



Prognostic and Clinical Role of Contrast Enhancement on Magnetic Resonance Imaging in Patients with Bell's Palsy

Original Investigation

Volkan Yücel¹, Serra Özbal Güneş², Kemal Keseroğlu¹, Ömer Bayır¹, Mehmet Furkan Çırakoğlu¹, Emel Çadallı Tatar¹, Güleser Saylam¹, Sevilay Karahan³, Orhan Yılmaz¹, Mehmet Hakan Korkmaz¹

¹Department of Otorhinolaryngology, Dışkapı Yıldırım Beyazıt Training and Research Hospital, University of Health Sciences Turkey, Ankara, Turkey

²Department of Radiology, Dışkapı Yıldırım Beyazıt Training and Research Hospital, University of Health Sciences Turkey, Ankara, Turkey

³Department of Biostatistics, Hacettepe University Faculty of Medicine, Ankara, Turkey

Abstract

ORCID ID of the authors:

V.Y. 0000-0003-4364-6138;
S.Ö.G. 0000-0003-1019-9925;
K.K. 0000-0002-6589-1663;
Ö.B. 0000-0001-9445-6129;
M.F.Ç. 0000-0002-2554-2928;
E.Ç.T. 0000-0003-3365-6308;
G.S. 0000-0002-6499-7140;
S.K. 0000-0002-8692-7266;
O.Y. 0000-0003-2254-1361;
M.H.K. 0000-0001-8732-3061.

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Objective: To investigate the prognostic value of the magnetic resonance imaging in Bell's palsy patients.

Methods: Patients who were diagnosed and treated with Bell's palsy between October 2013 and March 2016 retrospectively selected. House–Brackmann grades, pre- and post-treatment pure tone audiograms, stapedial reflexes were analyzed and magnetic resonance imaging (MRI) scans with gadolinium-based contrast agents were evaluated. Contrast-enhanced segments of the facial nerve were determined. MRI findings were compared statistically with pre- and post-treatment grade, recurrence rate of Bell's palsy, MRI scanning timing, presence of stapes reflexes and posttreatment recovery data.

Results: No significant correlation was observed between pretreatment House–Brackmann grades and enhancement ($p>0.05$). Similarly, there was no significant correlation between clinical recovery and enhancement ($p>0.05$). Also, no significant correlation was observed between MRI scanning time, the recurrence rate of Bell's palsy and MRI findings ($p>0.05$). None of the MRIs showed neoplastic contrast enhancement.

Conclusion: The routine use of the contrast-enhanced temporal MRI is not recommended in the diagnosis and monitoring of Bell's palsy patients, because the contrast enhancement pattern of the facial nerve has no effect on the prognosis of Bell's palsy. MRI should be used in cases that do not heal despite treatment, for the differential diagnosis of facial nerve tumors and in patients who are candidates for surgical decompression.

Keywords: Bell's palsy, facial nerve, magnetic resonance imaging, gadolinium DTPA, prognosis, temporal bone, radiology, acoustic reflex

Corresponding Author:

Volkan Yücel;
volkanyucel58@gmail.com

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Introduction

The most common cause of the sudden onset unilateral facial weakness is Bell's palsy (BP) (1). BP accounts for approximately 80% of all peripheral facial

palsy cases (2). The incidence of BP is 20 to 30 cases per 100,000 adults per year (1). The etiology of BP is unknown, but viral infections, microvascular ischemic pathologies and autoimmune diseases have been proposed as possible mechanisms (3).

The facial nerve has a long and tortuous intratemporal course between the internal acoustic meatus and stylomastoid foramen. Therefore, the spread of inflammation and edema around the nerve is known to play a major role in the pathophysiology of BP as it leads to the blockage of axonal flow as a result of the compression within the bony canal (3).

