Prospective Study

Comparison of Radiofrequency Ablation and Craniotomy Microvascular Decompression for Treatment of Hemifacial Spasm

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Disclaimer: The key discipline was established jointly by Zhejiang Province and Jiaxing City—Pain Medicine (2019-ssttyx). This study was also funded by the Natural Science Foundation of Zhejiang Province of China (LGF20H090021), the key R&D project of the Jiaxing Science and Technology Bureau (2022AZ3004), and the Ningbo Medicine Science and Technology Plan Project (2021Y05).

Conflict of interest: Each author certifies that he or she, or a member of his or her immediate family, has no commercial association (i.e., consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted manuscript.

Manuscript received: 09-14-2023
Revised manuscript received: 10-17-2023
Accepted for publication: 11-28-2023

Background: Hemifacial spasm (HFS) is distinguished by sudden and involuntary spasms of the facial muscles, predominantly on one side of the face. Microvascular decompression (MVD) is an efficacious surgical technique for treating HFS; however, MVD may occasionally lead to noteworthy postoperative complications. Previously, we reported the successful utilization of an innovative awake computed tomography-guided percutaneous puncture of the stylomastoid foramen for administering radiofrequency ablation (RFA) therapy in the treatment of HFS.

Study Design: Prospective clinical research study.

Setting: Department of Anesthesiology and Pain Medical Center, Ningbo, China.

Objectives: The aim of this study was to compare and contrast the clinical outcomes and adverse reactions associated with attempts to use RFA and MVD to manage primary HFS.

Methods: Three hundred patients received either RFA or MVD treatment (Group R and Group M). We tracked and recorded each patient's cure rate, remission rate, intraoperative and postoperative complications, short-term and long-term therapeutic outcomes, hospitalization duration, hospitalization expenses, and operation time.

Results: One hundred and fifty-eight patients were placed in the R group, and 142 patients were sorted into the M group. In the R group, 87.34% of patients showed improvement, 9.49% experienced relief, and 3.16% experienced treatment failure. Similarly, in the M group, 85.92% of patients showed improvement, 10.56% experienced relief, and 3.52% experienced treatment failure. The difference in therapeutic efficacy between the 2 groups was not significant. However, the M group had significantly lower recurrence rates at 3 months, 6 months, and one year post-operation than the R group did. Notably, the M group also experienced a higher rate of postoperative complications. Among the complications reported in the M group were 25 cases of dizziness or headache (17.6%) following the operation, 22 cases of hearing damage, including one case of complete hearing loss on the side involved, and 28 cases of peripheral nerve injury with abnormal skin sensation. Postoperative facial paralysis occurred in 15 patients, including 10 cases of moderate to severe facial paralysis that were relieved to grade II after one year. In comparison, the R group had 40 cases of grade II and 53 cases of grade III, and no cases of more severe facial paralysis were found. There were also 13 cases of peripheral nerve injury, such as local skin numbness and tenderness. Importantly, there were no cases of facial hematoma, intracranial hemorrhage, infection, or any other complications in either group, and no fatalities occurred during the study period.

Limitations: The limitations of this study are the exclusion of transient postoperative complications, the lack of in-person follow-up with patients, and the potential underestimation of certain complications.

Conclusion: The short-term outcome was found to be comparable between the 2 treatment modalities. Notably, RFA demonstrates both safety and efficacy as a method for managing primary HFS; however, the procedure may lead to mild facial paralysis. In situations during which surgery is contraindicated, especially among elderly or high-risk surgical patients, percutaneous facial nerve

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RFA at the stylomastoid foramen may be considered as an alternative therapeutic approach.

Key words: Hemifacial spasm, radiofrequency ablation, stylomastoid foramen, microvascular decompression

Pain Physician 2024: 27:E355-E361

Primary hemifacial spasm (HFS) is a neurological disorder characterized by paroxysmal or persistent twitches of unilateral facial muscles, starting with the periorbital muscles and progressing to the perioral muscles, platysma myoides, and other muscles that control facial expressions (1). As the disease advances, the spasms become more frequent and longer in duration, and they impact patients' daily lives significantly. Although the exact cause of primary HFS remains unclear, one dominant theory suggests that it involves microvascular compression of the facial nerve root by blood vessels from the brain stem (2). Craniotomy microvascular decompression (MVD) is a classic surgical technique used for treating HFS (3); however, MVD has been associated with serious complications, such as hearing damage, cerebrospinal fluid leakage, and perioperative death (4-6). To address these challenges, we developed the technique of computed tomography (CT)-guided percutaneous puncture of the stylomastoid foramen for the treatment of primary HFS. This procedure has been successfully applied and explored in clinical settings (7,8). Nevertheless, its efficacy and safety compared to traditional MVD remain unknown. Therefore, this study conducted a retrospective analysis of clinical data, treatment processes, and outcomes concerning patients with primary HFS who underwent either radiofrequency ablation (RFA) or traditional craniotomy MVD of the facial nerve.

