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Case Report

Ultra-extended euthermic pulsed radiofrequency for the treatment of ophthalmic neuralgia: A case report with elaboration of a new technique

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Abstract

Background: Pulsed radiofrequency although present for many years has been used little compared to ablative procedures for pain relief. Its use in trigeminal neuralgia is sparse and unreported in the ophthalmic division, where the possibility of sensory loss can lead to high morbidity. We wished to explore the potential of this reportedly safe modality for a prolonged duration in a highly sensitive anatomic neural location, however, in a very secure, structured, and staged manner.

Case Description: A patient suffering from ophthalmic division (V1) medically uncontrolled neuralgia with a preoperative visual analog scale (VAS) score of 9/10 was subjected to a percutaneous pain relief procedure. The patient was treated with prolonged duration pulsed radiofrequency (PRF) for 40 min, with corneal sensation monitoring under conscious sedation keeping a low voltage (7 V) and tip temperature at 37°C. The patient obtained immediate relief, which was verified on the operation table itself. Postoperative VAS score of 0/10 was recorded. More than 6 months after the procedure, the patient is completely free from neuralgic pain and continues to have a VAS score of 0/10.

Conclusion: As opposed to conventional PRF where mostly a tip temperature of 42°C and high voltage have been used for 2 to a maximum of 8 min, PRF with a tip temperature of 37°C and a safe voltage of 7 V over an ultra-extended duration of 40 min can give a more distinct and effective but equally safe result. Although our case verified the safety and efficacy of prolonged duration PRF in sensitive anatomic locations, more studies are warranted for establishing this as a standard line of treatment. The specific use of PRF in ophthalmic division neuralgia in the manner described in our case report has hitherto not been reported in medical literature and will open a new vista in the minimally invasive treatment of this disease.

Key Words: Low voltage, ophthalmic, prolonged, pulsed-radiofrequency, trigeminal neuralgia

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INTRODUCTION

Pulsed radiofrequency (PRF) is a technique used for creating a carefully controlled electrical field around an electrode. First used as a pain treatment option in the mid 1990's the technique involves application of discrete bursts of energy to the electrode intermittently. PRF is delivered in short (20 ms) bursts twice per second followed by a quiet phase (lasting 480 ms) in

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which no current is applied. This keeps the temperature very low, unlike the higher temperatures required for a radiofrequency ablation. Literature describes the use of short duration PRF for cervical and lumbar Z-joint pain, orchialgia, spinoradicular pain, and post-thoracotomy and inguinorraphy pain.[11-13] Recently, Thapa *et al.* reported the use of extended duration PRF for a maximum of 6 min in the treatment of medically refractory trigeminal neuralgia.[34] Its overall use in idiopathic trigeminal neuralgia is sparse. To the best of our knowledge, this is the first time PRF has been used in an ultra-extended fashion for the relief of not only ophthalmic division neuralgia but in the treatment of trigeminal neuralgia itself.

CASE REPORT

A 56-year-old chemical worker suffered from severe paroxysms of pain in the left eye radiating to the forehead and above since 6 years. These attacks were triggered by exposure to wind during a bike ride or in an auto rickshaw when outdoors, or on exposure to the fan or a blast of cold air-conditioned air when indoors. They were also provoked by touching the eyelid and the forehead. The paroxysms of pain lasted for 3–4 s, causing watering in the eye, and made him stop his work. He used to have 15–20 such attacks per day. Subsequently, he was well controlled on carbamazepine 200 mg tds for 3 years, and later had moderate relief for the next 18 months despite the addition of pregabalin 75 mg bid and baclofen 30 mg OD extended release tablets. His pain was completely uncontrolled for the last 18 months, and the attacks had increased in duration and frequency. He could not tolerate any increase in the dosage of neuropathic medications and felt giddy with any such attempt. The visual analog score (VAS) score was calculated on a 10-point scale between 0 (no pain) and 10 (maximum tolerable pain). The preoperative score in our patient was 9/10.

