

Using Foldable Gold Anchor Markers for Fiducial Tracking with the CyberKnife

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Objectives: Foldable gold anchor markers can be inserted using a 22 or 25 gauge needle, which is thinner than the 17 or 18 gauge needles used with standard solid gold fiducial markers. Gold anchor markers can also vary in shape, depending on the insertion technique. We have explored the possibility of using this marker for CyberKnife treatment with a phantom study and report on one clinical case.

Methods: The 25 gauge needle (120 mm in length) and 22 gauge needle (200 mm in length) contain either 10 mm or 20 mm long gold wire (0.28 mm in diameter). The gold wire has small notches every 2.0 mm. When injected into the tumor tissue, the wire is advanced by the stylet which forces the wire to fold into a dense *ball-shape* marker that automatically anchors itself, making migration less likely. Alternatively, retracting the needle without advancing the stylet leaves the gold wire in the tissue as a *linear* marker. A combination of injection and retraction can generate a *tadpole* shaped marker. In our phantom study, three 20-mm wires were placed into a superflab bolus and folded into ball, linear and tadpole shapes. A 10-mm wire was also inserted as a linear marker. In addition, three standard 0.8 x 3 mm standard markers were injected into the bolus. The bolus was placed on top of 10 cm thick solid water phantom and scanned transversely and longitudinally. A test plan was designed to verify the tracking feasibility and precision on both scans. For the clinical case, a 0.8 x 3 mm standard marker and a 10-mm anchor marker were applied by an interventional radiologist into a lung patient.

Results: In the treatment console, the anchor marker was visible under default X-ray parameters. The CyberKnife system could lock onto all gold anchor markers with 1 mm precision or better, except for the 20-mm linear marker. A visual similarity comparison between digital reconstructed radiograph (DRR) and real-time X-ray images confirmed the precision of the lock-on. It was felt that most of the tracking uncertainty arose from the deformation of the bolus rather than the anchor marker. In the clinical study, no toxicity was observed resulting from the fiducial placement. Details on our experience treating this patient will be presented.

Conclusions: The gold anchor markers appear comparable with traditional solid gold markers. Anchor markers were able to be tracked in the phantom and a single patient, with the exception of the 20-mm linear marker. Further clinical study is necessary to determine whether the thinner needle will result in reduced rate of pneumothorax with similar tracking capability

A. Types of Fiducial

a. Anchor Foldable marker

- i. 10 mm wire
- ii. 20 mm wire
- iii. 2mm notchs

b. Solid gold marker

B. Placement of Anchor Marker

1. Equipment

- a. 25 Gauge Needle
- b. 22 Gauge Needle

2. Placement

- a. Advancing Sylet -- ball shaped
- b. Retrack needle -- linear shaped
- c. Combined – Tadpole shaped

C. Tracking of Anchor marker

- 1. Ball and Tadpole successfully**
- 2. 2 cm linear not successful**
3. Clinical experience