Methods

Inclusion and Exclusion Criteria

This study adhered to strict inclusion and exclusion criteria, which were discussed and approved by the Medical Ethics Committee of Ningbo First Hospital and Jiaxing First Hospital (approval number: LS2019-013). Patients and their families were provided with comprehensive information about the treatment procedures, potential complications, and alternative options, and they signed informed consent forms before undergoing surgery.

Inclusion Criteria

Patients with HFS who met specific diagnostic criteria and visited the pain department of the author's hospital from October 2018 to October 2022 were included in the study.

Exclusion Criteria

The study excluded patients with cerebellaropontine angle-occupying lesions detected by preoperative head CT and brain magnetic resonance imageing (MRI), hemophilia or other coagulation disorders, mental disorders that would hinder tympanic cheek and eyelid closure during the operation, pregnant women, and individuals preparing for pregnancy who were not suitable for CT examination. Patients with pacemakers and those who refused the operation were also excluded.

Preoperative Preparation and Patient Grouping

Prior to surgery, each patient fasted for 4-6 hours, and a trocar was placed in the forearm vein for backup use. In the M group, after successful anesthesia, the patient was positioned in a side-lying orientation and underwent standard disinfection processes, followed by the placement of surgical drapes. A linear incision of approximately 8 cm was made behind the occiput, and the skin, subcutaneous tissue, and occipital muscle were dissected in layers with strict hemostasis (Fig. 1). Subsequently, the occipital bone was drilled, creating a bony window of approximately 3*3 cm, with the superior margin exposed to part of the transverse sinus and the posterior margin of the sigmoid sinus. The open mastoid air cell was filled with gentamicin-containing gelatin and sealed with bone wax, and then muscle glue was used to seal the skull base. A 3 mm L-shaped dural incision was made for the placement of an endoscope. Under the endoscope, the cisterna magna was opened to drain cerebrospinal fluid, and the cerebellum was gently retracted medially. Firstly, the arachnoid membrane around the lower cranial nerves was dissociated to expose the operative area. Secondly, the arachnoid membrane covering the facial nerve root was sharply dissected to locate the offending vessels compressing

Fig. 1. *The preoperative localization of MVD: a linear incision of approximately 8 cm in length was made behind the occiput.*

the facial nerve (Fig. 2), which were carefully separated to relieve the compression. Most of these vessels were found to be the vertebral artery and posterior inferior cerebellar artery. Thirdly, Teflon filaments were placed between the vessels and the nerves and fixed with medical glue (Hugulaishi®) (Fig. 3). The operative field exposure was carefully managed for hemostasis and covered with hemostatic gauze (SURGICEL®, Ethicon™, Johnson & Johnson). The dura was repaired with an artificial dura mater patch (Tianyifu), and the bone flap was fixed with a titanium connecting piece. Finally, the incision was sutured tightly in layers.

In the R group, when the patient entered the CT treatment room and verified his or her personal information, the patient was assisted in lying on the CT table on the healthy side, and CT positioning markers were placed anterior and posterior to the patient's tragus (Fig. 4). Nasal cannula oxygen was administered while the patient's blood pressure, electrocardiogram, pulse, and oxygen saturation were monitored. The mastoid region was scanned with a slice 3 mm thick using the axial head mode of CT. The level containing the stylomastoid foramen was selected as the puncture site, and the puncture path was further designed at this level. The affected side of the stylomastoid foramen served as the puncture target. For the anterior mastoid approach, a straight line was drawn forward from the target and up to the area of skin in front of the affected side of the mastoid process. For the posterior mastoid approach, a straight line was drawn backward from the target and up to the area of skin behind the affected side of the mastoid process, avoiding the barrier of the tympanic part of the temporal bone. The intersection point of the straight line and the skin marked the puncture entry point. If there was no bone block in either approach, one approach was selected.

