TECHNICAL NOTE

Simultaneous Three-dimensional Visualization of the Intra-parotid Facial Nerve and Parotid Duct using a Three-dimensional Reversed FISP Sequence with Diffusion Weighting

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We visualized the intraparotid facial nerve and parotid duct at 3 tesla using 3-dimensional reversed fast imaging with steady-state precession (FSIP) (3D-PSIF) with diffusion weighting. Excellent fat suppression by water-selective excitation, sufficient T₂-weighting of 3D-PSIF, vessel suppression by diffusion weighting, and high spatial resolution allowed the simultaneous visualization. We also present volumetric representation of the facial nerve and duct.

Keywords: *facial nerve, parotid duct, parotid gland, PSIF*

Introduction

Knowledge of the spatial relationship of the intraparotid facial nerve and parotid duct to a parotid tumor is important in planning safe surgical treatment.^{1–3} Major complications from treatment include facial palsy, Frey's syndrome, and salivary fistula.^{2–4} Especially in superficial conservative parotidectomy, the facial nerve should be preserved. The extracranial portions of cranial nerves II to XII, including the intraparotid facial nerve, have been identified as bright signal using 3-dimensional reversed fast imaging with steady-state precession (FSIP) (3D-PSIF) with diffusion weighting at 3 tesla.⁵ However, that study did not describe the parotid duct. We reviewed the frequency and length of the intraparotid facial nerve as demonstrated on 3D-PSIF diffusion-weighted imaging (DWI) and constructed volumetric images of the intraparotid facial nerve and parotid duct from the 3D-PSIF-DWI data obtained at 3T using a 32-channel array head coil.

Materials and Methods

All scans were performed on a 3T MR scanner (TRIO-TIM, Siemens Medical Solutions, Erlangen, Germany) using a 32-channel array head coil. Ten

patients (4 men, 6 women; aged 48 to 69 years, mean, 59.2 years) with suspected parotid gland disease underwent magnetic resonance (MR) imaging including axial T₁-weighted spin echo, axial fat-suppressed T₂-weighted fast spin echo, and sagittal slab 3D-PSIF-DWI. Eight patients were examined for a unilateral parotid region mass and the other two for suspected Sjögren's syndrome.

Scan parameters for 3D-PSIF-DWI were: water-selective excitation; sagittal single slab with 352 partitions; repetition time, 9.1 ms; echo time, 2.9 ms; flip angle, 35 degrees; field of view, 211 mm × 250 mm; matrix, 378 (phase direction, anterior-posterior) × 448 (readout direction, superior-inferior); pixel, 0.56 mm × 0.56 mm; 0.5-mm-thick slice over sampling of 36.4%; parallel imaging acceleration factor, 2; generalized autocalibrating partially parallel acquisitions (GRAPPA) technique;⁶ flow compensation in readout direction; diffusion moment in readout direction (superior-inferior) of 40 mT/m* ms; number of acquisitions, 1; bandwidth, 429 Hz/pixel; scan time, 7 min 20 s. Most of these parameters are similar to those previously reported.⁵ In this study, we chose higher diffusion moment values than those previously reported to increase contrast between the facial nerve and parotid gland.

Image analysis

A neuroradiologist with 20 years' experience retrospectively analyzed 3D-PSIF-DWI images.

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Images were reviewed on a 20-inch liquid crystal display (LCD) using picture archiving communication system (PACS) viewer software (Rapideye, Toshiba, Tokyo, Japan).

Visualized length of intraparotid facial nerve

We measured the visualized length of the intraparotid facial nerve by identifying the vertical segment of the facial nerve in the temporal bone, following it to the stylomastoid foramen by paging the sections, and measuring the linear distance from the entry point of the facial nerve in the parotid gland to the most distant peripheral point, where the high signal of the peripheral facial nerve could be traced while paging through the sagittal source images on the PACS viewer. When the facial nerve branched, we traced every branch and identified the most distant point. The measured linear distance was defined as the visualized length of the intraparotid facial nerve.

