Retrospective Study

Computed Tomography-Guided Percutaneous Stylomastoid Foramen Puncture and Radiofrequency Thermocoagulation for Treatment of Hemifacial Spasm via Mandibular Angle Approach

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Background: Hemifacial spasm (HFS) is characterized by progressive, paroxysmal, and involuntary convulsions on one side of the face. We have conducted in-depth exploration on the puncture approach through the mandibular angle, which is an important supplement to the first 2 approaches (i.e., premastoid approach and the postmastoid approach), especially for patients who cannot find a suitable way before and after the mastoid process.

Objectives: To investigate the effect of computed tomography (CT)-guided percutaneous mandibular angle radiofrequency thermocoagulation (RFT) of facial nerve through the stylomastoid foramen in treating HFS.

Study Design: A retrospective, observational study.

Setting: Pain Department, Jiaxing and Hangzhou, China.

Methods: A total of 89 patients with HFS who underwent CT-guided RFT in the Pain Department of Zhejiang Integrated Traditional Chinese and Western Medicine Hospital and the Pain Department of Jiaxing First Hospital, from June 2020 to June 2022, were retrospectively analyzed, including 29 men and 60 women, aged 34~88 (59.8 ± 11.1). They were divided into 3 groups: anterior mastoid approach group (Group A, n = 38), posterior mastoid approach group (Group P, n = 26), and mandibular angle approach group (Group M, n = 25), according to the different puncture approaches. Puncture time, minimum stimulating current triggering facial muscle twitches, temperature at the end of RFT and duration time of RFT at this temperature, and total treatment time, as well as degree of facial paralysis and complications one-day postoperation, were compared among the 3 groups.

Results: The puncture times (mean ± SD) of Group A, Group P, and Group M were (30.63 ± 4.88), (31.35 ± 5.89), and (35.08 ± 5.76), respectively, and the differences were statistically significant ($P = 0.006$). The puncture time of Group M was longer than that of Groups A and P ($P < 0.05$). The minimum stimulating current triggering facial muscle twitches in the 3 groups were (0.49 ± 0.16), (0.43 ± 0.14), and (0.28 ± 0.09), respectively, with a statistically significant difference ($P = 0.000$). The minimum stimulation current in Group M was less than that in Groups A and P ($P < 0.05$). The temperature at the end of RFT of the 3 groups was (78.29 ± 7.91), (76.54 ± 8.10), and (66.60 ± 8.00), respectively, and the differences were statistically significant ($P < 0.001$). The temperature of Group M was lower than Groups A and P ($P < 0.05$). There were no significant differences among the 3 groups in the total operation time or the degree of facial paralysis one-day postoperation ($P > 0.05$). No hematoma, infection, hearing impairment, or other complications were reported in any patients.

Limitations: The nonrandomized nature, small sample size, and retrospective design are limitations of this study.

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Conclusions: CT-guided RFT through the stylomastoid foramen is an effective treatment of HFS. Compared to the poster and anterior mastoid approaches, the mandibular angle approach was found to be more effective in terms of reduced minimum stimulating current and reduced-end RFT temperature, which means fewer potential complications to the patient postsurgery.

Key words: Hemifacial spasm, radiofrequency thermocoagulation, stylomastoid foramen, CT-guided

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Primary facial spasm, known as hemifacial spasm (HFS), is characterized by progressive, paroxysmal, and involuntary convulsions on one side of the face. It can affect the whole facial expression muscle group, and even cause continuous facial muscle contraction, resulting in symptoms, such as difficulty in opening eyes on the affected side, deviation of the angle of mouth, and neck muscle tremor, which can seriously impact patient quality of life. Computed tomography (CT)-guided percutaneous radiofrequency thermocoagulation (RFT) through the stylomastoid foramen has been shown to be effective in treating the facial spasm (1-3). However, the stylomastoid foramen is located between the styloid process root and the mastoid process root of the temporal bone, which can introduce surgical challenges due to anatomical variations in foramen diameter and angle. To address this challenge, an in-depth exploration of an alternative puncture approach through the mandibular angle was performed. This new approach serves as an important supplement to the first 2 approaches (premastoid approach and the postmastoid approach), especially for patients who cannot find a suitable way before and after the mastoid process (in some patients, the bone occlusions would be present in both anterior and posterior paths).

