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ORIGINAL ARTICLE - FUNCTIONAL NEUROSURGERY - MOVEMENT DISORDERS

Short-term versus long-term outcomes of microvascular decompression for hemifacial spasm

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Abstract

Background Microvascular decompression (MVD) is a useful treatment for hemifacial spasm (HFS), but the postoperative course is extremely diverse. The purpose of this study was to compare short- and long-term outcomes, find the earliest optimal time for determining the long-term outcomes, and investigate the prognostic factors involved in the outcomes over time.

Methods From July 2004 to January 2015, 1341 patients who underwent MVD for HFS were enrolled. Information on clinical features, operative findings, and surgical outcomes over time were collected by performing a review of electronic medical records, and their relationships were analyzed. The outcomes of MVD at 1, 3, 6, and 9 months were individually compared against those at > 12 months after surgery.

Results The mean follow-up period after surgery was 44.9 months (median, 36.8 months; range, 12.0–156.6 months). The overall improvement rate for the 1341 patients was 89.0%. Individual postoperative outcomes at 6 and 9 months showed no differences with those at > 12 months after surgery. Furthermore, in the uni- and multi-variable analyses, patients in whom the offending vessels were intraoperatively determined to be veins showed bad outcomes at 6, 9, and > 12 months ($p = 0.048$, $p = 0.004$, and $p = 0.003$, respectively). Patients with intraoperative indentation on the facial nerve showed good outcomes at 6, 9, and > 12 months ($p = 0.005$, $p = 0.039$, and $p = 0.020$, respectively). Patients with delayed facial palsy after surgery showed better outcomes at 6, 9, and > 12 months ($p = 0.002$, $p = 0.003$, and $p = 0.028$, respectively).

Conclusions Short- and long-term outcomes of MVD in patients with HFS manifested differently, but the outcomes at 6 and 9 months showed similarities with those at > 12 months. In patients in whom the intraoperatively detected offending vessel was not a vein, and in patients with intraoperative indentation on the facial nerve and postoperative delayed facial palsy, good outcomes could be predicted after 6 months of surgery.

Keywords Hemifacial spasm · Microvascular decompression · Outcome · Prognosis

Introduction

Hemifacial spasm (HFS) is a disorder characterized by intermittent and involuntary contractions of facial muscles in the hemiface. This is caused by benign compression of the facial motor nerve by offending vessels that leads to increased nerve excitability, although the mechanism that causes hyperexcitability of the facial nerve is not well known [9]. Microvascular decompression (MVD) is a useful curative method for almost all patients with HFS [14, 18]. However, the postoperative course of MVD varies between patients, and the endpoint for confirming whether the outcome of a surgery is successful remains unclear. In a systemic review, the proportion of patients with total relief of spasms was between 85 and 90%. Relief was obtained after a certain delay in 25–41% of patients in many series. The delay lasted about 1 year in 12% of them [18]. Complete resolution of spasms after MVD was reported in 91.1% of patients during a median follow-up of 2.9 years, but spasms recurred in 2.4% of patients, and 1.2% experienced reoperation during the follow-up period [14].

Thus, the outcome of the surgery needs to be predicted as soon as possible to minimize the anxiety and discomfort of the patient and to determine if reoperation is necessary. To date, several studies have aimed to determine the optimal method of predicting the outcomes of surgery, determine the predictors,

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and recognize the optimal prediction time. However, these remain uncertain and are still controversial [1, 3, 4, 11, 13, 15, 17, 19, 22]. This study aimed to evaluate the clinical outcomes beyond 1 year postoperatively, in patients with HFS after MVD, compare the short- and long-term outcomes, determine the earliest optimal time for assessing the outcome, and identify the prognostic factors related to the outcomes over time.

Methods

Data were collected by reviewing the electronic medical records of 2151 consecutive patients who received MVD for HFS, performed by a single surgeon (K.P.), between July 2004 and January 2015. Of these patients, 1341 were selected, and the following patients were excluded: (a) 759 patients with a follow-up less than 1 year and (b) 51 patients who had immediate facial palsy after surgery due to iatrogenic injury. This study was approved by the Institutional Review Board of the hospital and did not require patient consent because the exemption criteria were met.

Patient outcomes were classified into 2 groups according to the postoperative course: improvement of spasm and persistence of spasm. Improvement assessment was based on a subjective evaluation of each patient and reflected no or minimal spasms (the occurrence of very infrequent spasms with emotional stress). Persistence of spasm was defined as a spasm that continued or improved, but eventually resumed. The outcomes were evaluated at the following times: 1, 3, 6, 9, and more than 12 months after surgery.

