Radiofrequency thermocoagulation for the treatment of trigeminal neuralgia

ZHENGMING WANG[1], ZHIJIA WANG[2], KAI LI[3], XU SU[1], CHAO DU[1] and YU TIAN[1]

Departments of [1]Neurosurgery, [2]Radiation and [3]Anesthesia, The Third Hospital of Jilin University and China-Japan Union Hospital, Changchun, Jilin 130033, P.R. China

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Abstract. Although microvascular decompression (MVD) should be considered as the first-line treatment for classic trigeminal neuralgia (TN) owing to neurovascular compression of the trigeminal nerve, an increasing number of surgeons prefer radiofrequency thermocoagulation (RFT). RFT is a Gasserian ganglion-level ablative intervention that may achieve immediate pain relief for TN. It is used for emergency management when MVD is not suitable for the patient. As the gold surgical standard of classic trigeminal neuralgia, MVD has the advantage of longer efficacy. However, there are currently no high-quality controlled trials to evaluate the efficacy of MVD and RFT. For the present systematic review, the PubMed, Embase and Cochrane databases (all entries up until July 31, 2020) were searched to identify studies related to RFT in order to provide valuable information for clinical decision-making. The efficacy of the RFT method was evaluated in terms of the initial pain relief percentage, recurrence rate and follow-up time. Furthermore, the incidence rate of various postoperative complications was retrieved. RFT was used for a wider range of applications than MVD, including use for primary (owing to neurovascular compression of the trigeminal nerve), idiopathic and secondary (due to primary neurological diseases) TN, and provided a high rate of initial pain relief and long-term pain control. Although this method has several side effects, the incidence of complications could be reduced by precise cannulation. Furthermore, the complications that occurred were not permanent. Thus, RFT is a safe and effective minimally invasive method of pain relief for patients with TN.

Correspondence to: Professor Yu Tian or Professor Chao Du, Department of Neurosurgery, The Third Hospital of Jilin University and China-Japan Union Hospital, 126 Xiantai Street, Changchun, Jilin 130033, P.R. China
E-mail: tianyu@jlu.edu.cn
E-mail: duchao0987@yahoo.com

Key words: trigeminal neuralgia, radiofrequency thermocoagulation, Gasserian ganglion, ablative interventions, complications, recurrence rate

Introduction

Trigeminal neuralgia (TN) is defined as severe, episodic pain distributed along one or more branches of the trigeminal nerve (1,2). Surgical intervention is performed if pharmacotherapy is unsuccessful, either due to intolerable side effects or poor pain control. Although pharmacotherapy is frequently the preferred treatment option, several patients prefer surgery as a first-line treatment due to its long-lasting effect (3).

Radiofrequency thermocoagulation (RFT) was initially developed by Réthi (4) in 1913, although it was not until 1975 that Sweet (5) demonstrated that it is able to provide effective pain relief. MVD is the first choice of surgical treatment in patients with classical trigeminal neuralgia, while RFT (ablation treatment) should be the preferred choice when an MRI does not show any vascular contact. RFT is also used as an alternative option when a patient is thought unable to tolerate MVD (6). In clinical practice, compared with the invasive technique of MVD, RFT is minimally invasive. RFT has advantages and limitations in terms of its efficacy and complications. Although its side effects may not be permanent, they cannot be entirely excluded. Repeated puncture may cause unnecessary damage, although precise cannulation may reduce the incidence of complications. Inaccurate positioning is the major reason for puncture failure and is considered a significant cause of pain recurrence and complications (7-12). Various techniques and applications, such as CT navigation through use of a 3D template or frameless stereotactic navigation, have been proposed for addressing these issues (13).

As the gold surgical standard treatment of classic trigeminal neuralgia, MVD has the advantage of longer efficacy. However, there are currently no high-quality controlled trials to evaluate the efficacy of MVD and RFT. Therefore, this article evaluates the efficacy and complications of RFT to provide a basis for clinicians to make informed choices.

