Percutaneous Trigeminal Nerve Radiofrequency Rhizotomy Guided by Computerized Tomography with Three-dimensional Image Reconstruction

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Background: Percutaneous radiofrequency trigeminal rhizotomy offers high rates of complete pain relief for classic idiopathic trigeminal neuralgia. When performed under fluoroscopy, it may cause anxiety for an inexperienced neurosurgeon owing to lack of familiarity with the regional anatomy, lack of reliable landmarks on fluoroscopy, and perceived risks associated with inadvertent puncture of neurovascular structures near the foramen ovale. The purpose of this study is to describe a new procedure to maximize patient security and shorten operative time.

Methods: From January 2006 to May 2009, 79 patients with trigeminal neuralgia underwent computerized tomography (CT)-guided percutaneous radiofrequency trigeminal rhizotomy under local anesthesia at Chang Gung Memorial Hospital. These patients included 22 men and 57 women, whose ages ranged from 36 to 88 years. The authors analyzed the use of CT with three-dimensional image reconstruction for the guidance of rhizotomy needle placement to determine possible difficulties during surgery and to predict the outcome of surgery.

Results: The surgical outcome of CT-guided trigeminal rhizotomy was good in 63 (80%, 95% confidence interval [CI] 69.2-88.0%) of the 79 patients with more than 90% (95% CI 87.5-93.7%) pain relief. The outcomes did not differ from those of the fluoroscopy-guided procedures. However, the median time for adequate rhizotomy needle placement in the foramen ovale was reduced in the CT-guided compared with that in fluoroscopy-guided procedure (14 minutes and 40 minutes, respectively; $p < 0.001$) and the intra-operative discomfort of the patients was also decreased. There were no intra-operative failures.

Conclusion: For percutaneous trigeminal rhizotomy, three-dimensional image reconstruction provides for precise placement of the rhizotomy needle in a safe and timely manner, which improves patient comfort and shortens operative time.
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Key words: trigeminal neuralgia, radiofrequency trigeminal nerve rhizotomy, computerized tomography, percutaneous

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Trigeminal neuralgia is a common syndrome that manifests as facial pain. Its epidemiology has not been well described in the Asian population; however, it is presumed to share many clinical similarities with that in Caucasian patients with perhaps greater involvement of the mandibular branch than the maxillary branch of the trigeminal nerve.[1] After excluding secondary trigeminal neuralgia caused by multiple sclerosis and intracranial mass lesions, the condition is diagnosed by clinical presentation.[2]

Various anticonvulsants, either alone or in combination, remain the first choice in the medical treatment of trigeminal neuralgia.[3] Microvascular decompression or minimally invasive percutaneous lesioning of the trigeminal nerve, such as radiofrequency rhizotomy, glycerol rhizolysis, and balloon compression, are reserved for patients refractory to medication.[4,5] Among the percutaneous techniques, radiofrequency rhizotomy offers the highest rates of complete pain relief.[6,7] It is generally advised for elderly patients unfit for surgical microvascular decompression and for patients refractory to conservative treatment.

Percutaneous radiofrequency rhizotomy is a treatment modality not yet popularized owing to the perceived risk associated with fluoroscopy-guided puncture by neurosurgeons. In this study, we advocate the routine use of computerized tomography (CT) with the acquisition of a reconstructed three-dimensional image for the localization of the foramen ovale to refine the fluoroscopy-guided Hartel's procedure.[8]

METHODS

From January 2006 to May 2009, 79 patients with trigeminal neuralgia underwent CT-guided percutaneous radiofrequency trigeminal rhizotomy as an outpatient procedure at our hospital. A visual analogue scale (VAS), consisting of a 10 cm line with the two endpoints labeled as "no pain" and "most intense pain imaginable", was used to assess pain intensity. All of the patients had medical failure with carbamazepine and baclofen for at least 3 months and rated their pain as 9/10 or 10/10 on the VAS.

A light analgesic, ketorolac (30 mg, IV), was administered to the patient. Following Hartel's procedure, the rhizotomy needle (straight cannula, 10 cm x 5 mm, 22 gauge, Tyco Healthcare Group LP, Mass, U.S.A.) was inserted 2.5 cm lateral to the oral commissure, advanced in the direction of the medial aspect of the pupil, and then set smoothly around the foramen ovale without patient discomfort. Screening brain CT (Light Speed Plus, GE Medical Systems, WI, U.S.A.) was performed to exclude intracranial lesions. Treatment was aborted if organic lesions in the posterior fossa were found to be the cause of the neuralgia.