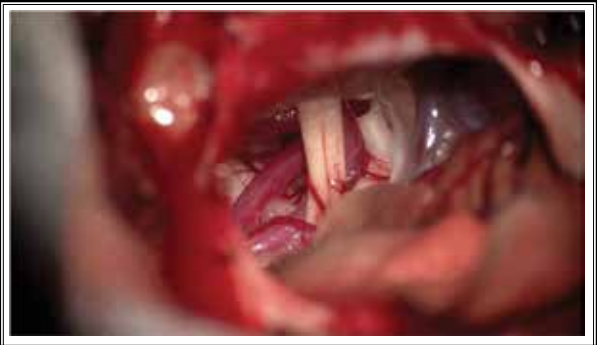

Fig. 2. *The arachnoid membrane covering the facial nerve root.*

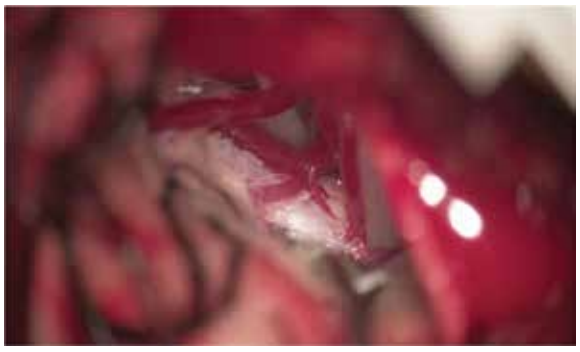

Fig. 3. *The placement of Teflon filaments between the vessels and the nerves.*

Fig. 4. *CT image showing the positioning grid placed in the lateral decubitus position (the handmade positioning grid was cut off by the interventional catheter and placed longitudinally before or after the earlobe).*

The puncture depth (the distance from the puncture point to the target point) and the puncture angle (the angle between the puncture straight line and the sagittal plane) were measured using the CT software's ruler tool (Fig. 5).

The surgical procedures were as follows: First, local anesthesia (2% lidocaine) was applied to the puncture site, and a No. 7 special RF puncture needle (model: PMG21-100-4, Henan Tuoren Co.) with a total length of 10 cm and a bare tip of 5 mm was inserted to the target under CT guidance according to the designed puncture path (Fig. 6). This step was further observed and confirmed by the CT software's 3-dimensional image reconstruction (Fig. 7). Next, after we pulled out the core of the RF needle and inserted the RF electrode, the motor function of the facial nerve was tested by electrical stimulation with the low-frequency (2 Hz) current of the RF instrument (model: PMG230, Bylis Company). The test was considered positive when current stimulation at a level below 0.8 mA could induce rhythmic twitching in the affected facial muscles at the same frequency as the electrical stimulation. Otherwise, the position of the RF needle tip had to be adjusted until a positive result occurred. Thirdly, a standard continuous RF was determined, with the starting temperature parameter set at 60°C for 30 seconds.

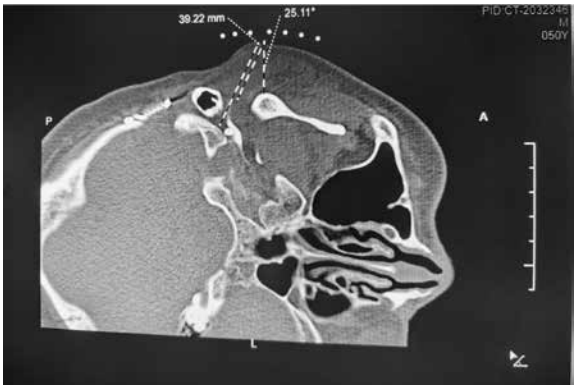

Fig. 5. *An example of the puncture path design through the anterior approach (puncture depth 3.75 cm, puncture angle [angle with a sagittal plane] 26 degrees).*

At the beginning of the RF treatment, the patient was instructed to maintain the position with the tympanic cheek closed and eyes shut throughout the operation. The patient's face was observed closely during the RF process. If air leakage occurred on the affected side of the tympanic cheek and the patient's eyes were not closed tightly, the RF treatment was terminated immediately. If the RF continued at 60°C for 30 seconds, the affected cheek continued to bulge, and the affected eye could still be closed, the RF time was kept unchanged for 30 seconds, and the temperature was gradually increased in increments of 5°C (up to 90°C). If the desired therapeutic effect could not be achieved at 90°C for 30 seconds, the needle tip had to be adjusted again, or the puncture path changed, and the RF treatment needed to be performed after retesting. After the surgery, the temperature at the end of the RF treatment, the total time of the treatment procedure (from the beginning of CT scan positioning to the end of the RF treatment), the treatment's efficacy, and the degree of facial paralysis were recorded.