Factors associated with the outcome of MVD were divided and analyzed as follows: clinical features (age at surgery, age at symptom onset, sex, alcohol use, smoking history, hypertension, diabetes, hyperlipidemia, cerebrovascular disease, history of facial palsy, family history of HFS, affected side, duration of symptoms, degree of preoperative spasm, headache and tinnitus associated with spasms, preoperative facial palsy, prior botulinum toxin treatment, postoperative delayed facial palsy, and operation year) and surgical findings (offending vessel, number of offending vessels, compressive patterns, indentation on the facial nerve, discoloration of the nerve, and abnormal muscle responses). The degree of preoperative spasm was categorized into 4 groups: grade I, localized spasm around the periocular area; grade II, involuntary movement spreading to other parts of the ipsilateral face and affecting other muscle groups, including the orbicularis oris, zygomaticus, frontalis, or platysma muscle; grade III, interference with vision because of frequent tonic spasms; and grade IV, disfiguring asymmetry with continuous contractions of the orbicularis oculi muscles affecting the opening of the eye [6]. Surgical findings were obtained from operative records. The compressive pattern was as follows: loop type, the vascular loop itself without any contributing factors creates the compression; arachnoid type, thick arachnoid trabeculae between the vessel and the brainstem cause the vessel to be tethered tightly to the nerve; perforator type, perforating arteries from the compressing vessel cause compression by tethering the vessel to the brainstem; branch type, the nerve is caught between the compressing vessel and its branch; sandwich type, the nerve is sandwiched between two different vessels independently; and tandem type, one vessel compresses another vessel which, in turn, compresses the nerve [16].

Statistical analysis

The collected data were analyzed using SPSS version 25.0. The mean and standard deviation or the number and percentage of the clinical characteristics were obtained. The short- and long-term outcomes were compared using McNemar's test with Bonferroni correction to identify similarity. The relationships among the characteristics and the postoperative outcomes were analyzed using the logistic regression method.

Results

The mean follow-up period after surgery was 44.9 months, with a median of 36.8 months (range, 12.0–156.6 months). For the 1341 patients included in the study, 1193 (89.0%) exhibited an improvement of spasm after surgery, and 148 (11.0%) exhibited persistence of spasm. There were 327 male and 1014 female patients with a mean age of 51.0 years (range, 18–80 years). Postoperative delayed facial palsy was found in 124 of 1341 patients (9.2%). With regard to postoperative facial palsy, 44 of 51 patients (86.3%) with immediate facial palsy showed improvement. Whereas, 123 of 124 patients (99.2%) with delayed facial palsy showed improvement. Intraoperatively, the offending vessel, including a vein, was present in 7 patients (0.5%), and indentation on the facial nerve was identified in 1228 patients (91.6%). Additional clinical characteristics and surgical findings are detailed in Table 1.

Short-term and long-term outcomes

As shown in Table 2, 1074 patients (80.1%) exhibited improvement of spasm at 1 month after surgery, and 267 (19.9%) exhibited persistence of spasm. There was a difference between the postoperative outcomes at 1 month and more than 12 months ($p < 0.001$). At 3 months after surgery, 1138 (84.9%) exhibited improvement of spasm, and there was a difference with the outcomes more than 12 months after surgery ($p < 0.001$). At 6 months after surgery, 1170 (87.2%) exhibited improvement of spasm, and there was no difference

Table 1 Clinical characteristics and surgical findings ($N = 1341$)

Characteristics		*M* (SD)/*n* (%)
Clinical features		
Age at surgery		51.0 (10.48)
Age at symptom onset		45.7 (10.59)
Sex	Female	1014 (75.6)
	Male	327 (24.4)
Affected side	Left	706 (52.6)
	Right	635 (47.4)
Duration of symptoms (month)		63.1 (59.01)
Degree of preoperative spasm[a] (Missing values, 6)	Grade I, II	702 (52.3)
	Grade III, IV	633 (47.2)
Preoperative facial palsy	Yes	48 (3.6)
	No	1293 (96.4)
Prior botulinum toxin treatment	Yes	431 (32.1)
	No	910 (67.9)
Postoperative delayed facial palsy	Yes	124 (9.2)
	No	1217 (90.8)
Operation year	To 2012	955 (71.2)
	From 2013	386 (28.8)
Surgical findings		
Offending vessel	Including vein	7 (0.5)
	AICA, PICA, VA, etc.	1334 (99.5)
Compressive patterns[b]	Perforator type	243 (18.1)
	Loop, arachnoid type, etc.	1098 (81.9)
Indentation on the facial nerve	Yes	1228 (91.6)
	No or unknown	113 (8.4)
Discoloration of the nerve	Yes	456 (34.0)
	No or unknown	885 (66.0)
Abnormal muscle responses	Disappeared	1118 (83.4)
	Absent from the beginning, or not disappeared, or not measured	223 (16.6)

