

# The ShapeTape: a novel approach for respiratory gating

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**Introduction:** If the scan duration in cardiac MRI exceeds the patient's breathhold capability data is acquired during free breathing. Typically, the respiratory position is determined by navigators either accepting or rejecting MR data [1], requiring an interruption of data acquisition which can yield to artifacts particularly in bSSFP-based imaging. To keep the interruption of data acquisition short, navigators are typically played out once per cardiac cycle in Cine imaging which can lead to breathing related artifacts e.g. in diastole. Here, we present a new approach of respiratory gating based on a fiber optical tape called ShapeTape (Measurand Inc., NB, Canada) which has previously been shown to be beneficial in brain imaging [2].

**Methods:** The ShapeTape consists of bend-sensitive optical fibres laminated to a substrate. Pose information in six degrees of freedom for the tip of the tape can be computed by combining data from all individual fibres. To ensure MR compatibility the optical fibre was laminated to a non-ferromagnetic substrate made from beryllium copper. A 10 m fibre optic cable is attached to the active part of the system, enabling easy transfer of the data out of the scanner room via a waveguide in the Faraday cage. Motion data is acquired at a rate up to 100 Hz and send to the scanner via network.

A tape was fixed to the surface of the abdomen to detecting the breathing motion. The breathing pattern – based on the translation in all dimensions – was detected by the shape tape for 5 sec before the actual MR scan to automatically determine the (expiration) position of the gating (acceptance) window. Cine bSSFP images were acquired at a 1.5T Siemens Symphony during breath-hold, free breathing without respiration control, and free breathing with shape tape respiratory gating with 4 and 10 mm widths of the gating window. Further imaging parameters are: TR=3.7 ms, temporal resolution 45 ms, spatial resolution: 1.25x1.25 mm, slice thickness 8 mm, flip angle 60°, kt-GRAPPA acceleration with R=3.

**Results:** The shape tape based respiratory gating with a small width of the gating window (TA=15 s, scan efficiency ~50%) yield to an image quality comparable to the breath-held acquisition (TA=7 s). A wider window clearly introduced more breathing related artifacts as indicated in the Figure.

**Discussion:** The shape tape can be easily and quickly attached to the abdominal surface and accurately detects the breathing motion. Since it does not require an interruption of data acquisition the gating is highly flexible and e.g. could be performed also on each cardiac frame. The approach may present an alternative to navigator gating e.g. for the acquisition of 3D Cine bSSFP imaging of the heart [3].

**References:** [1] Ehman et al. Radiology 1989;173:255–63. [2] Herbst et al. ISMRM 2011;170. [3] Jung et al. MRM 2002;48:921-25.

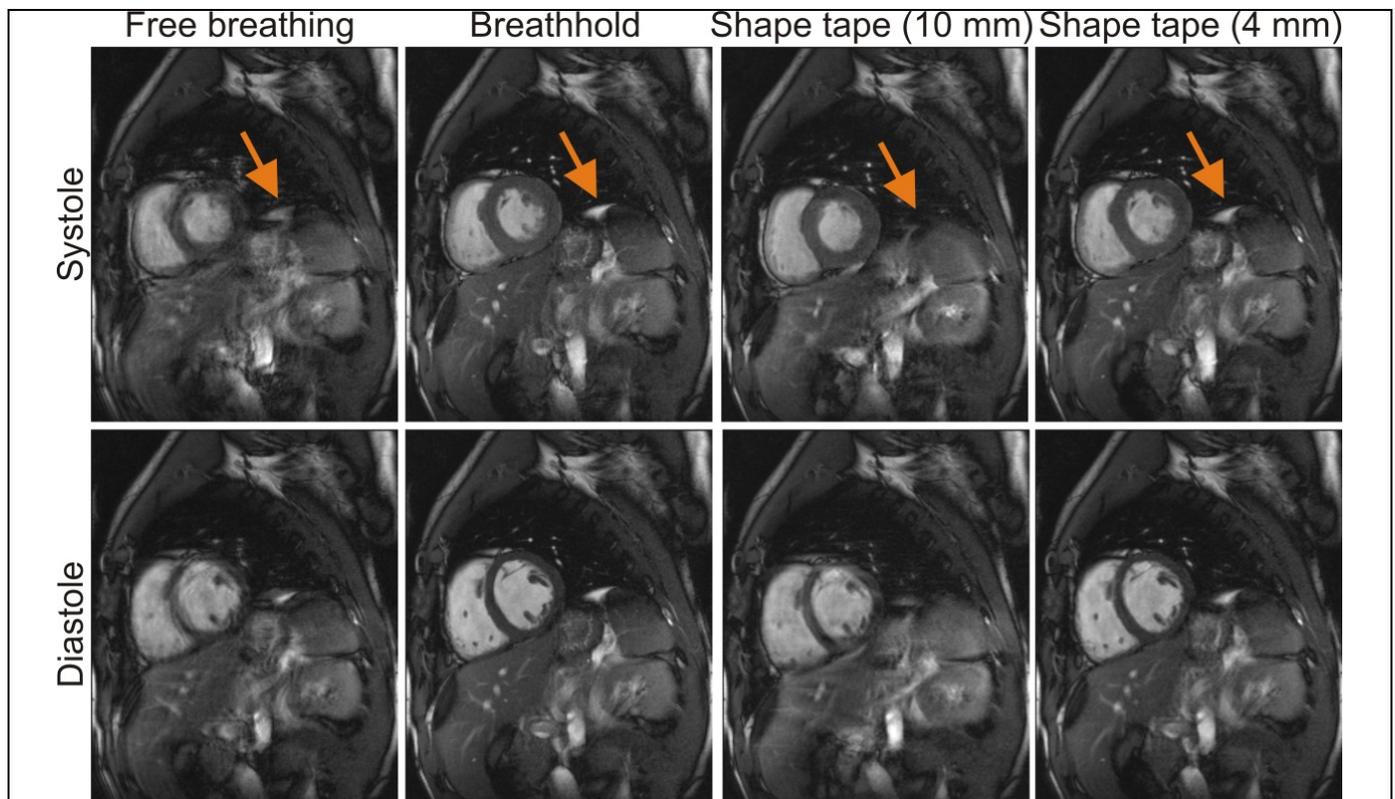


Fig. 1: Systolic and diastolic short axis images acquired as stated in the methods section. Note the breathing related artifacts in structures such as the diaphragm (arrows).