Volumetric visualization of parotid duct and intraparotid facial nerve

We used the maximum intensity projection (MIP) of the selected oblique slab to visualize the duct and nerve simultaneously. To make the section parallel to the facial nerve trunk in the parotid gland, we performed interactive multiplanar reconstruction (MPR) on the PACS viewer. We then thickened the slab to include part of the parotid duct and performed slab MIP. Slab thickness was 7 to 15 mm. In 2 patients, the visualized length of the intraparotid facial nerve in 2 parotid glands was longer than 16 mm. Visualization of contrast between the facial nerve and parotid gland parenchyma was excellent in these glands, probably from the significant fatty change in the glands. We selected these 2 glands for trial of further post-processing with volume rendering using Realia Professional software (KGT Inc., Tokyo, Japan) on a Windows PC.

The medical ethics committee of our institution approved this retrospective study and waived informed consent.

Results

The length of the visualized intraparotid facial nerve was 11 to 18 mm (mean 14.6 mm). We identified the facial nerve as the linear structure with higher signal than the parotid parenchyma and lower signal than the parotid duct, and we distinguished the branching point of the main trunk of the facial nerve into the cervicofacial division and temporofacial division in 18 of 20 parotid glands

(Fig. 1). In a case of Sjögren's syndrome, dilatation of the peripheral ducts and the presence of multiple cysts hindered clear delineation of the facial nerve and its branching point (Fig. 2). On MIP images, some part of the facial nerve and parotid duct were visualized simultaneously in all 20 parotid glands (Figs. 1, 3). On volume-rendered images, the facial nerve and duct could be visualized in different colors in 2 glands, those selected for volume-rendering trial (Fig. 1).

Discussion

The simultaneous visualization of the parotid duct and intraparotid facial nerve using a 3-dimensional Fourier-transform MR imaging sequence has been reported.^{1,7,8} Two of these studies indicated visualization of both the intraparotid facial nerve and parotid duct as linear structures of low intensity at 1.5T using a 3-dimensional gradient-recalled acquisition in the steady state (GRASS) sequence and a 3-inch surface coil¹ or a head-and-neck coil.⁸ In the other report, the intraparotid facial nerve showed low signal, and the parotid duct showed high signal on imaging with a balanced turbo field echo (BTFE) sequence⁷ at both 1.5 and 3T. These studies reported no volumetric images such as volume-rendered or MIP images, to visualize the parotid duct and facial nerve simultaneously. For the simultaneous volumetric display of the duct and nerve, positive signal of the nerve and duct is desired because the many fibrous septa in the gland show low signal intensity on most MR pulse sequences. The mean visualized length of the facial nerve in the previous study using BTFE was 12.7 mm at 1.5T and 10.9 mm at 3T,⁷ lengths shorter than the 14.6 mm of the present study. Recently, imaging of the human parotid gland has been attempted at 7T using a surface coil,⁴ but only the part of the facial nerve near the skull base could be visualized.

Because the PSIF sequence is a steady-state free precession (SSFP) sequence with characteristics of a spin-echo sequence, it has a dominant T₂ contrast compared with other spoiled or refocused gradient-echo techniques, such as fast low-angle shot (FLASH), GRASS, and FISP.⁵ The signal intensity of stationary CSF is very high in contrast to the low signal from the brain parenchyma. Important features of 3D-PSIF-DWI in the present study are the lack of signal from flowing blood⁹ and the excellent fat suppression by water-selective excitation at 3T. These features allowed the suppression of fat, vessel, and parotid gland parenchyma and permitted the simultaneous visualization of the intraparotid