Materials and methods

Search strategy. Previous publications written in English were searched using the PubMed, Embase and Cochrane databases. The search included studies that were published up to July 31, 2020. Publications were queried using the following key words, including synonyms and all of their possible combinations: 'Trigeminal neuralgia', 'Tic douloureux',

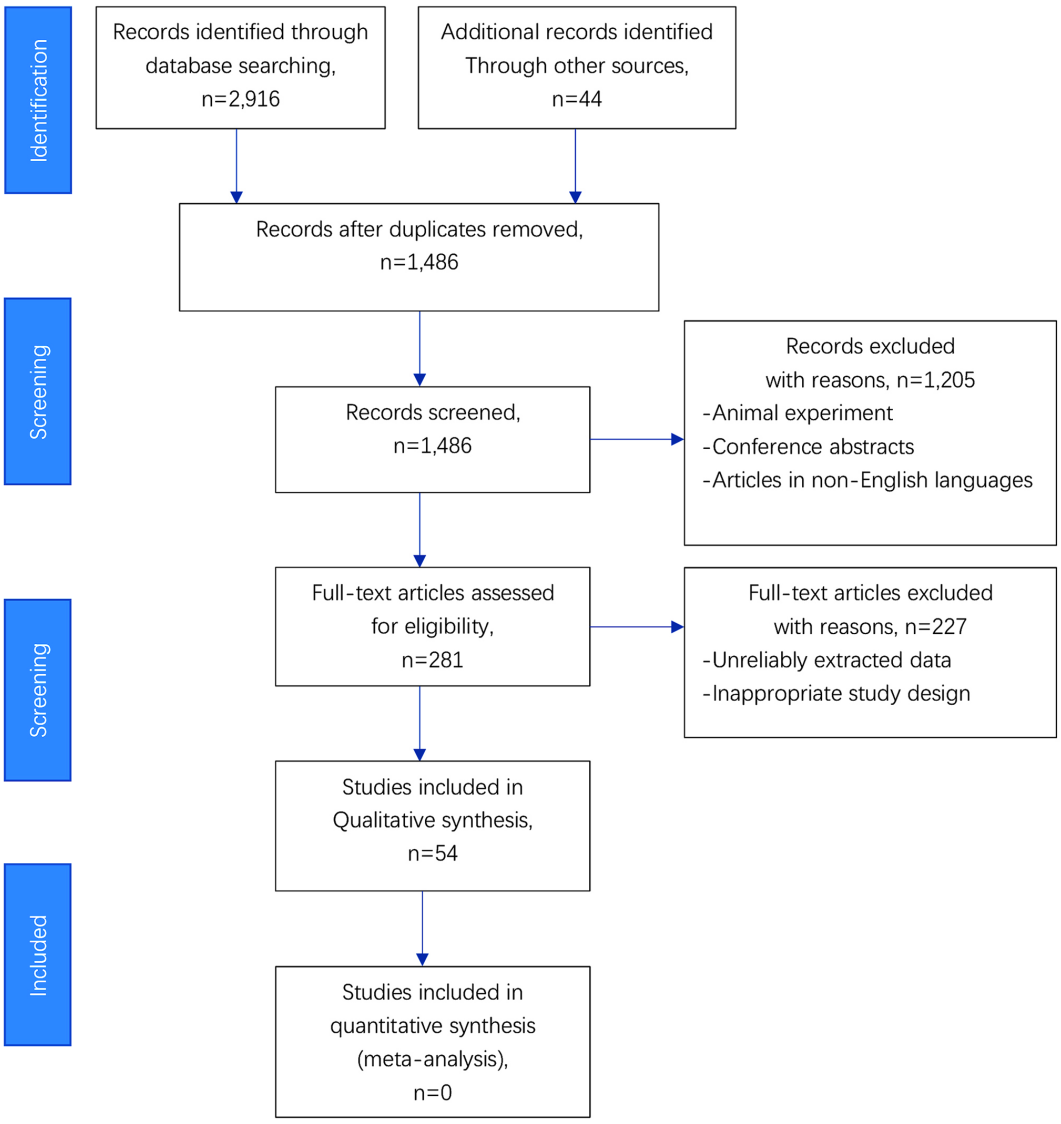

Figure 1. Flow chart depicting the process of study selection.

'trifacial neuralgia', 'radiofrequency thermocoagulation', 'radiofrequency therapy', 'percutaneous radiofrequency ablation', 'radiosurgery', 'radiofrequency ablation', 'radiofrequency thermal coagulation', 'radiofrequency thermal rhizotomy', 'thermocoagulation radiofrequency', 'radiofrequency trigeminal rhizotomy', 'percutaneous infrazygomatic radiofrequency neurolysis' and 'radiofrequency rhizotomy'. The search was limited to research articles involving human subjects. The reference lists of relevant articles were also retrieved and screened during the search. The present review was conducted following the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-analyses statement and the Cochrane Handbook for Systematic Reviews of Intervention (14), with the exception of protocol registration.

