



# ioCT-guided percutaneous radiofrequency ablation for trigeminal neuralgia: how I do it

Heinrich Weßling<sup>1</sup> · Sven Duda<sup>1</sup>

Received: 26 November 2018 / Accepted: 22 February 2019 / Published online: 25 March 2019  
© Springer-Verlag GmbH Austria, part of Springer Nature 2019

## Abstract

**Background** Percutaneous trigeminal nerve rhizotomy is usually performed by free-handed puncture of the foramen ovale under radiographic control with the patient kept semiconscious. The procedure has thus been reported to be highly uncomfortable for both the patient and surgeon. To our knowledge, this is the first description of a technique that includes precise navigated, CT-guided puncture of the foramen with the patient in general anesthesia and confirmation of needle placement by intraoperative CT. **Method** Radiofrequency ablation of the trigeminal nerve was guided by intraoperative CT navigation with neuromonitoring of trigeminal nerve function. The patient was kept under general anesthesia during the procedure. **Conclusion** CT-guided percutaneous trigeminal nerve rhizotomy is a safe and efficient treatment strategy for the management of trigeminal neuralgia without the need of the patient being in a semiconscious state.

**Keywords** Intraoperative computed tomography · Trigeminal neuralgia · Percutaneous rhizotomy · Radiofrequency thermocoagulation

## Relevant surgical anatomy

The trigeminal nerve consists of three divisions: the ophthalmic nerve (V1), the maxillary nerve (V2), and the mandibular nerve (V3). These distal branches of the nerve originate from the Gasserian ganglion. Both the ganglion and pre-ganglionic fibers can be targeted via the foramen ovale. The foramen ovale is a canal located at the skull base of the middle cranial fossa right next to the lateral pterygoid and contains the mandibular nerve, a venous plexus, and the pterygomeningeal artery. The carotid canal, jugular foramen, lacerate foramen, and inferior orbital fissure are neighboring foramina at the skull base [3, 6].

## Description of the technique

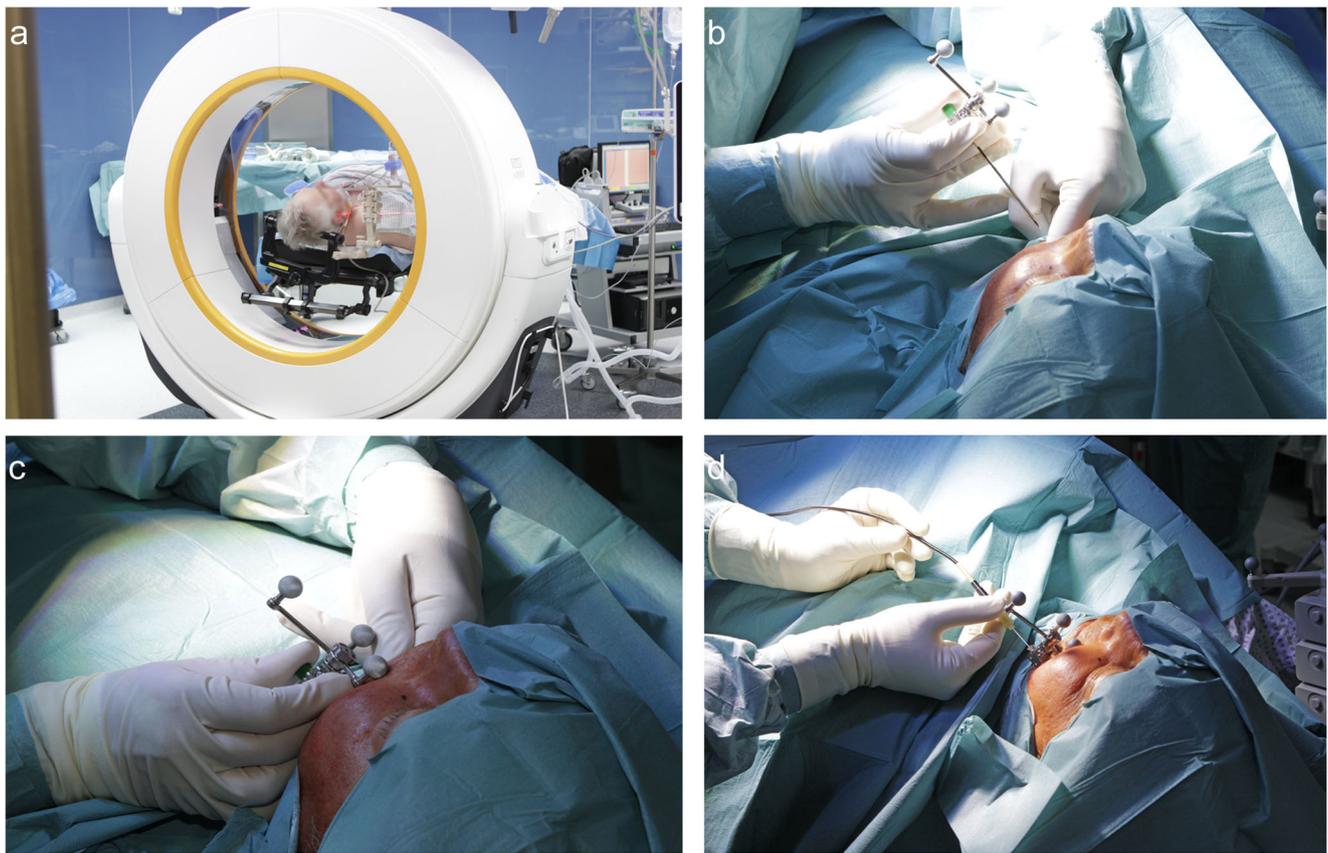
The patient is positioned supine. After administration of general anesthesia, the head is fixed in a Mayfield clamp. Once the head is secured, the patient's positioning remains completely unchanged throughout the whole procedure including all image acquisitions, in order to provide a maximum degree of precision for the navigation. An intraoperative CT (ioCT) scan is obtained with the AIRO® TruCT™ (Mobius Imaging, Massachusetts, USA) (Fig. 1a). A 3D model of the patient's cranium is generated with our cranial navigation software (Brainlab AG, Germany). The accuracy of the ioCT scan is checked by pointing at anatomical landmarks. EMG electrodes are put on to monitor the activity of the masseter muscle. Furthermore, subcutaneous electrodes for trigeminal nerve SEP are placed as described previously [7]. Härtel's anatomical landmarks are marked [2]. The index finger is inserted into the oral cavity right lateral to the upper molars to reach the lateral wall of the lateral pterygoid process (Fig. 1b). A guide cannula is inserted 2.5 cm lateral to the oral commissure on the affected site. The cannula is led to the foramen ovale by ioCT-guided neuronavigation (Figs. 1c, 2a, b). Härtel's marks are used for plausibility control. After entering the trigeminal cistern, CSF flow from the cannula is noted. Another ioCT scan is obtained to document satisfactory

