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Radiofrequency ablation in the management of spinal pain

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Abstract

Radiofrequency treatment has traditionally been regarded as an ablative method, blocking the conduction of nociceptive stimuli to the spinal cord. This concept has been challenged and the mode of action may not be exclusively thermal. This has led to the development of pulsed radiofrequency, with a reduced destructive effect.

Indication Radiofrequency treatment is indicated for pain with a constant and limited distribution. Neuropathic pain can be treated if the function of the relevant nerve is still partially intact.

Diagnosis A clinical diagnosis must be made first to exclude conditions that require a different form of treatment. The diagnosis is then confirmed by diagnostic nerve blocks.

Technique Positioning of the electrode should be monitored radiologically, either by computed tomography (CT)-guidance or by fluoroscopy. Once the electrode is in place, the correct position is confirmed by electrostimulation.

Results The efficacy has been confirmed by a number of randomised controlled trials (RCTs) for heat radiofrequency and by one RCT for pulsed radiofrequency. Reported results vary from 60 to 90%. There is a tendency for recurrence within 1–2 years, but the procedure can be repeated.

Complications Serious complications are very rare.

Conclusion Radiofrequency treatment is a relatively safe, well-tolerated technique to treat selected cases of chronic pain.

Mode of action of radiofrequency treatment

Radiofrequency (RF) treatment has traditionally been regarded as a purely ablative method. The application of RF electric fields to the tip of an electrode causes friction of ions, and this in turn causes the formation of heat. If the electrode is appropriately placed, this causes either coagulation of the target nerve, or a selective effect on unmyelinated fibres,[1] depending on the intensity of the lesion.

Recently, this concept has been challenged. The ablative model presupposes that the RF lesion is made between the nociceptive focus and the spinal cord. This is not necessarily the case. For example, applying a RF lesion to the dorsal root ganglion (DRG) of the compromised segmental nerve, or even to the formed segmental nerve itself, can effectively treat pain that is caused by a herniated intervertebral disc. Both locations are peripheral to the nociceptive focus.

This has raised the possibility that the mode of action of the RF electric fields is not exclusively thermal. On this basis, pulsed RF (PRF) has been developed.[2] In PRF, RF fields are applied intermittently, and this prevents the mean tip temperature rising to neurodestructive levels. As a result, it was thought initially that PRF was a completely non-destructive procedure. However, this is not the case and in experimental work, it has been found that there is destruction in a very thin layer around the electrode tip.[3–5]

The role of this limited neurodestruction in the mode of action of PRF remains to be clarified. There is an alternative explanation for the clinical effect which is that PRF has an effect on the dorsal horn. In experimental work, it has been shown that application of PRF to the DRG causes the expression of c-fos in the dorsal horn, both in the short[6] and long[7] term.

There is consensus that PRF is the treatment of choice for DRG procedures[8] and for peripheral nerves.[9] For trigeminal neuralgia, the choice is still under discussion because there are conflicting reports.[10,11] The medial branch is usually treated with conventional RF because there are RCTs to support this.

Indications

(P)RF lesions are indicated for nociceptive pain, and for some forms of neuropathic pain, with a constant and limited distribution, not responding to conservative

treatment. This includes pain of undetermined aetiology, such as the 12th rib syndrome or radicular pain that is not explained by an anatomical lesion.

Neuropathic pain can be treated if the function of the relevant nerve is at least partially intact, for example in neuropathic scar pain, and in pain that is caused by pressure on or by irritation of nerves. Pain caused by a herniated intervertebral disc or by neuropathy falls into this category.

RF treatment is not indicated if pain is centralised, if there is relevant pathology inside the spinal cord or if there is serious psychopathology.

Treatment algorithm

In patients who potentially qualify for RF treatment, a tentative diagnosis must first be made. Causes of pain that require a different form of treatment, such as tumours and infections, must be excluded and it should also be ascertained whether conservative treatment has been adequate.

In most cases, the diagnosis is then confirmed by diagnostic nerve blocks, but this is only indicated if such a block can be expected to provide information. This is not the case, for example, in a patient with a herniated intervertebral disc with concordant pain, or in a typical case of trigeminal neuralgia. The diagnosis of discogenic pain is not made by diagnostic nerve blocks, but by provocative discography.

