n$  represents the number of treatment encounters. Twenty-two patients underwent a combined total of 28 treatment encounters.

(PMC22-100-10). Electrodes were positioned as previously described at the anatomic structures targeted for the diagnostic nerve blocks. Electrodes were positioned perpendicular to the nervous structure such that 50 Hz stimulation elicited either a pressure sensation or paresthesia in the appropriate region at less than 0.2 V.

A Radionics lesion generator (RFG-#C Plus, Radionics, Burlington, MA, U.S.A.) was used for all applications. RF current applications were administered after acceptable stimulation was obtained. Current was delivered at 2 Hz for 120 seconds at 20-millisecond cycles. Tissue impedance was manipulated to be as low as possible by the injection of 0.5 to 1.0 mL of normal saline prior to treatment. This assured the delivery of greater than 200 mA of current for 120 seconds in all cases while not exceeding a tissue temperature of 43°C.

For each category, the duration in months from the time a patient received PRF therapy until they independently requested another treatment was averaged. Also, the voltage required for sensory stimulation (at 50 Hz) prior to PRF applications was analyzed (mean values and standard deviations).

## RESULTS

A total of 22 patients returning over the 2-week study period received a total of 28 PRF procedures. Procedures performed, average durations of relief, and the mean stimulation thresholds obtained (at 50 Hz) immediately prior to PRF application are given in Table 1. Stimulation threshold values were computed by averaging the mean stimulation voltages obtained at each individual nerve that was treated. PRF applications were carried out in 14 instances for lumbosacral facet disease and 2 for sacroiliac disease. Eight lumbosacral DRG applications, two cervical medial branch treatments, and one each of a suprascapular nerve and stellate ganglion applications were included. In all cases, the results of the treatment were immediately apparent and there were no complications post treatment.

**Table 2. Absolute Effective Durations from PRF Application (Months)**

Lumbosacral Medial Branch, Lateral Branch Nerves	Dorsal Root Ganglia
8*	7
5	4*
6	12*
9*	2
8*	2
8	6
6	10*
7*	10
12	
6*	
5	
10	
9*	
18	
12	
15	

\*Previous PRF application was still effective at that point in time.  
Lumbosacral medial branch, lateral branch nerves, dorsal root ganglia effective duration following 24 treatment encounters (months).

The mean duration of relief for lumbosacral facet and sacroiliac applications was 9 months and ranged from 5 to 15 months. In Table 2, the duration of treatment effect is noted in a total of 24 PRF applications. The effective treatment durations were calculated using values from patients who were still experiencing pain relief at the time of the interview (Table 2). Thus, the actual average time to request for another application would have exceeded the calculated 9-month value. Similarly, DRG and nerve root applications provided greater than 7 months of improvement before another treatment was requested. The effective duration ranged from 2 to 12 months. One patient had two DRG applications to no avail, obtaining only 2 months of relief each time. This individual subsequently underwent a successful spinal cord stimulation trial and implantation. The single stellate ganglion application for sympathetically mediated pain in the hand provided relief for 19 months. Of the two cervical facet applications observed, neither requested repeat treatment for nearly 1 year.

## DISCUSSION

Although the patients included were those seen consecutively, they were selected individuals who had already appreciated a favorable response to PRF treatment that persisted for a period greater than 6 weeks. This population would appear to eliminate subjects experiencing a false positive diagnostic procedure. Thus, at the time of their customary 6-week postprocedure evaluation, the discomfort for which they were treated was resolved to their satisfaction. In several cases, at the time of the interview, patients were not yet in subjective need of a repeat procedure. Thus, the results presented represent the minimal duration of efficacy selectively in a group of patients already identified as having relief of their painful condition extending beyond 6 weeks.

In the previously noted report,<sup>9</sup> the average effectiveness of PRF treatments for lumbosacral facet joint related pain was about 4 months. These results were based upon a retrospective review of visual analog pain scale scores obtained by a nurse. Here patient requests for repeat PRF application were used to define the duration of relief following PRF treatment.