This article is part of the Topical Collection on *Functional Neurosurgery - Pain*

**Electronic supplementary material** The online version of this article (<https://doi.org/10.1007/s00701-019-03859-8>) contains supplementary material, which is available to authorized users.

✉ Sven Duda  
svenduda@bundeswehr.org

<sup>1</sup> Department of Neurosurgery, Hospital of the German Federal Armed Forces, Lange Straße 38, 26655 Westerstede, Germany



**Fig. 1** ioCT-guided percutaneous access to the foramen ovale. **a** The patient is positioned supine with the head fixed in the Mayfield clamp to acquire the intraoperative CT scan. **b** A Tuohy needle is integrated into the neuronavigation setup. **c** The navigated placement of the Tuohy

needle through the foramen ovale into the middle cranial fossa. **d** Radiofrequency ablation is performed after the correct needle placement had been verified by another CT scan

entry to the trigeminal cistern. The 3D model allows the viewing of the intracranial portion of the cannula (Fig. 2c–f). The radiofrequency electrode is then inserted into the cannula (Fig. 1d). A stimulus intensity of 0.7 V with five pulses is set to evoke contraction of the masseter muscle for another plausibility control. The electrode tip is then inserted into the preferred division of the trigeminal root, and the lesion is set at 70 °C for 60–90 s. Pre- and post-lesioning trigeminal nerve SEPs are recorded. The patient is not awakened until the end of the procedure.

## Indications

In trigeminal neuralgia (TGN), there still remains an important role for neurodestructive procedures which aim at a symptomatic relief and which are performed via the transfacial cannulation of the foramen ovale and consecutive lesioning of the Gasserian ganglion within the middle fossa [1]. This is due to the fact that a considerable number of patients do not qualify for retrosigmoid craniotomy because of concomitant disease, advanced age, patient choice, or pathophysiological

