

# Suitability of Different Implanted Marker Types for Usage with ExacTrac Dynamic

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## Purpose

SBRT and IGRT with fiducial markers enable precise high-dose radiation delivery while sparing healthy tissue. Currently, ExacTrac Dynamic® (ETD) supports only two marker types (short and long), using standardized detection parameters that are not optimized for other marker designs. This work evaluated different implantable markers and identified optimal detection parameters for each, providing a basis for expanding automatic marker detection to a wider range of marker types in the future.

## Materials and Methods

Eleven clinical patient datasets and sixteen custom-developed marker phantoms including Gold Anchor MR+, BiomarC®, and NOVA™ fiducial markers were analyzed. The ETD automatic marker detection algorithm was evaluated using stereoscopic X-ray images provided by various hospitals (patient data) or acquired in clinical environment (phantoms). Detection parameters were systematically optimized by adjusting marker-specific settings and comparing standard versus optimized configurations. Detection rates (2D and 3D), failure modes, and localization accuracy were assessed. Additionally, the influence of ROI, CT slice thickness and number of implanted markers were investigated.

## Results

All investigated marker types were visible in CT and X-ray imaging and could be detected after marker-specific parameter optimization. Significant improvements in 2D and 3D detection rates were observed for both patient (see Figure 1 and 2) and phantom datasets. A smaller ROI consistently improved detection performance, while increasing CT slice thickness reduced detection rates for long markers due to inaccurate marker definition. The number of implanted markers had no measurable effect on detection success.

## Conclusion

Although the detection success rates were limited under standard settings, all investigated marker types were detectable when optimized parameters were applied. Consequently, the automatic detection algorithm of ETD can, in principle, be employed for clinical use with Gold Anchor MR+ markers, BiomarC® carbon markers, and NOVA™ markers. However, the study revealed that each marker type requires a distinct set of algorithm parameters, as no universal configuration could be established. These parameters are to be included in future ETD version to incorporate individualized, site- and patient-specific marker detection. Additionally, thinner CT slice thickness improved long-marker detection and reducing the X-ray ROI further increased detection rates.

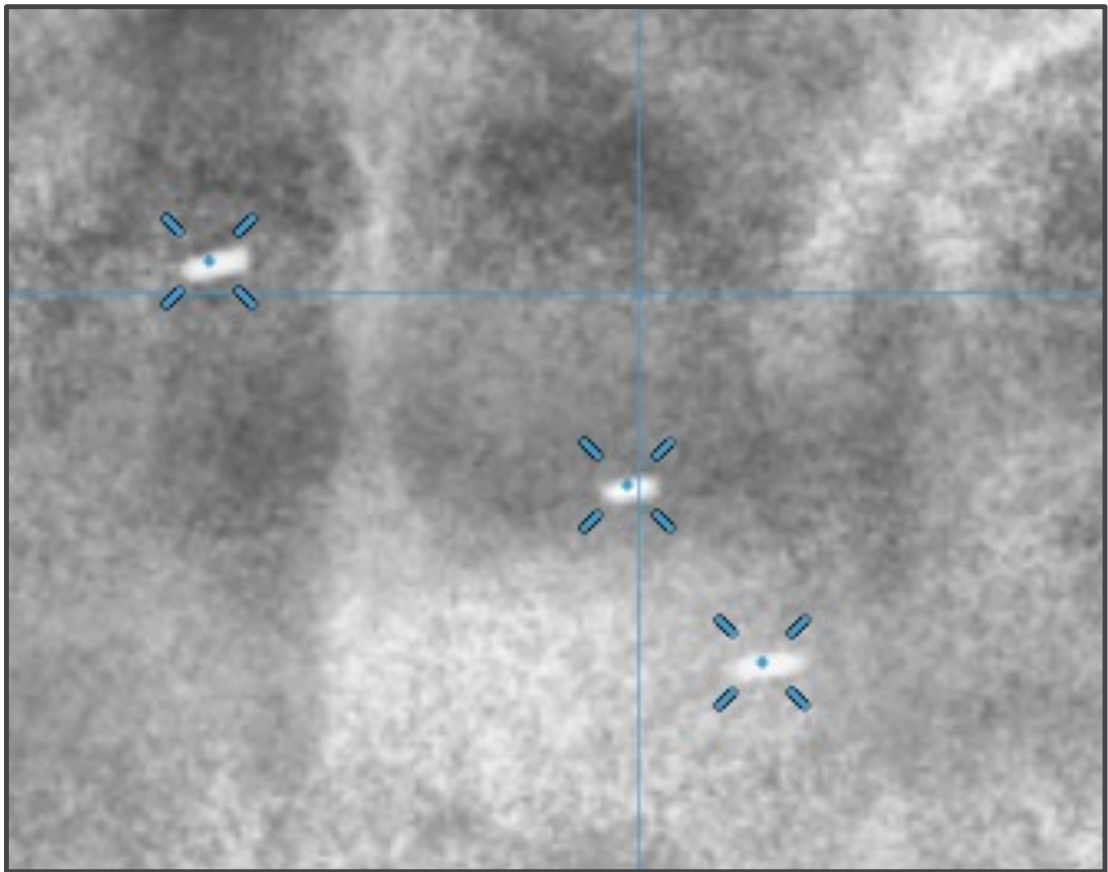


Figure 1: NOVA™ fiducial marker detected with optimized settings

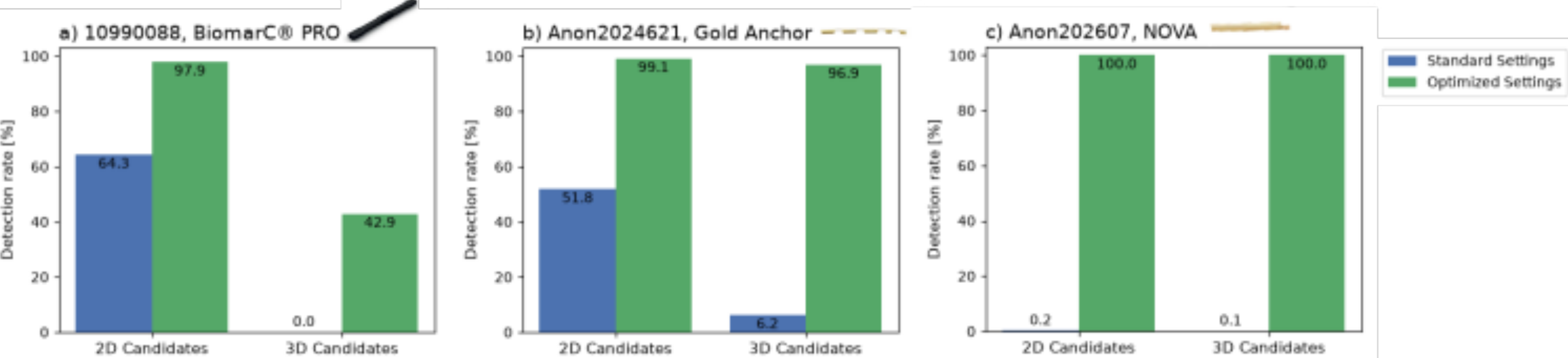


Figure 2: 2D and 3D detection rates for standard and optimized parameters for patient data with a) BiomarC® PRO, b) Gold Anchor, and c) NOVA™ fiducial markers