Supplementary material A

The extraction of three-dimensional target motion profiles from the Motion Monitoring cine MR images was performed in Matlab (Mathworks Inc., Natick, MA, USA) using an in-house tracking algorithm described in the following.

Alongside the cine MR images, the Motion Monitoring files contain a 2D binary mask of the PTV in the same frame of reference as the images. The cine images were cropped using a rectangular border created by expanding the PTV structure by 25 mm in the IS direction (both coronal and sagittal images) and 5 mm in the AP direction (sagittal images). Further pre-processing of the images included the application of a gradient filter.

The first image frame in each direction was discarded from further analysis as the contrast in these images differs from the rest in each image series. To track changes in the target position, a tracking algorithm performed a rigid translation registration between template 2D images and consecutively acquired 2D cine images in the two image planes as conceptualised by Keiper et al.[1]. The creation of the template images was based on extracting a 2D slice through the centre of the PTV from the 3D session image of the patient and applying a gradient filter. The geometric registration that aligns the two images was assumed to be the displacement of the target. The rigid image registration was based on Matlab's built-in algorithm called imregtform, using mutual information as an image similarity metric and gradient descent as an optimiser. The geometric starting point for each registration step was the displacement information acquired in the preceding registration step multiplied by 0.9.

[1] Keiper TD, Tai A, Chen X, Paulson E, Lathuilière F, Bériault S, et al. Feasibility of real-time motion tracking using cine MRI during MR-guided radiation therapy for abdominal targets. Med Phys 2020;47:3554–66. https://doi.org/10.1002/mp.14230.

Supplementary material B

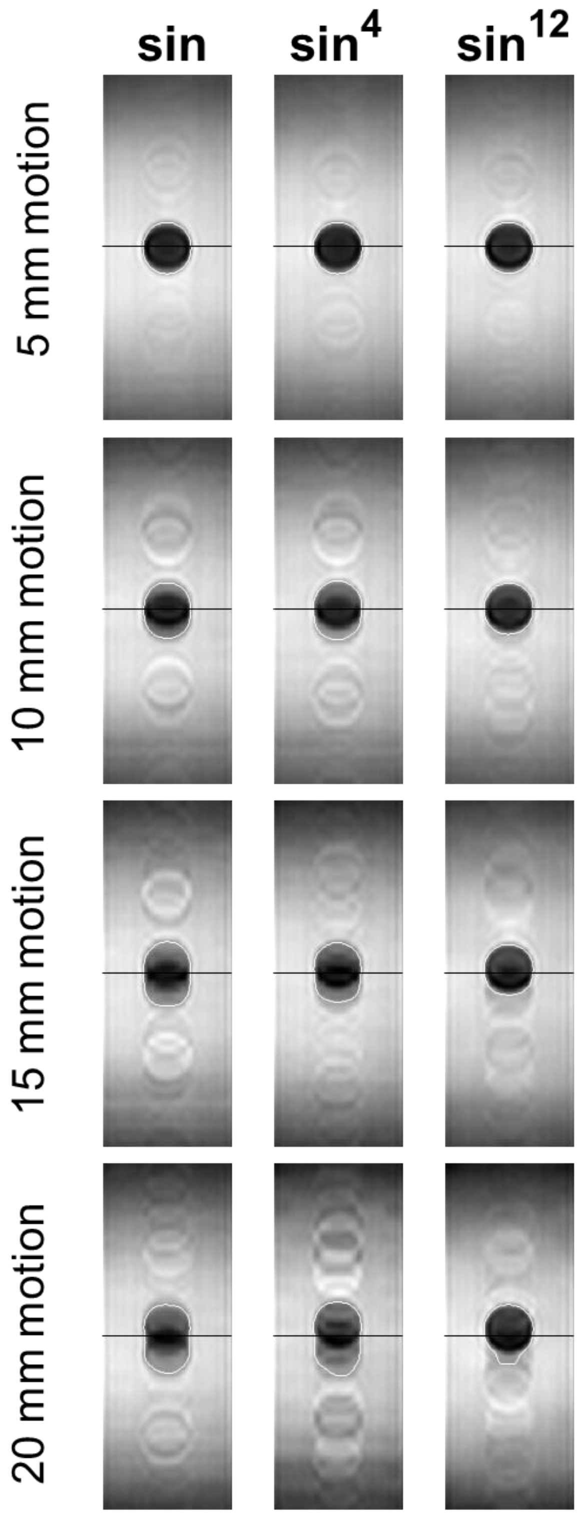

Figure Sup B: Central coronal slices of the Cartesian 3D MRI acquired while the target was moving according to the different mathematically defined motions sin(t), $sin^4(t)$ and $sin^{12}(t)$ (columns) with a period of 6s and different peak-to-peak amplitudes (rows). The horizontal line indicates the zero CC position. The grey contour shows the target identified automatically using k-means-clustering.