AICA anterior inferior cerebellar artery, *HFS* hemifacial spasm, *PICA* posterior inferior cerebellar artery, *VA* vertebral artery

[a] Degree of preoperative spasm: *grade I*, localized spasm around the periocular area; *grade II*, involuntary movement spreading to other parts of the ipsilateral face and affecting other muscle groups, including the orbicularis oris, zygomaticus, frontalis, or platysma muscle; *grade III*, interference with vision because of frequent tonic spasms; *grade IV*, disfiguring asymmetry with continuous contractions of the orbicularis oculi muscles affecting the opening of the eye [6]

[b] Compressive patterns: *loop type*, the vascular loop itself, without any contributing factors, creates the compression; *arachnoid type*, thick arachnoid trabeculae between the vessel and the brainstem cause the vessel to be tethered tightly to the nerve; *perforator type*, perforating arteries from the compressing vessel cause compression by tethering the vessel to the brainstem; *branch type*, the nerve is caught between the compressing vessel and its branch; *sandwich type*, the nerve is sandwiched between two different vessels independently; *tandem type*, one vessel compresses another vessel which, in turn, compresses the nerve [16]

with the outcomes more than 12 months after surgery ($p = 0.360$). At 9 months after surgery, 1184 (88.3%) exhibited improvement of spasm, and there was no difference with the outcomes more than 12 months after surgery ($p = 2.016$). These results indicate that short-term and long-term outcomes appear differently, but individual postoperative outcomes at 6 and 9 months showed similarities with those at more than 12 months after surgery. The similarities gradually increased from 79.3 to 89.3% over time. In addition, over time, the rates of spasm improvement gradually increased from 80.1 to 89.0%.

The patterns of postoperative outcome according to time were divided into 10 groups. Of 1074 patients who had improvement of spasm at 1 month postoperatively (early

Table 2 Comparison of short-term and long-term outcomes ($N = 1341$)

Outcome		More than 12 months, *n* (%)			*p*
		Improvement	Persistence	Total	
1 month	Improvement	995	79	1074 (80.1)	< 0.001
	Persistence	198	69	267 (19.9)	
3 months	Improvement	1057	81	1138 (84.9)	< 0.001
	Persistence	136	67	203 (15.1)	
6 months	Improvement	1097	73	1170 (87.2)	0.360
	Persistence	96	75	171 (12.8)	
9 months	Improvement	1117	67	1184 (88.3)	2.016
	Persistence	76	81	157 (11.7)	
	Total	1193 (89.0)	148 (11.0)	1341 (100.0)	

responders), 79 patients (7.4%) showed persistence of spasm at more than 12 months (late non-responders) and the spasms recurred at more than 12 months in 49 patients. On the contrary, of 267 patients who had persistence of spasm at 1 month postoperatively (early non-responders), 198 patients (74.2%) showed improvement of spasm at more than 12 months (late responders) and the spasms improved at 3 months in 89 patients. And of 267 early non-responders, 69 patients (25.8%) were unchangeably late non-responders (Fig. 1).

Prognostic factors

In uni-variable analyses, postoperative delayed facial palsy was associated with good outcomes at 1, 3, 6, 9, and more than 12 months postoperatively ($p < 0.001$, $p = 0.001$, $p = 0.002$, $p = 0.003$, and $p = 0.026$). The presence of a vein as an offending vessel intraoperatively was associated with bad outcomes at 6, 9, and more than 12 months ($p = 0.032$, $p = 0.002$, and $p = 0.002$). Intraoperative indentations on the facial nerve were associated with better outcomes at 6, 9, and more than 12 months after surgery ($p = 0.005$, $p = 0.041$, and $p = 0.020$). Duration of symptoms, degree of preoperative spasm, prior botulinum toxin treatment, and intraoperative abnormal muscle responses were not consistently significant (Table 3). Multi-variable analyses showed that the intraoperative offending vessel with or without a vein ($p = 0.048$, $p = 0.004$, and $p = 0.003$), intraoperative indentation on the facial nerve ($p = 0.005$, $p = 0.039$, and $p = 0.020$), and postoperative delayed facial palsy ($p = 0.002$, $p = 0.003$, and $p = 0.028$) significantly affected the postoperative outcomes at 6, 9, and more than 12 months after surgery (Table 4).

