Microendoscopic stereotactic-guided percutaneous radiofrequency trigeminal nucleotactotomy

Technical note

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Object. Over the past few decades, various authors have performed open or stereotactic trigeminal nucleotactotomy for the treatment of neuropathic facial pain resistant to medical treatment. Stereotactic procedures can be performed percutaneously under local anesthesia, allowing intraoperative neurological examination as a method for target refinement. However, blind percutaneous procedures in the region of the atlantooccipital transition carry a considerably high risk of vascular injuries that may bring prohibitive neurological deficit or even death. To avoid such complications, the authors present the first clinical use of microendoscopy to assist percutaneous radiofrequency trigeminal nucleotactotomy. The aim of this article is to demonstrate intradural microendoscopic visualization of the medulla oblongata through an atlantooccipital percutaneous approach.

Methods. The authors present a case of severe postherpetic facial neuralgia in a patient who underwent the procedure and had satisfactory results. Stereotactic computational image planning for targeting the spinal trigeminal tract and nucleus in the posterolateral medulla was performed, allowing for an accurate percutaneous approach. Immediately before radiofrequency electrode insertion, a fine endoscope was introduced to visualize the structures in the cisterna magna.

Results. Microendoscopic visualization offered clear identification of the pial surface of the medulla oblongata and its blood vessels, the arachnoid membrane, cranial nerve rootlets and their entry zone, and larger vessels such as the vertebral arteries and the branches of the posterior inferior cerebellar artery.

Conclusions. The initial application of this technique suggests that percutaneous microendoscopy may be useful for particular manipulation of the medulla oblongata, increasing the safety of the procedure and likely improving its effectiveness. (DOI: 10.3171/2011.8.JNS11618)

KEY WORDS • pain • percutaneous nucleotactotomy • endoscopy • radiofrequency • medulla oblongata

Abbreviations used in this paper: CN = cranial nerve; RF = radiofrequency; VAS = visual analog scale.
this region possible under local anesthesia with the possibility of patient participation. The accuracy of stereotaxy was added to patient guidance by intraoperative mapping for controlled electrical stimulation through the RF probe inserted into the target site at dorsolateral aspects of the medulla oblongata. However, the potential high risk of vascular injuries and potentially fatal subarachnoid hemorrhages caused the procedure to be abandoned by most authors.11,18 Only a few neurosurgical centers have continued to perform percutaneous procedures after technical improvements.13,23 Instead, most patients with refractory deafferentation facial pain syndromes are referred for motor cortex stimulation. However, the results of this more conservative technique are not satisfactory in a considerable number of patients, which leaves these patients without any treatment possibilities.15

Here, we demonstrate that microendoscopic exploration of the surgical field can be used in stereotactic procedures at the cranial-cervical transition by inserting a fine endoscope to combine the minimally invasive nature of the percutaneous approach with the accuracy of a computer-guided stereotactic procedure, thereby avoiding the risk of injuries to neural tissue and blood vessels (Video 1).

**Video 1.** Clip showing the dynamic microendoscopic visualization of the posterolateral aspects of the medulla oblongata after the occipitocervical stereotactic percutaneous approach. It is possible to identify clearly the vessels in the pial surface of medulla and arachnoid trabeculae moving with CSF pulsation. Click here to view with Windows Media Player. Click here to view with Quicktime.

**Case Report**

**History and Examination.** This 43-year-old man with previous immunodeficiency was diagnosed with postherpetic neuralgia that was initially treated by oral medication. He experienced partial improvement. One year after the development of the facial neuralgia, oral medication no longer controlled pain even at very high doses (gabapentin [4800 mg/day], nortriptyline [100 mg/day], and tramadol [600 mg/day]; or methadone [90 mg/day]). Despite oral medication, the patient experienced very intense burning pain (VAS Score 8–10/10), frequent shocklike sensations, and unbearable neuropathic pruritus associated with intolerable allodynia in the territory of the first 2 trigeminal divisions. A neurological examination revealed light tactile and pinprick hyperesthesia associated with a diminished sense of vibration, and mechanical and thermal allodynia in the territory of the first and second trigeminal branches (Fig. 1 left). No changes were detected in 2-point discrimination. A trial with transcranial magnetic stimulation in the motor cortex was performed, but no satisfactory improvement was observed. As motor cortex stimulation was not available at that time, trigeminal nucleotactotomy was offered, and after obtaining informed consent, the procedure was performed according to the following technique.

