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The Value of Diffusion Tensor Imaging in Evaluation of Patients with Bell's Palsy

ABSTRACT

Background: The aim of this study is to evaluate whether there is any correlation among House–Brackmann scoring, electroneuronography, and diffusion tensor imaging values of the cisternal and internal auditory canal segment of facial nerve and to examine diagnostic, prognostic, and grading usefulness of diffusion tensor imaging in patients with Bell's palsy.

Methods: Thirty-seven patients over 18 years old finally diagnosed as having Bell's palsy were enrolled in this study. House–Brackmann scoring, electroneuronography, and diffusion tensor imaging were performed at 3-5 and 21-24 days of Bell's palsy onset. The data of diffusion tensor imaging were extracted from a line that starts from the cerebellopontine angle, extends to internal auditory canal, and covers the facial and vestibulocochlear nerve complex using manual or line tractography.

Results: The apparent diffusion coefficient values of the affected nerve complexes measured in initial diffusion tensor imaging studies were significantly higher than those of contralateral nerve complexes ($P < .05$). The fractional anisotropy values of the affected nerve complexes were also significantly lower than those of contralateral nerve complexes ($P < .05$). The initial fractional anisotropy values were negatively correlated with initial House–Brackmann scoring ($r = -0.35$; $P < .05$) and degeneration indexes of orbicularis oculi and oris muscles ($r = -0.36$; $P < .05$, $r = -0.35$; $P < .05$, respectively).

Conclusion: Diffusion tensor imaging is giving us beneficial data for understanding the pathophysiology of Bell's palsy in the acute stage of the disease. House–Brackmann scale and electroneuronography are still the most reliable prognostic and diagnostic tools for patients with Bell's palsy. Clinical improvement in facial paralysis of patients with Bell's palsy does not mean radiologic amelioration in diffusion tensor imaging.

Keywords: Bell's palsy, diffusion tensor imaging, electroneuronography, prognosis, House–Brackmann scale, peripheral facial paralysis

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INTRODUCTION

Acute unilateral peripheral facial paralysis (AUPFP) is a rarely encountered disease with an annual incidence of 15-20 per 100 000 with 40 000 new cases each year in the United States.[1] In most cases, the exact etiology of facial paralysis cannot be determined and these cases are diagnosed as Bell's palsy (BP).[2] It has been hypothesized that reactivation of herpes simplex virus type 1 might be associated with BP.[3] Abnormal eyebrow position and movement, eyelid closure issues, facial asymmetry, speech, and articulation problems caused by oral dysfunction are the main problems of peripheral facial paralysis. House–Brackmann scoring (HBS) has been developed to provide an objective and reliable grading method to measure facial nerve (FN) function.[4] American Academy of Otolaryngology–Head and Neck Surgery has accepted HBS as the preferred method since 1984.[5] In patients with acute facial paralysis, estimating the time to complete recovery is a challenge. In fact, many researchers focused on developing prognostic tests. Esslen[6] introduced the use of electroneuronography (ENoG) in which the percentage of fibers that have degenerated is detected. Many studies have been performed to assess the prognostic value of ENoG in acute facial paralysis.[7-11] Electroneuronography is often performed by neurologists at 3 and 21 days after the onset of facial paralysis.[12] After the maximal transcutaneous stimulation of the common trunk of FN, the amplitude of the compound muscle action potential

Table 1. House–Brackmann Score (HBS) to Grade the Severity of Facial Nerve Palsy by Assessing Motility of Forehead, Eye, Nose, and Mouth as I-VI (4)

Grade	Description	Characteristics
I	Normal	Normal facial function in all areas
II	Mild dysfunction	Gross: Slight weakness noticeable on close inspection; may have very slight synkinesis At rest: Normal symmetry and tone Motion: Forehead – moderate to good function; eye – complete closure with minimum effort; mouth – slight asymmetry
III	Moderate dysfunction	Gross: Obvious but not disfiguring difference between 2 sides; noticeable but not severe synkinesis, contracture, and/or hemi-facial spasm. At rest: Normal symmetry and tone Motion: Forehead – slight to moderate movement; eye – complete closure with effort; mouth – slightly weak with maximum effort.
IV	Moderately severe dysfunction	Gross: Obvious weakness and/or disfiguring asymmetry At rest: Normal symmetry and tone Motion: Forehead – none; eye – incomplete closure; mouth – asymmetric with maximum effort.
V	Severe dysfunction	Gross: Only barely perceptible motion At rest: Asymmetry Motion: Forehead – none; eye – incomplete closure; mouth – slight movement
VI	Total paralysis	No movement