Modern imaging techniques play an important role to evaluate the etiology of peripheral facial paralysis. Computerized tomography (CT) and magnetic resonance imaging (MRI) are the commonly used imaging techniques to evaluate patients with facial paralysis. While MRI is often used as the imaging modality in the diagnosis of possible inflammatory and tumoral causes, CT is often used to assess the temporal bone in trauma, otitis media, and preoperative evaluation (4). Compared with other imaging modalities, MRI provides more accurate results in detecting the neural damage. Gadolinium, a paramagnetic imaging agent, causes enhancement of T1-weighted signal intensity. Contrast material is primarily distributed in extracellular fluid and its effect is mostly notable in areas where an increased extracellular compartment is found such as neoplasm, inflammation, and edema (5). The most common pattern of facial nerve enhancement in patients with facial palsy has been reported to be at the distal intracanalicular and LS segments (2). Some studies report that the presence and spread of neural enhancement correlate with the duration and prognosis of the disease (2).

In the presented study we aimed to assess the clinical significance and the prognostic value of quantitative analysis of MRI in terms of contrast enhancement in patients with BP.

Methods

Patients with idiopathic peripheral facial nerve palsy (BP) who were treated between October 2013 and March 2016 in a tertiary referral center were retrospectively reviewed. Approval was obtained from the Ethical Committee of Dışkapı Yıldırım Beyazıt Training and Research Hospital before commencing the study (decision no: 33/16, date: 12.12.2016).

Complete neurotologic examination records of all patients were reviewed. Patients with otologic diseases, otologic and cranial operation history, autoimmune and rheumatologic diseases, acoustic trauma, and head trauma were excluded from the study. At first admission audiological tests (pure tone audiometry and stapedial reflex test) were performed and facial palsy was graded clinically according to the House–Brackmann (HB) grading system. All patients were treated with methylprednisolone therapy. On the first day of diagnosis, 250 mg methylprednisolone intravenous infusion was administered. In the following days, 1 mg/kg oral methylprednisolone was started, and the dose was decreased 16 mg every three days and the treatment continued for two

weeks. We evaluated the progress of the disease and the final recovery for each patient. Recovery was accepted as at least one step improvement in the clinical grade of BP.

First, patients were classified clinically as primary and recurrent. Contrast enhancement rates between the two groups were compared. Then, patients with recurrent palsy were excluded, and other parameters were examined in primary patients. We compared MRI contrast enhancement patterns based on MRI examination time, HB grade, facial palsy, stapes reflexes and recovery rate after treatment.

All patients had been examined with 1.5-Tesla MRI device (Siemens, Magnetom Vision Plus VB33D, Erlangen, Germany). MRI was taken in coronal and axial planes using T1 sequences and T1-weighted postcontrast examination immediately after intravenous gadolinium-diethylenetriamine penta-acetic acid (Gd-DTPA) injection. On MRI scans specific anatomical segments of the facial nerve were determined and labeled as distal intrameatal (DIS), labyrinthine (LS), geniculate ganglion (GG), tympanic (TS), or mastoid (MS) segment of the facial nerve. Then each segment was assessed by the radiologist for the presence or absence of contrast enhancement (Figure 1). Enhancement results were recorded as positive or negative for each segment. All the images were examined by the same radiologist who was blind to the clinical grade of the facial palsy and the disease side.

Statistical Analysis

Standard deviation (SD), median, and rate values were used in the descriptive statistics of data. For qualitative data analysis, Pearson's chi-square test was used. A p-value less than 0.05 was considered significant. The Statistical Package for the Social Sciences for Windows, version 23.0 software program (Armonk, NY: IBM Corp.) was used.

Results

There were 81 female and 69 male patients with a mean age of 48 (18–85) years. Facial palsy was on the left side in 78 and on the right side in 72 patients. The average follow-up period was calculated as 7.1 ± 1.9 (2 to 15) months. Mean time from the onset of the palsy to the Gd-MRI examination was 9.81 days (range: 1–60 days). Forty-three patients had enhancement of the facial nerve on postcontrast images (27.7%).