Furthermore, this alternative approach via the mandibular angle has a higher coincidence between the puncture needle and the main trunk of the facial nerve, providing improved access for RFT.

Methods

Study Design

From June 2020 to June 2022, a total of 89 patients with primary facial spasm that underwent CT-guided RFT in the Pain Departments of Zhejiang Integrated Traditional Chinese and Western Medicine Hospital and Jiaxing First Hospital were retrospectively studied, including 29 men and 60 women, aged 34~88 (59.8 ± 11.1) years old, with a medical history of 8-240 (36.0 [26, 54 5]) months.

According to the puncture route, the patients were divided into 3 groups: anterior mastoid approach group (Group A, n = 38), posterior mastoid approach group (Group P, n = 26), and mandibular angle approach group (Group M, n = 25).

Inclusion Criteria

(1) Those who met the diagnostic criteria of HFS, and the Chinese grade of facial spasm with 4 points or more (4-6); (2) Patients who refuse to undergo microvascular decompression (MVD); and (3) Patients who refuse to receive botulinum toxin treatment repeatedly.

Exclusion Criteria

(1) Patients with local skin damage and infection; (2) Patients with bleeding and coagulation dysfunction; (3) Patients with severe systemic diseases who cannot tolerate treatment; and (4) Patients with mental illness unable to cooperate with the study.

Preoperative Preparation

All patients were hospitalized, and laboratory examinations, such as routine preoperative blood tests, coagulation tests, biochemical tests, tumor index tests, and preoperative infectious disease tests, were performed to eliminate puncture contraindications. Patients and their families were briefed on the procedures, expected outcomes, and possible complications of CT-guided RFT. Prior to surgery, patients were asked to fast for 4-6 hours, venous access was opened, and the patients were brought into the CT room. Routine oxygen inhalation was performed; blood pressure, heart rate, and pulse oxygen saturation were monitored; thin pillows were placed under the head; the affected side was placed on the CT examination bed; and a positioning grid was placed under the earlobe (Fig. 1).

Procedure

Axial CT scan in paranasal sinus mode was performed for all patients. After acquiring skull localizer images, an axial scan was performed on the mastoid region with a 3-mm slice thickness. The styloid process and mastoid process were found on the CT cross-sectional image to aid in locating the stylomastoid foramen, which serves as the target level slice. The distinct approach routes for RFT are as follows: 1) anterior mastoid approach group (Group A), where CT analysis software was used to pull a straight line from the target to the skin in front of the affected side mastoid. If there was no bone occlusion in the anteroposterior path, the anterior mastoid approach was selected. The puncture angle and depth were measured and marked (Fig. 2); 2) postmastoid approach group (Group P), where CT software was used to pull a straight line from the target point back and up along the mastoid-intercranial sulci to the skin behind the mastoid process. If there was no bone occlusion in the posterior or upper path, the posterior mastoid approach was selected. The puncture angle and depth were measured and marked (Fig. 3); and 3) mandibular angle approach group (Group M). This approach was selected if bone occlusions were present in both anterior and posterior paths. After taking the skull localization image with CT, 3-dimensional (3D) reconstruction was performed on the obtained image, and the 3D reconstruction image was rotated to expose the stylomastoid foramen. The mandibular angle was used as the puncture point, and the stylomastoid foramen and mandibular angle were connected as the puncture path. The 3D volume was rotated to the standard vertical position, and the puncture path and vertical angle were measured using vendor-provided CT measurement software. The 3D volume was rotated to the standard horizontal position, and the puncture path and horizontal angle were measured (Fig. 4).