(CMAP) from the affected side is compared to the CMAP on the normal side.[10,13]

Magnetic resonance imaging (MRI) is a useful imaging tool for the differential diagnosis of AUPFP and various pathologic conditions of the central nervous system.[14-17] Diffusion-weighted imaging is an MRI method in which the image is obtained from the contrast produced by the diffusion of water molecules through different tissues. The diffusion coefficient (DC) implies the velocity of movement at the molecular level. In biological tissues, the term "apparent diffusion coefficient" (ADC) is used instead of DC.[18] Diffusion tensor imaging (DTI) renders pure diffusion information by the elimination of the directional influences of anisotropic diffusion. Some descriptors derived from the tensor are used to represent the degree of anisotropy, and fractional anisotropy (FA) is the most commonly used one. Simply, FA can be assumed as a measure of how much not similar it is to a sphere or how much directionality the diffusion distribution has. Complete diffusion isotropy and complete anisotropy mean FA of zero and FA of one (an unachieved status), respectively.[19] Diffusion tensor imaging is usually used to evaluate the white matter and its pathologies but it is increasingly performed in the evaluation of the heart, prostate gland, skeletal muscle, adrenal medulla, breast, peripheral nerves, spinal cord, and also peripheral nerve injury.[20-22] Up to date, although MRI has been used to reveal the etiology of BP and to reveal the FN dimensions in patients with BP, the diagnostic and prognostic significance of DTI has not been investigated.[17-23]

In our study, we aimed to evaluate whether there is any correlation among HBS, ENoG, and DTI values of the cisternal and internal auditory canal segment of the FN and to examine diagnostic, prognostic, and grading usefulness of DTI in patients with BP.

MAIN PONTS

- Diffusion tensor imaging is a novel method for understanding the pathophysiology of Bell's palsy in the acute stage of the disease.
- There were significant changes in apparent diffusion coefficient and fractional anisotropy values of the affected facial nerve compared to the contralateral side.
- Initial fractional anisotropy values of facial–cochleo–vestibular nerve complex were correlated negatively with diffusion tensor imaging values and degeneration index of orbicularis muscles.
- House–Brackmann scale and electroneuronography are still the most reliable prognostic and diagnostic tools for patients with BP.

MATERIAL AND METHODS

Subjects

In this study, 37 patients, over 18 years old finally diagnosed as having BP were prospectively recruited from 2014 to 2015 at the Otolaryngology–Head and Neck Surgery Department of Adıyaman University Research and Education Hospital, which is a tertiary referral center in Adıyaman. The diagnosis of BP was established by the exclusion of other causes of peripheral facial paralysis. Patients discontinuing follow-up were excluded from the study. The patients were followed up for at least 6 weeks. Our study was approved by the ethical committee of Adıyaman University (approval no: 2014/ 09-8). All patients gave written informed consent.

House–Brackmann Scoring

House–Brackmann scoring is a function-based grading system that is used in the evaluation and documentation of the status of the FN function (Table 1). Post-treatment HB 1 was assumed as complete recovery. House–Brackmann scoring of each patient was performed 2 times (one at 3-5 and one at 20-24 days of initial presentation) by the same otolaryngologist.

Electroneuronography

A single channel of the standard electromyography system (Nicolet Synergy, Natus Medical, Inc., San Carlos, California) was used for ENoG. Supramaximal stimulation of FN trunk at the level of stylomastoid foramen was carried out with the superficial electrical stimulation device, and the reflective waves (CMAP) of orbicularis oculi (OOc) and orbicularis oris (OOr) muscles were recorded through superficial electrodes. The degeneration index (DI) was calculated as [100 – (CMAP amplitude of paralysed/normal side) × 100].[24] In this study, the ENoG was performed at 3-5 and 21-24 days of BP onset and the DI values of both OOc and OOr were recorded at each visit. All these images were performed by the same neurologist.

Imaging Study: Diffusion Tensor Imaging

All radiological images were provided and evaluated by the Radiology Department of Adıyaman University. T1-weighted 3D fast field echo (FFE) and DTI high iso sensitivity encoding (SENSE) studies of each patient were performed at the presentation and 3 weeks later and ADC and FA values of each DTI study were recorded. Diffusion tensor imaging was studied in the internal auditory canal (IAC) and cisternal segments of the FN. A 1.5 Tesla (1.5 T) whole-body MRI system (Achieva, Philips Medical Systems Best, The Netherlands, 2010), equipped with 33 mT/m gradient coils slew rate 120 mt/m/s and an eight-element receive neuroradiological head coil array was used for imaging studies in patients with AUPFP.

