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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

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Abstract

To reflect the extent of thermolesion of ganglion by testing the change of trigeminal somatosensory-evoked potential (TSEP) before and after ganglion radiofrequency thermocoagulation surgery (GRT), and evaluate long-term clinic effect by follow-up visiting of 1 year.

Patients with idiopathic trigeminal neuralgia (TN) in the second division were enrolled between October 2014 and October 2015. They were treated with computed tomography-guided GRT and a follow-up visiting of 1 year. Bilateral TSEP measurements were performed 1 day before and 2 days after the GRT surgery. The latency and peak-to-peak amplitude of W2 and W3 were recorded.

Immediate postprocedure pain relief (grades I–III) was 100% and 92.5% 1 year later. Facial numbness rate of grades III and IV was 70%, 40%, and 12.5%, respectively, at immediate, 2 days, and 1 year after GRT. No sever complications happened. The latency of W2 and W3 of patients who had no pain no numbness after 1 year of GRT was 1.74 ± 0.24 and 3.84 ± 0.66 ms, respectively, of TN side, and 1.71 ± 0.39 and 3.63 ± 0.85 ms of the healthy side before GRT. The amplitude of W2 and W3 was 1.13 ± 0.50 and 1.99 ± 1.09 uv, respectively, of TN side and 1.24 ± 0.40 and 1.89 ± 0.81 uv of the healthy side before GRT. There was no statistical difference of the latency and amplitude between 2 sides of W2 and W3 before surgery ($P > 0.05$). The latency of W2 and W3 delayed and the amplitude reduced especially in TN side after surgery comparing before ($P < 0.001$). And, comparisons of the latency and amplitude of W2 and W3 between TN side and the healthy side after surgery showed the latency of W2 and W3 delayed (W2: $P = 0.02$; W3: $P = 0.01$) and the amplitude of W2 reduced ($P = 0.003$), but the amplitude of W3 had no statistical difference ($P = 0.22$). The mean delayed latency and 95% confident interval of W2 and W3 were 0.22 ± 0.35 (0.1–0.34) ms and 0.35 ± 0.64 (0.14–0.57) ms, respectively. The mean decreased amplitude and 95% confident interval of W2 and W3 were 22 ± 24 (14–30)% and 23 ± 32 (12–34)%, respectively.

GRT can make the latency delay and the amplitude decrease of TSEP. And the latency and amplitude of W2 and W3 can be considered reliable and safe reference for monitoring the extent of thermolesion.

Abbreviations: CT = computed tomography, FO = foramen ovale, GRT = ganglion radiofrequency thermocoagulation surgery, TN = trigeminal neuralgia, TSEP = trigeminal somatosensory-evoked potential.

Keywords: ganglion radiofrequency thermocoagulation, trigeminal neuralgia, trigeminal somatosensory-evoked potential

1. Introduction

Ganglion radiofrequency thermocoagulation (GRT) is a safe training way of trigeminal neuralgia (TN), it has become an important method because of its better location technique by X-ray,[1] computed tomography (CT),[2–5] and electrophysiology[5,6] in recent years. But how to monitor the extent of the lesion is still a problem. Pain may recur if thermolesion is not enough and numbness may be obvious if thermolesion is excessive. Leandri and Gottlieb[7] tried to use trigeminal somatosensory-evoked potential (TSEP) to monitor the extent of the lesion. However, the study locked of follow-up visiting results, so the effect of such monitoring method is unknown. It is just the purpose of this study. Measure extent of thermolesion of ganglion by testing the change of TSEP before and after GRT, and evaluate the long-term clinic effect by follow-up visiting of 1 year.

2. Materials and methods

2.1. Patients

The study was approved by the institutional research ethics committee. Patients with idiopathic TN in the second division

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were enrolled between October 2014 and October 2015. They would accept CT-guided GRT for the first time and a follow-up visiting by telephone interviews. If neither the GRT operation nor telephone interview of patient was successful, the patients were excluded. Patients would be given electrophysiological tests of TSEP before and postoperation. If the shape of TSEP was abnormal before operation, patients were excluded, too. All of informed consent was obtained.