The rhizotomy needle was advanced under CT guidance (Fig. 1), and its appropriate position was confirmed by three-dimensional image reconstruction using 1.25-mm-thick slices (Advantage Workstation 4.0, GE Medical Systems, WI, U.S.A.) (Fig. 2). The correct localization and subsequent

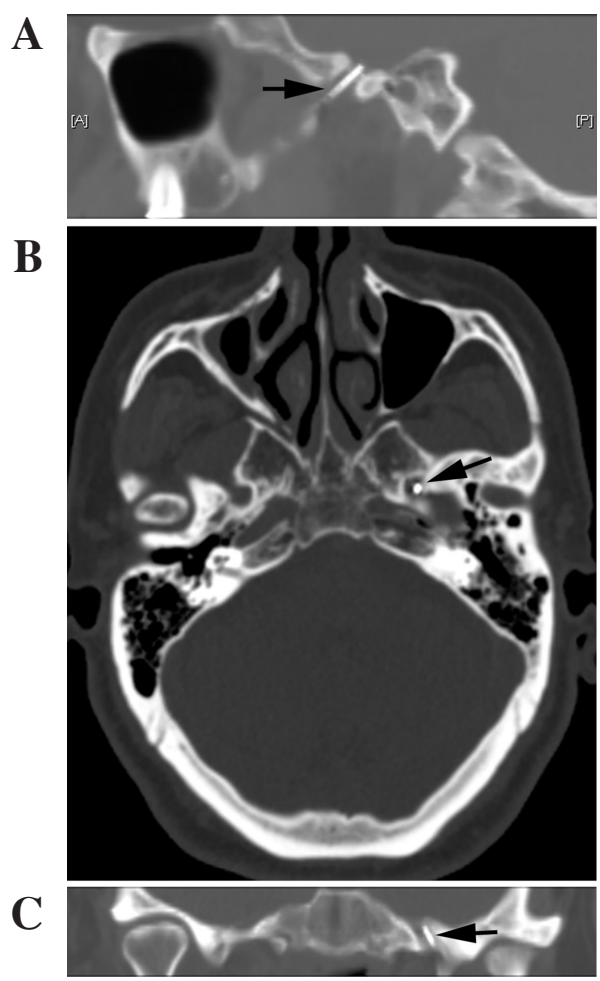

Fig. 1 Computerized tomography scans show the rhizotomy needle (arrow) well placed within the left foramen ovale in (A) sagittal, (B) axial, and (C) coronal views.

Fig. 2 Reconstructed three-dimensional image shows the rhizotomy needle (arrow) in the left foramen ovale.

lesioning depended on the reproduction of paresthesia upon stimulation, covering the distribution of a specific division of the trigeminal nerve. The lesion at the Gasserian ganglion was made by radiofrequency thermocoagulation (Radionics, Inc. Burlington, MA, U.S.A.) at 60°C for 60 seconds under propofol sedation without intubation.

A single operating neurosurgeon performed the CT-guided percutaneous trigeminal nerve radiofrequency rhizotomy for all 79 cases. The operative time was compared with that in 69 cases with fluoroscopic guidance from 2002 to 2005 in the same hospital. The different operative times between the two groups were compared with the two-sample Wilcoxon Rank-sum test because of non-normal distribution. All statistical analyses were performed with STATA statistical software (version 11.0, Stata Corp, College Station, TX, U.S.A.). A probability value of less than 0.05 was considered significant.

RESULTS

The time for adequate rhizotomy needle placement in the foramen ovale, obtained with the aid of CT with three-dimensional image reconstruction, ranged from 4 to 38 minutes (median: 14, interquartile range [IQR]: 10-18 minutes) which was shorter than that in the fluoroscopy-guided procedure (median: 40, IQR: 25-55 minutes) ($p < 0.001$) (Fig. 3). The patients felt more comfortable because of the shorter operative time and decreased frequency of needle adjustment. All of the punctures of the foramen ovale were successful without technical failure. There was complete follow-up in all patients, ranging from 3 months to 3.6 years (19.33 $\pm$ 10.94 months). The results were good with pain relief of more than 90% (95% confidence interval [CI] 87.5-93.7%) (decrease in VAS score from 9-10/10 to 0-1/10) in sixty-three (approximately 80%) (95% CI 69.2-88.0%) of the 79 patients. The other 20% (95% CI 12.0-30.8%) experienced various degrees of pain relief, rated as 2/10 to 10/10 on the VAS. There was no operative mortality and fewer than 32% (95% CI 21.6-43.1%) of the patients had permanent adverse effect of mild facial numbness postoperatively.