The DTI high iso images were obtained with a single-shot echo-planar sequence (EPI) [field of view (FOV): RL × AP = 200 × 200, repetition time (RT) (ms): 4408, echo time (TE) (ms): 100, angle value = 90° in-plane matrix = 100 × 98, voxel MPS (mm): 2.00/2.04/2.00, reconstruction voxel = 1.56/1.56/2.0, reconstruction matrix = 128, slice thickness = 2 mm, total slices 30/1020, directional resolution high,[32] EPI factor $r = 49$, minimum slice gap (mm) = 0, diffusion weighting with a maximal b-factor of 800 s/mm^2, and bandwidth (BW) in EPI frequency (Hz) = 1784.6].

We also acquired anatomical MR images [T1-weighted 3D FFE sequence (FOV = 200 × 246, TR = 25, TE = 3, Matrix = 156 × 188, voxel = 1.28/1.31/1.60, reconstruction voxel = .96/.96/.80, FA = 30°, slice thickness = 1.3, reconstruction matrix = 256, BW=220). The total time for DTI high iso SENSE and T1-weighted 3D FFE imaging was about 10 minutes.

Data post-processing: In the construction of tractography, we computed diffusion tensor images by using a PC hardware/software complex called Philips Extended MR Workspace 2.6.3.3 software. We constructed tractography considered to delineate FN as follows. First, we computed unrefined images of DTI in the workstation by means of fiber tract software (PHILIPS MR Release 2 series. 5-15. 5.4. Fiber Trak specialist package 5.4.1.). Thirty directions of DTI were used in the study. Second, we masked previously obtained T1-weighted 3D FFE sequence images over the unrefined images. Later on, we set the fiber tract region of interest (ROI) parameters as threshold value = 0.15 and an angle value = °30° for FA. After that we drew a line that starts from the cerebellopontine angle (CPA), extends to the IAC, and covers facial and vestibulocochlear nerve complex. We drew this line by means of manual or line tractography to build an ROI. Other nerve tracts and

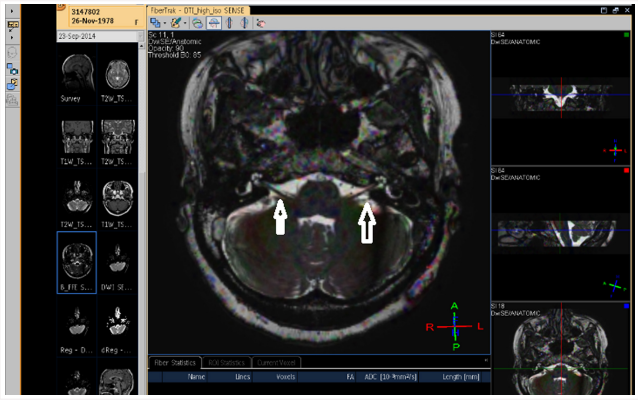


Figure 1. Bilateral seventh-eighth cranial nerve bundles (white arrows) from the brainstem to the internal acoustic canal are visualized on axial diffusion tensor imaging high iso sense sequence masked with–dimensional fast field echo sequence.

parenchymal structures of CPAs in the ROI were extracted. In this study, the reconstructions of the fiber tracts based on an ROI from the FA map were represented in Figures 1, 2, and 3. We measured the FA and ADC values of this ROI. All DTI examinations were evaluated by the same radiologist.

Statistical Analysis

The descriptive statistics were presented as the number and percentage for categorical variables and the mean and standard deviation for continuous variables. The differences between the ADC and FA values of the affected and contralateral normal nerve complexes measured in the initial MR studies were compared using paired Student's *t*-test. The differences between the ADC and FA values of the affected nerve complexes measured on initial and follow-up MR studies were compared using Student's *t*-test. The differences between the initial and follow-up HBSs and DI of OOc and OOr muscles were compared by using paired Student's t-test.