All patients were locally anesthetized with 1% lidocaine at the puncture point, and punctured with a 21-G RF needle (Cosman Medical, Burlington, MA; model: CC10521) with a length of 10 cm and a bare end of 5 mm. All the approaches were punctured according to the angle and depth of the planned path before surgery. A follow-up CT scan was used to confirm that the RF needle reached the stylomastoid foramen (Fig. 5). An RF instrument was connected (Cosman Medical, Burlington, MA; RFG-18 therapeutic instrument) and operated at a low-frequency current (2 Hz, 1000 μs) as a motor stimulation test to confirm proper need placement. If a current < 0.8 mA induced the affected side of the face to twitch at the same frequency as the electrical stimulation, then the needle tip position was considered satisfactory (1). RFT began at 60°C, during which the patient was instructed to puff out their cheeks and close his eyes (7). RFT was performed until mild facial paralysis was reached, defined as the Chinese facial paralysis score of 3 (6).

Fig. 1. *Surgical position: the affected side lies on the upper side, and positioning grid is placed.*

Fig. 2. *Presurgical planning of the routes from the stem mastoid foramen to the front of the mastoid process: 1 is the designed puncture path, and 2 is the designed puncture angle. The specific values of both are shown in the upper right corner of the figure. The path depth of this case is 3.78 cm, and the path angle is 21°.*

Assessments

Intraoperative Conditions

Several intraoperative conditions were recorded

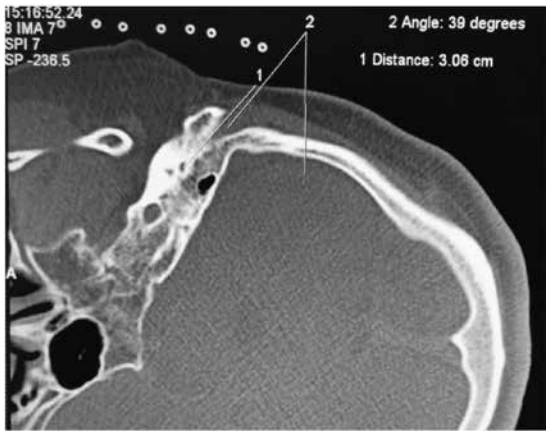

Fig. 3. *The posterior approach of the mastoid process is designed from the stylomastoid foramen to the posterior of the mastoid process: 1 is the designed puncture path, and 2 is the designed puncture angle. The specific values of both are shown in the upper right corner of the figure. The path depth of this case is 3.06 cm, and the path angle is 39°.*

and used in this study, including puncture time, the minimum stimulating current triggering facial muscle twitches, and the temperature at the end of RFT and RFT time.

Clinical Efficacy Evaluation

Several measures of clinical efficacy were recorded and evaluated. The patient's HFS on the first day after surgery was recorded with efficacy and was classified into 3 types based upon a global spasm score assessed following surgery: "cured," "effective," and "ineffective." If the facial muscle spasm completely disappears, the treatment effect is determined to be cured or a score of 0. "Effective" indicates a lower spasm score than prior to the operation. For "ineffective" the spasm was the same as preoperative. This spasm score integrates several aspects of the Chinese HFS grading standard, including spasm site, spasm amplitude, and frequency of spasm. The total score is 10, with 1 to 3, 4

Fig. 4. *Three-dimensional CT reconstruction before the mandibular angle approach. The red line is the puncture path. The depth of the path in this case is 55.1 mm. A) the angle between the puncture path and the vertical position, which is 17° in this case, and B) the angle between the puncture path and the horizontal position, which is 15° in this case.*
CT, computed tomography.

