Usefulness of contrast-enhanced 3-dimensional T1 VISTA for Diagnosis of Facial Neuritis: a Compared with contrast-enhanced T1-TSE

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Purpose

Facial neuritis is the most common form of acute facial nerve disorder, which is characterized by a rapid onset of peripheral facial palsy of unknown cause [1]. It is also called idiopathic facial palsy or Bell’s palsy. It is diagnosed through clinical symptoms, magnetic resonance (MR) imaging and electrophysiologic test (EPS) [1, 2]. In most patients, MR of the facial nerve is performed selectively in case of peripheral facial nerve palsy in patients with an atypical presentation or delayed recovery to exclude [2, 3]. Electrophysiologic test such as electroneuronography or needle electromyography can provide information of diagnosis and prognostic importance, however, it is no reliable diagnostic tool within 1 week of symptom onset [1, 4, 17]. In addition, prompt treatment within 72 hours of symptom onset is critical for patient prognosis and recovery rate significantly [17-19]. MR imaging of facial neuritis has been studied over the past 20 years whether MR imaging can provide diagnostic information in the acute phase of facial paralysis or not [2, 5-13]. Despite of many studies involving MR imaging of facial neuritis, conventional contrast-enhanced T1-weighted turbo spin echo (CE T1-TSE) sequence, commonly used sequence, has a significant limitation [6, 10]. It is that enhancement of normal facial nerve is also shown in 76% of patients due to flux of contrast material in the arteriovenous plexus (AVP) supplying facial nerve in the facial canal [3, 13-14]. Recently, 3-dimensional (3D) reformatted images are promising technique it offers improved anatomic accuracy with minimal flow artifact and thinner sections without gaps between slices when compared with conventional 2D imaging [16]. And there is no time consuming to obtain reformatted images because reconstruction is freely available. Also new 3D variable refocusing flip-angle volume isotropic turbo-spin-echo acquisition (3D-VISTA) have been introduced that differ from conventional TSE sequence. Long echo train and flip angle modulation carry magnetization as long as possible to avoid blurring and provide optimal signal at the effective echo time [15]. With this background, we hypothesized that contrast enhanced 3D T1-weighted VISTA (CE 3D T1-VISTA) images are more effective than conventional CE T1-TSE in diagnosis of facial neuritis. In our best knowledge, there has been no reported comparison of CE 3D T1-VISTA sequence and CE T1-TSE sequence with quantitative measurement in the facial neuritis.

In order to test this hypothesis, this prospective study evaluated the diagnostic usefulness of the CE T1-VISTA sequence when compared to CE T1-TSE sequence in patients with facial neuritis.

Methods and Materials

The current study was approved by our institutional review board, and written informed consents were obtained from all enrolled patients.
Patients

This study enrolled 35 consecutive patients who had been diagnosed with unilateral facial neuritis between May 2011 and November 2011. All patients were diagnosed by clinical symptom and EPS. Among them, 3 patients were excluded from the study. Two patients had intracranial tumors at symptomatic side and one patient is a 2 years-old infant with suspected CNS infection. IAC MR imagings of enrolled patients were performed with planned protocol. Finally, 32 consecutive patients (21 females; mean ± SD age, 52.4±13.6 years; range, 27-77 years; 25 right lesions) were enrolled in our study. The time interval between MR examination and symptom onset was 5.1±3.4 days (range, 0-12 days). Additionally we selected 10 normal controls (6 females; mean ± SD age, 48.8±16.4 years; range, 18-69 years) for evaluate diagnostic accuracy. All controls were performed IAC MR imaging with same protocol, but they had normal facial nerves.

