CyberKnife Markers Visible on CT and MRI

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Introduction

The CyberKnife planning and delivery system of SRS/SBRT makes extensive use of metallic marker tracking for soft tissue targets. These markers are identified in the planning phase and are used to develop the Digitally Reconstructed Radiographs (DRR's) which will form the basis of alignment during the treatment phase. For Fiducial Tracking, 3 or more fiducials are placed in the soft tissue targets approximately one week prior to simulation imaging with CT and MRI. For Synchrony Tracking, we employ the Miami technique of Xsight Spine alignment, and subsequently tracking on one or two fiducial markers previously placed in the soft tissue targets which will move with respiration. For soft tissue targets that will require fusion of MRI images to the primary CT data set, it is important that the markers are visible on both CT and MRI data sets. This is especially important for Fiducial Tracking in prostate targets and Synchrony Tracking in hepatic and other upper abdominal targets that move with respiration. The fiducials are identified on both the CT and MRI data sets in order and the viewing area set on the CT fusion screen is adjusted to encompass the anatomic volume at hand. Subsequently, the fusion algorithm is allowed to proceed with the operation until completed.

Figure 1 shows the physical appearance of the fiducial markers (Gold Anchor, Sweden) being deployed at the end of the 22 ga. needle. They come in 10 and 20mm lengths and "fold" upon themselves as they are deployed in tissue. This effect makes them extremely stable and migration of the markers is minimized.

New design of the markers include a small percentage of ferromagnetic material in the gold alloy allowing greater visibility on both T1 and T2 MRI sequence images.

As will be indicated, the use of the Gold Anchor fiducials has made the fusion process between targets on CT and MRI images easier to perform accurately. As a proviso, the CT images should be obtained first and the MRI images at a later time, insuring that the fiducials will appear on both image data sets. This sequence of imaging need not be adhered to for other forms of CyberKnife tracking, eg. 6D Skull tracking.

Fig.1. Physical appearance of Gold Anchor Fiducial being deployed

Methods

It is important to discuss the placement of the fiducials beforehand with the interventional radiologist (or other physician who will be inserting the fiducials). Good placement of the fiducials can make all the difference in, for example, fiducial targeting in a prostate plan. In this case, the T1 and T2 MRI sequences will display the fiducials as well. The CT fusion screen should be "cropped" only around the prostate gland and not bony anatomy which may distort the prostate gland fusion if allowed to become part of the fusion algorithmic base, especially if bladder or rectal contents have changed between CT scan and the acquisition of the MRI images. Figure 2 shows the appearance of a CT slice through the prostate gland containing two fiducial markers. Figure 3 shows the corresponding MRI slice through these fiducial markers that has been fused to the CT data set as described above. .

Fig. 2. CT slice through prostate gland containing two fiducial markers.

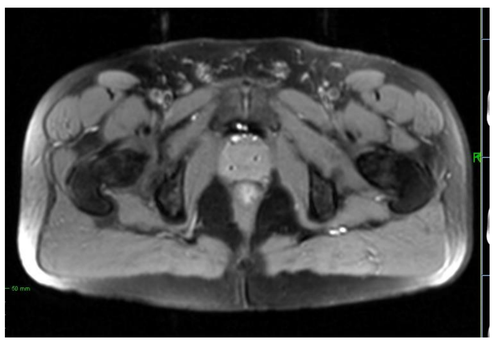

Fig. 3. Corresponding MRI image fused to the CT slice in Fig 2.

Results

The Gold Anchor fiducials have been used successfully in a number of our CyberKnife patients. We have in the past also used single gold markers for fiducial tracking when an MRI data set was not required. Most of the time these have worked out to be sufficient to track successfully. However, in a few instances, we have noted migration of these markers over time as evidenced by the growing rigid body errors that crop up. More and more, we have taken to using the Gold Anchor markers, even for fiducial tracking when MRI images were not required. This has obviated the migration over time of the markers in our experience.

Figure 4. illustrates the use of the Gold Anchor markers in a liver lesion that we have planned and treated. The hybrid image shows the bright image of the marker on CT and the corresponding defect the marker makes on the MRI image. Note again that the blue window on the CT fusion screen was closed only around the entire liver volume for the fusion process as the position of the liver will change relative to the other moving structures with respiration and those (vertebral bodies eg.) that are stationary. Markers are identified on CT and correspondingly identified on MRI and the fusion is allowed to proceed based on these assignments.

Fig. 4 Appearance of the fiducials in liver lesion with CT/MRI overlay. Bright CT fiducial image appears as defect on MRI T1 T2 sequences

Conclusions

We describe the use of the Gold Anchor fiducial markers in this poster. They have the advantage that a small amount of ferromagnetic material is mixed in the gold alloy to allow better visibility on MRI imaging than gold alloy fiducials alone. There are other markers that have been described (ref. 1) that also have a good signal on MRI imaging. One of the additional advantages of the Gold Anchor markers, however, is their crumpling effect that keeps them in position in soft tissue and low density lung tissues. Figure 5 shows the appearance of the Gold Anchor markers in lung tissue. We have had problems with single gold markers placed in these low density tissues migrating over time from their original deployed positions. We have been pleased with the performance of the Gold Anchor markers in this regard. There are times, however, that the Gold Anchor markers do no crumble properly on deployment. In these cases, it is important that the fiducial position assignment on the DRR images be identified at the end of the marker and this position should be identified on the live tracking images during treatment delivery – and checked that this position remains throughout treatment delivery.

Fig. 5 The appearance of the Gold Anchor fiducial deployed in the left lung of a patient. The "crumpling " of the fiducial insures positional stability through the planning and treatment phases.

Bibliography

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