2.2. GRT procedures

The patient was placed in a supine position with their shoulders setted with thin pillow. The puncture of Gasserian ganglion was according to Hartel anterior route. The puncture location at the foramen ovale (FO) was determined by CT scan. After sterilization, the route of puncture was given local anesthesia with 1% lidocaine. Then a 22-g radiofrequency needle with a 5-mm working zone (straight; Cosman, Burling-ton, MA) was inserted through the marked skin point to the FO according to the CT guidance. Repeated CT scan was needed to reconfirm the position of the needle tip after piercing needle into the FO. Motor (2 Hz, 1 ms) and sensory (50 Hz, 0.1 ms) stimulation were used to readjust the needle to make sure that the tip was just lied in the responsibility region. A proper needle position was that the stimulation voltage value was of <0.5 V when patient had apparent paresthesia of the corresponding trigeminal branches. Following certifying the proper location, patient was administered intravenous anesthesia with propofol (1–2 mg/kg) and ventilated by facemask oxygen. No tracheal intubation was performed. Radiofrequency thermocoagulation of ganglion corresponding of the second trigeminal branches was 75°C, 120 s twice. Complications and intensity of pain and facial numbness were recorded at once, 2 days, 1 year after GRT surgery. The pain intensity was evaluated by Barrow score,[8] a newly ordinal I–V scoring scale for TN (I: no pain, II: occasional pain, nonrequiring medication, III: some pain, controlled with medication, IV: some pain, not controlled with medication, and V: severe pain/no pain relief). Facial numbness was classified as follows: I, no obvious facial numbness (nor impair daily life); II, mildfacial numbness (impair daily life occasionally); III, moderate facial numbness (impair daily life frequently); and IV, painful dysesthesia (impair daily life severely).[9]

2.3. Technique for scalp recording of TSEP

A multichannel electromyography/evoked potentials machine (Natus: Medelec Synergy; Natus Neurology Incorporated; Middleton, WI, USA) was used for neurophysiological monitoring. Bilateral TSEP measurements were performed in neurophysiological room by special person 1 day before and 2 days after the GRT surgery. The patient lied in bed with 5% lidocaine cream wiping spread the skin of the infraorbital foramen before a pair of needle electrodes (each with a diameter of 0.3 mm and length of 25 mm, 1 mm apart from each other) pricked into it. The pair of needle electrodes was used as stimulus electrodes. The ground electrode was attached to the contralateral mastoid process. The exploring recording electrode was positioned on the vertex and the reference over the spinous process of C-7. All of these electrodes were taken of discoid electrodes. The stimulating intensity was 3 to 4 times of the sensory threshold of each subject. The recording conditions included a band-pass filter at 5 Hz to 3 kHz, frequency of stimulation at 2 Hz, and duration of stimulation at 0.2 ms. Recordings of 300 trials were averaged. To examine reliability, each measurement was performed 3 times. The latency and peak-to-peak amplitude of W2 and W3 were recorded.

Table 1

Clinical outcome of GRT (n = 40).

	Number of pain recurred (grades IV and V), n (%)	Number of facial numbness (grades III and IV), n (%)
Immediate	0 (0)	28 (70)
2 d	0 (0)	16 (40)
1 y	3 (7.5)	5 (12.5)

GRT = ganglion radiofrequency thermocoagulation.

2.4. Data analysis

Data were shown as mean ± standard deviation. Student *t* test for paired samples was used for patients who had no pain no numbness (pain intensity grades I–III, facial numbness grades I and II) after 1 year of GRT. A *P* value of 0.05 was considered significant; 95% confident interval of the mean delayed latency and mean decreased amplitude (W2 and W3) were calculated. Statistical analysis was performed using the Statistical Package for the Social Sciences version 16.0 (SPSS, Chicago, IL).

3. Results

This study included 25 female and 15 male patients. All operation and follow-up visiting had gone well. But 3 patients were excluded because of abnormal shape of TSEP before surgery. Maybe their face were convulsed with hypertension when stimulation. The mean age of included patients was 62 ± 12.46 years, and the course of disease extended from 0.5 to 20 years, averaged 4.88 ± 4.26.