MR Imaging analysis

IAC MR scanning including CE 3D T1-VISTA and CE T1-TSE was performed in all patients by use of 3T scanner (Achieva; Philips Medical Systems, Best, the Netherlands). Gadobutrol (Gadavist; Bayer Healthcare, Berlin, Germany) was intravenous hand injected at 0.1ml/kg by 3-way. MR scan was executed just after contrast media injection. Axial image plane was obtained in both sequences. And coronal image plane was additionally obtained in CE T1-TSE sequence. Scan order of CE 3D T1-VISTA and CE T1-TSE were performed randomly. Because timing of the scans can affect amount of contrast accumulation in the inflamed facial nerve. So constant order of IAC MR imaging can result prominent contrast enhancement in the certain sequence. CE 3D T1-VISTA was performed with the following parameters: TR, 350 ms; TE, 19.51 ms; matrix, 360x299; field of view, 113x180; in-plane voxel, 0.5x0.6; section thickness, 2 mm; flip angle, 90 °; SENSE-HEAD-8; total scan time, 3 minute 4 seconds. Parameters of CE T1-TSE are as follow: TR, 568.82 ms; TE, 11.00 ms; matrix, 256x205; field of view, 180x200; in-plane voxel, 0.97x0.78. section thickness, 2 mm; flip angle, 90 °; SENSE-HEAD-8; total scan time, 3 minutes 36 seconds. Fat suppression was performed both sequences.

To compare diagnostic accuracy of two sequence, 42 IAC MR imagings (32 enrolled goups and 10 normal controls) were independently reviewed by 2 neuroradiologists (C.W.R., S.M.K.) without any information of patient. At the time of image analysis, the radiologists randomly analyzed CE 3D T1-VISTA and CE T1-TSE sequences in single subject.

ROI measurements

For a quantitative analysis, the signal intensity was measured from three segments (canalicular, labyrinthine, and anterior genu) of the facial nerve. To ensure consistency, ROI measurements were performed by one radiology resident (S.J.Y) who was unfamiliar with the clinical information. This quantitative measurement was assessed on 64 facial
nerves (32 each on the left and right sides). ROIs were ovoid or linear and placed to cover enhancing portion of the each segment. This results were used for calculating quantitative lesion-to-normal contrast ratio (CR) of two MR sequences.

Statistical analysis

All data were analyzed by using MedCalc for Windows, Version 11.5 (MedCalc Software, Mariakerke, Belgium). There were 4 components to the statistical analysis: 1) calculation of diagnostic accuracy (sensitivity, specificity, accuracy, PPV, NPV) for each readers was assessed with Chi-square test or Fisher’s exact test by comparing actual diagnosis, 2) comparison of sensitivity, specificity and accuracy between two MR sequence by using McNemar test, 3) assessment of interobserver agreement by using weighted-Kappa value, 4) analysis of difference in quantitative CR between two MR sequences by using paired t-test.

Interobserver agreement analysis was performed by calculating the kappa value with its 95% confidence interval. A kappa value of 0-0.20 indicated poor agreement; 0.21-0.40, fair agreement; 0.41-0.60, moderate agreement; 0.61-0.80, good agreement; and 0.81-1.00, almost perfect agreement. P < 0.05 was considered statistically significant.

Images for this section:

**Fig. 1:** Patient selection
<table>
<thead>
<tr>
<th></th>
<th>CE 3D T1-VISTA sequence</th>
<th>CE T1-TSE sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>TR/TE (ms)</td>
<td>350/19.51</td>
<td>568.82/11.00</td>
</tr>
<tr>
<td>Matrix size</td>
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<td>256 x 205</td>
</tr>
<tr>
<td>Field of view (mm²)</td>
<td>113 x 180</td>
<td>180 x 200</td>
</tr>
<tr>
<td>In-plane resolution (cm²)</td>
<td>0.5 x 0.6</td>
<td>0.97 x 0.78</td>
</tr>
<tr>
<td>Section thickness (mm)</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Flip angle (°)</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>Coil</td>
<td>SENSE-HEAD-8</td>
<td>SENSE-HEAD-8</td>
</tr>
<tr>
<td>Scan time</td>
<td>3min 4 sec</td>
<td>3 min 36 sec</td>
</tr>
</tbody>
</table>

**Fig. 2:** MR protocol
Results

MR imaging analysis

Interobserver agreements were 0.898 and 0.782 for CE 3D T1-VISTA and CE T1-TSE, respectively. Especially interobserver agreement of CE 3D T1-VISTA was almost perfect.