It was the first attack of facial palsy for 127 patients and 23 patients had previous history. Nine of the recurrences were on the ipsilateral side and 14 were on the contralateral side. Fifteen of the patients with recurrent palsy were female and eight were male, with a mean age of 51 (22–80) years. Patients with recurrent palsy had fully recovered from the previous paralysis. Their average recurrence time was three years. The relationship between the recurrence of facial

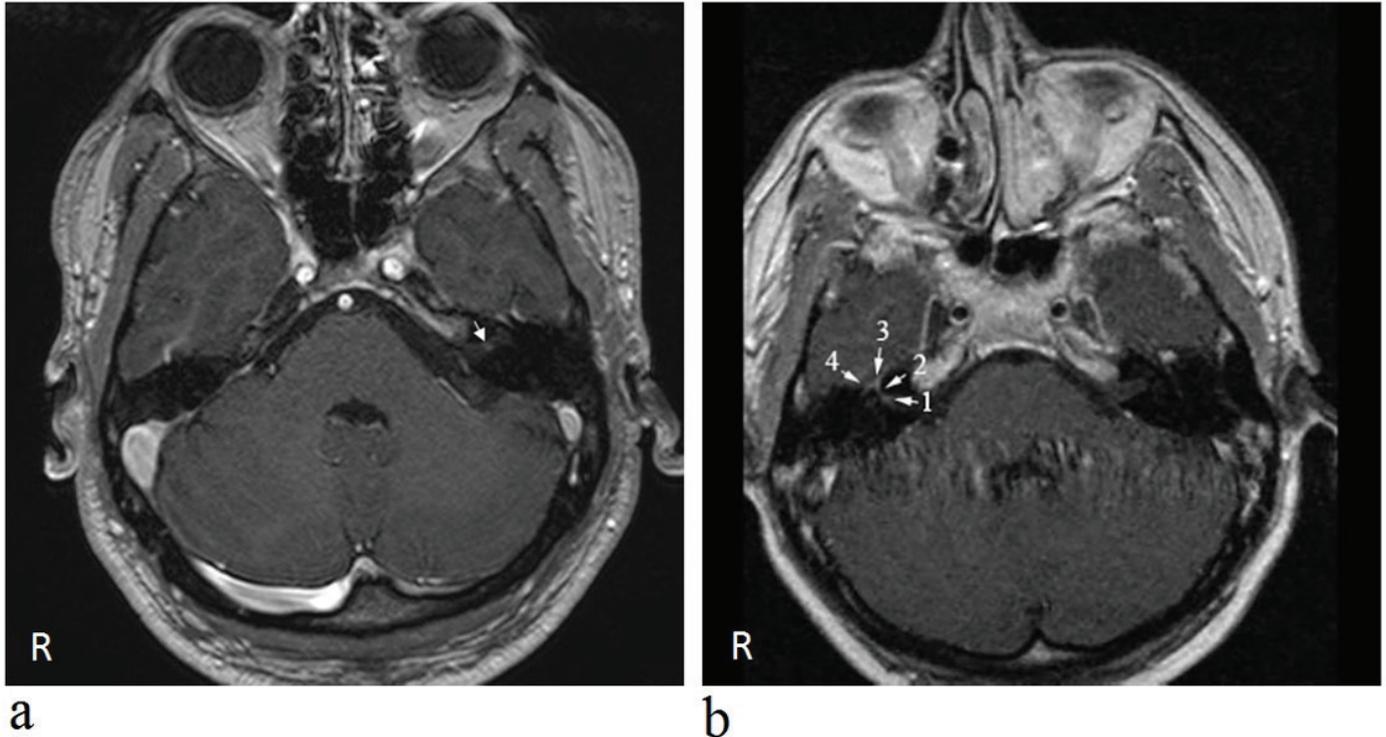


Figure 1. Contrast enhancement on T1-weighted axial MRI images a) Contrast enhancement of the left distal intrameatal segment, b) Contrast enhancement of right distal intrameatal (1), labyrinthine (2), geniculate ganglion (3) and tympanic segments (4) of another patient
MRI: Magnetic resonance imaging

paralysis and the facial nerve contrast enhancement on MRI was evaluated. Facial nerve enhancement was observed 29.1% in patients with first attack, whereas this rate was 26.1% in recurrent cases. The difference between the two groups was not statistically significant ($p=0.963$) (Table 1).

Patients with recurrent palsy were excluded and the enhancement distribution in the facial nerve segments of the primary patients was examined. Enhancement was observed in 37 of the 127 patients. While 18 of them had single segment involvement, 19 patients showed enhancement in more than one segment. The DIS segment was the most enhanced segment followed by LS, GG, TS, and MS, respectively (Table 2).