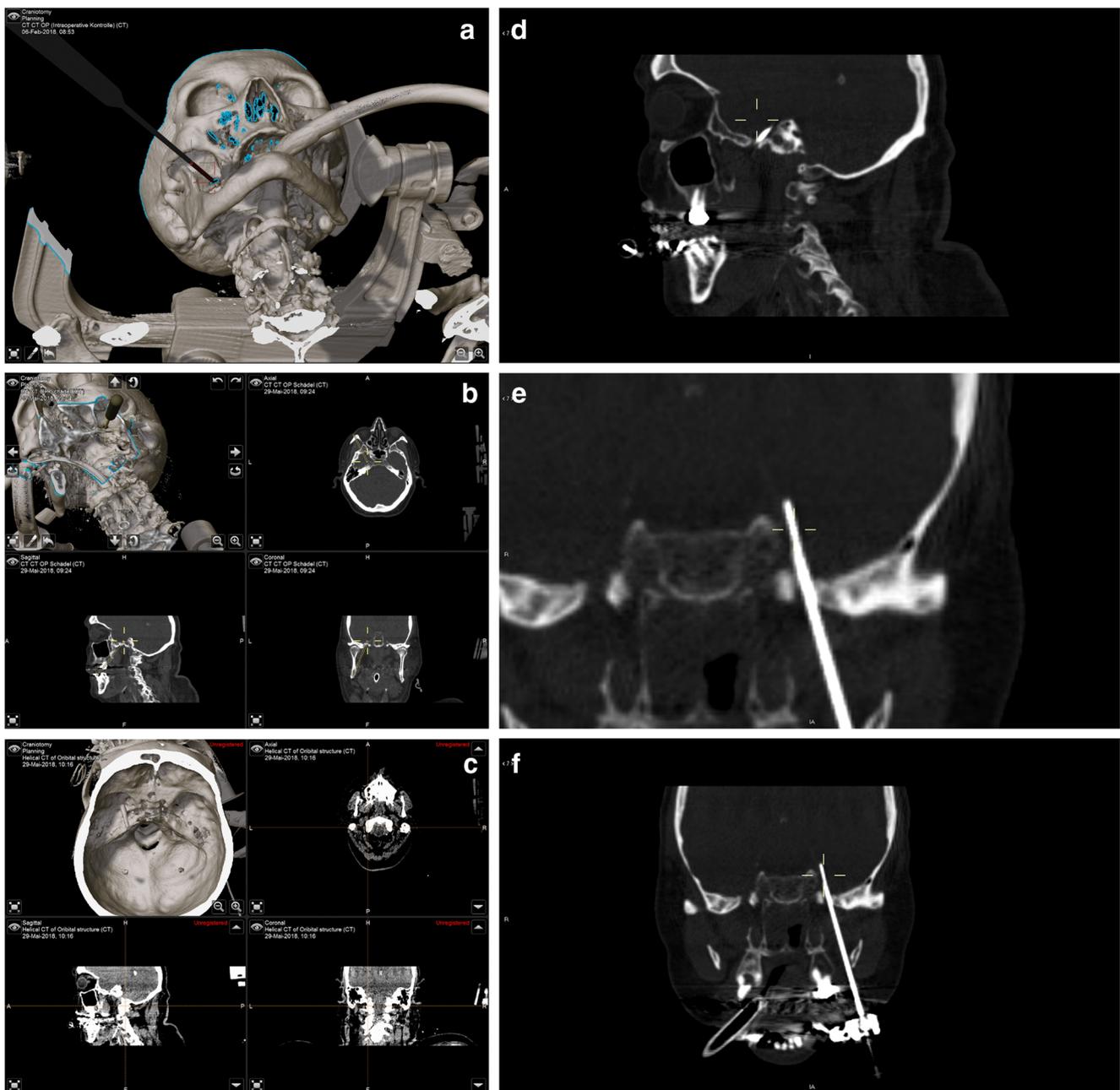
considerations (e.g., TGN as a secondary disease in MS or tumoral lesions).

## Limitations

Precise access to the trigeminal cistern can only be virtually shown on brain MRI as the incorporation of the post-puncture ioCT data showing the needle tip in the middle cranial fossa in the pre-existing MRI data is not technically feasible. This is due to the fact that the pre-puncture ioCT scan is further needed for a navigation purpose.

## How to avoid complications

The most dangerous complication is the puncture of adjacent foramina of the skull base. Furthermore, injury to cranial nerves near the cavernous sinus or to the carotid artery is possible [4]. To avoid this, a 3D model of the skull base with a precise visualization of the foramina is generated. The puncture is performed with an anteromedial trajectory to enter the



**Fig. 2** ioCT-navigated puncture of the Gasserian ganglion. **a** Surgical planning for right-sided TGN after acquiring a virtual 3D model from the ioCT data. **b** Screenshot after the puncture of the left foramen ovale in another patient. **c** Screenshot of the post-puncture ioCT scan documenting the correct position of the radiofrequency electrode inside the middle

fossa. **d** Sagittal view of the sectional plane of **e** and **f** reconstructed from **c**. **e** Close proximity of the needle tip to the cavernous sinus (arrow). **f** Documentation of the exact position of the needle tip within 22 mm from the foramen ovale in the trigeminal cistern

superomedial aspect of the foramen. Thereby, angulation of the needle towards the cavernous sinus is avoided.