Discussion

As in many studies, in our previous study, we developed an algorithm to predict the outcome after MVD for HFS [8]. In this study, we tried to find out the earliest optimal time for assessing the outcome and the factors that can predict the postoperative outcome by increasing the follow-up period to 1 year as well as evaluating short-term and long-term outcomes.

Group (n)	1 month	3 months	6 months	9 months	≥12 months
1 (935)	-	-	-	-	-
2 (60)	-	+/-	+/-	+/-	-
3 (49)	-	-	-	-	+
4 (30)	-	+/-	+/-	+/-	+
5 (89)	+	-	-	-	-
6 (51)	+	+	+	+	+
7 (44)	+	+	-	-	-
8 (39)	+	+	+	+	-
9 (26)	+	+/-	+/-	+/-	-
10 (18)	+	+/-	+/-	+/-	+

Fig. 1 Patterns of postoperative outcome over time ($N = 1341$). Minus symbol, improvement of spasm; plus symbol, persistence of spasm; plus-minus symbol, improvement or persistence of spasm, with discontinuous patterns

Table 3 Association between each characteristic and postoperative outcome over time

Characteristics	Significance (p value in uni-variable analysis)				
	1 month	3 months	6 months	9 months	≥ 12 months
Clinical features					
Age at surgery	0.087	0.093	0.131	0.128	0.428
Age at symptom onset	0.216	0.328	0.359	0.553	0.301
Sex	0.513	0.425	0.278	0.215	0.853
Affected side	0.845	0.434	0.142	0.212	0.375
Duration of symptoms (year)	0.242	0.135	0.191	0.032*	0.533
Degree of preoperative spasm[a]	0.001*	0.062	0.062	0.041*	0.958
Preoperative facial palsy	0.370	0.021*	0.003*	0.050	0.427
Prior botulinum toxin treatment	0.231	0.038*	0.377	0.520	0.299
Postoperative delayed facial palsy	< 0.001*	0.001*	0.002*	0.003*	0.026*
Operation year	0.003*	0.001*	0.011*	0.057	0.099
Surgical findings					
Offending vessel	0.147	0.059	0.032*	0.002*	0.002*
Compressive patterns[b]	0.007*	0.125	0.673	0.749	0.388
Indentation on the facial nerve	0.902	0.428	0.005*	0.041*	0.020*
Discoloration of the nerve	0.796	0.751	0.055	0.186	0.005*
Abnormal muscle responses	0.304	0.093	0.150	0.025*	0.136

*$p < 0.05$

[a] Degree of preoperative spasm: grade I, localized spasm around the periocular area; grade II, involuntary movement spreading to other parts of the ipsilateral face and affecting other muscle groups, including the orbicularis oris, zygomaticus, frontalis, or platysma muscle; grade III, interference with vision because of frequent tonic spasms; grade IV, disfiguring asymmetry with continuous contractions of the orbicularis oculi muscles affecting the opening of the eye [6]

[b] Compressive patterns: loop type, the vascular loop itself without any contributing factors creates the compression; arachnoid type, thick arachnoid trabeculae between the vessel and the brainstem cause the vessel to be tethered tightly to the nerve; perforator type, perforating arteries from the compressing vessel cause compression by tethering the vessel to the brainstem; branch type, the nerve is caught between the compressing vessel and its branch; sandwich type, the nerve is sandwiched between two different vessels independently; tandem type, one vessel compresses another vessel which, in turn, compresses the nerve [16]

Most importantly, we evaluated the clinical outcomes of patients with HFS after MVD over time to compare short-term outcomes with long-term outcomes and find the earliest optimal time for assessing the outcomes. Kim et al. [5] reported that a follow-up period of at least 3 months following MVD should be required in order to predict the prognosis of MVD for HFS. We compared the outcomes of 1, 3, 6, and 9 months after surgery with those of more than 12 months. The results revealed that similarities existed between the outcomes of 6 and 9 months and those of more than 12 months each other. These results indicate that the outcomes before 6 months vary significantly, the outcomes within a short period of time can change, and it is difficult to predict the final result in a short timeframe. On the other hand, we found that the similarities and the cumulative improvement rates of spasm according to the length of time gradually increased from 79.3 to 89.3% and from 80.1 to 89.0%, respectively. Furthermore, 7.4% of early responders became late non-responders and 74.2% of early non-responders became late responders. Thus, we suggest that surgeons wait 1 year to determine the postoperative results, even if the short-term results are unsatisfactory.