HB grade for primary cases were as follows: 54 patients grade II, 44 patients grade III, 12 patients grade IV, 13 patients grade V, and 4 patients grade VI. Pretreatment HB grade of the patients and facial nerve contrast enhancement rates on MRI were compared. There was no statistically significant relationship between HB grade and contrast enhancement ($p=0.868$) (Table 3). Pretreatment HB grade of disease was categorized as early and advanced. One hundred ten patients were in the early stage (HB II-III-IV) and 17 were in the advanced stage (HB V-VI). Then, the relationship between the early or late stage of the disease and the enhancement on MRI was evaluated. There was no statistically significant relationship between early or advanced stage disease and

Table 1. Relationship between contrast enhancement and facial paralysis recurrence

		Contrast enhancement		p-value
		-	+	
	First attack	n 90	37	
		% 70.9	29.1	
Facial paralysis recurrence	Same side recurrent	n 6	3	0.784
		% 66.7	33.3	
	Opposite side recurrent	n 11	3	
		% 78.6	21.4	

contrast enhancement ($p=0.573$) (Table 3). Further, we evaluated the relationship between the HB grade and the contrast enhancement of the single or multiple facial nerve segment. There was no statistically significant relationship between HB grade and single or multiple segment enhancement ($p=0.794$) (Table 4).

At first admission of the patients, stapedial reflex test was performed and the relationship between stapedial reflex and contrast enhancement on MRI was evaluated. Stapedial reflex was positive in 71 (55.9%) patients and negative in 56 (44.1%). Contrast enhancement was observed in 31.0% of the stapes reflex positive cases, whereas this rate was 26.8% in stapes reflex negative cases. The difference between the two groups was not statistically significant ($p=0.749$) (Table 5).

Table 2. Contrast enhancement of primary cases according to facial nerve segments and distribution of contrast enhanced facial nerve segments

Contrast enhanced facial nerve segment	n (%)	Contrast enhanced facial nerve segment	
		n (%)	
No enhancement	90 (70.9)	1	32 (86.5)
1	15 (11.8)	2	22 (59.5)
1,2	5 (3.9)	3	14 (37.8)
1,2,3	6 (4.7)	4	8 (21.6)
1,2,3,4	3 (2.4)	5	3 (8.1)
1,2,3,4,5	3 (2.4)	-	-
2	3 (2.4)	-	-
2,3,4	2 (1.6)	-	-

1: Distal intrameatal segment, 2: Labyrinthine segment, 3: Geniculate ganglion, 4: Tympanic segment, 5: Mastoid segment

Table 3. Relationship between contrast enhancement and pretreatment HB grade of primary cases

	Pretreatment HB grade		Contrast enhancement		p-value
			-	+	
			n		
II	n	38	16	0.868	
	%	70.4	29.6		
III	n	33	11		
	%	75.0	25.0		
IV	n	8	4		
	%	66.7	33.3		
V	n	9	4	0.573	
	%	69.2	30.8		
VI	n	2	2		
	%	50.0	50.0		
Early grade (HB II-III-IV)	n	79	31		
	%	71.8	28.2		
Advanced grade (HB V-VI)	n	11	6	0.573	
	%	64.7	35.3		

HB: House-Brackmann

The correlation between the post-treatment recovery rate of the patients and contrast enhancement on MRI was evaluated. During follow-up 119 patients showed improvement clinically and eight patients did not. While improvement was observed in 35 of the 37 patients with enhancement on MRI, improvement was observed in 84 of the 90 patients without enhancement. The difference between the two groups was not statistically significant (p=1.000) (Table 5).