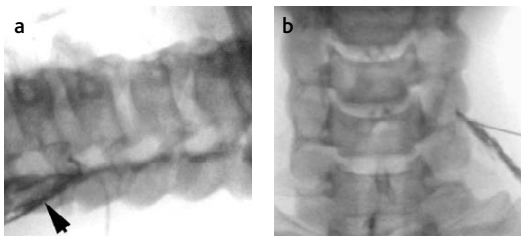


Figure 1. Diagnostic nerve block of the C6 segmental nerve. (a) Oblique projection. In this projection, the nerve (arrow) runs in a slightly posterior direction. (b) Anteroposterior projection.

Diagnostic nerve blocks are only meaningful if they are performed under radiological control, using contrast to monitor the spread (Figure 1).

Commonly used RF procedures and treatment sites

- **The medial branch of the posterior ramus.** This nerve innervates the zygoapophyseal (facet) joints. These joints may cause back and neck pain, associated with degenerative changes, trauma or postural abnormalities.
- **The DRG**, or the proximal part of the segmental nerve if the DRG cannot be reached for anatomical reasons, for example in the sacral region. DRG treatment is indicated for pain due to a herniated disc, to radiculopathy or to neurogenic claudication. It may also be used for regional pain syndromes with a limited segmental distribution.
- **Intradiscal RF procedures** for discogenic pain. In these procedures, heat is delivered through special catheters, either by radiant heat[12] or by RF.[13] The catheters are positioned in or near the annulus fibrosus. A new method applies high voltage, long duration PRF in the centre of the disc with a simple Sluijter-Mehta cannula (SMK) needle and electrode.[14]
- **The sympathetic chain**. This is a target for a variety of indications, such as vascular insufficiency, sympathetic mediated pain and persistent back pain following a vertebral fracture.
- **The splanchnic nerve** can be treated with RF in cases of intractable abdominal pain.[15]
- **The sphenopalatine ganglion**, for conditions such as therapy-resistant cluster headache,[16] side-locked migraine and some forms of atypical facial pain.
- **The Gasserian ganglion**[17] for the treatment of trigeminal neuralgia.
- **Percutaneous lateral cordotomy**. This elegant technique for unilateral cancer pain[18] is losing ground, now that technically simpler solutions such as the intraspinal administration of opioids are available.

Radiofrequency ablation in the management of spinal pain *continued*

Menno E. Sluijter MD, PhD

Technique

The most commonly used electrode system is the SMK system,[19] consisting of a disposable cannula – that is insulated except for an active tip of variable length (2–15 mm) – and a non-disposable fitting RF electrode. The electrode is connected to the lesion generator, which has facilities for electrostimulation, measuring the impedance, delivering the RF current and measuring the temperature at the tip.

The positioning of the cannula must be monitored radiologically. This can be done under CT-guidance or under fluoroscopy. Both methods have their pros and cons, and the choice will often depend on the experience of the operator. CT has the advantage that the target structure is often visible on the image, and on occasion this may facilitate accurate placement. Fluoroscopy has the advantage that it is undeniably faster, even in comparison with the most sophisticated CT equipment.

When fluoroscopy is used, the cannula is commonly introduced using a 'tunnel vision' technique.[20] In this technique, the target point is visualised, often in an oblique projection (see Figures 2–5). An entry point is marked over the target point, and the cannula is introduced in the direction of the X-rays. The level of penetration is checked frequently in another plane until the tip of the cannula is approaching, but not hitting, the target. The cannula is then advanced over the last few millimetres with the electrode in place, using electrostimulation as a guide.

Once the electrode system is in place, electrostimulation is carried out at a frequency of 50 Hz to monitor the proximity of the electrode to the target structure. If a RF thermolesion is to be made, this is followed by stimulation at 2 Hz. This causes motor contractions and it is intended to confirm a sufficient distance from motor structures. The (P)RF procedure is then carried out, with current intensity, impedance and temperature being monitored during the procedure.