On examination, facial sensations, corneal sensations, motor examination of the face, and the rest of the neurological, systemic and vital parameter examinations were normal. His magnetic resonance imaging (MRI) showed no cerebellopontine angle lesion or vascular loop abutment at the root entry zone (REZ) of the trigeminal nerve. The patient was hence offered the options of a time-tested supraorbital neurectomy or long available but yet untested percutaneous procedure of PRF for V1 ophthalmic division with its possible uncertainties. The patient opted for a sensation sparing percutaneous day care procedure with its likely pros and cons. A new plan with minimum possible temperature (euthermia) and low voltage settings but prolonged duration was designed to obtain an optimum result with minimized chances of complications. Permission was obtained from the local institutional body for the same. Local anesthesia was administered at the site of introduction of the RF needle (5 mm bare tip, straight, Radionics). Using Hartel's technique and the Dr. G. M. Khan guideline, under C arm guidance the needle was introduced through the foramen ovale.[37] Cerebropinal fluid (CSF) was obtained and it was clear. The needle was guided further to be positioned at 5 mm above clivus [Figure 1]. The patient was under the conscious sedation effect of dexmedetomidine. One milligram midazolam and 50 mcg of fentanyl citrate was administered as premedication at the start of the procedure. Intraoperatively, sedation was maintained by dexmedetomidine (50 mcg in 100 ml normal saline iv infusion). Using a RFG-3C PLUS ESU (Radionics™, Burlington, MA), stimulation was commenced. At 0.05 V stimulation, the patient reported the first signs of paraesthesia and pain in the left eye and left supraorbital forehead akin to regular neuralgic pain. This exercise was repeated three times, and after confirmation of the correct location of needle tip physiologically, PRF treatment was commenced. The corneal sensations were checked with a cotton wick at the beginning of the PRF treatment, which were normal. PRF was commenced, and to preserve corneal sensation, voltage and tip temperature were kept at bare minimum. A 33 mA current with a low output voltage of 7 V allowed the temperature to be maintained at 37°C (euthermia) [Figure 2]. This was delivered in 20 ms pulses at a frequency of 2 Hz for a period of 120 s. PRF was given five times in continuity for a duration of 10 min, and corneal sensations were rechecked which were found to be intact. The patient was awake throughout under conscious sedation. We performed a restimulation or check stimulation test to ascertain the efficacy of our therapeutic procedure.[37] If the procedure is successful the patient will not experience paraesthesia or pain at the previously recorded voltage threshold of stimulation. After the first train of 5 RF

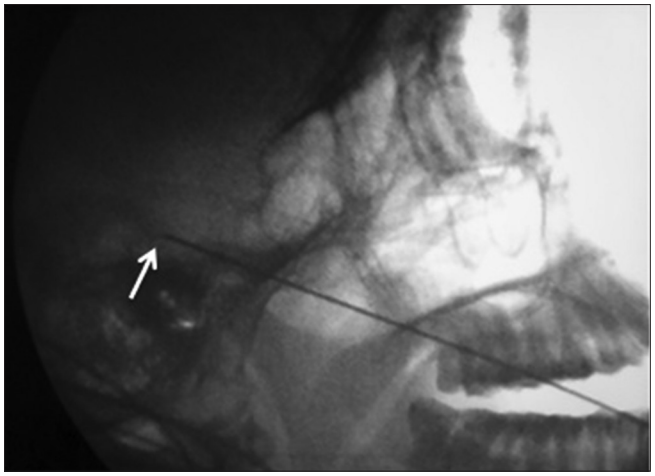

Figure 1: Lateral view fluoroscopic image shows entry of needle beyond foramen ovale and tip position about 5–6 mm above the clivus to be optimally located in V1 division of trigeminal nerve (original image)