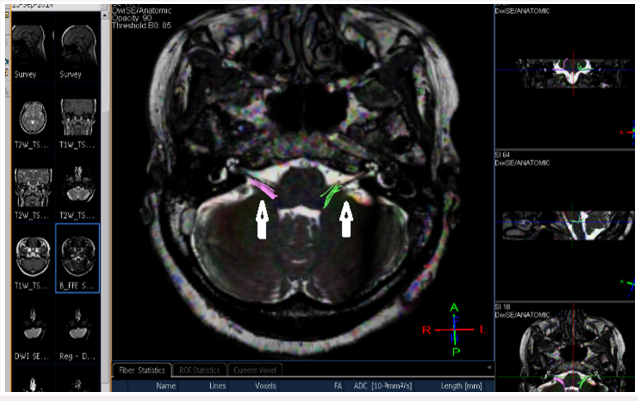


Figure 2. Color diffusion tensor image (DTI) appears after drawing a region of interest around seventh-eighth cranial nerve bundles (white arrows) on axial DTI high iso sense sequence masked with–dimensional fast field echo sequence.

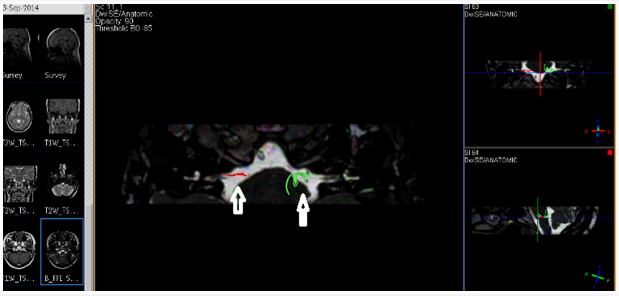


Figure 3. Course of seventh-eighth cranial nerve bundles (white arrows) from the brainstem to the internal acoustic canal is seen in color lines on coronal diffusion tensor imaging high iso sense sequence masked with 3-dimensional fast field echo sequence.

The correlations of initial and follow-up ADC and FA values of the affected nerve complexes and HBSs and DIs of OOc and OOr muscles were evaluated using Pearson correlation coefficient. Correlation coefficients ε0.7, >0.5 to <0.69, >0.3 to <0.49, >0.1 to <0.29, and >0.01 to <0.09 were interpreted as indicators of forceful, substantial, moderate, low, and negligible associations, respectively.[25] The *P* values <.05 were considered statistically significant.

Initial ADC and FA values of affected and contralateral nerve complexes and initial and follow-up ADC and FA values of affected nerve complexes were compared with each other. Initial and follow-up HBSs and initial and follow-up DIs of OOc and OOr were compared with each other. Correlations between initial and follow-up DTI parameters of affected nerve complexes and initial and follow-up HBSs were examined.

RESULTS

The present study includes 37 patients, out of which, 20 patients (54.1%) were female while 17 patients (45.9%) were males. Patient ages ranged from 18 to 81 (35.32 ± 15.06) years.

Initial ADC values of the affected nerve complexes (2.06 ± 0.38) were significantly higher than those of the contralateral nerve complexes (1.94 ± 0.24; *P* = .047). Initial FA values of the affected nerve complexes (0.29 ± 0.05) were significantly lower than those of the contralateral nerve complexes (0.31 ± 0.05; *P* = .029) (Table 2).

Initial ADC and FA values of the affected nerve complex and contralateral nerve complex are represented in Graph 1 to 3.

There were no significant differences between the initial and the follow-up ADC and FA values of the affected nerve complexes (follow-up ADC = 2.11 ± 0.37; follow-up FA = 0.29 ± 0.07). Initial HBSs (3.42 ± 0.99) were significantly higher than follow-up HBSs (1.29 ± 0.73; *P* < .001). Initial OOc (0.52 ± 0.24) and OOr (0.53 ± 0.23) DIs were significantly higher than follow-up ones (OOc DI: 0.10 ± 0.15, *P* < .001; OOr DI: 0.10 ± 0.14, *P* < .001) (Table 3).

Table 2. Comparison of Initial ADC and FA Values

	Affected Nerve Complexes	Contralateral Nerve Complexes	*P*
Initial ADC values	2.06 ± 0.38	1.94 ± 0.24	**.047**
Initial FA values	0.29 ± 0.05	0.31 ± 0.05	**.029**

ADC, apparent diffusion coefficient; FA, fractional anisotropy.

Affected versus contralateral ADC/FA or initial versus follow-up ADC/FA/HBS/OOc/OOr data of the patients are presented individually in Table 4.