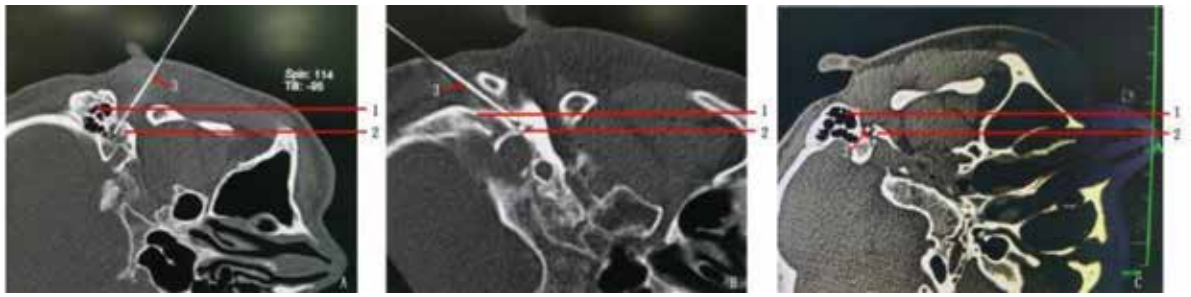

Fig. 5. *CT image of CT-guided percutaneous RFT in the treatment of HFS. A) The anterior mastoid approach (Group A) was designed and punctured from the stylomastoid foramen to the anterior mastoid; B) The posterior mastoid approach (Group P) was designed and punctured from the stylomastoid foramen to the posterior mastoid; C: Mandibular angle approach (Group M), defined as the path from the mandibular angle to the stylomastoid foramen and puncture.*
CT, computed tomography; RFT, radiofrequency thermocoagulation; HFS: hemifacial spasm.
Note: 1: mastoid; 2: styloid process; 3: puncture needle, the high signal indicated by the red arrow is the puncture needle.

to 6, and 7 to 10 corresponding to light, moderate, and severe, respectively.

Facial Paralysis on the First Day Postoperation

Another evaluation of clinical efficacy assessed in this study was the degree of facial paralysis on the first day postoperation. Facial paralysis was recorded according to the Chinese facial paralysis classification standard (10 points, 3 levels) and includes assessment of eye closure, facial symmetry, and a forced puff of air test. The total score is 10, 1~3, 4~6, and 7~10 correspond to mild, moderate, and severe facial paralysis, respectively.

Side Effects

All adverse events were recorded, including postoperative bleeding, infection, hearing impairment, and other complications.

Follow-up

All patients received followed-ups for 12 months, and any recurrence was recorded.

Ethical Statement

This study was reviewed and approved by the Ethics Committee of Zhejiang Integrated Traditional Chinese and Western Medicine Hospital ([2020] Kuai Shen [181]) and the Ethics Committee of Jiaxing First Hospital (LS2019-013). All patients signed the informed consent form.

Statistical Analysis

Data were presented as mean ± SDs and analyzed using SPSS Version 23.0 (IBM Corporation, Armonk, NY). After the homogeneity test of the square difference, the intergroup comparison is conducted by one-way analysis of variance under the premise of the same variance. If there are differences, the least significant difference method is used for multiple comparisons. For measurement data with nonnormal distribution, M (Q1, Q3) was used, and the rank sum test was used for comparison between groups. Count data were expressed as frequency and component ratio, and the chi-square test was used for comparison between groups. A bilateral test, the test level α = 0.05, $P < 0.05$, was considered statistically significant.

Results

General Information

There was no statistically significant difference in gender, age, medical history, and size of the 3 groups ($P > 0.05$) (Table 1).

Intraoperative Conditions

Puncture Time

Significant differences in puncture time were observed between the 3 groups (F = 5.38, $P = 0.006$); however, the puncture time of Group A and Group P were similar (q = 1.39, $P = 0.607$). The puncture time in Group M was slightly longer than that in Group A and Group P, with a statistically significant difference (q =1.40, $P = 0.002$; q = 1.52, $P = 0.016$) (Table 2).