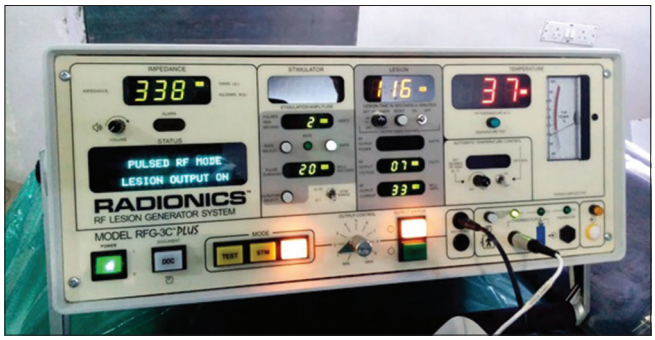

Figure 2: Radiofrequency generator [Model RFG-3C PLUS ESU, Manufacturer: Radionics™, Burlington, MA], displaying Pulsed RF mode "on." In view of the procedure being performed on the ophthalmic division, the output voltage was kept low at 7 V and tip temperature at 37°C (original image)

pulses, pain was still being felt which was now mild to moderate, i.e. 25–50% of original intensity. Another train of 5 RF pulses of 120 s each was given for 10 min and corneal sensations were confirmed once again to be intact. There was no pain at the previous experienced voltage, and the restimulation test now showed that the threshold for paraesthesia and pain elicitation had been raised to 0.07 V. There was no pain on touching the left eyelid or forehead. In view of the remarkable safety margin with PRF,[11] and with an aim to ensuring longstanding pain relief, as planned, the threshold was raised to double its initially elicited value under these controlled conditions. An additional two trains of 5 RF pulses each were given along with corneal sensation monitoring until the pain threshold had progressively, in stages, been elevated to first 0.09 V and then beyond 0.11 V. Some paraesthesia and mild pain could now be elicited only at 0.12 V. At the end of this process the patient's corneal sensations were intact; a full 40 min of PRF voltage bursts had been delivered in one sitting under neurological monitoring of consciousness, corneal sensations, and other vital parameters. The patient was completely and immediately relieved of pain and a VAS score of 0/10 was verified on the table itself. At the end of a 6 month follow-up, the patient was completely asymptomatic with intact corneal sensations, without medications, and has returned back to normal life. The VAS score has consistently remained 0/10 over the 6-month follow-up period.

DISCUSSION

Continuous radiofrequency (CRF) or radiofrequency thermocoagulation (RFTC) is a popular procedure being practiced for nearly four decades.[10] In contrast PRF was introduced in the late nineties by Sluijter who wrote the first report of the clinical effects of PRF on dorsal root ganglia in 1998.[28] PRF describes a process wherein short bursts of RF are delivered to a target nerve producing effects on signal transduction to reduce pain.[26] Recent evidence suggests that microscopic damage to axonal microfilaments and microtubules can occur, with greater changes seen in C fibers than A-β or A-δ fibers.[14,5]

There are few reports of the use of PRF for idiopathic trigeminal neuralgia.[15,34,36] van Zundert *et al*. reported trigeminal neuralgia treated with PRF at 42°C for 120 s.[36] Three of their 5 patients demonstrated complete pain relief at long-term follow-up, ranging from 10 to 20 months. One patient had 90% pain relief at 22 months.[36]

Mandibular (V3) and maxillary (V2) divisions are much more frequently affected by neuralgia than the ophthalmic division (V1).[3] RFTC has been used, mainly for V2, V3 divisions because RFTC of V1 results in loss of corneal sensations and ulceration, which is a dreaded and serious complication. This has been one of the limitations of the use of RF technology for four long decades in the treatment of V1 Neuralgia. Most reports of PRF use suggest an application time of a short duration.[11,34] Its effective use in V1 neuralgia for a prolonged duration has not been reported to the best of our knowledge. Thapa *et al*. reported the use of PRF in trigeminal neuralgia for a maximum of 8 min.[34] Since it is known that little or no damage accrues from the use of PRF,[11] we decided to apply it for optimal effect in an ultra-extended or prolonged fashion. This was done in a total of four interrupted sets of five pulses each in the same sitting with full neurological and vital parameters monitoring. Tanaka reported that a group of animals where PRF was applied for 6 min showed increased withdrawal latency and increased anti-allodynic effects compared to the groups with 2 or 4 min of PRF application.[33]