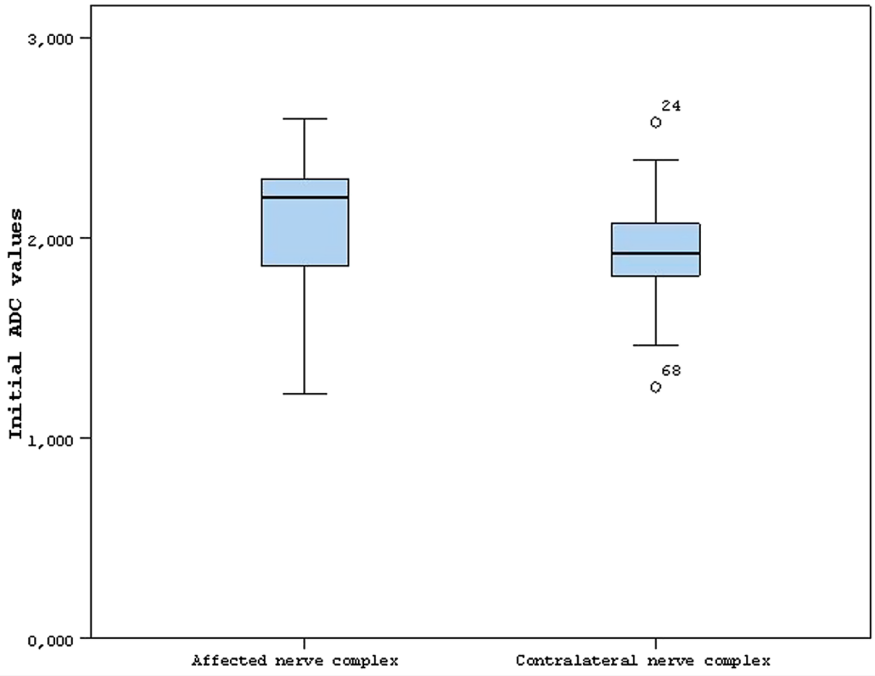
The correlations of initial FA values of nerve complexes with initial HBSs (*r* = −0.35; *P* < .05), OOc DIs (*r* = −0.36; *P* < .05), and OOr DIs (*r* = −0.35; *P* < .05) were negative, moderate, and significant.

DISCUSSION

Bell's Palsy is the final diagnosis in most cases of AUPFP which is the most commonly encountered pathology of FN.[2] Bell's Palsy manifests itself with problems in eyelid and lip movements, taste, and physical appearance of the face. Therefore, patients with BP feel uncomfortable and have low self-esteem. The management of facial paralysis is crucial for patients. Diagnostic workup includes anamnesis, physical examination, topographical tests, electrophysiological tests, radiological imaging, and laboratory tests.

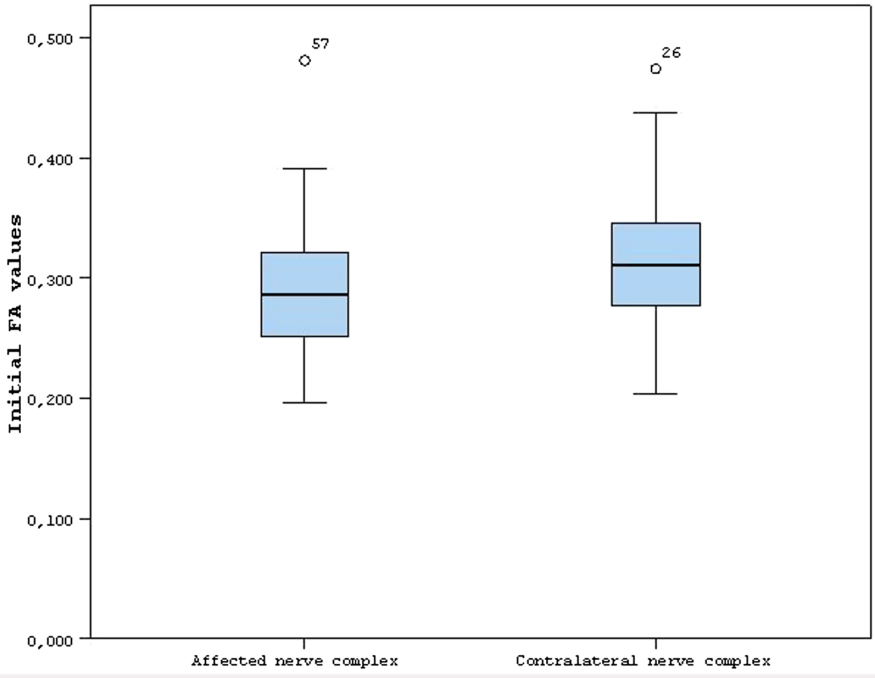
Up to date, the prognostication of BP in its acute phase has been performed most commonly with nerve excitability test, maximal stimulation test, and ENoG, also referred to as evoked electromyography. Among these tools, ENoG was reported to be the most reliable tool. It was reported that if an ENoG of 25% or more is maintained up to the 10th day of BP onset, there is a 98% chance of having a satisfactory recovery of BP. If ENoG value remains between 11% and 24%, there is an 84% of chance of recovery. If ENoG value remains 10% or less, there is a 21% of chance of recovery.[7,26,27] Similarly, Chow et al[28] studied patients with BP and determined that ENoG values <72.63% had a >90% chance of recovery to HB grade II or better within 2 months. Andresen et al[10] reported that percent degeneration on ENoG was correlated to HB score at 1 year for patients with BP. However, Lee et al[29] asserted that ENoG value performed between days 7 and 10 for BP is not a precise prognostic indicator and it is not reliable enough to assess the prognosis of facial palsy quantitatively. In our study, when compared with the initial DIs, the follow-up DIs were significantly lower and the initial HBSs were significantly higher than the follow-up HBSs. Furthermore, there were significant correlations between the initial and follow-up DIs and HBSs.

