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STEERABLE NEEDLE WITH SHAPE SENSING FOR MR-GUIDED INTERVENTIONS

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Introduction Accurate positioning of the needle tip is essential in percutaneous therapies such as radiofrequency ablation of liver tumors. Navigating a steerable needle with a robotic system guided by MRI could improve the targeting accuracy in these procedures. Therefore, an MR-compatible steerable needle is developed, which is equipped with fiber Bragg gratings (FBGs) for shape sensing.

Approach The aim is to develop a flexible shaft that incorporates optical fibers and steering cables in its wall. The device, and consequently all components and materials, should be MR-compatible and MR-safe. In addition, devices currently used in percutaneous interventions in the liver should fit through the shaft, while the outer diameter of the shaft should be as small as possible.

Results The needle consists of a 20cm tube with a steerable tip made of PEEK with an inner and outer diameter of 2 and 3.2mm, respectively. Each steering segment in the tip can be rotated up to 5°. The Dyneema steering cables and the fibers with FBGs are integrated in the wall of the tube. A cutting stylet that runs through this channel enables penetration of the tissue during insertion and can be removed when the target has been reached. After this, any other flexible instrument can be inserted in the channel to execute the actual procedure. During needle insertion as well as during treatment, the shape of the needle is detected by the FBGs at high frequency (<20 kHz) with an accuracy of estimated tip position of 1 mm. The location of the target and the effect of the treatment can be monitored on MR images at lower refresh rate.

Discussion This needle fulfills all requirements and allows dexterous navigation of different instruments to targets within the liver with one single needle insertion. It supports targeting accuracy, but also allows difficult areas to be reached without damaging other important tissues such as the lungs.