3.1. Clinical outcome

In this study, immediate postprocedure pain relief (grades I–III) were 100% and 92.5% 1 year later. Facial numbness rate of grades III and IV was 70%, 40%, 12.5% at immediate, 2 days, and 1 year after GRT (Table 1).

3.2. Results of TSEP

Stable TSEP could be recorded by the above-mentioned electrophysiologic method (Figs. 1 and 2). The latency of W2 and W3 of patients who had no pain no numbness after 1 year of GRT was 1.74 ± 0.24 and 3.84 ± 0.66 ms, respectively, of TN side, and 1.71 ± 0.39 and 3.63 ± 0.85 ms, respectively, of the healthy side before GRT; the amplitude was 1.13 ± 0.50 and 1.99 ± 1.09 uv, respectively, of TN side, and 1.24 ± 0.40 and 1.89 ± 0.81 uv, respectively, of the healthy side before GRT. There was no statistical difference of the latency and amplitude between 2 sides of W2 and W3 before surgery ($P > 0.05$, Fig. 1). The latency of W2 and W3 delayed and the amplitude reduced especially in TN side after surgery comparing before ($P < 0.001$). And, comparisons of the latency and amplitude of W2 and W3 between TN side and the healthy side after surgery showed the latency of W2 and W3 delayed (W2: $P = 0.02$; W3: $P = 0.01$) and the amplitude of W2 reduced ($P = 0.003$), but the amplitude of W3 had no statistical difference ($P = 0.22$) (Tables 2 and 3; Fig. 2). The mean delayed latency and 95% confident interval of

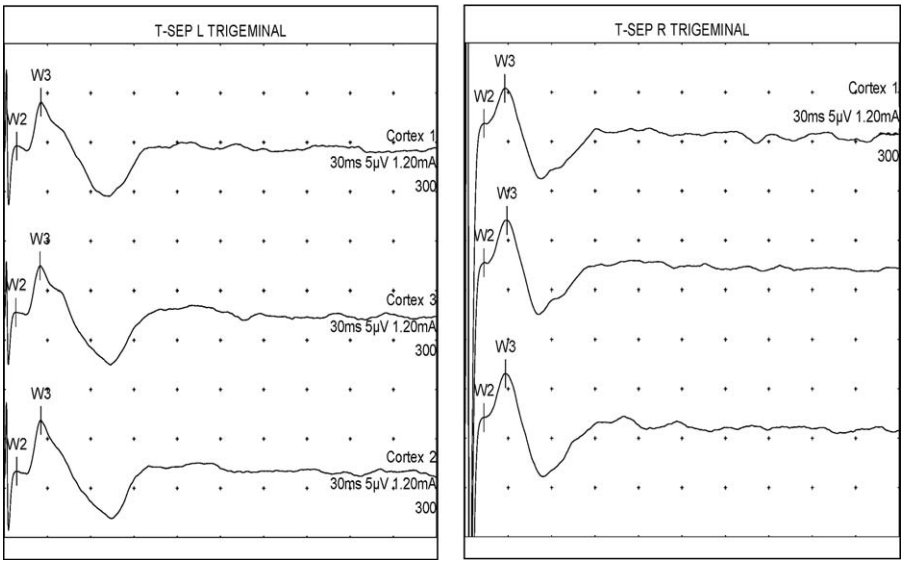

Figure 1. Bilateral trigeminal somatosensory-evoked potential before ganglion radiofrequency thermocoagulation. There is no difference of the latency and amplitude between trigeminal neuralgia side (right) and the healthy side (left) of W2 and W3 before surgery.