Efficacy Evaluation and Follow-Up Observations

The curative efficacy of the procedure applied to the HFS was evaluated postoperatively as follows: (1)

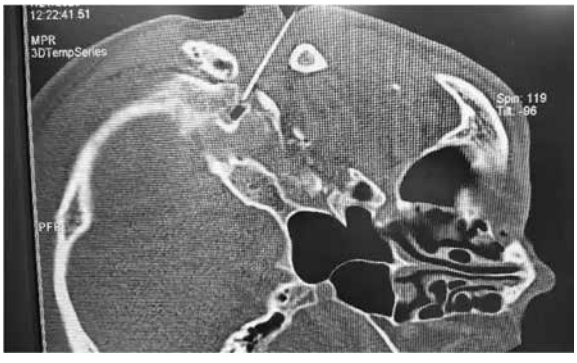

Fig. 6. *Successful puncture through the anterior approach.*

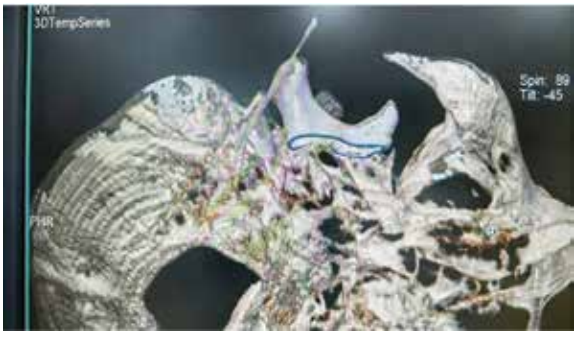

Fig. 7. *Three-dimensional reconstruction of successful puncture.*

cure: the involuntary twitch of the hemifacial muscles disappeared completely; (2) remission: patients still experienced involuntary twitching, but the degree was less than before the operation; (3) ineffectiveness: HFS symptoms remained the same as before the treatment; (4) recurrence: the HFS disappeared for more than one week after surgery but recurred later. After the surgery, the puncture site was observed for hematoma, and the patients were asked about tinnitus, hearing damage, facial pain, or facial paralysis, and the degree of each effect was further graded and recorded according to the House-Brackmann grading standard. (Grade I was defined as normal without facial paralysis, grade II as paresis, grade III as moderate paralysis, grade IV as moderate-severe paralysis, grade V as heavy paralysis, and grade VI as total paralysis) (9). The curative efficacy and complications patients experienced were followed up by telephone or WeChat video at one month, 3 months, 6 months, and one year after surgery, and a detailed follow-up database was established for all patients.

Data and Statistical Analyses

All statistical analyses were performed using SPSS 16.0 software. Normally distributed measurement data were presented as mean ± SD, while non-normally distributed measurement data were expressed as median and interquartile range. Count data were expressed as rates or percentages. Either Fisher's probability test or the chi-squared test was used, and statistical significance was set at a P value < 0.05.

Results

General Information

A total of 371 patients with HFS met the inclusion criteria. During the follow-up period, 71 patients were lost to follow-up, and 300 patients were finally enrolled in the study. The male-to-female ratio was 94:206, with an age range of 30 to 86 years (mean age: 57.56 ± 9.30 years), and the disease duration ranged from one to 480 months.

The Process of the Treatment

In the present study, 142 patients were included in Group M to undergo craniotomy microvascular decompression, and 158 patients were included in Group R to undergo RF ablation of the facial nerve. The general conditions and disease duration of the 2 groups were compared in Table 1 and Table 2, and no significant difference was found.