Supplementary material C

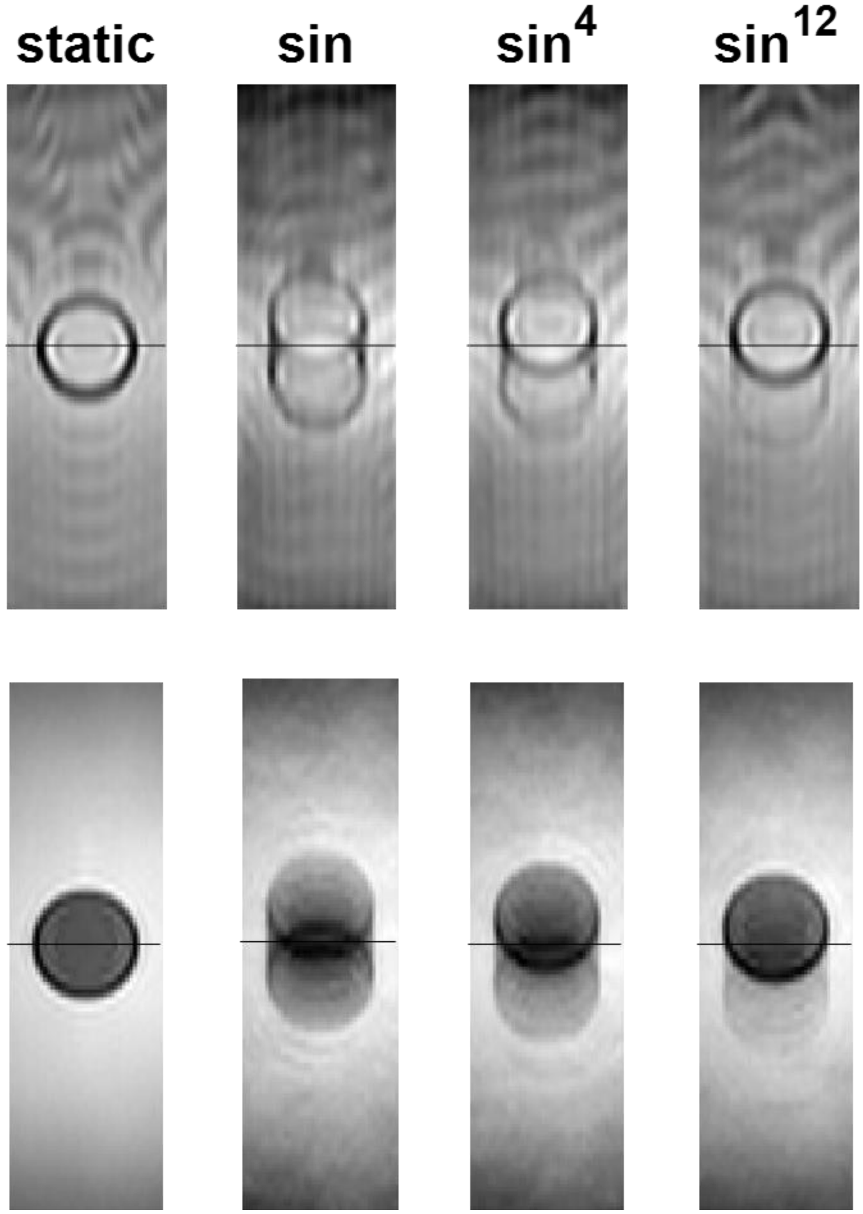

Figure Sup C: Central coronal slices of the 3D MRI acquired while the target was static or moving according to different mathematically defined motions (sin(t), $\sin(t)^4$ and $\sin(t)^{12}$) with 20 mm peak-to-peak amplitude and a 5 s period. The horizontal line indicates the zero CC position. Top row : bFFE 3D Vane XD sequence (FOV 500mm x 500mm x 220mm, acquisition resolution 1.7 mm x 1.7mm x 3.0mm, recon resolution 0.8 mm x 0.8mm x 1.5mm, TR 3.3 ms TE 1.3 ms) . Bottom row: In house 3D MRI T2w sequence (FOV 400mm x 448mm x 250mm, acquisition resolution 1.1 mm x 1.1mm x 2.0mm, recon resolution 1 mm x 1 mm x 2 mm ,TR 1400 ms TE 137 ms).