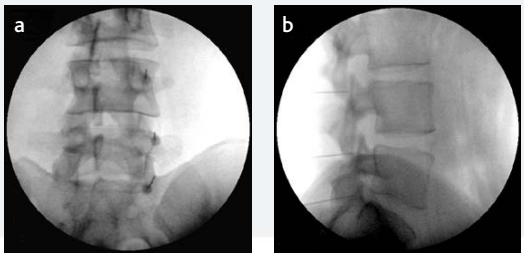


Figure 2. RF procedure of the medial branches L3, L4 and L5 R. The nerves run in the groove between the superior articular and transverse processes. A slightly oblique projection facilitates identification of the groove. The cannulae have been entered in tunnel vision. (a) Oblique projection. (b) Lateral projection.

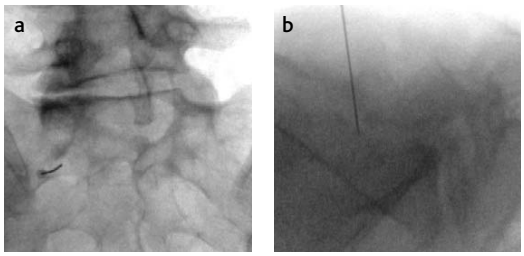


Figure 3. PRF procedure of the S1 nerve. (a) The needle in place in the S1 foramen. The axial rotation of the C-arm has been adjusted showing a clear image of the L5/S1 disc. In this plane, a slightly oblique projection is used to show the foramen. (b) Lateral projection, with the tip of the needle just ventral to the visible part of the sacral canal.

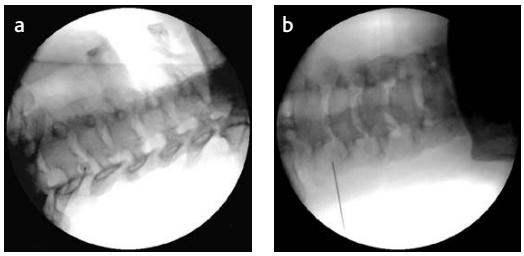


Figure 4. PRF procedure of the DRG C7. (a) Oblique projection. The needle has been positioned using tunnel vision. (b) Anteroposterior projection. The tip is projected over the middle of the facetal column.

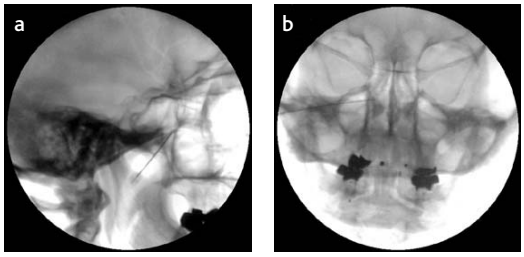
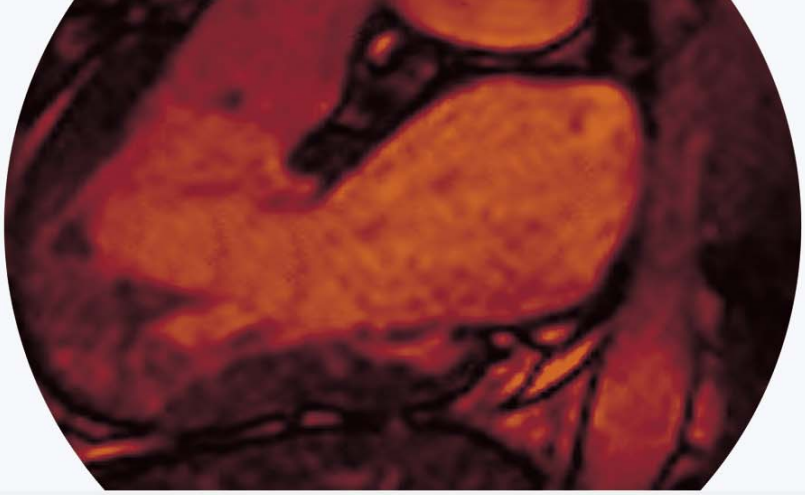


Figure 5. PRF procedure of the sphenopalatine ganglion. (a) Lateral projection. This is not a tunnel vision procedure, since the anterior mandibular process projects over the fossa in the lateral projection. The approach is from slightly posteroinferior, between the mandibular processes and just under the zygomatic arch. (b) Anteroposterior projection. The tip of the needle has entered into the sphenopalatine foramen.



