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## Introduction

High geometric MRI accuracy is essential for stereotactic localisation in Gamma Knife radiosurgery. The Elekta Vantage Frame, being made from non-metallic, composite materials, promises low distortion, stereotactic localisation. However, prior to clinical implementation, no suitable commercial Known Target Phantom existed, creating a challenge in verifying localisation accuracy. Our staged approach towards implementation began with improvised methods, progressed to a clinical accuracy audit, and culminated in full 3D verification using the first commercially available Known Target Phantom.

## Methods and Materials

Initial commissioning was performed using an RTsafe PRIME phantom with an MRI geometric insert. The phantom was scanned using a clinical T1 sequence and landmarks compared with reference CT/CBCT datasets.

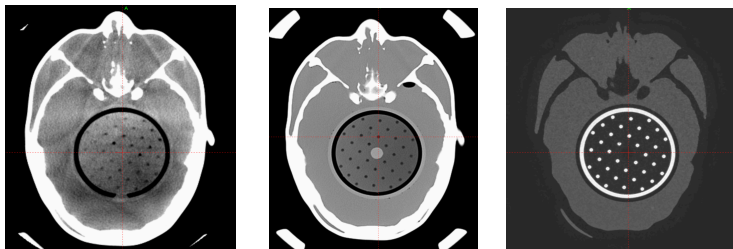


Figure 1. CBCT scan on left, Diagnostic CT in middle, MR scan on right, demonstrating difficulties visualising the internal structure of the MR insert with CBCT

Secondly, a prospective clinical audit of 72 Vantage frame patients were evaluated for MRI fiducial error, MRI-CBCT co-registration quality, and maximum shot displacement (MSD). Finally, an IBA QUASAR™ Advantage Phantom with 1813 control points, was scanned under routine imaging conditions. This enabled volumetric distortion mapping across the stereotactic volume. The associated analysis software generated a distortion vector field and a report detailing x, y, z and radial distortion values with corresponding uncertainty for each control point.

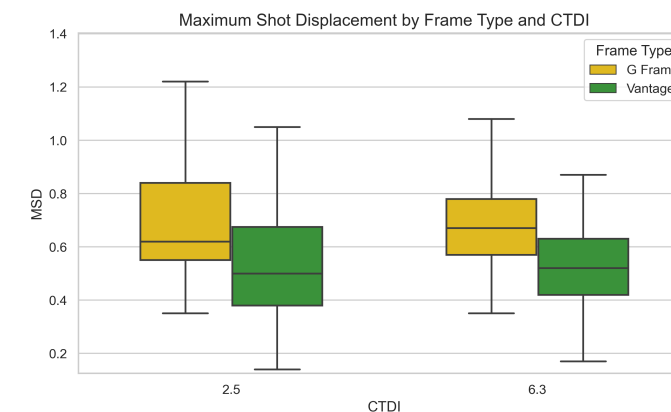


Figure 2. The IBA Advantage phantom

## Results

MRI to CT comparison demonstrated mean discrepancies of less than 1 mm across scan volumes for T1 sequences. The clinical audit confirmed sub-millimetric stereotactic accuracy, including a mean MRI fiducial localisation error of 0.37 mm, over 70% of cases with CBCT-to-MRI co-registration rated as “Good,” and a mean MSD of 0.53 mm.

All evaluated metrics remained within institutional tolerance and consistency across patient workflows. The IBA Advantage phantom demonstrated geometric distortion of less than 1 mm throughout the clinically relevant stereotactic volume, validating both the initial commissioning methodology and clinical performance.



Mean MSD per CTDI for Vantage frame: CTDI 2.5 0.53 and CTDI 6.3 0.52 ( $p \geq 0.05$ )

## Conclusion

MRI distortion evaluation remains essential for Gamma Knife radiosurgery. Improvised testing, when followed by structured clinical audit and subsequent 3D phantom verification, provides reliable assurance of stereotactic accuracy. Continued distortion monitoring is critical to maintaining safe and precise MRI-based Gamma Knife practice.