By reader 1, the sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) for detection of facial neuritis were 81.25% (26/32), 100% (10/10), 100% (26/26), and 62.5% (10/16) respectively, for CE 3D T1-VISTA, and 75% (24/32), 90% (9/10), 96% (24/25), and 52.94% (9/17) respectively, for CE T1-TSE. By reader 2, the sensitivity, specificity, PPV, and NPV were 90.62% (29/32), 100% (10/10), 100% (29/29), and 76.92% (10/13) respectively, for CE 3D T1-VISTA, and 75% (24/32), 90% (9/10), 96% (24/25), and 52.94% (9/17) respectively, for CE T1-TSE. The accuracy for detection of facial neuritis for CE 3D T1-VISTA and CE T1-TSE were 85.71% (36/42) and 78.57% (33/42) respectively by reader 1. By reader 2, the accuracy were 92.86% (39/42) and 78.57% (33/42) respectively. The sensitivity, specificity and accuracy of the CE 3D T1-VISTA sequence were better than those for the CE T1-TSE sequence for detecting facial neuritis in both readers, however they are not significantly different (sensitivity, $P = 0.125 \sim 0.727$; specificity, $P = 1.000$; accuracy, $P = 0.070 \sim 0.508$).

Lesion-to-normal contrast ratio (CR)

The mean CR of canalicular, labyrinthine, and anterior genu segments were 2.32, 2.22, and 1.97, respectively, for CE 3D T1-VISTA and 2.17, 1.72, and 1.68, respectively, for CE T1-TSE. The mean CR of labyrinthine, and anterior genu segments for the CE 3D T1-VISTA were significantly higher than those for the CE T1-TSE (labyrinthine, $P < 0.001$, 95% confidence interval, 1.99-2.44; anterior genu, $P = 0.002$, 95% confidence interval, 1.85-2.13). But the mean CR of canalicular segment was not significantly different ($P = 0.169$, 95% confidence interval, 2.10-2.59).

Images for this section:
<table>
<thead>
<tr>
<th></th>
<th>Reader 1</th>
<th></th>
<th>p - value</th>
<th>Reader 2</th>
<th></th>
<th>p - value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T1-VISTA</td>
<td>T1-TSE</td>
<td></td>
<td>T1-VISTA</td>
<td>T1-TSE</td>
<td></td>
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<tr>
<td>Sensitivity</td>
<td>81.25</td>
<td>75</td>
<td>0.727</td>
<td>90.62</td>
<td>75</td>
<td>0.125</td>
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<tr>
<td>(%)</td>
<td>(26/32)</td>
<td>(24/32)</td>
<td></td>
<td>(29/32)</td>
<td>(24/32)</td>
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<tr>
<td>Specificity</td>
<td>100</td>
<td>90</td>
<td>1.000</td>
<td>100</td>
<td>90</td>
<td>1.000</td>
</tr>
<tr>
<td>(%)</td>
<td>(10/10)</td>
<td>(9/10)</td>
<td></td>
<td>(10/10)</td>
<td>(9/10)</td>
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<tr>
<td>Accuracy</td>
<td>85.71</td>
<td>78.57</td>
<td>0.508</td>
<td>92.86</td>
<td>78.57</td>
<td>0.070</td>
</tr>
<tr>
<td>(%)</td>
<td>(26/42)</td>
<td>(33/42)</td>
<td></td>
<td>(39/42)</td>
<td>(33/42)</td>
<td></td>
</tr>
<tr>
<td>PPV</td>
<td>100</td>
<td>96</td>
<td></td>
<td>100</td>
<td>96</td>
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<tr>
<td>NPV</td>
<td>62.50</td>
<td>52.94</td>
<td></td>
<td>76.92</td>
<td>52.94</td>
<td></td>
</tr>
<tr>
<td>(%)</td>
<td>(10/16)</td>
<td>(9/17)</td>
<td></td>
<td>(10/13)</td>
<td>(9/17)</td>
<td></td>
</tr>
</tbody>
</table>

**Table 1:** Results of diagnostic accuracy for each reader

<table>
<thead>
<tr>
<th></th>
<th>CE 3D T1-VISTA</th>
<th>CE T1-TSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kappa value</td>
<td>0.898</td>
<td>0.782</td>
</tr>
</tbody>
</table>

* Classification and interpretation of agreement (Altman, 1991)

<table>
<thead>
<tr>
<th>Value of K</th>
<th>Strength of agreement</th>
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</thead>
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<tr>
<td>&lt; 0.20</td>
<td>Poor</td>
</tr>
<tr>
<td>0.21 - 0.40</td>
<td>Fair</td>
</tr>
<tr>
<td>0.41 - 0.60</td>
<td>Moderate</td>
</tr>
<tr>
<td>0.61 - 0.80</td>
<td>Good</td>
</tr>
<tr>
<td>0.81 - 1.00</td>
<td>Very good</td>
</tr>
</tbody>
</table>

