

Radiofrequency Neurotomy in Patients with Posterior Spinal Hardware

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Myth: Radiofrequency neurotomy (RFN) cannot be performed in the setting of posterior spinal hardware due to the risks of heating undesired neurologic structures and unintended nerve injury.

Fact: The existence of posterior spinal hardware is not an absolute contraindication to RFN, but direct contact with hardware should be avoided.

Facetogenic pain is a common cause of chronic low back pain that is commonly treated with RFN of the spinal medial branch nerves [1,2]. RFN involves conversion of radiofrequency waves transmitted via an electrode, introduced into a cannula, and conducted through a metal tip. Radiofrequency waves are then converted into thermal energy in the tissues adjacent to the metal tip of the cannula. Thermal energy is also conducted after conversion through the adjacent tissue. The resultant thermal coagulation of the medial branch nerves disrupts the pain signaling pathways from the facet joint(s) to the central nervous system, allowing for durable analgesia. RFN is a low-risk procedure [3]. While conventional RFN is commonly performed at 80-90°C, neural injury can occur at temperatures as low as 42°C [4].

Facetogenic pain may develop in the setting of a prior spinal arthrodesis. The spine is predisposed to accelerated degeneration adjacent to fused segmental levels [5]. If hardware is utilized to establish spinal stability, there will be hardware present at the medial branch level that innervates the mobile facet joint immediately adjacent to the fused segments. Additionally, incomplete fusion resulting in the presence of pseudarthrosis may also result in persistent pain [6,7]. There is controversy as to whether the medial branch nerve is destroyed by the surgical exposure or by the pedicle screw itself at most lumbar levels. However, because the medial branch nerve may remain intact in a proportion of these patients, as well as at levels of posterior cervical and thoracic fusions, many physicians elect to place an RFN electrode in close proximity to

spinal hardware. RFN may be effective at controlling pain in these scenarios. Sensitive neurologic structures that are not the intended target of RFN may be in proximity to posterior spinal hardware (e.g., the spinal nerve exits beneath the pedicle through which a pedicle screw might pass). Concern has been raised about the safety of RFN in the setting of posterior spinal hardware.

A 2015 cadaveric study evaluated temperature changes resulting from lumbar spinal medial branch RFN in the presence of both titanium and steel pedicle screws [8]. Direct contact of the radiofrequency cannula metal tip with the pedicle screws produced temperature changes of the pedicle screw and surrounding soft tissue compared to controls. The effect was more pronounced with titanium than with stainless steel. The temperature of the titanium screw heads increased by 6.66°C and the screw tips increased by 16.72°C when the cannula was placed on top of the pedicle screw and heated to 80°C for 90 seconds. In contrast, the temperature of stainless-steel screw heads increased by 4.4°C at the head and 2.46°C at the tip when there was contact of the RFN cannula with the pedicle screw at the same location. Titanium, therefore, appears to heat to a greater extent and conduct heat through the length of the screw more effectively than stainless steel, presenting a greater potential risk for unintended neural or vascular injury at and distal to the RFN site if there is contact with the pedicle screw. The risk of neural injury may be greater in the setting of malpositioned/migrated hardware (e.g., pedicle screws in close proximity to spinal nerve roots due to extra-osseous passage in any direction). When

the cannula was placed at or near the conventional RFN target, but not in direct contact with the pedicle hardware, there was heating of the hardware, but that difference (up to 1.84°C for titanium and 0.86°C for stainless steel) was small in comparison to direct contact, and likely of no clinical significance. The study did not make note of the exact distance between the cannula and the hardware. The study had several limitations, including the use of a cooled cadaver torso with a non-standardized baseline temperature. The heat generated from RFN increased the baseline temperature of the local cadaveric tissue to closer to room temperature. Even after allowing cooling time between repeated ablation cycles, the cadaver temperature did not return to baseline. Finally, the cadaver model was dissected such that the spine was open.