In addition to this difference in successful outcome definition, there are several patient management differences in the current case series that could account for the appearance of improved therapeutic duration. Diagnostic blocks were performed with less volume of injectate (0.3 mL vs. 0.5 mL). This measure should decrease the incidence of false positive responses, resulting in a more highly selected and presumably more favorable patient population. The average sensory stimulation threshold accepted prior to PRF application in the previous patient population exceeded 0.2 V. In the current series, the average sensory stimulation threshold obtained by 50 Hz stimulation averaged 0.11 V. The ability to position the electrode in closer proximity to the targeted nervous structure could, in part, account for the improved outcomes. Another difference in the current treatment series was the effort to minimize tissue impedance prior to PRF applications in order to assure a minimum delivery of 200 mA PRF current over the 120-second treatment period. This was facilitated by the injection of normal saline through the cannula just prior to treatment in order to decrease tissue impedance, preferably near or below 250  $\Omega$ . This simple maneuver resulted in the ability to greatly increase the amount of PRF current delivered (always exceeding 200 mA and consistently greater than 350 mA). Unlike the previously reviewed patient population,<sup>9</sup> careful scrutiny

assured the delivery of at least 200 mA of current for 120 seconds in the PRF applications. Moreover, the magnitude of current delivery was not previously described, but was reported only to be delivered to a maximum that did not result in tissue temperatures exceeding 43°C.

The current analysis reviewed patients who had already received at least 6 weeks of satisfactory improvement following PRF treatment. Excluding patients consuming controlled substances eliminates one confounding motive. The duration of efficacy was determined by noting the time after effective PRF therapy before the patient made the decision to repeat the application because of return of discomfort. This is not a direct measure of pain relief, and other factors might influence a patient's decision to have a repeat procedure or even return to the clinic for evaluation. Nevertheless, although subjective, the patients' requests for another unpleasant PRF procedure should represent an alternative clinically valid indicator of the efficacy of previous treatment. Here, patients electively requested a repeat treatment (or not). Routinely, patients do not receive a repeat treatment until the pre-existing pain has returned to at least 50% of its previous intensity. All patients requesting retreatment complained of discomfort that was at least back to 50% of its original intensity. Despite this, although not used in this practice, visual analog scores provide another valid measurement of pain.

The use of CRF treatments has been well-accepted in the realm of pain management practices, yet there remains a diverse body of conflicting literature that calls into question, not only its mode of action, but also its effectiveness.<sup>10,11</sup> Several studies fail to support nervous ablation, if actually occurring at all, as being responsible for the pain relief. In a recent report, Windsor reported that up to six CRF applications (70°C, 80 seconds) were necessary to sufficiently interrupt sensory neurotransmission in lumbar medial branch nerves in order to double the amount of 50 Hz current necessary to transmit the sensory impulse.<sup>11</sup> This evidence strongly suggests that the beneficial effects of CRF treatments are independent of tissue destruction. Van Kleef<sup>5</sup> demonstrated that the pain relief produced by CRF of a DRG long outlasted the clinical evidence of denervation. Slappendel et al.<sup>12</sup> demonstrated equal efficacy of CRF and PRF treatments. It has become more apparent that the generation of the electromagnetic field created by the RF current alters C fiber transmission by possibly altering sodium channel activity with associated changes in c-fos production in

the dorsal horn.<sup>13</sup> Pioneers in RF technology and treatment have even stated as much: “Eventually all this resulted in the suspicion that our assumptions might have been wrong and that heat might not be the element causing the clinical effect of a RF lesion.”<sup>14</sup> Moreover, the risk of neuritis due to nervous tissue destruction is greatly reduced or eliminated with PRF. Because there was no obvious nervous tissue destruction, with its attendant potential for painful neuritis, the “stun phase” was presumed to be responsible for the immediate relief of discomfort and was consistent with previously reported work.<sup>14</sup> Thus, PRF, unlike CRF, can be and is used to treat peripheral nerves for various painful maladies.<sup>15</sup>

It is important to note the divergent techniques used in the two types of application. With CRF, electrode placement is directed parallel to the nerve, while with PRF, as most of the current is discharged through the electrode tip, the electrode is positioned perpendicular to the targeted structure. Also, as surrounding tissue fluids are felt to represent a “heat sink,” high tissue impedance is desired with CRF treatment. As a low tissue resistance allows more PRF current to be administered, efforts are made to maintain low tissue impedance during these applications. Moreover, when comparing RF studies, there is wide variability in the methodology used. For example, the proximity of the electrode to the targeted structure, as reflected by sensory stimulation parameters, is often accepted to be any value less than 1 V.

Carefully controlled, double-blinded studies in chronic pain are difficult to perform. In addition to the subjectivity of outcome data, ethical problems exist when a control group receives an invasive sham treatment. Finally, it must be appreciated that there is no “cure” for most chronic pain conditions presenting to pain management practitioners. Although invasive, PRF represents a modality that is nondestructive and relatively safe. In this patient population, with documented subjective improvement following PRF treatments in patients not consuming opioids, the results support the further study of PRF as an effective tool in interventional pain management. Efforts to place the electrode in close proximity to the targeted structure and decrease tissue impedance, and thereby increase current output, may improve the efficacy of PRF therapy.

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