**Table 2:** Interobserver Agreement
Fig. 3: Lesion to normal ratio

The graph shows the lesion to normal ratio for different segments:
- Canalicular: CR 2.22 (CE 3D T1-VISTA) vs 2.17 (CE T1-TSE)
- Labyrinthine: CR 2.02 (CE 3D T1-VISTA) vs 1.72 (CE T1-TSE)
- Anterior genu: CR 1.99 (CE 3D T1-VISTA) vs 1.68 (CE T1-TSE)

The p-values are:
- Canalicular: 0.624
- Labyrinthine: 0.030
- Anterior genu: 0.004

* p-value: Canalicular: 0.624, Labyrinthine: 0.030, Anterior genu: 0.004
**Fig. 4:** 63 year old female patient with right facial palsy undergoing MRI CE 3D T1-VISTA first. CE 3D T1-VISTA shows strong enhancement of labyrinthine segment and anterior genu of right facial nerve, so reader 1 and 2 interpreted right facial neuritis. But in CE T1-TSE, both facial nerves do not show difference of enhancement, so reader 1 and 2 interpreted normal facial nerves.

**Fig. 5:** 66 year old female patient with right facial palsy undergoing MRI CE T1-TSE first. CE T1-TSE does not show strong enhancement of both facial nerve but CE 3D T1-VISTA show enhancement of canalicular to anterior genu segments of left facial nerve.
Conclusion

According to our results, CE 3D T1-VISTA showed higher contrast between lesion and normal facial nerve than CE T1-TSE. Among three segments of facial nerve, labyrinthine and anterior genu segments are meaningfully higher. Moreover CE 3D T1-VISTA showed very good interobserver agreement.

The results of our study may be due to the advantages of 3D T1-VISTA sequence. First, 3D T1-VISTA uses variable flip angle refocusing pulses that achieve long echo train for effective flow suppression. This sequence is designed to get a target signal level by an abrupt drop in the initial flip angle. This minimizes signal blurring from T2 decay while reducing radiofrequency power [23]. Second, this sequence has reported that higher signal to noise ratio (SNR), contrast to noise ratio, (CNR) and black blood effect compared with conventional TSE sequence [20-22]. It is able to distinguish from pathologic enhancement and normal enhancement of facial nerve which result in higher diagnostic accuracy. Lim et al, reported that contrast-enhanced 3D fluid-attenuated inversion recovery (FLAIR) technique can improve specificity and overall accuracy of patient with idiopathic facial palsy [2]. But CE-FLAIR technique is lower SNR, CNR and CER (contrast- enhancement rate) than T1CE. Because intravenous administration of contrast medium take shortening time of T1, result aggrandizement of contrast disparity between lesion and normal. T1CE is more suitable for viewing T1 shortening effect [24]. Also, on CE-FLAIR image, hyperintensity may be due to either T1 shortening or T2 lengthening. This feature may limit the usefulness of a post-contrast FLAIR sequence [25]. Third, this sequence can correct asymmetric appearance of the facial nerve during normal spin-echo imaging was found to result from the angle dependence or motions induced phase shifts.

Unlike other studies, this study was meaningful regard to several points. It was designed prospectively and first results of CE 3D T1 VISTA sequence for diagnosis of facial neuritis. Also it was overcome important restriction which previous studies were noted. There is a little chance for the facial nerve to be more enhanced by switching the order of scanning. And the narrow time interval from onset of facial palsy to MR imaging, ranged from 0-12 days, may affected accurate result.

Our study has several limitations. First, patients in each group was relatively small. Second, contrast injection was performed by hand injection, not injector. Third, difference in the voxel sizes between two sequences.

Despite limitations, CE 3D T1-VISTA was superior to CE T1-TSE regarding image contrast between lesion and normal facial nerve. By using CE 3D T1-VISTA image, diagnostic performance of facial neuritis can be improved. Consequently, in patient with unilateral facial palsy, we believed that CE 3D T1-VISTA was helpful and can be routinely obtained after intravenous administration of contrast media.
References


**Personal Information**

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