The patient was comfortable under dexmedetomidine conscious sedation. This lent a unique opportunity to have regular quick and effective monitoring of neural integrity intraoperatively in the form of intact corneal sensations and consciousness. As the patient continued to be well preserved, we proceeded to our set goal of raising the pain threshold to double its initial value to ensure long-term relief and could achieve it safely. Our case, thus, demonstrates that pain relief can be immediate as well as complete in PRF just as in RFTC but without its associated sensory and motor deficits. This, however, needed application of PRF for an extended duration keeping the tip temperature of RF needle as well as voltage low. The case also demonstrates for the first time in medical literature the safety of the application of PRF for a prolonged duration of 40 min without any disturbance of heart rate, blood pressure, consciousness, or corneal sensations. It opens way for further use of PRF in the application of ophthalmic neuralgia where RFTC has been a contraindication for nearly four decades. PRF may involve a temperature-independent pathway mediated by a rapidly changing electrical field, as our case demonstrated, because it was conducted at normal

body temperature of 37°C. Chua *et al*. suggested that one of the main reasons for unsatisfactory results with PRF is the insufficient PRF dose applied in some of the studies.[11] Our case effectively demonstrates the efficacy of an adequate dose in the form of ultra-extended or prolonged duration PRF and endorses this opinion. The emergence of PRF technology represents a promising step toward treating complicated pain conditions. As the evidence in support of PRF accumulates, it is likely that its potential to be applied more broadly will also increase.[10]

Other percutaneous techniques developed to overcome the limitations of RF ablation include glycerol rhizolysis and percutaneous microballoon compression (PMC). Gamma knife radiosurgery (GKR) is also known to be a minimally invasive and effective treatment for trigeminal neuralgia. However, potential eye complications including dry eye and corneal numbness have been reported.[23,25] Naseri reported vision loss [20/200] due to neurotrophic punctate epithelial keratopathy associated with the onset of right-sided facial numbness 10 months after low dose (40 Gy) GKR for trigeminal neuralgia.[24] Lopez reported loss of the corneal reflex in up to 10% of the cases following administration of 80 Gy and 90 Gy, and concluded that similar to other ablative techniques, stereotactic radiosurgery does not preserve trigeminal function.[20] Serrano-Rubio in a follow-up study conducted among 30 patients, who underwent radiosurgery using a Novalis linear accelerator, reported a 76.7% rate of side effects with 3 patients having developed facial anesthesia and loss of corneal reflex.[27] Matheiu reported a median time to pain relief of 6 months with gamma knife surgery for trigeminal neuralgia in patients with multiple sclerosis.[22] Zahra *et al*. observed a median time to pain control of 8.5 days (range: 1–70 days) with gamma knife surgery for trigeminal neuralgia.[38] The PRF procedure described in our patient was associated with total preservation of corneal sensations and immediate, complete pain relief. Gamma knife surgery does not permit intraoperative verification of corneal sensation, and typically, the maximal level of pain relief is achieved within 1 month.[21] GKR injures all fibre types nonselectively,[6] unlike the selective nature of PRF. Furthermore, GKR has been documented to be more than 3 times as expensive as radiofrequency rhizotomy,[16] and since PRF uses the same apparatus as RFR, it involves similar expenditure. We believe this may be of significance in providing pain relief to larger patient populations in developing nations.

