Deflectable Catheter for Interventional Cardiovascular MRI

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INTRODUCTION

Commercial devices available for catheter-based procedures are largely in-compatible with the MRI environment due to significant magnetic metallic components such as stainless steel used to impart desired mechanical characteristics. These components can create obstructive artifacts which interfere with anatomic imaging (1) and long metallic components have the potential for RF-induced heating (2). Deflectable catheters are used to access difficult target anatomies and enable a variety of procedures but require additional, typically metallic components to produce the desired deflection. To permit these procedures under MRI guidance, compatible devices are necessary which provide similar performance to their x-ray counterparts. We have developed a 0.035" guidewire-compatible deflectable catheter which minimizes long metallic components while providing requisite torque control, shaft support, and tip deflection in a suitably sized construction.

METHODS

Kevlar, a para-amid synthethic fiber, was used in the construction of the catheter shaft braiding and for the deflection pulling mechanism in place of traditional metallic components (Figure 1). Kelvar braiding in the shaft construction provides additional columnar support and critical torque responsiveness typically limited in polymer-only constructions. A short (<5cm) nitinol laser-cut slotted tube and nitinol spring at the tip were used to provide kink resistance during deflection and to help restore the catheter shape upon release of tension on the pulling thread. The inner lumen of the deflectable catheter contained a polytetrafuoroethylene (PTFE) liner to allow smooth guidewire passage. Thermoplastic elastomer (Pebax) covering sealed the entire device and components. A custom handle provided deflection control at the hub.

To evaluate the catheter's mechanical performance, the tip deflection angle and curve reach were measured. Torque responsiveness of the shaft was determined with a fixed rotation applied at the proximal handle and corresponding distal tip rotation measured.

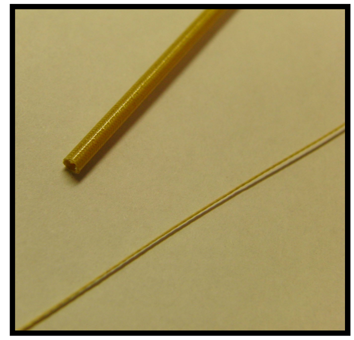

Figure 1: Kevlar braided tubing and deflection pulling mechanism.

RESULTS

The distal tip allowed variable deflection up to a maximum angle up to 180° (Figure 2). The catheter also enabled deflection and advancement of a guidewire through the deflected tip. The entire length of the deflectable catheter (~80cm) and handle can be seen in Figure 3. The torque response of the deflectable catheter was 1:1 while maintaining sufficient shaft support and flexibility. The operator could easily manipulate the catheter and deflect the distal tip smoothly using the custom handle.

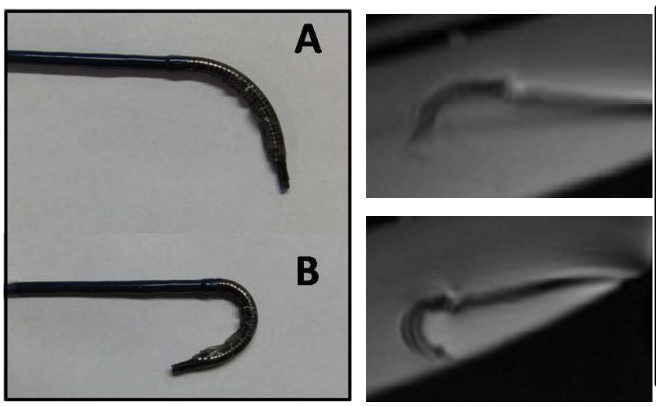

Figure 2: Distal tip and deflectable portion of catheter in A) 90° deflection and B) 180° deflection and corresponding phantom MR images.

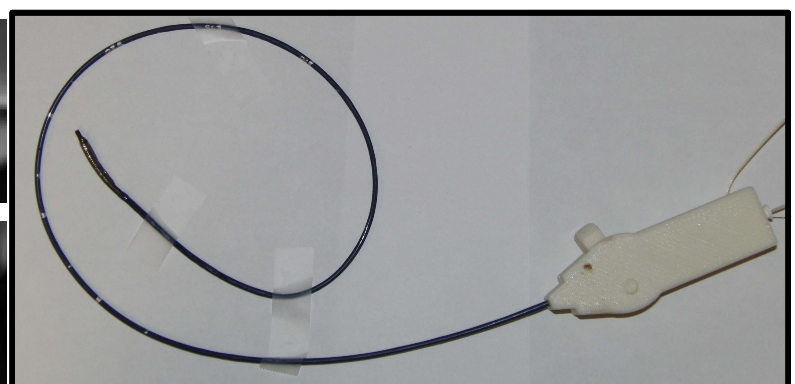

Figure 3: Deflectable catheter and handle.

DISCUSSION

Kevlar fiber provides excellent tensile strength in a small diameter and experiences minimal elongation, important characteristics to generate the force necessary to deflect the catheter tip. Further miniaturizaiton is possible with smaller components such as the Kevlar pulling wire. Mechanical characteristics such as deflection angle, curve reach and torque responsiveness were comparable to commercial deflectable catheters available for x-ray procedures.

REFERENCES

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