Radiological imaging of patients with BP includes mainly CT and MRI. Computed tomography is superior to other modalities in the assessment of bony abnormalities, especially preferred for imaging the intratemporal FN pathologies. High-resolution temporal bone CT should be performed to evaluate IAC and the facial canal. Magnetic resonance imaging is useful in the evaluation of soft tissue abnormalities of FN like neoplasms, inflammatory disorders, and hemifacial spasms. Magnetic resonance imaging can reveal FN from the brainstem to the fundus of IAC, and MRI can detect the presence of perineural invasion from parotid tumors.[23] Due to the complex anatomy of the brainstem

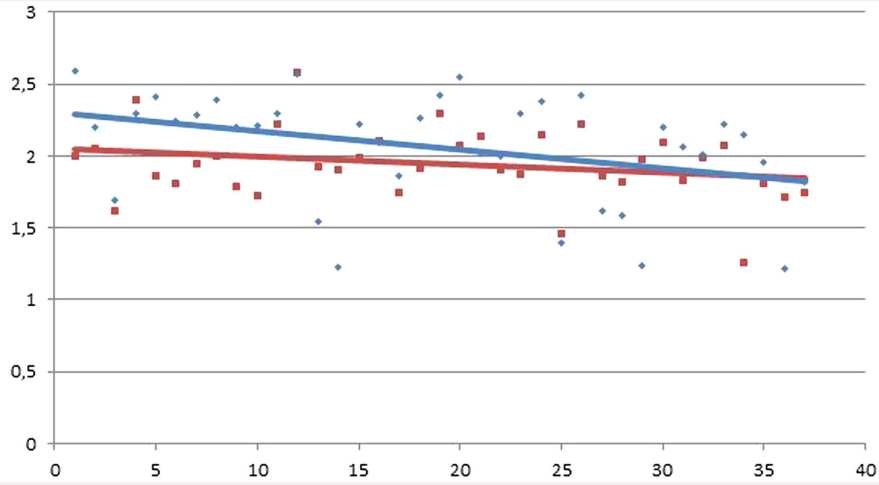


Graph 1. Initial apparent diffusion coefficient values of affected nerve complex and contralateral nerve complex.

and surrounding cisterns, detailed imaging of this area is so important for neurosurgeons, neuroradiologists, and otolaryngologists. Facial and vestibulocochlear nerves arise from pons and they are in close proximity with each other in cisterna and IAC. Diffusion tensor imaging is especially advantageous in imaging the FN before the stylomastoid foramen.[30] In a meta-analysis consisting of 234 cases, Saverdekar et al[31] reported that preoperative DTI is beneficial for FN identification. Diffusion tensor imaging successfully identified the complete FN course in 96.6% of vestibular schwannomas and FN identification by DTI was accurate in 90.6% of cases. In the cases with CPA tumors, the accuracy of preoperative DTI was 81.6%, sensitivity was 88.57%, and positive predictive value was 91.18%.[32] Ulrich et al[33] studied 7 patients with pontine cavernomas and concluded that



Graph 2. Initial fractional anisotropy values of affected nerve complex and contralateral nerve complex.