Adverse effects related to the neurodestructive nature of the procedure occur even if the procedure is performed with the help of neuronavigation and neurophysiological monitoring. Here, the precision in the depth of needle insertion that is provided by the ioCT can help reduce the probability of occurrence of these side effects.

### Specific perioperative considerations

Pre-operative acquisition of MRI CISS and contrast-enhanced sequences is needed to distinguish primary from secondary TGN. Thin-slice CT of the skull base may be helpful to rule out anatomical variants and developmental defects of the skull base foramina. As we repeatedly experienced, short periods of bradycardia and even asystolia from trigemino-cardiac reflex,

the anesthetist has to be aware of cardiac complications [5]. Pre-operative application of parasympatholytic drugs should be considered.

## Specific information to give to the patient about surgery and potential risks

Access to the target area and ablation of the affected portion of the trigeminal nerve is only guided by anatomical landmarks as reflected by imaging and navigation. Motor stimulation with monitoring of the masseter muscle and CSF flow are only indirect signs of access to the trigeminal cistern. Therefore, there remains at least some risk to not successfully lesion the affected portion of the trigeminal nerve or much more important to lesion healthy trigeminal nerve divisions.

**Acknowledgements** We would like to thank our patients for providing their anonymous data, and the press and information center of the medical service of the German Armed Forces for the photo documentation of the operative procedure.

## Compliance with ethical standards

**Conflict of interest** The authors declare that they have no conflict of interest.

**Informed consent** Informed consent was obtained from all patients whose treatment data were included in the paper or from their legal representatives

## Key points

1. Pre-operative MRI CISS and contrast-enhanced sequences are needed to decide on the pathogenesis of TGN and the preferred surgical procedure.
2. Thin-slice CT of the skull base may be helpful to study the anatomy of the foramina at the skull base of the middle cerebral fossa.
3. An intraoperative CT-scan is acquired for intraoperative neuronavigation and 3D modeling.
4. Härtel's anatomical landmarks are used for plausibility control.
5. The distance of the electrode tip to the floor of the sella and the calvarial line in the lateral X-ray projections (CT scout image) is used to determine the puncture of the correct portion of the trigeminal nerve.
6. The needle position is verified by another intraoperative CT scan.
7. Intraoperative neuromonitoring of the masseter muscle and trigeminal nerve SEPs allows additional quality control.
8. The patient is kept under general anesthesia during the entire procedure.
9. The puncture of adjacent foramina of the skull base and asystolia due to the trigemino-cardiac reflex are severe complications of the procedure.
10. Pre-operative application of parasympatholytic drugs should be considered to avoid cardiac complications.

## References

1. Cheng JS, Lim DA, Chang EF, Barbaro NM (2014) A review of percutaneous treatments for trigeminal neuralgia: operative. *Neurosurgery* 10(1):25–33
2. Härtel F (1912) Intrakranielle Leitungsanästhesie des Ganglion Gasseri. *Zentralbl Chir*
3. Joo W, Yoshioka F, Funaki T, Mizokami K, Rhoton AL (2014) Microsurgical anatomy of the trigeminal nerve: microsurgical anatomy of the trigeminal nerve. *Clin Anat* 27(1):61–88
4. Kanpolat Y, Savas A, Bekar A, Berk C (2001) Percutaneous controlled radiofrequency trigeminal rhizotomy for the treatment of idiopathic trigeminal neuralgia: 25-year experience with 1,600 patients. *Neurosurgery* 48(3):524–532 discussion 532–534
5. Leon-Ariza DS, Leon-Ariza JS, Nangiana J, Vargas Grau G, Leon-Sarmiento FE, Quiñones-Hinojosa A (2018) Evidences in neurological surgery and a cutting edge classification of the Trigemino-cardiac reflex: a systematic review. *World Neurosurgery* 117:4–10
6. Schünke M, Schulte E, Schumacher U, Voll M, Wesker K, Schünke M (2018) Kopf, Hals und Neuroanatomie: 1801 Illustrationen, 123 Tabellen, 5., vollständig überarbeitete Auflage. Georg Thieme Verlag, Stuttgart New York
7. Zhao Y-X, Miao S-H, Tang Y-Z, He L-L, Yang L-Q, Ma Y, Ni J-X (2017) Trigeminal somatosensory-evoked potential: a neurophysiological tool to monitor the extent of lesion of ganglion radiofrequency thermocoagulation in idiopathic trigeminal neuralgia: a case-control study. *Medicine (Baltimore)* 96(3):e5872

**Publisher's note** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.