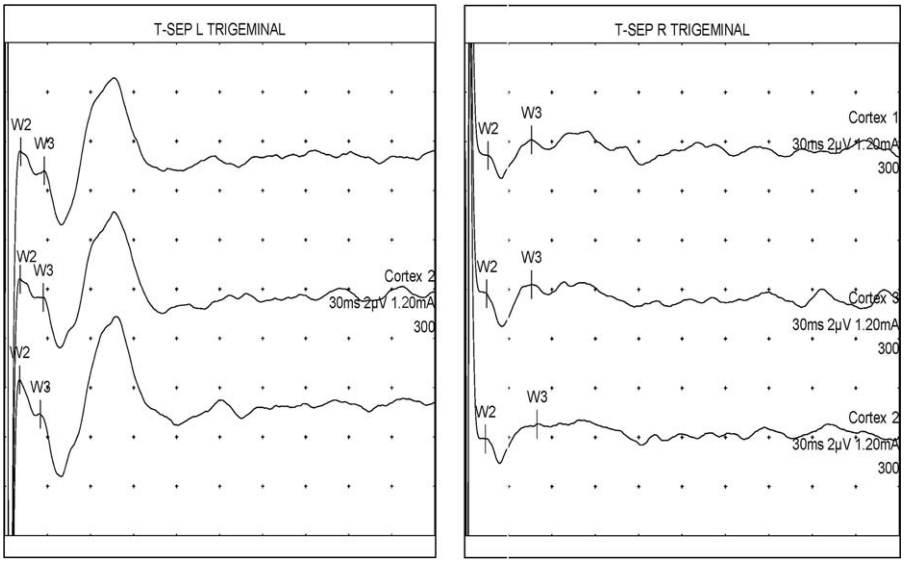

Figure 2. Bilateral trigeminal somatosensory-evoked potential after ganglion radiofrequency thermocoagulation. The amplitude reduce in W2 and W3 and the latency increase slightly (right).

W2 and W3 were 0.22±0.35 (0.1–0.34) and 0.35±0.64 (0.14–0.57) ms. The mean decreased amplitude and 95% confident interval of W2 and W3 were 22±24 (14–30)% and 23±32 (12–34)% (Table 4).

4. Discussion

Pain may recur if thermolesion is not enough and numbness may be obvious if thermolesion is excessive. So it is very important for

Table 2

Latency of bilateral TSEP before and after GRT (n=32).

	TN side (mean±SD), ms		Healthy side (mean±SD), ms	
	W2	W3	W2	W3
Before	1.74±0.24	3.84±0.66	1.71±0.39	3.63±0.85
After	1.93±0.40*	4.20±0.76*	1.70±0.46†	3.79±0.79†

GRT=ganglion radiofrequency thermocoagulation, SD = standard deviation, TN=trigeminal neuralgia, TSEP=trigeminal somatosensory-evoked potential.

* Comparisons between the effects before and after GRT in TN side, $P<0.001$.

† Comparisons between TN side and the healthy side after surgery, $P<0.05$.

Table 3

Amplitude of bilateral TSEP before and after GRT (n = 32).

	TN side (mean ± SD), uv		Healthy side (mean ± SD), uv	
	W2	W3	W2	W3
Before	1.13 ± 0.50	1.99 ± 1.09	1.24 ± 0.40	1.89 ± 0.81
After	0.86 ± 0.42*	1.54 ± 1.07*	1.33 ± 0.72†	1.76 ± 0.79

GRT = ganglion radiofrequency thermocoagulation, SD = standard deviation, TN = trigeminal neuralgia, TSEP = trigeminal somatosensory-evoked potential.
* Comparisons between the effects before and after GRT in TN side, $P < 0.001$.
† Comparisons between TN side and the healthy side after surgery, $P < 0.01$.

Table 4

Change of latency and amplitude of W2 and W3 before and after GRT (n = 32).

	W2	W3	W2 (95% CI)	W3 (95% CI)
Δ Latency, ms	0.22 ± 0.35	0.35 ± 0.64	0.10–0.34	0.14–0.57
Δ Amplitude, %	22 ± 24	23 ± 32	14–30	12–34

95% CI = 95% confident interval, GRT = ganglion radiofrequency thermocoagulation.

quantitating the extent of lesion. Neural electrophysiology is used to solve the problem. The measurement of TSEP is highly objective and reliable; it has been used as an established technique in neurologic diagnostics for decades. For example, in the surgery of rapid palatal expansion,[10] sagittal split ramus osteotomy,[11]and bilateral sagittal split osteotomy,[12,13] it has been used frequently to judge the injury of the trigeminal nerve. Leandri and Gottlieb[7] tried to use TSEP to monitor the extent of lesion. The effect of lesion was monitored via the variation of W2 that was one of the very early components. The limited popularity of this method was the need for specific expertise and equipment, and the technique was expensive, time-consuming.[14] In this study, we took of needle electrode. Because stimulation of needle electrode is more precise and reliable than surface electrode but rather invasive. We used 5% lidocaine cream to wipe spread the skin of the infraorbital foramen before puncturing. Patients were uncomfortable during the whole monitoring procedure. With the above-mentioned electrophysiologic set-up, we obtained reproducible stable waves of W2 and W3. Because of stimulus artifact in some patients, we could not get stable W1.