DISCUSSION

Percutaneous trigeminal rhizotomy for the treatment of trigeminal neuralgia was first attempted by Hartel in 1914, and radiofrequency lesioning was introduced by Sweet in the early 1970s. Although the procedure has been an established treatment for trigeminal neuralgia for decades with successful pain relief in about 78% of patients,[9] the importance of accurate placement of the rhizotomy needle cannot be overemphasized. Around the foramen ovale, the foramen lacerum (posteriorly), inferior orbital fissure (superiorly), carotid artery (medially), and jugular

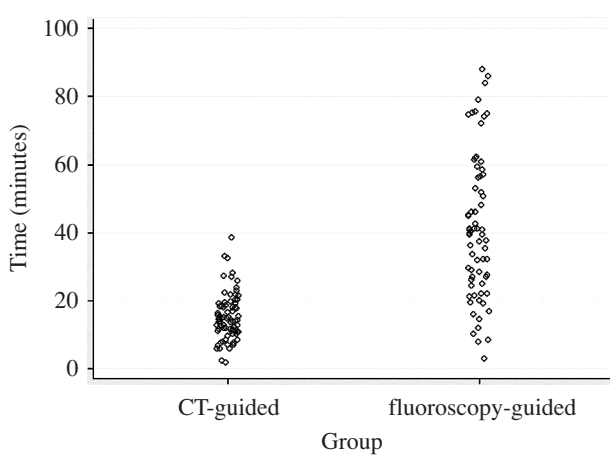

Fig. 3 The scattered dot graph shows the duration (in minutes) of CT-guided and fluoroscopy-guided rhizotomy needle placement in the foramen ovale. $p < 0.001$ between groups.

foramen may be punctured accidentally, leading to catastrophic neural and vascular sequelae.[10] Even with a clean puncture into the foramen ovale, insertion of the rhizotomy needle farther than planned can result in complications such as carotid-cavernous fistula, cranial nerve pareses, cerebrospinal fluid fistula, and intracranial hemorrhage.[11] Since then, various descriptions have been made to improve visualization under fluoroscopy and skin landmarks have been devised to facilitate the localization of the foramen ovale.[12] However, these can be confusing for an inexperienced surgeon and at times, the foramen ovale cannot be observed with confidence under a fluoroscope. Intraoperative failure rates have been reported to be as high as 4%.[13]

Percutaneous puncture of the foramen ovale has evolved from fluoroscopic guidance to the use of CT, and more recently, the employment of various neuronavigation systems, in an attempt to maximize the outcome and minimize morbidity and mortality from inadvertent puncture of vital structures around the foramen ovale.[14-16] The addition of three-dimensional imaging reconstruction has produced effective and safe results.[13,17,18] In our procedure, the relationship of the rhizotomy needle within the foramen ovale is better appreciated on three-dimensional images than on the traditionally obtained coronal and sagittal scans. It assists the operating surgeon in building a clear mental picture of where to direct the rhizotomy needle and it confers confidence and hastens the maturation of this commonly feared procedure.

In summary, three-dimensional image reconstruction for treatment of trigeminal neuralgia allows precise placement of the rhizotomy needle in a timely manner, which not only improves the surgeon's skill, but also makes the patient more comfortable by shortening the operative time.

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3D 電腦斷層影像重組導引經皮三叉神經根射頻切斷術

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背 景： 經由表皮三叉神經根射頻切斷術可提供典型三叉神經痛的高治癒率。然而，對此技術較無經驗的神經外科醫師，常在施行傳統 X 光透視定位射頻針時，由於對於此處解剖位置的不熟悉，因而擔心傷及鄰近卵圓孔的正常神經血管結構。此研究之目的在於提出新的手術方式以增加病人手術安全性及縮短手術時間。

方 法： 從 2006 年 1 月至 2009 年 5 月，共 79 位三叉神經痛病患於局部麻醉下，在嘉義長庚紀念醫院接受 3D 電腦斷層影像重組導引經由表皮三叉神經根射頻切斷術。這些病患包括 22 位男性及 57 位女性，年紀從 36 至 88 歲。本文作者分析使用 3D 電腦斷層重組技術去置放射頻針之可能困難及其手術預後。

結 果： 3D 電腦斷層影像重組導引三叉神經根射頻切斷術在 79 位病人中有 63 位病人可得到 90% (95% 信賴區間爲 87.5-93.7%) 以上的三叉神經痛症狀解除，此和傳統 X 光透視定位技術之治療結果相似。然而，置放射頻針至卵圓孔的中位手術時間可從 40 分鐘減少至 14 分鐘，病人在手術中的不舒服亦可減少，且無手術中定位失敗之情形。

結 論： 治療三叉神經痛，使用 3D 電腦斷層影像重組導引射頻針之方法，可提供手術的安全性，改善病人手術中的舒適度，及縮短手術時間。

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關鍵詞：三叉神經痛，三叉神經根射頻切斷術，電腦斷層，經皮術

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