Fig. 1. A 57-year-old woman with dry mouth suspected of having Sjögren's syndrome. However, Sjögren's syndrome was ruled out by a blood test, lip biopsy, Schirmer test measuring tear production, and this magnetic resonance (MR) imaging. All of the images are 3-dimensional reversed fast imaging with steady-state precession diffusion weighting (3D-PSIF-DWI). (a)-(c) Sagittal source images of the 3D-PSIF-DWI. The facial nerve is visualized as a linear structure with high signal from the vertical segment to the stylomastoid foramen (arrow, a). (b) Two millimeters lateral to (a). The intraparotid facial nerve can be traced (arrow, b). (c) Twenty millimeters lateral to (a). The parotid duct can be identified as the branching linear structure with higher signal than the facial nerve (short arrow, c). (d) Sagittal oblique slab maximum intensity projection (MIP) image simultaneously shows branching point of the facial nerve (long arrow) and some part of the parotid duct (short arrow). (e) Coronal oblique slab MIP image shows the facial nerve (long arrow) and duct (short arrow). Incidentally presumed intraparotid lymph node (dotted arrow) is seen between the facial nerve and duct. Oblique lateral view (f) and oblique frontal view (g) of the volume-rendered image of the parotid gland. The facial nerve (long arrow) and parotid duct (short arrow) can be visualized in different colors. The presumed intraparotid lymph node is also seen (dotted arrows).

facial nerve and parotid duct as structures with high signal. Furthermore, the position of the parotid gland in the surface area of the craniofacial

region is suitable for imaging with a 32-channel array head coil.¹⁰ High spatial resolution 3D-PSIF-DWI has been applied for visualizing the lumbo-

Fig. 2. A 61-year-old woman with Sjögren's syndrome

(a) An oblique coronal slab maximum intensity projection (MIP) image based on 3-dimensional reversed fast imaging with steady-state precession diffusion weighting (3D-PSIF-DWI). Contrast between the facial nerve (long arrows) and parotid gland is not as good as in the case in Fig. 1 because of increased signal of the gland from disease. Some part of the duct is visualized (short arrow). (b) An oblique sagittal slab MIP image based on 3D-PSIF-DWI visualizes significant dilatation of the main duct (short arrow) and its branches. The facial nerve is barely visible (long arrow). Signal of the parotid parenchyma is high, probably from disease.

sacral plexus¹¹ as well as the cranial nerves. The diffusion moments used in the present study were not strong enough to suppress the signal of saliva in the parotid duct.

Diffusion-weighted echo-planar imaging (EPI) pulse sequence to visualize nerves has been reported,^{12,13} but its limited spatial resolution and image distortion hinder its broader application, especially in small structures, such as cranial nerves. In patients with acoustic neurinoma, diffusion-tensor tractography using EPI has been employed to visualize the facial nerve in the cerebellopontine angle cistern,¹⁴ but the intraparotid facial nerve has not been visualized using EPI.

Our study using 3D-PSIF-DWI is limited because

we lack surgical confirmation of the nerve and duct position visualized on the images, although the visualized structure agrees with anatomical knowledge of the parotid duct and facial nerve. In addition, background suppression of parotid gland tissue is insufficient in cases of Sjögren's syndrome, in which the ducts dilate and cysts form.¹⁵ Possible diffuse microcalcification may have impaired visualization of the intraparotid facial nerve. As well, our patients ranged in age from 48 to 69 years, and much younger subjects might have less fatty infiltration of the parotid gland, resulting in poorer signal suppression of parotid parenchyma. Finally, we tried a volume-rendering technique successfully in only 2 glands, those with significant fatty infiltra-

Fig. 3. A 47-year-old man with a surgically proven Warthin tumor in the right parotid gland

(a) Sagittal 3-dimensional reversed fast imaging with steady-state precession diffusion weighting (3D-PSIF-DWI). The parotid duct (short arrow) and tumor (dotted arrow) are clearly demonstrated. (b) An oblique sagittal slab maximum intensity projection (MIP) image based on the 3D-PSIF-DWI. The tumor (dotted arrow), parotid duct (short arrow), and intraparotid facial nerve (long arrow) are simultaneously visualized.

tion. Slab MIP is the first choice for the simultaneous volumetric presentation of intraparotid facial nerve and parotid duct in most cases using currently available technology. Further study is necessary to assess the utility of 3D-PSIF-DWI in patients with large metallic dental devices or with infiltrative malignant tumor.

In conclusion, simultaneous 3-dimensional visualization of the intraparotid facial nerve and parotid duct is possible using 3D-PSIF-DWI and a 32-channel array coil at 3T. Further studies are warranted for surgical confirmation of the relationship between the facial nerve, duct, and lesion. The clinical utility of 3D-PSIF-DWI in surgical planning for various parotid lesions requires further clarification.

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