We choose the subjects who experienced pain in the second trigeminal branch (V2) for several reasons. First, patients with TN in V2 are more. Second, the puncture of V2 is safer and easier, and the clinical effect is satisfied. Third, the monitoring effect of TSEP of this branch is best, and possible changes are most easily detected.

The 2 important aspects of GRT are the correct position of the needle and the appropriate thermocoagulation. Using CT guidance with sensory (50 Hz) and motor (2 Hz) test stimulation to locate trigeminal branches in ganglion is effective.[2,9–15] GRT is quite easy and safe, especially applied in elderly patients who are considered as poor surgical risks.[9–16] In this study, immediate postprocedure pain relief was 100% and 92.5% 1 year later. Our outcome is better than the previous reports. One possible explanation is that we used CT, rather than X-ray fluoroscopic, which enable the cannula through the FO to the Gasserian ganglion exact.[2–16] Another reason is that our patients suffered from idiopathic TN in the second division. According to a cohort study of long-term effective rate of different branches of idiopathic TN after radiofrequency thermocoagulation, V2 division obtained the best pain relief rate: 91%, 89%, 80%, 72%, 60%, and 54% at 1, 3, 5, 7, 9, and 11 years, respectively.[17] In addition, the grades I–III of pain intensity was thought of pain relief.

The drawbacks of GRT are different degrees of facial numbness in most of patients and recurred pain at follow-up time. In this study, facial numbness rate of grades III and IV was 70%, 40%, and 12.5% at immediate, 2 days, and 1 year after GRT, although we had used a low temperature of 75°C of radiofrequency.[18]And their patients (7.5%) recurred TN in primary area.

There was no statistical difference of the latency and amplitude between 2 sides of W2 and W3 before surgery ($P > 0.05$). But after surgery, the latency of W2 and W3 delayed (W2: $P = 0.02$; W3: $P = 0.01$) and the amplitude of W2 reduced ($P = 0.003$) in TN side, the amplitude of W3 had no statistical difference ($P = 0.22$). We also compared the latency and amplitude of W2 and W3 in TN side before and after surgery, the latency of W2 and W3 delayed and the amplitude reduced after surgery ($P < 0.001$). The results indicated that trigeminal nerve conduction way of ganglion was destroyed by radiofrequency thermocoagulation partly, and such alteration could be monitored by TSEP. It may be concluded that the latency and amplitude of W2 and W3 can be considered reliable and safe reference for monitoring the effect of thermolesion. Leandri and Gottlieb[7] reported in their paper that thermolesions were made until W2 decreased its amplitude by 20% to 50% of the original value or until it was delayed by 0.30 ms. But there were not follow-up visiting results, so the effect of such thermolesions standards is not known. In this study, the clinical effect of GRT was followed-up about 1 year, 7.5% patients recurred of TN in situ (grades IV and V), and 12.5% patients had severe facial numbness (grades III and IV). Nobody suffered both pain and facial numbness. We tested the mean delayed latency and 95% confident interval of W2 and W3 were 0.22 ± 0.35 (0.1–0.34) and 0.35 ± 0.64 (0.14–0.57) ms. The mean decreased amplitude and 95% confident interval of W2 and W3 were 22 ± 24 (14–30)% and 23 ± 32(12–34)%.

Further study should increase the sample to statistics the difference of TSEP between pain recurred and cured patients, and between patients with facial numbness and no numbness. Then a standard reference ranges may be given.

5. Conclusion

It may be concluded that the latency and amplitude of W2 and W3 can be considered reliable and safe reference for monitoring the effect of thermolesion.