Inclusion and exclusion criteria. All types of studies performed on patients with classical TN undergoing RFT with or without a control group were included. Studies published in a language other than English and conference abstracts were excluded.

Study selection. In total, two authors (ZMW, ZJW) independently assessed titles and abstracts retrieved via database searches, as well as full texts of potentially relevant studies. Any discrepancies between authors were resolved by involvement of the third author (KL).

Data extraction process. In total, two authors (ZMW, ZJW) independently extracted the following information from each study: Name of the first author, year of publication, study design, comparator, inclusion and exclusion criteria, number of participants, follow-up period, complication rate, initial pain relief rate, recurrence rate and mean time to pain recurrence. Discrepancies were resolved by the third author (SX).

Risk of bias and methodological assessment. In total, two authors with formal training (ZMW, ZJW) performed the assessment of the medical literature according to the principles of evidence-based medicine to determine the risk of bias. The risk of bias of randomized controlled trials (RCTs) was assessed using the Cochrane Risk of Bias Tool (15) and the risk of bias of non-RCTs was performed

Table I. Efficacy of radiofrequency thermocoagulation in previous studies.

First Author (year)	N	Initial pain relief rate (%)	Recurrence rate (%)						Mean time to pain recurrence	Follow-up duration	(Refs.)
			6 months	1 year	2 years	3 years	5 years	Total			
Xue (2019)	40	90		17.5						1 year	(17)
Huang (2019)	12	100		8.3						13±7.87 months	(18)
Guo (2018)	4	100						0		26 months	(19)
Liu (2018)	41	97.6	2.4	9.8	17.1					2 years	(20)
Telischak (2018)	6	100		16.7						1 year	(21)
Elawamy (2017)	11 (PRF)		18	90.9	100					2 years	(59)
	12 (CRF)		25	25	50					2 years	
	20 (CCPRF)		5	15	30					2 years	
Yao (2016)	62 (68˚C)	100		6.5		21.9	25.6			5 years	(60)
	62 (75˚C)	100		4.9		15.7	19.3			5 years	
Yao (2016)	28 (CRF)	100		18.4	31.6	31.6				3 years	(61)
	28 (CCPRF)	100		8	8	16.4				3 years	
Yao (2016)	446 (62˚C)	94.2		16.2		23.3	41	59.4		9 years	(62)
	438 (65˚C)	98.3		9.9		19.5	35.7	46.3		9 years	
	470 (68˚C)	98.8		8.6		11.8	22.8	39.7		9 years	
Noorani (2016)	155	79		38.2						19 years	(22)
Huang (2016)	80	98.75								3 months	(23)
Kosugi (2015)	37 (V2)	100		59.5	80.4				9 months	3-48 months	(24)
	38 (V3)	100		19.8	45.1				36 months	3-48 months	
	67 (V2+V3)	86.6		50.7	82.9				12 months	3-48 months	
Jin (2015)	90		16.7							6 months	(25)
Tang (2014)	304	100		15		25	29	51		10 years	(26)
Singh (2014)	18	77.8	20	36.4				67.7		18 months	(63)
Huang (2014)	12	100	0	10						1 year	(64)
Koning (2014)	28	89		40	50					32 months	(27)
Udupi (2012)	39	94.8		21.2	42.2	51.5			28.7±18.7 months	3-60 months	(65)
Son (2011)	38	100			20.2	29.1		28.9	26.1±11.5 months	38.2 months	(28)
Fouad (2011)	312	100		13.5						3 years	(29)
Degn (2010)	10 (type 1 TN)			29		29				3 years	(30)
	33 (type 2 TN)			67		100			8 months	3 years	
Huang (2010)	30 (CTN)	86.7		23.3	26.7	26.7			28 months	3 years	(31)
	27 (MTN)	48.1		53.4	58.6	58.6			15.7 months	3 years	

Table I. Continued.