Although surgeons were initially optimistic about the procedure, glycerol rhizolysis is a destructive procedure, and its success rate is not high.[32] The highest rate of pain recurrence was 54% with glycerol rhizolysis in a series with a mean follow-up period of 4 years.[32] Almost 33% who underwent percutaneous retrogasserian glycerol rhizolysis (PRGR) had a seemingly persistent corneal hypesthesia.[2] Khan *et al*. reported an incidence of dysesthesias in 14% and corneal sensory impairment in 11% patients.[19] Furthermore, glycerol rhizotomy is not division selective.[6] Sweet and Poletti reported disappointing results with regards to pain relief, sensory loss, corneal anesthesia, and dysesthesia in 77 patients treated with glycerol injections and referred to similar experiences of other workers in the field.[31] Hearing loss, although rare, has been reported after PRGR, and is thought to occur due to overflow of glycerol into the posterior fossa.[2] A high rate of technical obstacles, up to 47.3%, and high frequency of surgical difficulties was reported in an analysis of 260 consecutive RGR analyzed by Blomstedt and Bergenheim.[4] Further, apart from mild affection of facial sensibility, the same authors reported in 28.1% patients, an incidence of slightly graver complications such as labial herpes (3.8%), anesthesia dolorosa (0.8%), moderate or severe affection of sensibility (18.8%), dysesthesia (22.7%), chemical meningitis (1.5%), and infectious meningitis (1.5%). In 5 patients (1.9%), hearing was also affected. In one of them, this condition was also caused by tinnitus, and in another patient, a preexisting tinnitus deteriorated.[4] The reported PRF technique, in contrast to PRGR, is division selective and exhibits excellent results with regards to pain relief, corneal sensation and hearing preservation, incidence of dysesthesias, tinnitus, labial herpes, chemical meningitis, anaesthesia dolorosa, and sensibility affection.

PMC is a simple and effective treatment for trigeminal neuralgia. Sean Mullan introduced the technique of percutaneous balloon compression for trigeminal neuralgia in 1983 based upon the concept that intraoperative manipulation of the trigeminal ganglion gives pain relief.[8] However, PMC has been reported to be complicated by hypesthesia, dysesthesia, masseter muscle weakness, anesthesia dolorosa, corneal anesthesia, absent corneal reflex, aseptic meningitis, transient sixth nerve palsy, otalgia, or trochlear nerve palsy.[1,7,8,29,35] Significant morbidity has been reported due to needle misplacement during cannulation in PBC procedures.[18,30] Studies have demonstrated a higher incidence of masseter muscle weakness and dysesthesias after balloon compression than with other ablative procedures.[9,21] The incidence of mild masseter weakness with balloon compression is reportedly as high as 100%.[21] Brown noted a recurrence rate of 30% at 10 years and higher rates of recurrence in patients with multiple sclerosis reaching up to 50%.[6] The PRF technique elaborated in our report did not cause any masseter weakness, cranial nerve palsies, decrease in corneal sensation, dysesthesias, or anaesthesia dolorosa.

RF systems facilitate fully controlled, selective lesioning. There is no way to predict or to control the degree and extent of lesioning in methods such as

peripheral alcohol blocks, glycerol rhizolysis, balloon microcompression,[17] and radiosurgery. The PRF procedure described involved a controlled and selective lesioning of the V1 division devoid of sensory deficit, and thus successfully, explores for the first time a new aspect of RF technology, as applied to V1 neuralgia. We do not believe that the therapeutic benefit was due to mere needle manipulation because throughout the procedure a cause-and-effect phenomenon vis-a-vis pulsed RF application and pain threshold increase was continually being demonstrated.

These preliminary findings from a single patient need to be validated by well-designed studies. An ideal cure for trigeminal neuralgia would mean reversal of the demyelination process in the sensory root by remyelination, if need be, by direct injection of stem cells.[37] Until then the potential of options such as PRF must be fully explored. Our case suggests that apart from trigeminal neuralgia, trials with prolonged PRF may be worthwhile in many cases where ablative lesioning has hitherto been used viz Parkinson's disease, essential tremor, dystonia, dyskinesias, epilepsy, spasticity, depression, and obsessive compulsive disorders and in other conditions in spine and peripheral nerves, given its cost effectiveness and safety record.

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Conflicts of interest
There are no conflicts of interest.

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