The Triple Wire Technique for Delivery of Endovascular Components in Difficult Anatomy

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We describe a novel endovascular technique in which three 0.014″ guidewires are placed in parallel through a 0.035″ lumen catheter, in order to create a stiff platform to allow for delivery of 0.035″ profile devices through challenging anatomy. Three illustrative cases are presented: a difficult aortic bifurcation during lower extremity intervention, a tortuous internal iliac artery during placement of an iliac branch device, and salvage of a renal artery after inadvertent coverage during proximal cuff deployment for type 1a endoleak. We also quantify the relative stiffness of the triple 0.014″ wire configuration, using several well-known 0.035″ wires for comparison. The "triple wire technique" is an effective method for tracking endovascular devices through difficult tortuous anatomy, and can be used in a variety of clinical settings. The technique is especially useful when a traditional, stiff 0.035″ wire will not track without "kicking out." Each 0.014″ wire is reasonably soft and traverses the tortuous vessel easily, but when the 3 wires are used together as a rail it provides a stiff enough platform for delivery.

INTRODUCTION

With advances in endovascular technology, vascular surgeons and other interventionalists are now performing increasingly complex procedures on a regular basis.[1,2] Difficult anatomy, particularly tortuosity that forces devices and sheaths in opposing directions, can often be overcome with innovative solutions from experienced practitioners. One commonly encountered problem occurs when a target vessel requires cannulation with a stiff wire in order to advance components (sheaths, balloons, stents, etc.) into position for treatment. Although it is often easy to cannulate the vessel with a soft wire and catheter, any significant associated angulation may cause a stiffer wire to "kick out" and follow a more linear path during wire exchange. Here, we describe a novel yet simple technique to overcome this challenge, where three 0.014″ guidewires are advanced individually and sequentially into position through a single 0.035″ catheter. Each wire is not stiff enough by itself to kick the system out. All 3 wires can then be used as a single wire or rail to advance the required components that are meant for the 0.035″ platform. This technique is illustrated with several clinical case examples, and we also provide some objective measurements in order to quantify the effect and compare relative stiffness of several wires well known to endovascular surgeons.

DESCRIPTION OF TECHNIQUE

Once a target vessel has been identified, it is cannulated in the traditional method using a soft 0.035″ guidewire and catheter combination of the operator's choice. The soft wire is then removed, and three 0.014″ wires are advanced sequentially through the catheter in parallel. Note that while only triple configurations of 0.014″ wires are

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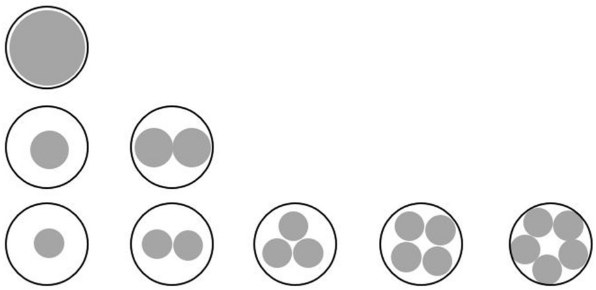

Fig. 1. Assuming a catheter internal diameter of 0.038″, up to one 0.035″ (*top row*), two 0.018″ (*middle row*), and five 0.014″ (*bottom row*) wires can theoretically fit in parallel.

discussed in the following case studies, 4 or 5 parallel 0.014″ wires, or two 0.018″ wires, can also theoretically fit in a 0.038″ catheter inner lumen (Fig. 1). Our wire of choice for this technique is the Grand Slam (Asahi Intecc, Tustin, CA), but any 0.014″ guidewire of reasonable stiffness can be used according to preference. Once the wires are in position the 0.035″ catheter is removed, leaving the 3 wires in place. The wires can then be used as a single rail, advancing any 0.035″-compatible component into position. In order to prevent longitudinal translation of the wires relative to one another during component delivery, the back ends can be clamped together.

