Visualization of Continuous Radiopaque Filament Marker within a Digitally Reconstructed Radiograph

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Introduction:

- Filament markers (FM) are multi-plane, radiopaque continuous strand woven into the tumor bed to assist in accurate contouring following lumpectomy (Rafie et al., 2024).
- Their structure allows for visualization across multiple planes, improving 3D target delineation in breast-conserving radiotherapy compared to traditional clips, which represent single discrete points and may not be distributed across axial planes (Shukla et al., 2023).
- While metallic clips are highly visible due to their larger size and high Hounsfield Unit (HU) values, it is potentially hard to use them as patient setup markers if they are not placed in a 3D space.
- Although FM are metallic, they are thinner, flexible and elongated, they exhibit lower HU due to volume averaging.
- As a result, visualization of FM within digitally reconstructed radiographs (DRRs) may be difficult.
- This limitation may prevent their effective use for patient setup in external beam radiotherapy.
- This case report demonstrates a method to optimize FM visualization within DRRs for clinical use.

Case Report:

- An anonymized patient treated with right breast lumpectomy who was implanted with FM to delineate the tumor bed was selected for analysis.
- Optimal visualization of the filament marker was achieved by adjusting imaging parameters.
- A key modification included rotating the kV cone beam gantry to 50° to avoid rib superimposition, which otherwise obscured the marker (Figure 1).
- DRR parameter adjustments, particularly CT windowing, markedly influenced FM visibility.
- Multiple window level settings were evaluated to determine optimal contrast for clinical setup.
- Narrow CT window level ranges (0 – 400 HU) improved contrast between the FM and surrounding tissue (Figure 1).
- Overlaying the FM contour further enhanced localization confidence (Figure 2).
- Lower HU of FM, while initially a limitation, allowed better integration with surrounding anatomy without requiring density overrides.

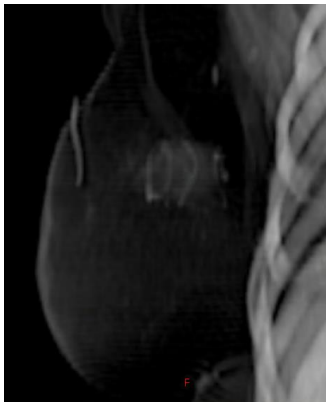

Figure 1. Settings to achieve optimal visualization of FM on the DRR: Gantry Rotation = 50°, Collimator Rotation = 0°, Couch Rotation = 0°, DRR parameters (Weight = 1, CT Window [HU] from 0 to 200).

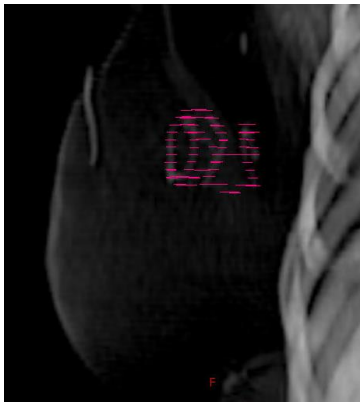

Figure 2. Pink Contour of FM overlaying the DRR: Gantry Rotation = 50°, Collimator Rotation = 0°, Couch Rotation = 0°, DRR parameters (Weight = 1, CT Window [HU] from 25 to 150).

Discussion:

- Although FM has lower radiodensity compared to traditional clip fiducials, this characteristic can be advantageous.
- Unlike clips, which often require HU overrides to approximate soft tissue density, FM can remain unmodified while still providing adequate visualization when imaging parameters are optimized.
- Proper adjustment of gantry angle and CT windowing enables reliable identification of FM within DRRs, supporting their use in patient setup and alignment.

Conclusion:

- This case report demonstrates that with appropriate imaging parameter optimization, particularly gantry rotation and CT windowing, FM can be effectively visualized within DRRs, overcoming prior limitations associated with their lower radiopacity.
- It also allows for potential use of FM for patient setup in breast-conserving radiotherapy, particularly for hypofractionated modalities such as Accelerated Partial Breast Irradiation and breast Stereotactic Body Radiotherapy, where accuracy in setup is crucial for delivering higher doses in a safe manner.

References:

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