First Author (year)	N	Initial pain relief rate (%)	Recurrence rate (%)						Mean time to pain recurrence	Follow-up duration	(Refs.)
			6 months	1 year	2 years	3 years	5 years	Total			
Huibin (2009)	20 (CRF)	90				25	35			3 years	(66)
	30 (PRF)	87				27	40			3 years	
Haridas (2008)	145	95.9	6.5	8.6	27.4	39.3	34.1	36.7		5 years	(32)
Fraioli (2009)	158	98.7						7.6		8.8 years	(33)
Liu (2005)	18	94.4	11.1					16.7		31.5 months	(34)
Teixeira (2006)	273	100		4.5				10.2		22.6 months	(35)
Xu (2006)	26 (Navigation)	100		15	25					36±7 months	(12)
	28 (Without navigation)	95		46	60					34±5 months	
Kanpolat (2001)	1,216			10	38	38	41	44		60 months	(36)
Tronnier (2001)	206				50		75			14 years	(37)
Zakrzewska (1999)	31 (TN)		6	10	36	36			40 months	30±12 months	(67)
	17 (MTN)		13	20	36	46			36 months	30±12 months	
Scrivani (1999)	215	92						27		6-68 months	(68)
Lee (1997)	235	92.3						25		7.2 years	(38)
Oturai (1996)	185		26	30	37	42	44	49		96 months	(39)
Taha (1995)	154	99.4					15	25		14years	(40)
Tan (1995)	80	87.5		25							(41)
Broggi (1993)	712	95						18		14 years	(42)
Hamid (1993)	127	86						-		1-10 years	(43)
Zakrzewska (1993)	265							22	24 months	45 months	(44)
Moraci (1992)	568	96						16		1-10 years	(45)
Meglio (1990)	33	81.8			42.4					2 years	(46)
Broggi (1990)	1,000	94.8				12.8		18.1		9.3 years	(47)
Fraioli (1989)	533	97.4						9.2		6.5 years	(48)
Frank (1989)	912					25				3 years	(49)
Mittal (1986)	280	90.7	6	12							(50)
Latchaw (1983)	96		12	23	35	39	40	47		60 months	(51)

TN, trigeminal neuralgia; CRF, continuous radiofrequency; PRF, pulsed radiofrequency; CCPRF, combined CRF with PRF; CTN, classical trigeminal neuralgia; MTN, mixed trigeminal neuralgia; V2, maxillary division of TN; V3, mandibular division of TN.

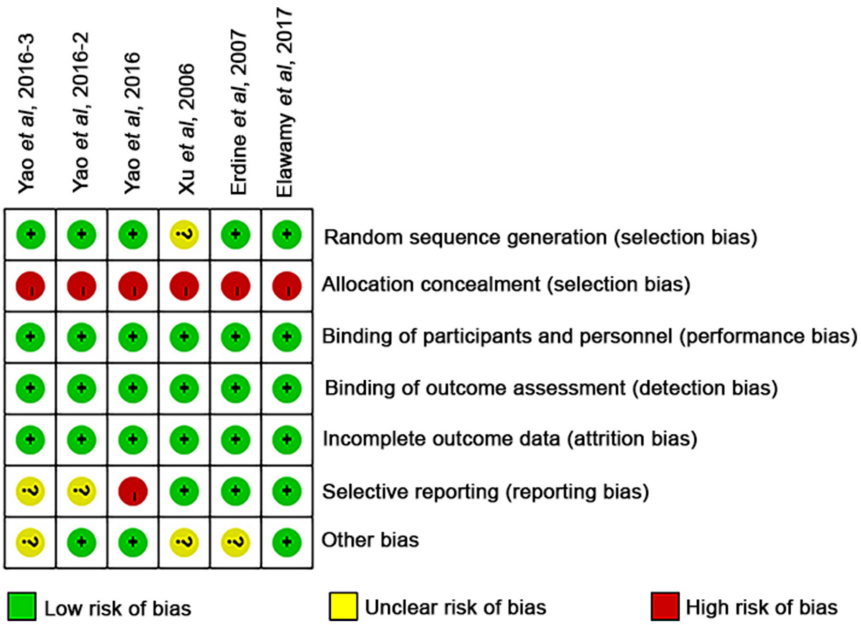

Figure 2. Overall risk of bias summary of randomized controlled trials.

