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## INTRODUCTION

MR imaging enables precise tumor targeting but is affected by geometric distortions that can impact submillimeter accuracy. Fixation frames contribute to these distortions. The G frame (aluminum, titanium) may induce eddy currents and field perturbations, while the Vantage frame (glass fiber–reinforced epoxy, PEEK) is designed to minimize these effects.

**Aim:** Compare MR distortions between G and Vantage frames and evaluate geometric accuracy of radiosurgery imaging.

## MATERIALS AND METHODS

An anthropomorphic head phantom CIRS 603A with a 3D grid was used to assess MR geometric distortion, with both G-frame and Vantage frame mounted according to clinical protocol. MR imaging was performed on 1.5 T and 3 T scanners using MPR, T1 TSE (axial and coronal), and CISS sequences, with CBCT as the reference standard. Thirty grid points were compared between MR and CBCT to calculate 3D spatial displacement. Statistical analysis included paired t-tests and three-way ANOVA.

Sequence	Scanner	Frame	$\Delta$ (3D) (mm)	p-value
MPR	Avanto 1.5 T	G-frame	0.9 ± 0.2	< 0.05
		Vantage	0.7 ± 0.2	
	Skyra 3 T	G-frame	1.1 ± 0.2	< 0.05
		Vantage	0.9 ± 0.2	
T1 TSE TRA	Avanto 1.5 T	G-frame	1.1 ± 0.2	< 0.05
		Vantage	0.7 ± 0.2	
	Skyra 3 T	G-frame	1.9 ± 0.7	< 0.05
		Vantage	1.1 ± 0.5	
T1 TSE COR	Avanto 1.5 T	G-frame	1.0 ± 0.3	< 0.05
		Vantage	0.8 ± 0.3	
	Skyra 3 T	G-frame	1.6 ± 0.5	< 0.05
		Vantage	1.2 ± 0.5	
CISS	Avanto 1.5 T	G-frame	0.7 ± 0.3	> 0.05
		Vantage	0.6 ± 0.2	
	Skyra 3 T	G-frame	0.7 ± 0.3	> 0.05
		Vantage	0.7 ± 0.2	

Table : Results for all combinations of sequence, scanner and frame

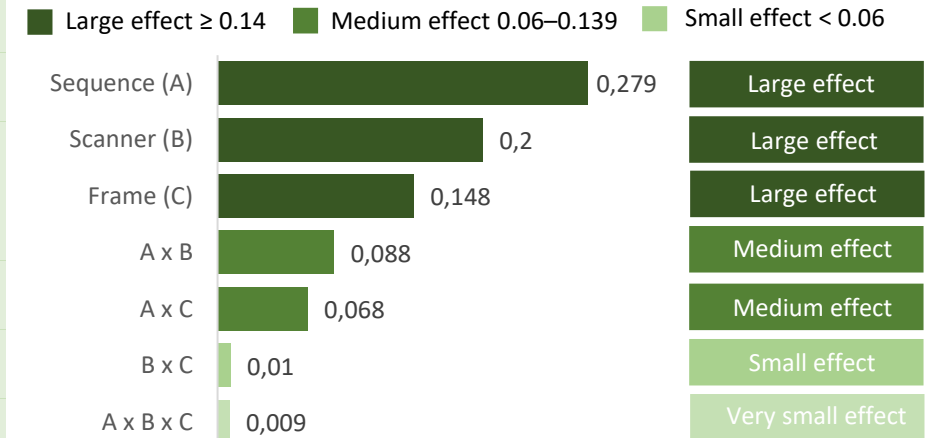


Figure: Partial eta-squared ( $\eta^2p$ ) values from the three-way ANOVA on geometric distortion and the effects of each parameter

## RESULTS

The analysis demonstrated that the Vantage frame consistently reduced geometric distortion compared with the G-frame across most MRI sequences and both field strengths. The greatest improvements were observed in T1-weighted TSE sequences. In the TSE TRA sequence, 3D displacement decreased from 1.1 to 0.7 mm on the 1.5 T scanner and from 1.9 to 1.1 mm on the 3 T scanner ( $p < 0.05$ ). Similarly, in the TSE COR sequence, displacement was reduced from 1.0 to 0.8 mm at 1.5 T and from 1.6 to 1.2 mm at 3 T ( $p < 0.05$ ).

For the MPR sequence, the Vantage frame also showed lower geometric distortion, with 3D displacement decreasing from 0.9 to 0.7 mm at 1.5 T and from 1.1 to 0.9 mm at 3 T ( $p < 0.05$ ). In contrast, the CISS sequence showed the lowest overall distortion values and no significant differences between frames at either field strength. Higher geometric distortions were consistently observed at 3 T compared with 1.5 T, particularly in TSE-based sequences.

Three-way ANOVA revealed significant effects of sequence, scanner, and frame on geometric distortion ( $p < 0.001$ ), with sequence showing the strongest effect, followed by scanner and frame. Interaction effects were present but in smaller magnitude.

## CONCLUSION

The analysis demonstrated that the Vantage frame consistently reduces 3D geometric displacement compared with the G-frame across most MRI sequences, with the largest differences observed in TSE acquisitions and at 3 T. Three-way ANOVA confirmed that sequence, scanner, and frame all have a significant effect on geometric distortion, with sequence being the dominant factor. These results indicate that both frame design and imaging parameters contribute to stereotactic spatial accuracy, with the Vantage frame providing improved precision.

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