Treatment Effects

Among the 158 cases in Group R, 138 patients (87.3%) were cured, 15 (9.5%) were relieved, and 5 (3.2%) found the treatment ineffective. In Group M, out of 142 patients, 120 (84.5%) were cured, 14 (9.9%) were relieved, and 8 (5.6%) found the treatment ineffective. There was no significant difference in the effects of the treatment between the 2 groups, according to the Fisher test (P = 0.616 > 0.05). In Group M, 25 patients experienced dizziness or headache following the operation, and among them, 6 cases were severe, including 2 cases of severe headache or dizziness during an attack, 2 cases of consciousness disturbance syncope due to dizziness, one case of secondary hospitalization due to hydrocephalus, and one case of limitation of intense physical activity. Hearing damage was observed in 22 patients, including one case of complete hearing loss on the involved side. Additionally, there were 28 cases of peripheral nerve injury with abnormal sensations in the local skin. Postoperative facial paralysis

Table 2. *Comparison of disease duration (months) between Group M and Group R.*

Grouping	Disease Duration (months) M (P25, P75)	Mann-Whitney U Test	
		Z	*P*
Group M	36(12,60)	0.154	0.877
Group R	36(21.75, 54.75)		

Note: The K-S test indicated that the data in both groups did not follow a normal distribution. Therefore, the Mann-Whitney U test was applied, and a P value < 0.05 was considered statistically significant. The test results showed that there was no significant difference in disease duration between the 2 groups.

Table 1. *General comparison between Group M and Group R.*

General Information	Group M	Group R	T Value/X^2	*P* Value
Age (Years)	56.60 ± 8.41	58.71 ± 10.19	0.236	0.104
Laterality (Left/Right)	55/54	77/75	0.001	0.975
Gender (Male/Female)	41/101	53/105	0.758	0.384

Note: Differences with P < 0.05 were considered statistically significant. However, the general conditions between the 2 groups showed no statistically significant differences.

occurred in 15 patients, including 10 cases of moderate to severe facial paralysis (House-Brackmann Facial Paralysis Scale grade IV or above), and one out of 10 cases showed improvement to grade II after one year. In Group R, 40 patients had scores of grade II, and 53 patients had scores of grade III. No more severe facial paralysis was found in this group. Thirteen patients experienced peripheral nerve injury, such as local skin numbness and tenderness.

Moreover, both groups experienced recurrence after the surgery (Table 3, Fig. 8). In Group R, 5 cases recurred one month after the surgery, 14 cases recurred at 3 months, 8 cases at 6 months, 12 cases at 12 months, and 2 cases recurred at one year or more after the surgery. In Group M, 5 cases recurred one month after the surgery, one case recurred at 3 months, one case at 6 months, 8 cases at 12 months, and 2 cases recurred at one year or more after the surgery. One patient experienced recurrence at 6 months after surgery, 8 cases of recurrence happened at one year after surgery, and 2 patients' cases recurred at one year or more after surgery.

Table 3. *Recurrence of hemifacial spasm at different follow-up time points.*

	M Group	R Group
1 month after surgery	5	5
3 months after surgery	1	14
6 months after surgery	1	8
12 months after surgery	8	12
1 year or more after surgery	2	2
TOTAL	17	41

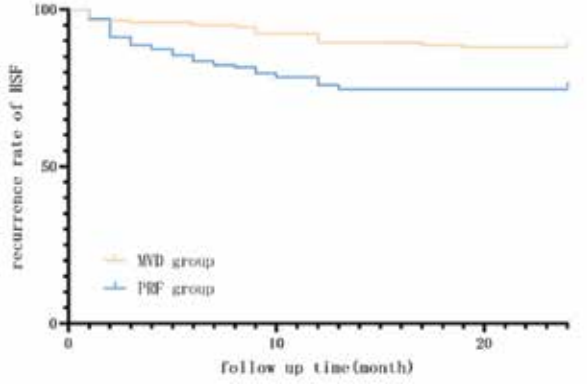

Fig. 8. *Both groups experienced recurrence after the surgery.*

Discussion

Although the incidence of HFS is not statistically high in proportion to China's large population base, many patients still have HFS.

The incidence of primary HFS in the world's general population is not yet fully understood. Studies have shown varying rates across different ethnic groups. For instance, among white Americans, the incidence rate is approximately 14.5 cases per 100,000 women and 7.4 cases per 100,000 men, indicating a higher occurrence in women (10). A multi-ethnic study also revealed a higher incidence of HSF in Asians compared to Caucasians from the same region (11). However, we were unable to find specific epidemiological studies related to this condition in China. In our included cases, the gender ratio was approximately 1:2.2 (male/female = 94/206), which aligns with previous reports.

Microvascular compression theory is considered the pathogenesis of HFS, and MVD is the treatment for the condition's etiology.