Graph 3. The graph of the comparison of the affected nerve side with the normal nerve complex. (red points; apparent diffusion coefficient (ADC) of normal side, blue points; ADC of the affected side, red line; linear regression of normal side, blue line; linear regression of affected side).

DTI accurately demonstrates key anatomical structures in pons and the distortion resulted from the lesion invisible on conventional MRI. In our study, the mean ADC value of cisternal and IAC segments of affected sides was significantly higher than that of the contralateral side on initial DTI. The mean FA value of the affected sides was significantly lower than that of the contralateral side. Increased ADC with decreased FA values implied that there was vasogenic edema on the affected side.[34,35] The mean initial and follow-up ADC values of affected sides did not differ from each other statistically. Similarly, the mean initial and follow-up FA values of the affected sides did not reveal any significant differences from each other. Although the correlations of initial FA values of paralyzed facial segments with initial HBSs, OOc DIs, and OOr DIs were negative, moderate, and significant, the correlations of follow-up FA values of paralyzed facial segments with follow-up HBSs, OOc DIs, and OOr DIs were not significant. Thus, it is suggested that there was a sudden alteration or edema of axonal structures causing a decline in the directional coherence of water diffusion with a resultant decrease in FA at initial presentation. At the follow-up presentation, there was possibly some improvement in the acute injury at a microscopic level without obvious change in FA values. When the clinical progression of facial paralysis was considered, as previously mentioned, mean HBSs of follow-up presentation were significantly lower than that of the initial presentation. These findings suggested that there was no significant radiologic improvement at the end of the third week of onset of facial paralysis. This inconsistency between clinical and radiologic findings can be attributed to ongoing inflammation of FN. For this reason, control DTI could not yield the significant difference as seen at control HBSs or control ENoG values in the acute phase of BP. In a cohort study by Urban et al[36] the median recovery time was found to be 2.6 months, 54.9% of cases achieved complete recovery, and if steroid treatment started during the first 96 h, the recovery rate increased significantly. Hato et al[37] studied 664 patients with BP, divided the patients into three groups in terms of severity of palsy, and the rate of recovery among these groups varied from 80.2% to 99.3% at the end of 6 months of facial paralysis onset. Sullivan et al[38] evaluated 496 patients with BP and 9 months were needed for full recovery in 94% of them. The complete recovery rate in the phase III trials was about 85–94% within 9–12 months.[36] The increase in the rate of patients who demonstrate functional recovery over time may be due to the onset of treatment and the prolonged disease process. The timing of the control DTI examinations in our study might be suboptimal and long-term DTI examinations might be needed to be able to demonstrate improvements in the imaging findings. The relatively small number of patients enrolled in this study and short follow-up time (at least 6 months) are other limitations of our study. In our study, we used a 1.5 Tesla MRI device because we have the inability to access 3 Tesla MRI devices. Since ADC values were found to be higher and FA values were found to be lower with the use of 3 Tesla MRI in previous studies, the statistical significance could have been found lower if 3 Tesla MRI was used in our study.[39]

Table 3. Comparison of Initial ADC and FA Values

	Initial	Follow-Up	*P*
ADC values	2.06 ± 0.38	2.11 ± 0.37	.391
FA values	0.29 ± 0.05	0.29 ± 0.07	.769
HBS	3.42 ± 0.99	1.29 ± 0.73	**<.001**
OOc	0.52 ± 0.24	0.10 ± 0.15	**<.001**
OOr	0.53 ± 0.23	0.10 ± 0.14	**<.001**

ADC, apparent diffusion coefficient; FA, fractional anisotropy; HBS, House–Brackmann scoring; OOc, orbicularis oculi; OOr, orbicularis oris.

In conclusion, while ENoG is a beneficial tool in the diagnostic work-up of patients with BP, DTI is giving us beneficial data for understanding the pathophysiology of BP in the acute stage of the disease. There were significant changes in ADC and FA values of the affected neural structures in the acute stage. House–Brackmann scale is still a useful clinical grading system for evaluating facial function and there is a good correlation

Table 4. Affected Versus Contralateral ADC/FA or Initial Versus Follow-up ADC/FA/HBS/OOc/OOr Data of the Patients Were Presented Individually