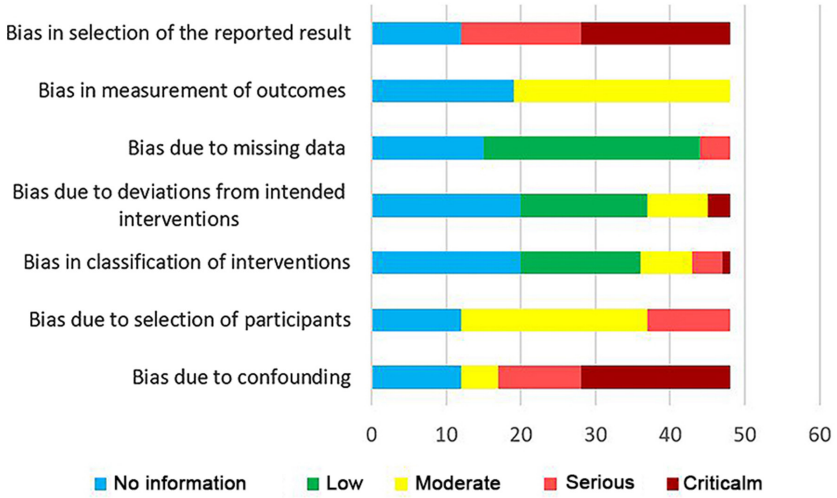

Figure 3. Overall risk of bias summary of non-randomized controlled trials.

using the non-randomized studies of interventions-I tool (16). Discrepancies were resolved by the third author (KL). Due to considerable heterogeneity in the interventions amongst the included studies, along with the difference in the study types, no meta-analysis was performed and the results of the current study are presented in a descriptive fashion.

Results

Study selection. A flow chart depicting the study retrieval and selection process is presented in Fig. 1. Of the relevant studies identified, 54 studies were included (Tables I and II) in the present review, and 2862 studies were excluded. A total of 13,410 patients were included.

The studies had various designs, including 41 historical cohort studies (17-57) and 13 prospective cohort studies (58-69). Of the 13 prospective cohort studies, six were RCTs (59-62,12,69) and only one RCT (12) did not describe the method used to generate the allocation sequence in sufficient detail. Despite this, the study was included in the present analysis.

Risk of bias of included studies. The risk of bias summary of the RCTs is presented in Fig. 2 and the risk of bias summary of the non-RCTs is presented in Fig. 3. From all randomized studies, in the first domain, random sequence generation, five studies had a low risk for a particular randomization method. For the allocation concealment domain, all studies had a high risk of bias, because the surgeon knew the personal information of patients. Due to the nature of the intervention, surgical observation studies were difficult to achieve double blinding or triple blinding. Objective evaluation indicators were used so to have minimum effect on the results. Risk of bias for the domain 'blinding of participants and personnel', 'blinding

Table II. Complications of radiofrequency thermocoagulation.

First Author (year)	N (subgroup)	Moderate facial hypoesthesia (%)	Bothersome dysesthetic (%)	Anesthesia dolorosa (%)	Masticatory weakness (%)	Facial swelling (%)	Corneal involvement (%)	6th nerve palsy (%)	Otalgia or hypoacousia (%)	Cerebrospinal fluid leakage (%)	Carotid artery puncture (%)	Meningitis (%)	Nausea/ vomiting (%)	(Refs.)
Xue (2019)	40	100			77.5	37.5	55							(17)
Huang (2019)	12		16.7		25	16.67								(18)
Guo (2018)	4	25												(19)
Liu (2018)	41	100			9.8								12.2	(20)
Telischak (2018)	6	80			40	0	0							(21)
Elawamy (2017)	11 (PRF)		0			8.3							0	(59)
	12 (CRF)		0		18.2								9.1	
	20 (CCPRF)		10		5								5	
Yao (2016)	62 (68°C)	12.9			4.8	17.7	1.6							(60)
	62 (75°C)	79			25.8	21	19.4							
Yao (2016)	28 (CRF)	10.7				21.4	42.9			32.1			7.1	(61)
	28 (CCPRF)	7.1				17.9	10.7			28.6			10.7	
Yao (2016)	446 (62°C)		1.79		0		0		0.45				10.1	(62)
	438 (65°C)		9.81		0.68		2.97		0.23				12.1	
	470 (68°C)		21.7		2.55		5.74		0.21				10.2	
Noorani (2016)	155	89.3	4.5											(22)
Huang (2016)	80	97.5					18.75							(23)
Tang (2016)	1,161	95			8.4		2.6	1.7	0.4	0.2				(52)
Singh (2014)	18	33.3			61.1		72.2						11.1	(63)
Koning (2014)	28	56			12		20					3.6		(27)
Huang (2014)	12	100			41.7	16.7	8.3							(64)
Tang (2014)	304	100	8.6		8.8		4.6	0.9	1.6					(26)
Udupi (2012)	39	79.5	7.7				12.8							(65)
Degn (2010)	10	89												(30)
Son (2011)	38	18.4	2.6		15.8		0	0						(28)
Fouad (2011)	312	100	36		1.6		1					0.3		(29)
Huang (2010)	20	83.3	26.7	6.7	50	26.7								(31)
	30	74.1	14.8	3.7	40.7	14.8	26.7							
Fraioli (2009)	158		3.8		3.8	5.7								(33)
Huibin (2009)	20 (CRF)	25			10		10							(66)
	30 (PRF)	20			0		0							