In this study, we found that the offending vessel, including a vein, was an important classifier that was able to predict patient outcomes at 6, 9, and more than 12 months after surgery. Wang et al. reported that a vein can play an important role and can be the offending vessel in MVD for HFS, even though HFS caused by a venous offender is rare [21]. Furthermore, other previous studies demonstrated that venous compression may correlate with worse prognosis, even with thorough decompression in HFS [15, 20]. Therefore, we propose that careful exploration for offending vessels is needed to avoid surgical failure.

With regard to intraoperative indentation on the facial nerve, most previous studies have reported that severe indentation on the root exit zone is closely associated with postoperative improvement [2, 4, 8, 10, 13]. In our study, patients with indentation on the nerve showed a better outcome at 6, 9, and more than 12 months after surgery. The improved results

Table 4 Multi-variable analysis of prognostic factors after 6 months of surgery

Characteristics (reference group)		Estimate	Standard error	Wald	Significance	Odds ratio
Offending vessel[a], Vein (etc.)	6 months	− 1.528	0.774	3.897	0.048*	0.217
	9 months	− 2.223	0.772	8.292	0.004*	0.108
	≥ 12 months	− 2.317	0.773	8.985	0.003*	0.099
Indentation on the facial nerve, Yes (no or unknown)	6 months	0.704	0.249	7.979	0.005*	2.023
	9 months	0.551	0.267	4.268	0.039*	1.734
	≥ 12 months	0.620	0.267	5.406	0.020*	1.859
Postoperative delayed facial palsy, Yes (No)	6 months	1.871	0.591	10.021	0.002*	6.496
	9 months	1.755	0.591	8.807	0.003*	5.782
	≥ 12 months	0.943	0.429	4.834	0.028*	2.567

Reference group: persistence of spasm

*$p < 0.05$

[a] Offending vessel: vein, anterior inferior cerebellar artery (AICA), posterior inferior cerebellar artery (PICA), vertebral artery (VA), etc.

observed for cases of indentation on the nerve might be attributed to the fact that indentation is evidence of definitive compression by an offending vessel. Thus, it is necessary to identify indentation on the facial nerve during the surgery.

Patients who exhibited delayed facial palsy after surgery constantly experienced an excellent outcome at 1, 3, 6, 9, and more than 12 months postoperatively. Previous studies also reported that significantly better results were observed in the patients with delayed facial palsy than in those without delayed facial palsy in terms of the overall disappearance of HFS [7, 8]. Lee et al. proposed that the occurrence of delayed facial palsy is due to manipulations or the gradual development of postoperative edema [7]. Although the causes of delayed facial palsy postoperatively are unknown, 6.5–14.5% of the patients who underwent MVD experienced it, and most patients showed complete recovery [7, 12]. Therefore, it is important to inform patients of the possibility of delayed facial palsy after surgery and to enhance psychological stability by reassuring patients that it can completely resolve and become a beneficial prognostic factor for postoperative spasm patterns.

As mentioned earlier, the postoperative course of MVD for HFS is extremely diverse before 6 months, and a vein as an offending vessel, indentation on the facial nerve intraoperatively, and postoperative delayed facial palsy were the prognostic factors to predict initial postoperative outcomes over 6 months after surgery. We believe that these results will help to make decisions when evaluating and reassuring patients or considering reoperation. The present study has several limitations. First, this study was inherently biased due to its retrospective nature. Second, the indicator for evaluating the postoperative outcomes was based on the subjective description of individual patients. Third, the postoperative follow-up period varied.

Conclusions

In this study, short-term and long-term outcomes after MVD in HFS patients were different. However, the outcomes at 6 and 9 months showed similarities with those at more than 12 months after surgery. In addition, we found that the vein not being the intraoperatively detected offending vessel, intraoperative indentation on the facial nerve, and postoperative delayed facial palsy were stronger favorable prognostic factors for more than 6 months postoperatively. Thus, if these criteria are met, initial good outcomes can be predicted after 6 months of surgery.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflicts of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee (Institutional Review Board of Samsung Medical Center/SMC 2015-12-102) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. For this type of study, formal consent is not required.

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