The relationship between the time to MRI examination from the onset of the disease and the pathological facial nerve contrast examination was evaluated. Median time to MRI examination was seven days (mean: 9.81, SD:

Table 4. Relationship between pretreatment HB grade and contrast enhancement of single or multiple facial nerve segment

	Pretreatment HB grade		Contrast enhancement			p-value
			-	Single segment	Multiple segments	
			n			
II	n	38	10	6	0.794	
	%	70.4	18.5	11.1		
III	n	33	4	7		
	%	75.0	9.1	15.9		
IV	n	8	2	2		
	%	66.7	16.7	16.7		
V	n	9	2	2	0.794	
	%	69.2	15.4	15.4		
VI	n	2	0	2	0.794	
	%	50.0	0.0	50.0		

HB: House-Brackmann

Table 5. Relationship between pretreatment HB grade and contrast enhancement of single or multiple facial nerve segments on the MRIs done in the first seven days

	Pretreatment HB grade		Contrast enhancement			p-value
			-	Single segment	Multiple segments	
			n			
II	n	23	4	5	0.658	
	%	71.9	12.5	15.6		
III	n	16	3	1		
	%	80.0	15.0	5.0		
IV	n	6	2	1		0.658
	%	66.7	22.2	11.1		
V	n	7	0	1	0.658	
	%	87.5	0.0	12.5		
VI	n	2	0	1	0.658	
	%	66.7	0.0	33.3		
Total %	n	54	9	9	0.658	
	%	75.0	12.5	12.5		

HB: House-Brackmann, MRI: Magnetic resonance imaging

9.62). We compared contrast enhancement on MRIs done in the first seven days and after the 7th day. There was no statistically significant difference between the two groups (p=0.329) (Table 6). We then examined the relationship of the contrast enhancement with pretreatment HB grade in patients who had their MRI in the first seven days. There was no statistically significant relationship between HB grade and contrast enhancement (p=0.658) (Table 6). The impact of contrast enhancement on the recovery rate was also analyzed in patients who had MRI in the first seven days. Recovery ratios were 88.9% and 92.6% in the enhancement positive and enhancement negative groups, respectively. The difference between the two groups was not statistically significant (p=0.636) (Table 6).

Table 6. Relationship between contrast enhancement and MRI examination time and relationship between contrast enhancement and pretreatment HB grade and recovery rates of patients who underwent MRI in the first 7 days

		Contrast enhancement				p-value		
		-		+				
MRI examination time	0-7 days	n	54	18		0.329		
		%	75.0	25.0				
	>7 days	n	36	19				
		%	65.5	34.5				
Patients with MRI in the first 7 days								
		Contrast enhancement				p-value		
		-		+				
Pretreatment HB grade	II	n	23	9		0.658		
		%	71.9	28.1				
	III	n	16	4				
		%	80.0	20				
	IV	n	6	3				
		%	66.7	33.3				
	V	n	7	1				
		%	87.5	12.5				
	VI	n	2	1				
		%	66.7	33.3				
			Contrast enhancement				p-value	
			-		+			
		n	%	n	%			
		66.7	75.8	33.3	24.2			
Recovery after treatment	-	4	7.4	2	11.1	0.636		
	+	50	92.6	16	88.9			

HB: House-Brackmann, MRI: Magnetic resonance imaging

Discussion

BP is a peripheral facial nerve palsy accompanied by any identifiable disease or external injury. It is the most frequently encountered type of peripheral facial nerve palsy and is thought to be mainly due to viral infections (1). The imaging method for the facial nerve disorders should be selected according to the suspected type and location of the pathology. Patients with BP generally have no abnormality in the bony canal of the facial nerve, therefore usually no pathological findings are seen on the temporal bone in CT (3, 6, 7). Thus, contrast enhanced MRI is mostly used by clinicians to evaluate any inflammation or tumorigenesis around the facial nerve for differential diagnosis (3, 8).

In MRI, gadolinium is used as the contrast agent to evaluate the facial nerve and the enhancement pattern is evaluated in T1-weighted series. Gadolinium mostly penetrates extracellular fluid. Although gadolinium cannot pass into the cranial nerves under normal conditions, it can penetrate through blood vessels in the presence of inflammation or

edema, resulting in nerve enhancement (5, 8, 9). However, there are studies showing that there may be contrast enhancement in a facial nerve with normal functions (8, 10). In BP patients, MRI is used to gain insight into the severity and prognosis of the disease and to rule out possible tumoral pathologies by evaluating how much contrast enhancement each segment shows. Based on the hypothesis that facial nerve edema and inflammation increase the severity of facial paralysis, the increase in contrast enhancement on MRI may be correlated with the severity of facial paralysis (5, 9, 11). MRI can also reveal an enlargement of the facial nerve, a condition that is also seen in a neoplastic process. Facial nerve schwannomas appear as well-circumscribed round or fusiform soft tissue masses with low to intermediate signal intensity on T1 images, and after gadolinium injection show moderate to intense enhancement along the course of the facial nerve (cerebellopontine angle, internal auditory meatus, LS segment, GG, TS or MS segments and within the parotid gland) (6, 12).

