CT-guided selective percutaneous radiofrequency thermocoagulation via the foramen rotundum for isolated maxillary nerve idiopathic trigeminal neuralgia

Quan Wan, MD,1 Daying Zhang, MD,1 Xintian Cao, MD,1 Yong Zhang, MD,1 Mengye Zhu, MD,1 and Wei Zuo, MD2

Departments of 1Pain and 2Anesthesia, First Affiliated Hospital of Nanchang University, Nanchang, Jiangxi, China

OBJECTIVE Although CT-guided selective percutaneous radiofrequency thermocoagulation (PRFT) via the foramen rotundum (FR) has been used in the clinic as a novel successful treatment for isolated, second division (maxillary nerve [V2]), idiopathic trigeminal neuralgia (ITN), there is only very limited related literature published to date. This report aims to provide more detail for physicians about this technique.

METHODS Between March 2013 and April 2014, 20 patients with isolated V2 ITN refractory to or intolerant of drug treatment were treated by CT-guided selective PRFT via the FR at the First Affiliated Hospital of Nanchang University. The outcome of pain relief was assessed using the Barrow Neurological Institute (BNI) pain score, and grouped as good (BNI Class I or II, no medication required) and bad (BNI Class III–V, medication required or failed). Recurrence was defined as a relapse to a previous lower level after attainment of any higher level of pain relief. Adverse effects and complications were also monitored and recorded.

RESULTS All patients (100%) obtained good pain relief including BNI Class I in 17 patients (85%) and BNI Class II in 3 patients (15%) immediately postoperatively. None of the patients were lost to follow-up. During the mean follow-up period of 24.3 months (range 18–30 months), 2 patients (10%) experienced recurring pain and the mean time until recurrence was 10.5 months (range 8–13 months). No adverse effects or complications occurred except for transient numbness restricted to the V2 dermatome in all patients (100%) and facial hematoma in 3 patients (15%).

CONCLUSIONS In the current study, CT-guided selective PRFT via the FR not only achieved absolute selective lesioning to V2, but also helped patients attain successful pain relief with few adverse effects. These limited data suggest that CT-guided selective PRFT via the FR appears to be a feasible, safe, effective, and even relatively ideal treatment for isolated V2 ITN, but these findings need confirmation from further studies.

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KEY WORDS trigeminal neuralgia; foramen rotundum; foramen ovale; radiofrequency; thermocoagulation; selective lesion; CT-guided; functional neurosurgery; pain

Abbreviations

BNI = Barrow Neurological Institute; FO = foramen ovale; FR = foramen rotundum; ITN = idiopathic trigeminal neuralgia; PRFT = percutaneous radiofrequency thermocoagulation.

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ing of adjacent divisions that may lead to corresponding complications.\textsuperscript{2,3,6,7,11,13} Recently, Li et al.\textsuperscript{10} reported on the technique of CT-guided selective PRFT via the foramen rotundum (FR) for isolated V2 ITN, which appeared to be able to overcome this significant deficiency. However, to the best of our knowledge, not much information is available about this novel method.\textsuperscript{6,10} In the current study, the outcomes of 20 patients with isolated V2 ITN treated by this method, surgical steps, and the potential advantages of this method are presented.

**Methods**

**Patient Population**

Following Institutional Review Board approval and written informed consent, 20 patients diagnosed with isolated V2 ITN between March 2013 and April 2014 at the Department of Pain of the First Affiliated Hospital, Nanchang University, were included in the study. The diagnosis of ITN was based on The International Classification of Headache Disorders, Third Edition, beta diagnostic criteria for ITN.\textsuperscript{3} There were 11 women and 9 men: the mean age of the study population was 63 years (range 52–74 years), the mean duration of symptoms was 6.9 years (range 0.5–21 years), and the sex preoperative visual analog scale score was 7.2 (range 5–9). Fourteen patients had pain on the right side and 6 patients had pain on the left side. All patients had previously received drug treatment, including carbamazepine (400–800 mg/day) in 12 patients, gabapentin (1200–1800 mg/day) in 6, and pregabalin (300–450 mg/day) in 2; tramadol (200–400 mg/day) was combined in 7 patients. None of the patients had undergone any surgical treatment that could have resulted in other types of pain. The CT-guided selective PRFT via the FR was recommended due to lack of efficacy or poor tolerance to drugs.

**Operative Technique**

All procedures were performed by the same experienced physician in the radiology room equipped with a 16-slice spiral CT scanner (SOMATOM Sensation 16, Siemens). Patients were supine with the neck slightly extended. A wide band fixed to the forehead and a roll under the neck were used to secure the position of the head and prevent accidental head movement. Electrocardiography, pulse oxygen saturation, and blood pressure were continuously monitored. A long, metal, marking needle was attached to the cheek of the painful side parallel to midline. Oblique-coronal scanning was conducted with the scanning frame approximately parallel to the plane connecting the dorsum sellae to the ipsilateral maxillary central incisor, according to the study of Li et al.\textsuperscript{10} (Fig. 1A). The specific CT image plane that could clearly display the external opening of the FR and the FR canal (white arrow) was used to design the needle puncture route. Note that the white dot on the left cheek is a transverse view of the metal marking needle. The distance from the designed needle entry point to the marking needle, depth of needle insertion, and needle entry angle could be measured by the intrinsic measurement tool of the CT machine. Figure is available in color online only.