CASE EXAMPLES

Case #1

A 66-year-old man with a chronic, nonhealing wound of the right lower extremity presented for angiography and possible revascularization. The contralateral groin was accessed under ultrasound guidance, and an aortoiliac angiogram demonstrated a steep aortic bifurcation and tortuous iliac arteries (Fig. 2A). An angled 0.035″ Glidewire and Glidecath (Terumo Medical, Somerset, NJ) were used to cross the aortic bifurcation. Multiple attempts were made to exchange for a stiff wire, but due to the acute angle the wire would not pass and would only kick the catheter back up the aorta, even with the catheter buried far down the contralateral femoral artery. Three 0.014″ Grand Slam wires were advanced into the right superficial femoral artery (SFA) (Fig. 2B), and over these a 6F Ansel sheath (Cook Medical, Bloomington, IN) was advanced up and over the bifurcation in order to create a stable working platform (Fig. 2C). The patient then underwent successful recanalization of a distal SFA occlusion.

Case #2

A 76-year-old woman with a history of endovascular aortic aneurysm repair (EVAR) performed at an outside institution presented with a ruptured right iliac aneurysm, for which she underwent coil embolization of her internal iliac artery and limb extension into the external iliac artery. Her left common iliac artery had initially been sealed with a 32-mm aortic cuff, and had also degenerated into an aneurysm now measuring 3.5 cm in maximal diameter. In order to prevent a similar rupture on the left, she was taken for elective repair using the Gore Iliac Branch Excluder (IBE) device (W. L. Gore, Flagstaff, AZ). Percutaneous left femoral access was obtained, as well as open left brachial access for delivery of a Gore VBX balloon-expandable stent graft (W. L. Gore) for the internal iliac branch component. After deployment of the IBE main body, the contralateral gate and internal iliac artery were cannulated with a 0.035″ Glidewire (Terumo Medical). Due to extreme tortuosity of the internal iliac (Fig. 3A), neither a stiff wire nor the 8F target sheath could be advanced into position without buckling in the aorta above and kicking out. Through a 0.035″ Quick-Cross catheter (Spectranetics, Colorado Springs, CO), three 0.014″ Grand Slam wires were advanced sequentially into the internal iliac (Fig. 3B). An 8F, 90 cm sheath was then advanced and positioned over all three 0.014″ wires, and an 8L × 59 mm VBX stent was successfully deployed (Fig. 3C). The remainder of the repair proceeded without complication.

Case #3

A 94-year-old man was taken to the operating room for repair of a type 1a endoleak due to distal migration of a prior EVAR. A proximal aortic extension cuff (W. L. Gore) was deployed, followed by multiple Heli-FX EndoAnchors (Medtronic, Santa Rosa, CA) to secure it. On completion aortogram, it was noted that the cuff was covering the majority of the left renal artery, resulting in diminished flow (Fig. 4A). In order to preserve flow to the left kidney, we elected to attempt to place a chimney stent to hold down the fabric covering the origin of the renal artery. The target renal was cannulated with a Glidewire and the aid of a 6.5F TourGuide steerable sheath (Medtronic). However, due to the angle, a stiff wire was unable to be advanced without kicking back into the aorta and losing access from the renal. After successfully placing a 0.035″ Quick-Cross catheter, three 0.014″ Grand Slam wires were advanced into the target vessel. A