Table II. Continued.

First Author (year)	N (subgroup)	Moderate facial hypoesthesia (%)	Bothersome dysesthetic (%)	Anesthesia dolorosa (%)	Masticatory weakness (%)	Facial swelling (%)	Corneal involvement (%)	6th nerve palsy (%)	Otalgia or hypoacousia (%)	Cerebrospinal fluid leakage (%)	Carotid artery puncture (%)	Meningitis (%)	Nausea/ vomiting (%)	(Refs.)
Erdine (2007)	20 (CRF)	100	0	5						25				(69)
	20 (PRF)	100	0	0						15				
Liu (2005)	18	72.2			5.6		5.6							(34)
Xu (2006)	26 (Navigation)		0		0		0			0				(12)
	28 (Without navigation)		7.14		3.6		10.7			3.6				
Teixeira (2006)	273	30.4				0.4		1.5						(35)
Tronnier (2001)	206		0.9	0										(37)
Kanpolat (2001)	1,600		1	0.8	4.1		6.3		0.88	0.13		0.06		(36)
Mathews (2000)	258		8.1	1.9	28.7		3.9					0.78		(53)
Scrivani (1999)	215		8.4	1.8	28.8	0	3.2	0				0.9		(68)
Yoon (1999)	81		9.9		4.9		17.3							(54)
Tew (1995)	1,200		3	1	23		8					0.2		(55)
Taha (1995)	154	92	8		14.3		18.8							(40)
Tan (1995)	80	87.5	25				15							(41)
Broggi (1993)	712		6.7		10.5		19.7							(42)
Hamid (1993)	127				0.79	3.14	3.14		8.66		0.79			(43)
Moraci (1992)	568	80	0.3		13.3		0.9							(45)
Ischia (1990)	124		6.5	3.2			22.6					0.8		(56)
Meglio (1990)	33	24.4												(46)
Broggi (1990)	1,000		5.2	1.5	10.5		20.3	0.5						(47)
Fraioli (1989)	533		15.2	1.5	3		22.1							(48)
Frank (1989)	700			0.6	8		1	0.14						(49)
Mittal (1986)	229		6.1	9.6	8.9		2.4							(50)
Latchaw (1983)	96		12.5	1	5.2		15.6							(51)
Burchiel (1981)	69			4.3			2.9							(57)

TN, trigeminal neuralgia; CRF, continuous radiofrequency; PRF, pulsed radiofrequency; CCPRF, combined CRF with PRF.

of outcome assessment' and 'In complete outcome data' was defined as low in all studies. In the 'selective reporting' domain, one study was judged to have a high risk of bias and three to have a low risk of bias. In the last domain, other bias, none of the trials was pre-registered, three studies had a low risk of bias due to consistency of methods and results.

Results on efficacy and complications. The percentages of patients experiencing initial pain relief after RFT ranged from 77.8 to 100% (17-24,26-29,31-35,38,40-43,45-48, 50,58,60-66,68), with a mean time to pain recurrence of 8-40 months (24,28,30,31,44,65,67). The recurrence rate following RFT ranged from 0 to 26% (20,25,32,34,39,50, 51,59,63,64,67) at 6 months, from 4.5 to 67% (17,18,20-22, 24-27,29-32,35,36,39,50,51,59-65,12,67) at 1 year, from 8 to 82.9% (20,24,27,28,31,32,36,37,39,46,51,59-61,65,12,67) at 2 years, from 11.8 to 58.6% (26,28,30-32,36,39,47,49,51, 60-62,65,66,67) at 3 years and from 15 to 75% (26,32,36, 37,39,40,51,60,62,66,67) at 5 years (Table I). All statistical results are continuous radiofrequency (CRF). Pulsed radiofrequency (PRF) and combined CRF with PRF (CCPRF) are not included. There were two studies that (26,63) separately counted the results of mixed TN (MTN). Since other studies did not discuss MTN separately, the results of MTN were not included in the statistics. Only one study (25) discusses type 2 TN (a constant burning, dull background pain), these results were also excluded. The results for MTN and type 2 can be viewed in Table I.

