Journal of Computer Assisted Tomography
14(1):163–164, January/February

Technical Note

Nasal Orientation Device to Control Head Movement during CT and MR Studies

Paul S. Tofts, Allan G. Kermode, David G. MacManus, and W. H. Robinson

Abstract: Cooperative patients can often keep still during a long examination of the brain provided that they are given cues about their position in space. In a U-shaped head support, the only movements likely are rotation in the sagittal or transverse planes. These can be detected by a nasal orientation device (NOD), simply a ring around the nose, close but not touching. Any unintentional movement is felt on the nose by the patient, who can return to the original (nontouching) position. With this device the patient can keep immobile to within approximately ±2 mm during long examinations. We have used the NOD to improve the quality of dynamic Gd-DTPA scanning for the measurement of blood–brain barrier permeability. The NOD can be of value in any neurological imaging procedure that is currently degraded by head movement.
Index Terms: Brain—Computed tomography, apparatus and equipment—Magnetic resonance imaging, apparatus and equipment—Gadolinium.

Patient movement during long examinations may represent a problem in neuroimaging. Improvements in instrumental spatial resolution are futile if the patient is likely to move during the imaging procedure. In many cases the movement is necessary for the normal functioning of the body (e.g., cardiac, respiratory, or peristaltic) and the solution may lie in gated data collection (only when the movement is regular and predictable) or in fast data collection [e.g., fast CT scans or echo planar magnetic resonance (MR) imaging]. In other cases the amount of movement is likely to be less than the spatial resolution of the imaging device and therefore does not degrade the image (e.g., in neurological imaging by positron emission tomography or single photon emission CT). We are concerned with small amounts of random movement in high-resolution quantitative dynamic neurological imaging. In such a dynamic scan, pixel values are measured every few mintues for a period of up to 1 h to follow the time course of tracer distribution (e.g., Gd-DTPA) (1,2), and stability of the head is essential. Ideally the scans should register exactly and the same region of interest (ROI) should be used for the whole set of scans, so as to eliminate noise in the time curve caused by movement of the ROI relative to the tissue of interest. Movement of the patient is difficult to compensate for by moving the ROI; even if the ROI could be placed in the same position with respect to the tissue, the image intensities are likely to be altered because of varying partial volume effects caused by movement perpendicular to the imaging plane.

Head frames and other manual restraints such as straps and polystyrene-filled bags that can be evacuated have been used for immobilization. However, these are relatively uncomfortable, they may be invasive, and they may take time to set up.

We have found that some cooperative patients are highly motivated and attempt to keep still for long periods. However, if they do move, they have no way of knowing what their original position was. Nor can they counteract a slow drift. What they require is feedback on their current position. We have developed a simple yet effective nasal orientation device (NOD) based on this feedback principle. In a U-shaped head rest, the movement is likely to be, in order of decreasing magnitude: (a) rotation

From the Multiple Sclerosis NMR Research Group, Institute of Neurology, Queen Square, London WC1N 3BG, England. Address correspondence and reprint requests to Dr. P. S. Tofts.

in the sagittal plane; (b) rotation in the transverse plane; (c) shift toward or away from the feet. All of the movements will produce a movement of the nose, and therefore we provide feedback to the patient in the form of a ring around the nose. At the start of the examination, this ring is set up close to the nose but not touching it. Any movement of the nose, either laterally or toward or away from the feet, is immediately detected by the patient, who can then return to the correct (nontouching) position. The ring is positioned in an oblique transverse/coronal plane around the end of the nose, so that movement of the nose by more than ~2 mm is detected. Positioning of the ring is comfortable, noninvasive, and quick.

The angle can be adjusted according to the shape of the particular patient's nose. A supporting arrangement allows the position of the ring to be adjusted in three ways, to fit the patient: (a) vertically; (b) horizontally toward or away from the feet; (c) tilting to adjust the transverse/coronal obliquity.

The support should be constructed of materials that do not interact with the scanner and are of sufficient rigidity so that the ring is fixed to within better than 1 mm. We have used this device for measurement of Gd-DTPA enhancement in MR; however, it could also be used in dynamic X-ray CT studies. Figure 1 shows an early prototype, constructed from bent wire mounted on a plastic board that can slide along the head coil. Vertical movement is achieved using an adjusting screw. No tilting to adjust transverse/coronal obliquity was provided in this case.

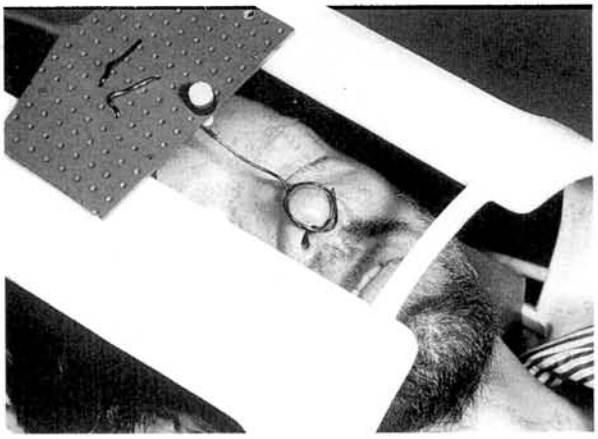

FIG. 1. An early prototype of the device, constructed from bent copper wire attached to a plastic board that slides along the head coil case. Vertical adjustment is provided by moving an adjusting screw against the springiness of the wire. Note the small clearance (~2 mm) between the wire and the skin.

With this device our dynamic Gd-DTPA scans, lasting ~1 h, have improved dramatically, with all images in good registration. Previously there was nearly always some movement, resulting in jagged dynamic curves with steps at the times of movement. With the NOD the resulting dynamic curve from any particular ROI is smooth and can be least-squares-fitted to a model function to measure blood–brain barrier permeability (3,4).

The experience of subjects being scanned is that small semiinvoluntary movements, such as swallowing, coughing, talking, or moving the limbs to alleviate cramp, produce a nose-touch. This indicates that all these movements produce motion of at least 2 mm in the brain. The head position is then immediately finely readjusted to remove the sensation of nose-touch.

Possible enhancements to the design include (a) ear cues to provide a three-point definition of the position (then the head rest becomes less important in positioning) and (b) a neonatal version based on the baby's dummy to immobilize the mouth rather than the nose. The device could be fixed to the scanning couch itself, rather than to the head coil as in Fig. 1, so as to facilitate changing the coil. We believe the NOD will be of value in any neurological imaging procedure where movement currently degrades the quality of the images produced.

The NOD is the subject of a provision patent filed in the U.K.

REFERENCES

1. Kermode AG, Tofts PS, McDonald WI, MacManus DG. Towards quantification of gadolinium-DTPA leakage in multiple sclerosis [Abstract]. Society of Magnetic Resonance in Medicine 7th annual meeting, 1988:21.
2. Kermode AG, Tofts PS, MacManus DG, et al. The early lesion in multiple sclerosis. *Lancet* 1988;2:1203–4.
3. Tofts PS, Kermode AG. Measurement of blood brain barrier permeability using Gd-DTPA scanning. Society of Magnetic Resonance Imaging annual meeting, Los Angeles, 1989.
4. Tofts PS, Kermode AG. Blood brain barrier permeability measured in multiple sclerosis using labelled DTPA with PET, CT and MRI. *J Neurol Neurosurg Psychiatry* 1989;52: 1019–20.