The Minimum Stimulating Current Triggering Facial Muscle Twitches

There was a statistically significant difference be-

Table 1. *Comparison of general data of patients with HFS treated by RFT through different approaches (mean ± SD).*

Group	Cases	Gender (M/W)	Age	Medical History	Lateral (L/R)
Group A	38	12/26	59.79 ± 11.11	34.0 (25.25, 53.00)	20/18
Group P	26	8/18	58.27 ± 9.13	36.0 (22.00, 44.25)	15/11
Group M	25	9/16	61.64 ± 12.91	48.0 (29.00, 63.00)	15/10
F/Z/χ^2		0.189	0.590	1.666	0.367
P		0.910	0.559	0.195	0.832

Note: HFS: hemifacial spasm; RFT: radiofrequency thermocoagulation.

Table 2. *Comparison of RFT through different approaches in the treatment of HFS.*

Group	Cases	Puncture Time (min)	Minimum Stimulation Current (mA)	Termination Temperature (°C)	RFT Time(s)
Group A	38	30.63 ± 4.88[a]	0.49 ± 0.16[a]	78.29 ± 7.91[a]	23.47 ± 6.47
Group P	26	31.35 ± 5.89[a]	0.43 ± 0.14[a]	76.54 ± 8.10[a]	22.35 ± 6.97
Group M	25	35.08 ± 5.76	0.28 ± 0.09	66.60 ± 8.00	21.60 ± 6.37
F		5.38	17.69	17.35	0.64
P		0.006	0.000	0.000	0.530

Note: Group A: anterior mastoid approach group; Group P: postmastoid approach group; Group M: mandibular angle approach group; RFT: radiofrequency thermocoagulation; HFS: hemifacial spasm.

tween the 3 groups (F = 17.69, $P < 0.001$). The minimum stimulation current in Group M was less than that in Group A and Group P (q = 0.35, $P < 0.001$; q = 0.38, $P < 0.001$) (Table 2).

Temperature at the End of RFT Treatment

There was a statistically significant difference between the 3 groups (F = 17.35, $P < 0.001$), the termination temperature of RFT in Group M was lower than that in Group A and Group P (q = 2.06, $P < 0.001$; q = 2.24, $P < 0.001$) (Table 2).

RFT time

There was no statistically significant difference among the 3 groups (F = 0.64, $P = 0.530$) (Table 2).

Clinical Efficacy Evaluation

All 89 patients had a rhythmic twitch on the affected side of the face induced by electrical stimulation before RF treatment. The facial spasm disappeared on the first day postoperation and the score was 0, which was clinically cured. The effective rate on the first day postoperation was 100%. There was no statistically significant difference in facial paralysis on the first day postoperation among the 3 groups ($\chi^2 = 1.51$, $P = 0.959$) (Table 3).

Postoperative Complications and Follow-up

We successfully followed-up on all patients in these 3 groups. There were no postoperative complications, such as hematoma, intracranial hemorrhage, infection, and hearing impairment, in the 3 groups. Three patients recurred after 12 months of follow-up. There were one case in Group A and 2 cases in Group P. One case was graded as 6 points on the Chinese facial spasm score, and the spasm disappeared after repeated RFT; 2 patients scored 3 and were not treated and continued to follow-up. The effective rate on the 12 months postoperation was 96.7%, which is similar to another clinical research on HFS (1). We will continue to follow-up and observe the effective rate on the 24 months postoperation.

Table 3. *Comparison of postoperative facial paralysis in patients with facial spasm treated by 3 kinds of approach RFT through stylomastoid foramen.*

Group	Cases	Score			
		3	4	5	6
Group A	38	8(21.1)	16(42.1)	11(28.9)	3(7.9)
Group P	26	5(19.2)	10(38.5)	8(30.8)	3(11.5)
Group M	25	5(20.0)	13(52.0)	5(20.0)	2 (8.00)

Note: Group A: anterior mastoid approach group; Group P: postmastoid approach group; Group M: mandibular angle approach group; RFT: radiofrequency thermocoagulation.