References

[1] Kanpolat Y, Savas A, Bekar A, et al. Percutaneous controlled radiofrequency trigeminal rhizotomy for the treatment of idiopathic trigeminal neuralgia: 25-year experience with 1,600 patients. Neurosurgery 2001;48:524–32.

[2] Huang B, Yao M, Feng Z, et al. CT-guided percutaneous infrazygomatic radiofrequency neurolysis through foramen rotundum to treat V2 trigeminal neuralgia. Pain Med 2014;14:18–28.

[3] Guo Z, Wu B, Du C, et al. Stereotactic approach combined with 3D CT reconstruction for difficult-to-access foramen ovale on radiofrequency thermocoagulation of the Gasserian ganglion for trigeminal neuralgia. Pain Med 2016;17:1704–16.

[4] Xue T, Yang W, Guo Y, et al. 3D image-guided percutaneous radiofrequency thermocoagulation of the maxillary branch of the trigeminal nerve through foramen rotundum for the treatment of trigeminal neuralgia. Medicine (Baltimore) 2015;94:e1954.

[5] Li X, Yue J, Yang L, et al. Application of antidromic conduction monitoring in ganglion radiofrequency thermocoagulation for locating trigeminal branches in trigeminal neuralgia. Pain Pract 2015;16:305–10.

[6] Lin B, Lu X, Zhai X, et al. Use of sensory and motor action potentials to identify the position of trigeminal nerve divisions for radiofrequency thermocoagulation. J Neurosurg 2014;121:1497–503.

[7] Leandri M, Gottlieb A. Trigeminal evoked potential-monitored thermorhizotomy: a novel approach for relief of trigeminal pain. J Neurosurg 1996;84:929–39.

[8] Rogers CL, Shetter AG, Fiedler JA, et al. Gamma knife radiosurgery for trigeminal neuralgia: the initial experience of the Barrow Neurological Institute. Int J Radiat Oncol Biol Phys 2000;47:1013–9.

[9] Tang YZ, Jin D, Bian JJ, et al. Long-term outcome of computed tomography-guided percutaneous radiofrequency thermocoagulation for classic trigeminal neuralgia patients older than 70 years. J Craniofac Surg 2014;25:1292–5.

[10] Li Q, Wang W, Gu S, et al. Measurement of somatosensory-evoked potential to evaluate function of the trigeminal nerve after rapid palatal expansion treatment in a rabbit model. Oral Surg Oral Med Oral Pathol Oral Radiol 2012;114:S54–9.

[11] Takazakura D, Ueki K, Nakagawa K, et al. A comparison of postoperative hypoesthesia between two types of sagittal split ramus osteotomy and intraoral vertical ramus osteotomy, using the trigeminal somatosensory-evoked potential method. Int J Oral Maxillofac Surg 2007;36:11–4.

[12] Nakagawa K, Ueki K, Takatsuka S, et al. Somatosensory-evoked potential to evaluate the trigeminal nerve after sagittal split osteotomy. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2001;91:146–52.

[13] Nakagawa K, Ueki K, Takatsuka S, et al. Trigeminal nerve hypesthesia after sagittal split osteotomy in setback cases: correlation of postoperative computed tomography and long term trigeminal somatosensory evoked potentials. J Oral Maxillofac Surg 2003;61:898–903.

[14] Leandri M. The neurophysiologist, the neurosurgeon and the trigeminal thermorhizotomy. Br J Neurosurg 2012;26:932.

[15] Tang YZ, Jin D, Li XY, et al. Repeated CT-guided percutaneous radiofrequency thermocoagulation for recurrent trigeminal neuralgia. Eur Neurol 2014;72:54–9.

[16] Obermann M. Treatment options in trigeminal neuralgia. Ther Adv Neurol Disord 2010;3:107–15.

[17] Tang YZ, Wu BS, Yang LQ, et al. The long-term effective rate of different branches of idiopathic trigeminal neuralgia after single radiofrequency thermocoagulation: a cohort study. Medicine (Baltimore) 2015;94:e1994.

[18] Tang YZ, Yang LQ, Yue JN, et al. The optimal radiofrequency temperature in radiofrequency thermocoagulation for idiopathic trigeminal neuralgia: a cohort study. Medicine (Baltimore) 2016;95:e4103.