Regarding complications, moderate facial hypoesthesia occurred in 7.1-100% of patients who underwent RFT (Table II) (17,19-23,26-31,34,35,40,41,45,46,52,58,60,61, 63-66,69), whereas bothersome dysesthesia occurred in 0-36% of patients (12,18,22,26,28,29,31,33,36,37,40-42,45,47, 48,50,51,53-56,59,62,65,68,69) and anesthesia dolorosa was present in 0-9.6% of patients (31,36,37,47-51,53,55-57,68,69). The percentage ranges of patients identified for the other complications examined were as follows: Masticatory weakness in 0-77.5% (12,17,18,20,21,26-29,31,33,34,36,40,42,43,45, 47-55,59,60,62-64,66,68), facial swelling in 0-37.5% (17,18,21, 31,33,35,43,59-61,64,68), corneal involvement in 0-72.2% (17, 18,21,23,26-29,31,34,36,40-43,45,47-57,60-66,68), sixth nerve palsy in 0-1.7% (26,28,35,47,49,52,68), otalgia or hypoacousia in 0.21-8.66% (26,36,43,52,62), meningitis in 0.06-3.6% (27,29, 36,53,55,56,68), nausea or vomiting in 0-12.2% (20,59,61-63), cerebrospinal fluid leakage in 0-32.1% (36,52,61,12,69) and carotid artery puncture in 0.79% of patients (43).

Discussion

The mean initial pain relief provided by RFT was 95.31%, whereas the range was 77.8-100%. Although the lowest reported initial pain relief rate was 77.8%, 92.4% of the studies had an initial pain relief rate of >90%. A longer follow-up period was associated with a higher number of relapses. Recurrence following RFT was found in 69.57% of the reported studies and the peak range was 1-2 years (17,18,20-22,24-32,34-37,39, 41,46,50,51,59-65,12,67). The median value of the mean time to pain recurrence was 26.1±11.5 months (28).

Among the studies assessed, moderate facial hypoesthesia was the most common complication of RFT, although sensory impairment may be necessary for optimal clinical results (70). Bothersome dysesthesia is also common with RFT but it has rarely been mentioned in the past decade (17,19-21,23,27,52, 59-61,63,64). Anesthesia dolorosa is common following RFT (31,36,53,56,12), although this complication has rarely been mentioned in the past decade. Complications of corneal involvement are common in RFT and their incidence was particularly high when RFT was used to treat the ophthalmic division (V1) of TN (23,61). During RFT treatment, precise location of the needle tip selectively damages the unmyelinated fine fibers in the lesion area, thereby reducing the occurrence of complications and relapses (7-12). This result is consistent with those of a previous study by our group (19). The only complication of the treatment, which combines the stereotactic approach with 3D CT reconstruction and RFT of the Gasserian ganglion (19), was moderate facial hypoesthesia. Facial swelling occurs mostly due to soft-tissue damage caused by repeated punctures or damage to blood vessels during puncture. Its risk is reduced by accurate puncture. Although masticatory weakness was mentioned as a complication of RFT, it is more frequent and severe following percutaneous balloon compression (PBC) (71-76).

Several factors exist that influence ablative interventions. Koning *et al* (27) investigated sensory stimulation and the side effects of RFT for TN. They concluded that low sensory stimulation increased hypesthesia and that high stimulation may be less effective. However, this study did not determine the optimal sensory stimulation level.

Continuous radiofrequency (CRF), pulsed radiofrequency (PRF) and combined CRF with PRF (CCPRF) are three radiofrequency treatments used for TN. Although CRF has more complications than PRF, the majority of them are minor and transient. Compared with PRF, CRF exhibits a higher satisfaction rate and lower recurrence rate (64). Therefore, PRF is not considered an effective method for TN (69). CCPRF aided the elimination of postoperative complications (77) and achieved a level of pain relief comparable to that afforded by CRF (78). Yao *et al* (61) recommended the clinical use of CCPRF for treating V1 TN.

