Kinematic imaging of the orbit: comparison of FIESTA and FSE images for the evaluation of the coular movement

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Introduction After orbital fracture or even surgical repair of the fractured orbit, diplopia is one of the major problems due to the adhesion of the extraocular muscle. Magnetic resonance (MR) imaging is a suitable modality for the evaluation of the soft tissue in the orbit. Kinematic approach may be useful to assess the causes of the dysfunction of the extraocular muscles. MR imaging has no radiation effect, thus with repeated acquisitions of images for the kinematic evaluations, MR imaging can be safely used. In this study, both fast spin echo (FSE) and true FISP type of images such as fast imaging employing steady-state precession (FIESTA) were used in the assessment of the ocular movement. The purpose of the study was to compare these two sequences regarding their image quality and abilities of the detection of the dysfunction of the ocular movement using a kinematic display. This study was composed of two parts. The first part was for the evaluation of the image quality with T1-weighted FSE and FIESTA sequences in the normal subjects. And the second part of the study was for the evaluation of the ability of the kinematic T1-weighted FSE and FIESTA images in the detection of the causes of the dysfunction of the ocular movement.

Materials and Methods *Subjects*: In the first part, 11 normal volunteers (5 men, 6 women, mean age 30 years old) were studied, who had no known orbital, neurological, or any other diseases related to the movement of the eyes. In the second part, a total of 41 subjects (15 normal volunteers having normal function of the ocular movement; 10 patients having dysfunction of the ocular movement in the horizontal direction, 16 patients having its dysfunction in the vertical direction) were evaluated. *MR imaging*: All the subjects were studied with a 1.5T superconducting magnet (Excite, GE medical system, WI) using a 5-inch surface coil. Axial images and oblique-sagittal images parallel to the optic nerve were obtained in all the normal subjects, and either axial or oblique-sagittal images, or both were obtained in the patients according to the symptoms, past-history of the trauma, or medical records for the surgery. In the gantry, the marks were set in front of the subjects for the adjustment of the degrees of the ocular movement. The marks were aligned in the horizontal direction as well as the vertical direction with 10 steps. To evaluate the horizontal or vertical ocular movement, the subjects sequentially followed each mark in order along the horizontal or vertical direction, respectively. For the kinematic imaging, either FSE or FIESTA was repeated while the subjects moved eyes in the horizontal or vertical direction, respectively. T1-weighted FSE was obtained with the following parameters; repetition time (TR) 200msec, effective echo time (eTE) 13ms, Flip angle (FA) 90 degree, section thickness 5mm, matrix 256x128, field of view (FOV) 16x12cm, In-plane resolution 0.63x1.25mm, ETL 2, acquisition 1 phase 12sec. FIESTA were TR 4.5msec, TE 2ms, FA 60 degrees, section thickness 5mm, matrix 384x256, FOV 22x22cm, in-plane resolution 0.57x0.86mm, acquisition 1 phase 1sec. *Evaluations*: In the first part of the study, subjective analysis of the image quality, susceptibility artifact was made using a 100 point-scale. And contrast ratio (CR)(extraocular muscle or optic nerve) = [SNR(orbital fat)-SNR(extraocular muscle or optic nerve)]/ SNR(orbital fat) was obtained. In the second part, image quality, susceptibility artifact, existence of the adhesions were evaluated with the kinematic display of each imaging method as well as with the static single slice image using a 100 point-scale. 1 stands for the worst image quality, or definitely existence of adhesion and 100 stands for the excellent image quality, or definitely no-adhesion. All the evaluation was made on the workstation (Advantage Windows, GE). For the evaluation of dysfunction of the ocular movement, the point of lower than 50, and higher than or equal to 50 was regarded as for the existence and absence of the dysfunction, respectively.

Results In the first part of the study, CR of the extracoular muscle or optic nerve was higher on FIESTA images (0.7-0.9+/-0.1) than on FSE images (0.6-0.8+/-0.1). In the second part, in the evaluation of the horizontal ocular movement with axial images, motion artifacts were less on FIESTA images (93.5+/-5) than on FSE images(82.3+/-9.2), and overall image quality was better on FIESTA images (90.3+/-7.2) than on FSE images(85.1+/-7.5). Susceptibility artifacts were more prominent on FIESTA images (84.5+/-9.3) than on FSE images (90.0+/-8.0). In the evaluation of the vertical ocular movements with oblique-sagittal images, there was no significant difference in motion artifact between two types of images (90.9+/-4.7, 89.0+/-6.8) although susceptibility artifacts were much more prominent on FIESTA images (72.6+/-9.4) than on FSE images (92.2+/-5.0). Over all quality was better on FSE images (90.6+/-6.0) than on FIESTA images (85.7+/-6.9). Sensitivity, specificity, and accuracy for the detection of the ocular movement on the kinematic and static display of each image are summarized in Table.

Summary Kinematic information of the orbit is essential for the evaluation of the ocular movement. In the evaluation of the horizontal ocular movement, FIESTA images provide good quality and useful accurate information in the short period of time. However, in the evaluation of the vertical movement of the eyes, susceptibility artifacts due to the air in the maxilla and operative effects including the set of the metallic plate were problematic on FIESTA images. FSE images require longer time but are less susceptible to inhomogeneity of the magnetic fields. Static images provide limited information regarding the cause of the diplopia or dysfunction of the extraocular muscle.

Conclusion FIESTA images provide useful kinematic information of the ocular movement in a very short time. When susceptibility artifact is problematic, FSE imaging may be an alternate especially in oblique-sagittal plane.

Table Detection of the dysfunction of the ocular movement

	Kinematic (axial)		Kinematic (obl-sagittal)		Static (axial)		Static (obl-sagittal)	
	FSE	FEISTA	FSE	FIESTA	FSE	FIESTA	FSE	FIESTA
Sensitivity	0.64	0.78	0.88	0.94	0.18	0.22	0.69	0.75
Specificity	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.93
Accuracy	0.83	0.92	0.94	0.97	0.63	0.71	0.84	0.84