Results

There is ample evidence in the literature testifying the efficacy of RF heat lesions. RCTs have been reported relating to the lumbar[21,22] and the cervical[23] medial branch, and cervical DRG.[24] The success rate for the lumbar medial branch procedure varies from 60% to 90% in a very strictly selected group of patients.[25] In the cervical region, a success rate of 71% was reported.[26] The method also has good results (80%) in cervicogenic headache.[27]

Recently, the results of the first RCT on PRF have become available, indicating a positive outcome.[28] In addition, a number of retrospective clinical studies on PRF have been published, all reporting results that seem to be in the same range as the results of heat RF.[29-32] The initial study on the DRG procedure in patients with a herniated intervertebral disc[33] reported a 90% long-term success rate. This compares favourably to steroid root infiltrations, which do not affect the ultimate rate of surgical intervention and which have an incidence of very serious complications.[34] An overview of the available materials on PRF, including an extensive bibliography will be published shortly.[35]

The results of the intradiscal procedures using catheters and thermal destruction are mixed.[13,35] It seems to be a good procedure for a relatively small population of sufferers from discogenic pain. The first report on the PRF procedure[14] is very hopeful, but the number of patients studied was small and these data have to be confirmed.

Most reports indicate that there is some loss of effect of RF treatment over the first 1–2 years following the procedure. This is of course regrettable, but most of the procedures are simple and well tolerated, and they can easily be repeated.

Complications

Procedure-related complications following conventional RF heat lesions have been rare. RF seems to be a safe method if normal precautions are taken. The treatment of the medial branch has been virtually free of complications, while the treatment of the DRG with heat lesions has occasionally led to denervation sequelae and to motor weakness in the myotome of the treated level. One serious complication, contralateral paresis caused by spinal ischaemia, has been reported.[37] A serious complication (cauda equina syndrome) has also been described following intradiscal catheter treatment for discogenic pain.[38]

PRF has so far been free of complications. There is no appreciable sensory loss following the procedure, and motor complications have not been reported.

Conclusion

RF is a well-tolerated procedure for treating nociceptive pain, and some forms of neuropathic pain with a limited distribution. It has an acceptable success rate, but the procedure has to be repeated in many patients from time to time. Serious complications have been described following intradiscal heat lesions using specific catheters and following a DRG procedure with heat RF. Otherwise, the technique seems to be relatively safe. The use of PRF has widened the possibilities of RF to the treatment of neuropathic pain and of peripheral nerves, and it may reduce the complication rate even further.

Radiofrequency ablation in the management of spinal pain *continued*

Menno E. Sluijter MD, PhD

Key Learning

- The role of heat in the mode of action of RF is under discussion. PRF has been developed as a much less destructive variant of RF
- PRF is suitable for treating neuropathic pain, if the function of the relevant nerve is still partially intact
- RF procedures should be preceded by accurately performed diagnostic nerve blocks with the use of contrast, unless there is a clear anatomical lesion with concordant pain
- Pain due to a herniated intervertebral disc, with or without moderate neurological deficit, is a very good indication for PRF of the dorsal root ganglion or the formed segmental nerve. This is a safer and probably more effective method than the injection of steroids
- A proportion of patients have recurrence of pain in the 1–2 years following RF treatment. The procedure must then be repeated

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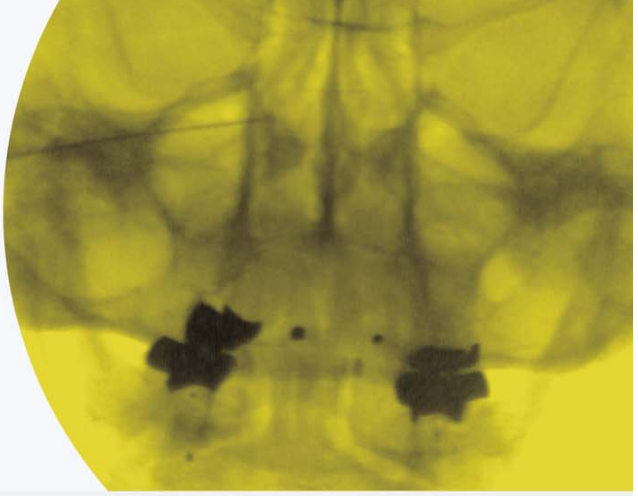

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