Assessment of Three Head Restraint Methods for fMRI: Foam Pillow, Vacuum Mold and Foam Mold.

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Introduction: Head motion is the bane of fMRI research. Although there are post-processing methods available to correct for this, the best approach is to limit head motion in the during data acquisition. To this end, all fMRI studies use some form of head restraint, but little is known about the comparative effectiveness of these various methods. In the present study, we compare the effectiveness of three different head restraint methods: a foam pillow, a vacuum mold, and a foam mold (Figure 1).

The MIND Clinical Imaging Consortium (MCIC) is a multi-center imaging study of schizophrenia that includes an fMRI component. The four sites involved are the University of New Mexico (NMEX), the University of Minnesota (MINN), the Massachusetts General Hospital at Harvard (MGH), and the University of Iowa (IOWA). Prior to fMRI studies of patients and controls, 10 healthy normal volunteers traveled to each site to assess fMRI repeatability. Three of the sites (NMEX, MGH, MINN) have Siemens scanners and all 3 used the prospective motion correction methods (PACE, Thesen et al., 2000) available from this vendor. However, each site used a different method of head restraint. This created an excellent opportunity to compare the effectiveness of the 3 methods of head restraint at these sites.

Methods: Ten volunteers (mean age: 44, range: 29 - 61, 5M/5F) traveled to 3 sites (NMEX, MGH, MINN) and participated in two identical fMRI studies on different days (Visit1 and Visit2), which consisted of several activation tasks. The data used to assess head motion was taken from two tasks, a sensorimotor task (2 runs, 4 min per run, 120 TRs, TR=2 sec) and an oddball task (4 runs, 3.2 min per run, 96 TRs, TR = 2 sec). The sensorimotor task involved finger tapping to a flashing checkerboard and used a block design. The oddball task involved finger tapping to “odd” tones embedded in a long sequence of “standard tones”, and employed an event-related design. The data available consisted of 354 motion estimates from 6 tasks, 10 subjects per site and 2 visits per subject. One visit from one subject was not available.

When the PACE algorithm detects motion during image acquisition, the gradients are reprogrammed to adjust for the movement. Adjustments are made for 3 translations (ant-post, lft-rgt, sup-inf) and 3 rotations [pitch (nodding your head indicating “yes”), roll (shaking your head indicating “no”), yaw (bringing your ear close to your shoulder)]. Movements must be greater than a preset threshold size before gradient reprogramming occurs. Each time gradient reprogramming is performed, the nature of the movement is recorded in the DICOM image header, in mm units for translations and in degrees of angle for rotations. The data were extracted and processed to obtain estimates of total movement across each run. Specifically, we recorded the sum, over TRs, of the absolute value of every movement for all six motion parameters. The final values compared were: (1) translations (in mm) per TR *1000; (2) rotations (deg) per TR *1000.

The different head restrain methods are illustrated in Figure 1.

Foam Pillow: A Tempur-Pedic pillow was employed (http://www.tempurpedic.com/pillows/).

Vacuum Mold: This device employed was a VACFIX Model vf-142 system (S & S Par Scientific, http://www.parscientific.com/VacuumCushions.html). The pillow was substantially modified by removing roughly half of the beads. The pillow was then divided into 4 compartments (back of head, left side, right side and top). Once the head was placed in the pillow, the beads were shifted manually in the side compartments so that the side compartments fit snuggly around the head and ear phones. The top compartment was placed over the top of the head to cover the top of the forehead. The pillow was then evacuated as the operators molded the beads to insure that the pillow did not interfere with the subject's view of the screen.

Foam Mold: The molding material is “Kit K-8” available from KGF Enterprises, (Chesterfield, MI) and consists of 2 bottles, Part A and Part B. Approximately 100 cc from each bottle is mixed and then poured into a double plastic bag which is placed in the head coil. The bag is held closed as the foam rises and the foam is molded about the subjects head and forehead. A videotape illustrating the use of this material is available from the first author.

Statistical analysis assessing the effect of the head restraint methods was performed with a Mixed Model ANOVA (SAS Proc Mixed), with subject as a random effect and method and task as fixed effects. There were no method * task interactions, so this term was dropped from the model. There were task effects which will be reported separately. Post-hoc p-values were adjusted for multiple comparisons using the Tukey method. For Table 1, all of the Ftests had 2 and 16 df.

Results: The 3 head restraint methods did not differ significantly on any translation measure and did not differ on the amount of Yaw rotation (See Table 1). There were significant method effects for Pitch rotation (Figure 1, Table 1) and Roll rotation (Figure 2) (Table 1). Post-hoc comparisons indicated that for Pitch, the Foam Pillow method was significantly less effective than the Foam Mold method, and was nearly significantly less effective than the Vacuum Mold method (Table 2). For Roll, the Foam Mold was significantly more effective than both of the other methods.

Discussion: The results indicate that the Foam Mold method is the most effective method in reducing Pitch and Roll rotation. The Foam Mold forms a hard mold around the subject’s head, and fits tightly. It does take some practice to properly employ, but once mastered, comfortable, effective molds can be produced routinely. The NMEX center has used the Foam Mold system on many control subjects as well as at least 10 patients with schizophrenia. There have been no complaints about the system from any of the patients. The Vacuum Mold is probably an improvement over the Foam Pillow.

References: Thesen S, Heid O, Mueller E, Schad LR. Prospective acquisition correction for head motion with image-based tracking for real-time fMRI. Magn Reson Med. 2000 Sep;44(3):457-65.

FIGURE 1

HEAD RESTRAINT SYSTEMS

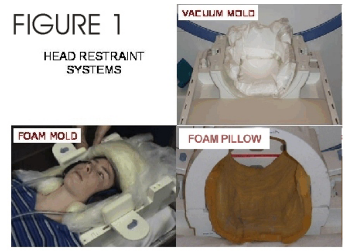

FIGURE 2

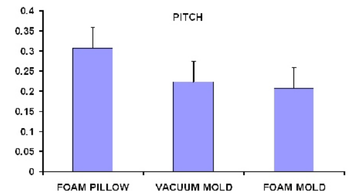

FIGURE 3

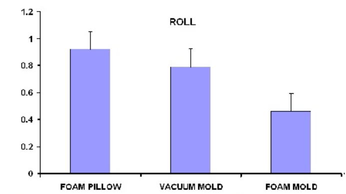

TABLE 1

MOVEMENT TYPE	FValue	ProbF
ANT-POS TRANSLATION	0.54	0.59
LFT-RGT TRANSLATION	0.44	0.65
SUP-INF TRANSLATION	1.41	0.27
YAW	0.9	0.4
PITCH	4.6	0.023
ROLL	9.5	0.002

TABLE 2

MOTION	COMPARISON	ADJ. P-VALUE
PITCH	FOAM PILLOW vs VACUUM MOLD	0.070
PITCH	FOAM PILLOW vs FOAM MOLD	0.027
ROLL	FOAM PILLOW vs FOAM MOLD	0.001
ROLL	VACUUM MOLD vs FOAM MOLD	0.019