Although the pathogenesis of HSF remains unclear, the microvascular compression theory is widely accepted by most scholars. According to this theory, the compression of microvessels leads to nerve demyelination, resulting in abnormal nerve discharge and involuntary facial muscle spasm in patients. Consequently, many scholars consider the MVD procedure the only approach that can provide a complete cure for this condition. However, it is important to note that this theory has not yet been proven definitively. In clinical practice, there is no clear definition of the vessels involved in microvascular compression, which also impacts the effectiveness of MVD (12). Furthermore, the numerous and potentially severe complications associated with MVD, such as hearing damage, cerebrospinal fluid leakage, and even perioperative death, often deter some patients from opting for MVD treatment.

RFA is a convenient, safe, and economical treatment.

In our previous study, CT-guided RF thermocoagulation was demonstrated to be effective in treating HSF, with results lasting for at least one year (13).

To investigate the effects of RFA and MVD as HFS treatments, we conducted a 2-year follow-up on 300 patients. The 2 groups showed no significant differences in cure rate, response rate, or inefficiency, leading us to conclude that effects of the RFA treatment are comparable to those of MVD for at least 2 years.

Additionally, we observed that the long-term complications of RFA consisted mainly of mild-to-moderate facial paralysis (House-Brackmann grade II or III) and peripheral nerve injury. On the other hand, MVD-treated patients experienced symptoms that could impact their lives negatively, such as dizziness, headache, hearing damage, or even complete hearing loss, along with severe facial paralysis (House-Brackmann grade IV or above). This marked difference highlights that severe complications are rare in RFA treatment and that the impact of RFA-related complications on patients' lives is lower than that associated with the effects of MVD. Hearing damage is often discussed as one of the postoperative complications of the MVD treatment. This result may be due to the treatment's focus on the VII cranial nerve, and hearing damage may arise from direct damage to the VIII cranial nerve during the operation. In our study, 22 patients developed hearing damage after MVD, with one patient experiencing complete hearing loss on the affected side without signs of improvement. However, we did not compare the preoperative and postoperative pure tone audiogram (PTA) or speech discrimination score (SDS) during the follow-up. Instead, we followed up only on the occurrence of hearing damage, which might have missed some patients with hearing damage but not deafness. A retrospective review suggested that, for various reasons, the reported incidence of hearing damage might be lower than its actual rate (14). Moreover, another study suggested that the incidence of hearing damage in the elderly population (over 60 years old) undergoing MVD was almost twice as high as in the population under 60 years old (15).

Furthermore, complications related to the central nervous system, such as cerebrospinal fluid leakage, stroke, and intracranial hematoma, are evident disadvantages of MVD. One patient included in our study was readmitted to the hospital approximately one year after the procedure due to recurrent dizziness, and an MRI scan revealed a cerebellar fluid collection, which might have been a complication of MVD for this patient.

In contrast, since RFA is performed on the facial nerve at the stylomastoid foramen and is not intracranial, central nervous system-related complications are rare and limited. As of the completion of this paper, we have not observed an association between this technique and other complications involving the central nervous system.

Performing MVD twice is difficult, while repeating the RFA treatment is easy.

It has been demonstrated that the rate of permanent complications is significantly higher in patients undergoing a second MVD for HSF recurrence. In contrast, our previous study showed that secondary RFA was safe for patients with recurrent HSF (16).

In our study, apart from the aforementioned differences, RFA also boasts a shorter treatment time (31.41 ± 9.65 min vs. 276.50 ± 40.5 min), a reduced hospital stay (4.79 ± 2.33 days vs. 14.53 ± 1.96 days), and lower hospitalization costs (£5286.62 ± £429.37 vs. £36,102.19 ± £539.24) compared to MVD. These numbers suggest that patients who receive RFA rather than MVD bear a lower economic burden and experience less time cost, enabling them to return to their normal lives more quickly with minimal disruption. As a minimally invasive technique, RFA offers a viable treatment option for patients who are ineligible for MVD. From a hospital staff's perspective, RFA provides comparable efficacy to MVD while utilizing fewer medical resources (with MVD requiring at least one doctor, one assistant, and one nurse) due to the use of local infiltration anesthesia.

Conclusion

Compared to traditional MVD, RFA offers a viable alternative with similar short-term efficacy while effectively avoiding the high risks associated with craniotomy MVD. For patients who are ineligible for MVD treatment, RFA surgery is a promising and minimally invasive option for managing HSF.

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