In 2016, a prospective study evaluated six patients during a total of 10 RFN procedures, in which a temperature probe was placed via a cannula adjacent to posterior hardware in order to monitor temperature during RFN [9]. Pedicle screw head temperature increased during six of the 10 RFN procedures. In two cases, the temperature rapidly rose to 42°C requiring abrupt termination of the procedure. The authors concluded that monitoring of hardware temperature should be performed during RFN using a secondary probe. Limitations of this study included the small sample size and the fact that cannulae appeared to be placed under oblique fluoroscopy without a corroborating AP or lateral view. In particular, the supplied image appears to demonstrate a cannula position more lateral on the transverse process rather than at its junction with the superior articular process, in closer proximity to the hardware. It also appears that the temperature monitoring cannula was of different gauge than the therapeutic cannula, which is of uncertain but potential significance.

Additional studies have not demonstrated evidence of increased risk of neural injury when RFN is applied in patients with posterior spinal hardware. A 2018 retrospective review of 56 RFN procedures (11 cervical, one thoracic, 44 lumbar, with levels ranging from the third occipital nerve to the L5 dorsal ramus) also reported no complications [10]. The paper includes fluoroscopic procedural images demonstrating suboptimal needle placement and multiple cases of mislabeling of the intended procedures. This generates concerns regarding the authors' understanding of the RFN procedures, the ability to have appropriately analyzed the data from a retrospective chart review;

and therefore, the validity of the conclusions drawn. A 2020 retrospective case-control study that evaluated 52 patients who had received RFN at the level of hardware, of which 36 were spinal, reported no complications [11]. The retrospective nature of the study, limited population, and the lack of clarity regarding procedural standards were all limitations of this paper.

Conclusion

RFN causes heating of soft tissue surrounding posterior spinal hardware. Further, heat may be transmitted through the length of the hardware. One study reported a marked difference between heating at the distal ends of titanium screws compared to steel, especially when there was direct contact of the RFN cannula with hardware [8]. Although there is evidence of temperature elevation in the tissue surrounding the hardware when the cannula tip is placed at conventional RFN target sites but not in direct contact with the pedicle hardware, the effect appears to be of negligible clinical significance. Monitoring of hardware temperature has been performed concurrently during RFN procedures. The necessity of temperature monitoring has not yet been clearly demonstrated, though it may present a safeguard to unintentional hardware heating. There has yet to be a report of unintended neural injury associated with a spinal RFN procedure in the setting of posterior spinal hardware. While larger cohort studies would provide additional reassurance, it appears that RFN may be performed safely in patients with posterior spinal hardware when the cannula tip is not in direct contact with the hardware.

Recommendations

- The medial branch nerves may be destroyed in the process of placing pedicle screws for securing posterior spinal hardware. However, in cases where there is concern that the medial branch nerve has not been destroyed, RFN may be considered if there has been an appropriate response to initial and confirmatory medial branch blocks targeting the post-surgical level(s).
- The greatest risk of undesired heat conduction through posterior spinal hardware likely occurs when the RFN cannula tip is in direct contact with the hardware. Care should be taken to ensure there is no direct contact of the cannula with posterior spinal hardware.

- Heat may conduct through the entire length of the pedicle screw. Axial imaging should be reviewed prior to RFN to identify malpositioned/migrated hardware particularly if extra-osseous migration/placement has occurred with deviation of metal adjacent to neural or vascular elements.
- As with all medial branch RFN procedures, physicians should communicate with and monitor patients to assess for pain that may signal heating of undesired neurologic structures.
- Physicians may consider temperature monitoring of adjacent hardware with the use of an additional probe while performing RFN at a level that incorporates posterior spinal hardware, particularly if titanium pedicle screws are present. Consideration should be given to abort the RFN procedure if temperature reaches or exceeds 42°C.
- The safety of cooled RFN in this setting has not been established.

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