In the light of this information, we investigated the effectiveness of temporal MRI in evaluating the severity and the prognosis of BP. For this purpose, we examined the facial nerve enhancement patterns on the temporal MRI scans of 150 patients who were treated for BP. Of these, 127 were primary and 23 were recurrent BP patients. There were no significant differences in contrast enhancement between primary and patients with recurrent palsy, but patients with recurrent palsy were excluded from the study to avoid bias. MRI scans of only 29.1% of the primary patients showed contrast enhancement. In fact, even this value alone raises suspicion about how suitable temporal MRI is for evaluating patients with BP; as contrast enhancement was seen in approximately one-fourths of the 127 patients, while there were no pathologies in the temporal MRI of the remaining 90 patients. None of the temporal bone MRIs showed a facial nerve tumor.

Recent studies on the benefit of temporal MRI in determining the prognosis of BP report confusing results. There are studies reporting that the presence and the spread of neural enhancement correlate with the duration and the prognosis of the disease (2, 10). According to the study of Yetiser et al. (2), there is a strong correlation between the presence of enhancement and the delay of recovery, and furthermore, involvement of more than one segment negatively affects the recovery. According to Sartoretti-Schefer et al. (10), the presence and the extent of enhancement are closely related to the duration and the outcome of the disease. It is worth noting that both studies have low numbers of cases. However, some studies also show that MRI did not have an association with the severity, the course, and the recovery of the disease (5, 8, 13, 14). In addition, there are studies in the literature that show that enhancement could occur even in normally functioning facial nerves. According to Gebarski

et al. (15) the geniculate, TS, and MS segments of the facial nerve have peri- and epineural venous plexus, so they can show enhancement under normal conditions. They found enhancement in 142 (76%) of 186 normal facial nerves in their study.

As known, prognosis is expected to be worse in advanced stage BP patients. We examined whether or not there were any differences in contrast enhancement in MRI according to the stages of the disease. We thought that there could be more contrast enhancement or enhancement in more segments in advanced stage patients. For this purpose, we first examined the contrast enhancement status in MRIs in all stages one by one and in early stage (HB II, III, IV) and advanced stage (HB V, VI) patients, and we did not see any statistically significant differences between the stages of the disease in terms of enhancement. In the literature, there are studies showing that involvement of multiple segments in MRI were related with the severity of the disease and prognosis in patients with BP (2, 10). In our study, we grouped patients as single segment and multiple segments involvement according to contrast enhancement on MRI and evaluated the relationship with the severity of the disease according to the HB staging. There were no statistically significant differences between single or multiple segments involvement and the severity of the disease. The relationship between post-treatment recovery rates and facial nerve enhancement seen on MRI was another issue we looked into in terms of the prognosis of BP.

In our study, facial nerve enhancement was observed in two of eight patients without clinical recovery and 35 of 119 patients with recovery after treatment. Thus, these results showed no statistically significant correlation between the enhancement of MRI and the recovery of BP. According to these results, we think that enhancement has no effect on prognosis and final outcome of the disease.

Time from the onset of palsy to MRI examination was considered to be another factor that could affect contrast enhancement on temporal MRI. It was deemed that there could be decreased contrast enhancement as the time from the onset of the disease increased, since the inflammation of the facial nerve would be alleviated by the treatment (5). There is also a study suggesting that enhancement could increase as the time to MRI is delayed (16). In our study, analysis of the time to MRI examination showed a median value of seven days. Presence of MRI enhancement was calculated as 25.9% in the first seven days after the onset of the disease and 32.3% after the seventh day. There was no statistically significant difference between the two groups, and it was concluded that the time to MRI examination had no correlation with facial nerve enhancement. Considering that the time to MRI could have an effect on enhancement and that the MRI times spanned a wide range, we wanted

to analyze only those patients who had their MRIs done in the first seven days. There were no statistically significant differences between the clinical stages and the contrast enhancement rates of these patients. Moreover, there were no significant differences between the recovery rates and enhancement rates of this patient group. As a result, we do not recommend early detection with MRI since the time to MRI has no significant clinical benefits.