Discussion

The pathogenesis of facial spasm is still unclear, like trigeminal neuralgia. At present, it is mainly based on pulsatile vascular compression theory (8,9). Local injection of botulinum toxin and MVD are still the main treatment methods (10,11). However, the duration of botulinum toxin is short and the MVD is relatively risky, which has a high-related mortality of 0.13%~0.80%, as well as a high cost. Percutaneous RFT of the facial nerve through the stylomastoid foramen is safe, minimally invasive, cost-effective, and long lasting, especially suitable for elderly patients who cannot tolerate craniotomy under general anesthesia (12-15). The facial nerve exits the skull from the stylomastoid foramen, and presents plexiform and multiple branches running about 16 mm. Therefore, the closer to the stylomastoid emulsion foramen, the easier to access the main facial nerve, which could achieve a more perfect therapeutic effect (5). During the puncture process of the mandibular angle approach, the RF needle is inserted from the mandibular angle in the superior direction. This approach has fewer obstructions than the anterior and posterior mastoid approaches and is more accessible for needle tip insertion in the stem-mastoid orifice. Additionally, the stimulating current to induce regular twitch is lower than that of the anterior and posterior mastoid approaches, indicating that this approach is closer to the target site, and thus has a better therapeutic effect.

In the mandibular angle approach, the puncture needle was approximately parallel to the main facial nerve, with a line-shaped effective treatment area. This differs from the anterior and posterior mastoid approach where the puncture needle crosses the facial nerve, and the effective treatment area is at a single focal point. Therefore, the effective treatment area of the mandibular angle approach is larger than that of anterior and posterior mastoid approaches, and the clinical effect is more obvious. This can well explain that in this study the span of RF temperature step-up of Group M is significantly lower than that of the other 2 approaches, that is, the treatment can be completed at relatively low temperature, which to some extent shows that this approach has higher therapeutic efficacy. Other efforts are studying the treatment of facial nerve dysfunction by

pulse RF modulation (5). The "line" treatment area of the mandibular angle approach is more advantageous in pulse RF modulation, and is expected to achieve better clinical efficacy.

During the mandibular angle approach, the surgeon can clearly observe the stylomastoid foramen from the CT 3D image, measure the angle between the vertical and horizontal planes, and plan the puncture path accurately. This approach is similar to the traditional facial nerve block path. In the past, the facial nerve block was conducted by inserting the needle in the middle point of the line between the mastoid process and mandibular angle, then to search for foreign body sensation upward, backward, and inward, with a vague location. Although ultrasound guidance or nerve stimulation guidance has been reported, the puncture accuracy is not as good as that of CT 3D image guidance in this study (16,17). However, in this study, the surgeon needs to consider 2 angles at the same time for a puncture, which requires the surgeon to have a certain sense of 3D space, and it is slightly difficult compared with the other approaches. Based on this problem, our research group is studying the use of 3D printing guide technology to make the mandibular angle approach puncture achieve better prepuncture planning, further improve the clinical operability of the approach, and give full play to the advantages of the approach.

Limitations

There are some limitations in our study. This is a nonrandomized study with no control arm and a small study size. In addition, the single-center, facility nature, and retrospective nature of the review produce moderate selection bias. Future multicenter, randomized, and controlled studies could be improved by prospectively evaluating a larger number of patients, which aims to lower bias.

Conclusions

CT-guided percutaneous RFT of stylomastoid foramen can effectively treat primary facial spasm. While the anterior and posterior mastoid approaches are more convenient and maneuverable, the mandibular angle approach is closer to the main facial nerve trunk and has better therapeutic efficacy. However, its puncture path design is not as intuitive as the previous 2 approaches, which still needs to be explored continuously in future studies.

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