**Operation.** Stereotactic trigeminal nucleotactotomy was performed under local anesthesia. The morning of the procedure, a contrast-administered stereo-CT scanning study (TM-Micromar frame, Micromar) was performed and fused with the MR images (Gd-enhanced T1-weighted volumetric sequences) using computer software (MNPS, Mevis) for target and trajectory planning (Fig. 2). This technique provided accurate representation of the brainstem, cerebellum, upper cervical spinal cord, occipitocervical bone structures, and the greater arteries within the cisterna magna. The target plan aimed the point in the distal medulla oblongata at the level of the obex, 5 mm from the midline. The probe trajectory was drawn from the intended target through the posterolateral atlantocipital interspace with a lateral angle of 35° laterally from midline. Under light sedation, the patient was placed in a lateral position with his head firmly fixed in the stereotactic frame. After a local anesthetic was administered, the 18-gauge guide cannula was inserted percutaneously according to the stereotactic trajectory plan, and it gently punctured the dura mater. A fine endoscope (0.9-mm-thick microendoscope, MYELOTEC, Inc.) was inserted through the cannula for direct view of the anatomy in the cisterna magna. This endoscopic device renders a 70° field of view at 40° x 40° angle of view, which provides a clear image through the CSF. The endoscopic visualization offered clear identification of the pial surface of the medulla oblongata and its blood vessels, the arachnoid membrane, the CN rootlets and their entry zone, and larger vessels such as the vertebral arteries and the branches of the posterior inferior cerebellar artery (Fig. 3). After removal of the endoscope, an RF electrode (1-mm exposed fine tip, 0.27 mm in diameter; Radionics) was inserted through the same cannula, reaching the pial surface of the medulla at the determined point. Fortunately, the trajectory in this case was clear of vessels. In cases in which vessels are in the exact pathway of the endoscope, a new trajec-
tory must be oriented by changing the angles of the stereotactic apparatus to avoid contact between the vessels and the probe. Continuing the procedure, conventional recording of tissue impedance guided the insertion of the electrode into the medulla (approximate impedance: CSF, 200 Ω; and medulla, 800 Ω). Further controlled electrical stimulation (75 Hz and 1-msec pulse width) provided target refinement by eliciting a tingling sensation over the ipsilateral facial area. The target was confirmed once the patient noted that the area of evoked sensation included the painful spot. This control was possible because the patient was awake and fully participating in the procedure at this time. The lesion was then made by applying RF, reaching a temperature of 75°C during 60 seconds. In this particular case, 3 consecutive lesions in the longitudinal axis of the medulla were enough for satisfactory thermoanalgesia on the ipsilateral side of the face reaching the V1 and V2 territory. The first lesion was made at the level of the obex, and the other two lesions were made caudal to the first to include the upper and more peripheral portions of the face and forehead. Immediately after the lesions were made, the microendoscope was again inserted into the CSF space to view the spot of the electrode insertion on the pial surface of medulla. There was no bleeding or other complication during the procedure. No CSF leak was detected during the early or late postoperative period. Figure 4 shows the changes of the RF lesion on postoperative MR images.

Postoperative Course. In addition to immediate pain relief and resolution of allodynia and neuropathic pruritus, tactile and thermal hypesthesia (especially in the left V1) and an expected mild ipsilateral upper-limb ataxia remained but improved within 4 weeks. No additional postoperative neurological deficits were observed. The patient was reexamined at last follow-up (26 months), maintaining pain relief (VAS Score 2) in the very limited region of V2 (Fig. 1 right). He also was able to gradually reduce his medication doses to nortriptyline (25 mg/day).

Discussion

Although deafferentation trigeminal pain syndromes are not very common, their severity and resistance to medication are often observed in patients suffering from these conditions. Postherpetic neuralgia, anesthesia dolorosa, and other deafferentation pain syndromes such as radiation-induced trigeminal neuropathy and Wallenberg syndrome are the most frequently described.11,19 Initially, a variety of surgical procedures have been proposed for pain relief, leading to partial improvement in, but sometimes worsening of, the pain process. However, satisfactory pain outcome was only reached when the surgical...
procedures were based on the knowledge about the functional anatomy of the brainstem and on the pathophysiology of neuropathic pain. The complex sensory function of facial structures is mediated by the entire trigeminal complex, whereas the spinal trigeminal nucleus is responsible for the integration and processing of nociceptive information from the face. The topographic arrangement of the subnucleus caudalis of the trigeminal spinal nucleus has an onion-skin pattern, in which the central or oral region of the face projects into the rostral part of the nucleus up to the obex and the peripheral areas project into its caudal part down to the level of C-4.

In 1937, Sjoqvist performed a trigeminal tractotomy through the open procedure. Since then, the technique underwent several modifications, with Kunc et al. developing the high cervical access and Fox et al. reporting on the percutaneous freehand technique. Thus, Crue et al. developed the stereotactic procedure, which was later modified by Hitchcock and Schwarcz. In 1972, these authors published their promising results of RF lesioning in the descending trigeminal tract for the treatment of postherpetic trigeminal pain. This technique made the procedure more accurate and reduced the number of complications of the open technique, such as ipsilateral ataxia, paralysis of the recurrent laryngeal nerve, contralateral vocal cord paralysis, gait disturbance, and loss of postural stability. Moreover, the RF stereotactic approach differs from periphereral procedures because it disrupts not only the afferent but also the second-order neurons and tracts of the trigeminal spinal complex.

As mentioned previously, the target at the level of the obex is used as a standard starting point for trigeminal nucleotractotomy, followed by intraoperative refinement. The ablative procedure performed according to this technique enables careful microstimulation mapping, thereby avoiding superfluous lesions and consequently minimizing undesired neurological deficits. More recently, Kanapolat et al. described technical improvement of the percutaneous procedure guided by intraoperative CT. The option of mapping the functional anatomy of the nucleus added great advantages to the stereotactic or CT-guided percutaneous techniques. However, none of these advantages overcame the risk of vascular injuries.

Although nucleotractotomy became less invasive and produced encouraging results even for drug-resistant deafferentation pain syndromes, presently it is not widely used probably because of the high risk of vascular injury. The intent of this report is to demonstrate that microendoscopic assistance has emerged as an adjuvant technique that could increase the safety and therefore expand the range of spinal percutaneous procedures.

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Microendoscopic percutaneous trigeminal nucleotracotomy

permitting direct vision through limited exposures. Recently, our group described the use of fine endoscope to assist percutaneous cordotomies with a microendoscope that fits in an 18-gauge cannula.

Conclusions

This report demonstrates that it is possible to use microendoscopy not only in freehand cordotomies but also in procedures in which there is a stereotactic-mounted apparatus. Current microendoscopic technology and new computer stereotactic programming software can be added to the standard stereotactic method, providing exceptional control with regard to the location and size of the lesion, reducing postoperative tissue trauma, and perhaps reducing the morbidity and mortality rates associated with percutaneous procedures in the craniocervical region.

Disclosure

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References