![FIG. 1. A: Oblique-coronal CT scanning was conducted with the scanning frame (purple quadrilateral) approximately parallel to the plane (yellow line) connecting the dorsum sellae to the ipsilateral maxillary central incisor. B: The specific CT image plane that could clearly display the external opening of the FR and the FR canal (white arrow) was used to design the needle puncture route. Note that the white dot on the left cheek is a transverse view of the metal marking needle.](image)

**Outcome Assessment**

Patients were regularly followed up clinically. Pain relief was assessed using the Barrow Neurological Institute (BNI) pain score, and grouped as good (BNI Class I or II, no medication required, no or only occasional pain) and bad (BNI Class III–V, medication required or failed, some or severe pain).\textsuperscript{12} Recurrence was defined as a relapse to a previous lower level after attainment of any higher level of pain relief.\textsuperscript{8} Complications and adverse effects were also recorded.

**Results**

In all 20 patients, the needle tip reached the FR successfully through 1–4 attempts and the total duration
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of the operation was less than 30 minutes. All patients (100%) experienced good pain relief postoperatively and discontinued previously used drugs, including BNI Class I in 17 patients (85%) and BNI Class II in 3 (15%). During the mean follow-up duration of 24.3 months (range 18–30 months), 2 patients (10%) experienced recurrence of pain (assessed as BNI Class IV) 8 and 13 months postoperatively. Both of these patients subsequently underwent a repeat CT-guided PRFT via the FR at our pain management center and obtained complete pain relief (BNI Class I) in the remaining follow-up. All patients (100%) experienced mild to moderate numbness in the V2 dermatome immediately postoperatively. However, the numbness was not reported as very bothersome or intolerable, and gradually subsided from 3 weeks to 4 months postoperatively. Facial hematoma was observed in 3 patients (15.0%), which regressed gradually after application of sequential cold and hot compresses during postoperative Week 3. No other serious complications were observed.

Discussion

PRFT of the Gasserian ganglion or rootlets via the FO under radiographic guidance has become the most frequently used treatment for patients with ITN who experience unsuccessful conservative treatment due to its minimally invasive, safe, effective, controlled, repeatable, and low-cost characteristics. Controlled lesioning is the primary difference between PRFT and other percutaneous procedures such as peripheral alcohol blocks, glycerol rhizolysis, and balloon microcompression. However, it is reported that the classic technique has caused unselective lesioning with a high rate of approximately 16.7%–50%, especially when the final target is only V2. The unintentional lesioning of V1 or V3 may lead to numbness in the corresponding dermatome, motor weakness, absent corneal reflex or corneal keratitis, and even permanent vision loss. In the current study, the absolute selective lesioning of V2 was achieved in 100% of patients treated by CT-guided selective PRFT via the FR. Different from the classic FO approach, this novel technique specifically ablates the V2 at a more peripheral location (the FR level), which is outside the Meckel’s cave and completely separated from V1 and V3, which avoids nonselective lesioning. Moreover, the FR approach could also avoid some other complications that may occur in the FO approach, including inadvertent puncture of the foramen spinosum, carotid artery, and jugular foramen; CSF leak; intracranial hematoma; and meningitis.

As for the effectiveness of this approach, immediate and sustained pain relief was achieved in a majority of patients during the relatively short follow-up period (mean 24.3 months). Due to the small sample size and lack of control group, the outcomes could not yet be compared with the traditional FO approach. Two patients (10%) experienced recurrence of pain and the mean duration until recurrence was 10.5 months. However, we do not consider pain recurrence to be a serious event when compared with the risk of nonselective lesioning. These 2 patients with recurring pain also achieved successful pain relief after a repeat procedure, which implies that even with a significant recurrence rate, this procedure—which can be repeated without difficulty and still will obtain successful pain relief—may still be preferable.

The needle tip reached the FR through 1–4 attempts in all 20 patients. In clinical practice, we have found some rules that are useful for improving the efficiency of puncture. First, the appropriate needle skin entry point is always located at the puncture point of the superior border of the zygomatic arch, the posterior border of the maxilla, and the anterior border of the mandible’s coronoid process (the projection area of the pterygopalatine fossa on the cheek). Second, the FR is usually easy to reach when the needle is advanced in the direction of the intersection of a coronal plane parallel to the CT gantry and a sagittal plane approximately tangential to the external wall of maxillary sinus. And third, to avoid the inadvertent puncture of the superior orbital fissure or optic canal that are located at the posterosuperior orientation of FR, the needle should not be advanced too cranially and too deeply.

Although CT can show precise anatomical structure, exposure to radiation energy may be a concern in CT-guided procedures. In our cases, the CT scanning parameters were as follows: 80 mA, 120 kV, and 0.75-mm slice thickness, and total scanning duration was between 3 and 7.5 seconds. The radiation dose did not appear to be greater when compared with the traditional fluoroscopy guidance.
technique. Moreover, the narrow scanning field, a low-milliampere technique, and reduced puncture attempts are helpful to decrease the radiation exposure further.

Conclusions
Our initial experience with CT-guided selective PRFT via the FR demonstrates that this technique could not only achieve good short-term pain relief, but could also avoid the nonselective lesioning of the V1 or V3 division and other complications stemming from the FO approach, including injury of neurovascular structures around the FO, CSF leak, intracranial hematoma, and meningitis when being used for isolated V2 ITN. Although the effectiveness and safety of the technique still need confirmation from randomized controlled trials with large sample sizes and long follow-up periods, this technique is still very promising and could be considered as an alternative for patients with isolated V2 ITN.

References

Disclosures
The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions
Conception and design: D Zhang, Wan. Acquisition of data: Wan, Cao. Analysis and interpretation of data: D Zhang, Wan. Drafting the article: D Zhang, Wan. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: D Zhang. Statistical analysis: D Zhang, Wan. Administrative/technical/material support: D Zhang, Y Zhang, Zhu, Zuo. Study supervision: D Zhang.

Correspondence
Daying Zhang, Department of Pain, First Affiliated Hospital of Nanchang University, 17 Yongwai Rd., Nanchang 330006, Jiangxi, China. email: zdy@medmail.com.cn.