Patient Number	Initial ADC of Affected Side	Initial FA of Affected Side	Initial ADC of Contralateral Side	Initial FA of Ccontralateral Side	Follow-up ADC of Affected Side	Follow-Up FA of Affected Side	Initial HBS	Follow-Up HBS	Initial OOc	Follow-Up OOc	Initial OOr	Follow-Up OOr
1	2.595	0.273	1.997	0.273	1.168	0.532	5	2	0.79	0.31	0.79	0.32
2	2.201	0.351	2.051	0.263	1.965	0.365	4	2	0.66	0.16	0.68	0.18
3	1.688	0.349	1.616	0.371	2.151	0.238						
4	2.293	0.222	2.391	0.211	2.623	0.201	3	1	0.42	0	0.44	0
5	2.415	0.321	1.861	0.348	1.867	0.302	5	1	0.82	0	0.81	0
6	2.245	0.247	1.812	0.307	2.458	0.259	3	3				
7	2.282	0.288	1.947	0.312	2.615	0.252	4	1	0.63	0.13	0.65	0.14
8	2.389	0.233	2.002	0.259	2.049	0.227	3	1	0.51	0.05	0.52	0.11
9	2.197	0.286	1.791	0.368	1.809	0.297	3	1	0.24	0.08	0.26	0.08
10	2.211	0.231	1.729	0.346			3	1				
11	2.295	0.352	2.223	0.277	2.425	0.289	4	1	0.63	0.16	0.65	0.14
12	2.574	0.232	2.578	0.238	2.294	0.283	5	4	0.95	0.46	0.95	0.47
13	1.542	0.391	1.921	0.474	1.833	0.314	5	1	0.86	0	0.88	0
14	1.228	0.326	1.905	0.356	2.307	0.252	3	1	0.45	0	0.46	0
15	2.222	0.267	1.99	0.353			2	1	0.21	0	0.24	0
16	2.095	0.287	2.101	0.309	2.121	0.311	4	1	0.68	0.03	0.68	0.03
17	1.863	0.354	1.744	0.321	1.901	0.331	4	1	0.72	0	0.73	0
18	2.258	0.281	1.919	0.301	2.391	0.249	2	1	0.15	0	0.16	0
19	2.423	0.227	2.291	0.271			2	1	0.18	0	0.19	0
20	2.553	0.251	2.073	0.204	2.476	0.217	2	1	0.14	0	0.15	0.08
21	2.015	0.295	2.135	0.248	2.552	0.253	3	1	0.34	0.07	0.35	0.08
22	1.999	0.264	1.907	0.314	2.522	0.322	4	1	0.63	0	0.66	0
23	2.293	0.271	1.871	0.355			4	1	0.62	0.04	0.64	0.06
24	2.377	0.209	2.142	0.277	1.911	0.234	4	1	0.61	0.12	0.62	0.12
25	1.392	0.288	1.464	0.438	2.405	0.242	3	1	0.46	0.15	0.46	0.15
26	2.425	0.251	2.217	0.283	-	-	3	1	0.44	0	0.46	0
27	1.615	0.353	1.864	0.311	1.858	0.284	4	4	0.63	0.61	0.65	0.61
28	1.583	0.323	1.819	0.304	2.161	0.254	2	1	0.17	0	0.15	0
29	1.234	0.481	1.983	0.289	1.878	0.442	4	2	0.75	0.31	0.76	0.31
30	2.203	0.196	2.098	0.296			2	1	0.21	0	0.22	0
31	2.058	0.291	1.826	0.321	1.833	0.298	4	1	0.68	0.11	0.68	0.11
32	2.013	0.281	1.985	0.311	1.171	0.418	3	1	0.46	0.15	0.48	0.14
33	2.226	0.289	2.071	0.305	2.187	0.291	3	2	0.66	0.38	0.68	0.24
34	2.149	0.291	1.256	0.314			5	1	0.89	0.12	0.92	0.12
35	1.961	0.276	1.813	0.342			3	1	0.44	0	0.46	0
36	1.219	0.297	1.711	0.371	2.089	0.344	2	1	0.16	0	0.16	0
37	1.814	0.271	1.747	0.335			3	1	0.43	0	0.46	0

ADC, apparent diffusion coefficient; FA, fractional anisotropy; HBS, House–Brackmann scoring; OOc, orbicularis oculi; OOr, orbicularis oris.

between ENoG values and HB scores. Clinical amelioration in BP does not mean radiologic improvement at 3 weeks and further studies including more patients with long-term follow-up should be performed to evaluate the time needed for complete radiologic recovery and for complete resolution of the FN edema.

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Informed Consent: Written informed consent was obtained from all participants who participated in this study.

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