The stapes reflex is a diagnostic method that is frequently used in the clinical evaluation of BP patients, and it can be negative or positive. There are studies showing that this difference had an influence on prognosis, and prognosis is thought to be worse when stapes reflex is negative (17, 18). We could not find a study in the literature that investigated the relationship between stapes reflex and enhancement in MRI. We thought that in patients with negative stapes reflex, enhancement rate and spread could be higher because of the worse prognosis of the disease. Therefore, the relationship between stapes reflex and contrast enhancement on temporal MRI was evaluated. In our study, pretreatment stapes reflex was evaluated and found positive in 55.9% and negative in 44.1% of the patients. In cases with positive stapes reflex, 31.0% of the cases had contrast enhancement, whereas for those with negative stapes reflex it was 26.8%. The difference between the two groups was not statistically significant. We did not find that the stapes reflex had any effect on contrast enhancement. This result showed us that there were no relationships between enhancement on MRI and prognosis and the course of the disease. Two recently published clinical guidelines on the diagnosis, treatment and follow-up of BP, supporting our results, emphasize that routine MRI should not be performed in BP patients for clinical follow-up (19, 20).

There are some limitations of our study. The first and most important of these is that the imaging of the patients were made with a 1.5-Tesla MRI. More detailed and reliable results can be obtained in studies with the 3-Tesla MRI. Burmeister et al. (21) examined facial nerve enhancement in more detail in their studies using 3 Tesla MRI, but they showed that even this did not have a significant effect on predicting prognosis. In addition, contrast enhancement on MRI was evaluated by a single radiologist in our study. This evaluation may vary according to the experience of the radiologist (22). Lastly, this was a retrospective study and there was no standard MRI examination time. More accurate results may be obtained by conducting a prospective study with a larger patient group and standardized times to MRI.

Conclusion

In our study, the rate of contrast enhancement on MRI was extremely low and there were no statistically significant

relationships between contrast enhancement and the grade and the prognosis of the disease. Therefore, routine use of contrast-enhanced temporal MRI is not recommended in the initial phase of BP patients. Also, no facial nerve tumor was detected in our temporal bone MRIs. MRI should be used for nonhealing and progressive disease despite treatment, for the differential diagnosis of facial nerve tumors, and for patients who are candidates of surgical decompression.

Ethics Committee Approval: For this study ethics committee approval (decision no: 33/16, date: 12.12.2016) was obtained from the Ethical Committee of Dışkapı Yıldırım Beyazıt Training and Research Hospital, Ankara, Turkey.

Informed Consent: Informed consent was obtained from all individual participants included in the study.

Peer-review: Externally and internally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: V.Y., K.K., M.F.Ç., Concept: V.Y., Ö.B., O.Y., Design: V.Y., K.K., E.Ç.T., G.S., M.H.K., Data Collection and/or Processing: V.Y., S.Ö.G., S.K., Analysis and/or Interpretation: V.Y., S.Ö.G., S.K., Literature Search: V.Y., K.K., Ö.B., M.F.Ç., Writing: V.Y.

Conflict of Interest: The authors have no conflicts of interest to declare.

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Main Points

- Bell's palsy is the most common cause of sudden onset unilateral facial weakness.
- Magnetic resonance imaging is one of the most commonly performed examination in Bell's palsy.
- The aim of our study was to investigate the prognostic value of magnetic resonance imaging in patients with Bell's palsy.
- The routine use of contrast-enhanced temporal MRI is not recommended in the diagnosis and monitoring of Bell's palsy patients, because the contrast enhancement pattern of the facial nerve has no effect on the prognosis of Bell's palsy.
- MRI should be used in cases that do not heal despite treatment, for the differential diagnosis of facial nerve tumors, and in patients who are the candidates for surgical decompression.

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