The radiofrequency temperature is another factor that affects the outcomes of RFT, although no current standard exists for the selection of the CRF temperature required for TN treatment. Yao *et al* (60,62) reported that 68˚C was the optimal radiofrequency temperature for treating the maxillary (V2) and mandibular (V3) division of idiopathic TN (62) and bilateral idiopathic TN (60). Zhao *et al* (77) suggested that 70˚C was the optimal temperature for RFT. Tang *et al* (52) recommended a temperature of 75˚C for idiopathic TN. Wu *et al* (79) reported that patient satisfaction was improved when the temperature range was 68-70˚C, whereas the efficiency was improved at a temperature range of 66-80˚C. In other studies, the temperature range of 60-65˚C for V1 and the temperatures of 72˚C and 75˚C for V2 and V2/V3 TN, respectively, were used and the results indicated excellent patient satisfaction (19,80). For PRF, a temperature range of 45-50˚C has been recommended, particularly for elderly patients (77,79).

In a non-RCT by Huang *et al* (18) V3 TN was treated under CT guidance with both bipolar and monopolar techniques. This study indicated that bipolar RFT exhibited a more favorable efficacy and recurrence rate than monopolar RFT, which was

likely due to larger lesion sizes in the bipolar RFT group (18). However, due to the small sample size, higher-quality evidence from larger-scale, well-designed, RCTs is required.

Huang *et al* (31) compared the efficacy of classic and mixed TN. It was indicated that 48.1% of patients with mixed TN reported improvements following RFT compared with 86.7% of patients with classic TN. Similarly, Kosugi *et al* (24) compared the long-term efficacy of isolated V2 TN, isolated V3 TN and mixed TN. The data demonstrated that the pain relief time of isolated V3 TN was longer than that of V2 and mixed TN. RFT was effective for classic TN and was relatively reliable for mixed TN. RFT had a positive outcome when used to manage provoked paroxysmal pain TN or mixed pain (provoked and constant pain) TN compared with constant, dull, aching pain TN (25). Degn and Brennum (30) reported that RFT was an effective intervention for type 1 TN (brief lancinating pain) but not for type 2 TN (continuous pain).

Liu *et al* (20) compared the efficacy and complications between RFT treatment of initial TN and recurrent TN. They indicated that the efficacy and the complication rate of repeated TN treated by RFT was similar to that of the initial TN.

Filippiadis *et al* (58) described an alternative approach for RFT, which included the entry point from the lateral side near the zygomatic bone. This approach used to be performed under local anesthesia (81-85) and this was the first time that it was applied to RFT. Furthermore, Ding *et al* (86) described a submandibular approach through a mandibular angle to reach the foramen ovale. These studies suggested the use of an alternative approach instead of the Härtel anterior approach that may reduce the complication rate, obtain long-term pain control of TN and achieve higher target selectivity for RFT.

In conclusion, in the present systematic review, the role of RFT in pain management provided to patients with TN was analyzed. RFT offered a high initial pain relief rate and a long pain-free interval after treatment. The recurrence rate was acceptable and the recurrence peak was 1-2 years. RFT may be repeated easily if pain recurs and has a longer learning curve for junior surgeons compared with that of PBC.

There are no sham-controlled or comparative trials on any neurosurgical intervention, which is a limitation of the present study. However, the incidence of complications was low and the majority of the complications were able to be recovered. Owing to the considerable heterogeneity and risk of bias in the included studies, strong conclusions could not be drawn. Additional high-quality RCTs assessing the role of RFT in TN management are required to strengthen the current evidence. The reduction of the difficulty of RFT puncture and of the recurrence and complication rates following RFT treatment are the main issues that need to be addressed in future studies.

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Availability of data and materials

All data generated or analyzed during this study are included in this published article and its supplementary files.

Authors' contributions

ZMW, ZJW, KL and XS acquired, analyzed and interpreted the data. ZJW and KL confirm the authenticity of all the raw data. ZMW drafted the manuscript. CD and YT conceived and designed the current study, and revised the manuscript for important intellectual content. Each author participated sufficiently in the work to take public responsibility for appropriate portions of the content and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All authors read and approved the final manuscript.

Ethics approval and consent to participate

Not applicable.

Patient consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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