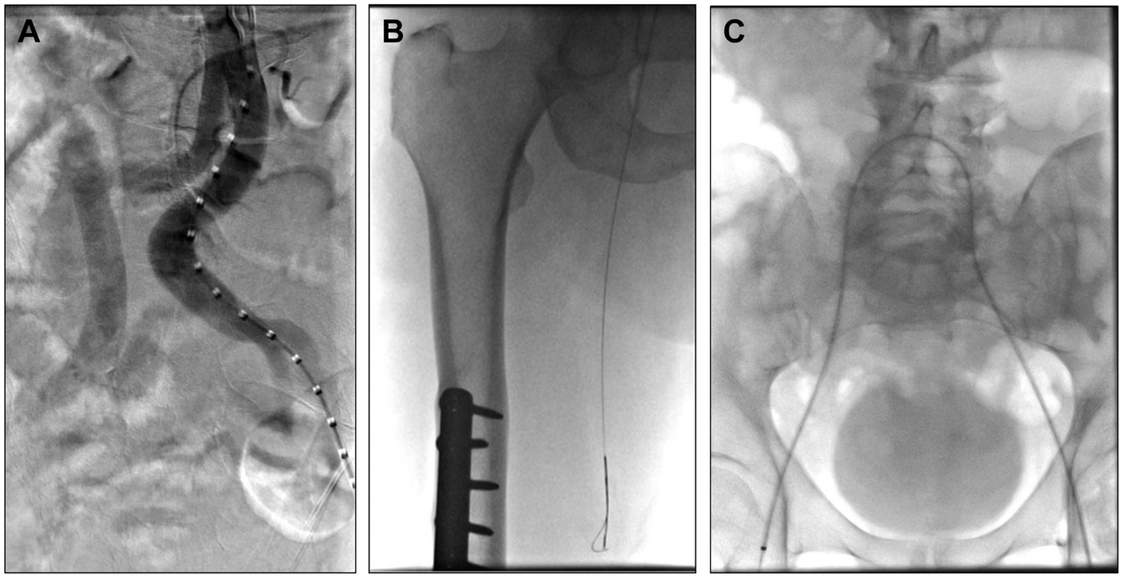

Fig. 2. Difficult aortic bifurcation. **(A)** Flush aortogram demonstrates a steeply angled aortic bifurcation and tortuous iliac arteries. **(B)** Three 0.014″ Grand Slam wires are advanced up and over the bifurcation. **(C)** A 6F sheath is able to be tracked into position.

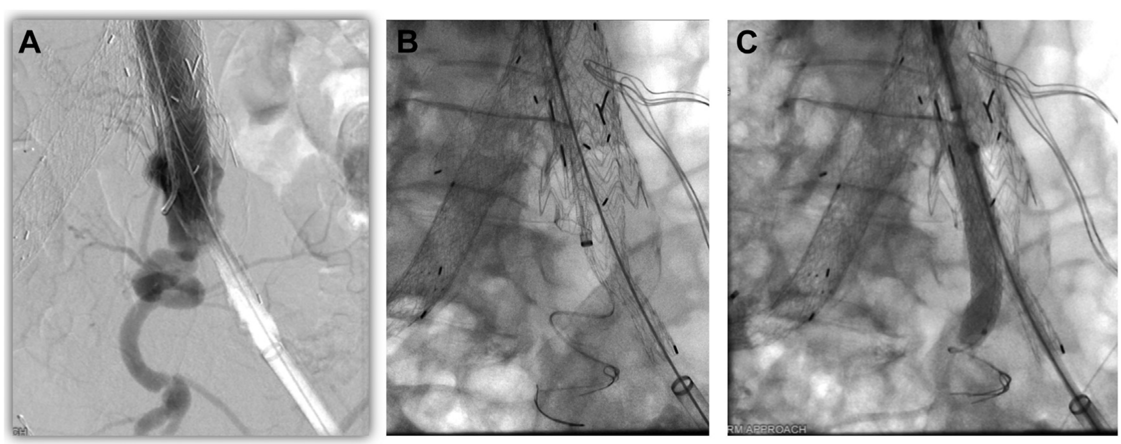

Fig. 3. Tortuous internal iliac artery. **(A)** During deployment of an iliac branch device, the internal iliac is noted to be extremely tortuous. **(B)** Three 0.014″ Grand Slam wires are advanced into position deep in the target vessel. **(C)** Bridging stent is successfully deployed.

6 × 29 mm VBX stent was then easily advanced and deployed as a chimney (Fig. 4B), and completion angiogram demonstrated normal filling of the left kidney (Fig. 4C).

WIRE STIFFNESS TESTING

Three-point bend testing was performed on single, double, triple, quadruple, and quintuple wire configurations for 0.014″ Asahi Grand Slam and 0.014″ Cook Approach Hydro ST (Cook Medical) wires, single and double configurations for 0.018″ Abbott Hi-Torque Steelcore (Abbott Vascular, Santa Clara, CA), and single 0.035″ Terumo Glidewire, 0.035″ Cook Rosen Curved (Cook Medical), and 0.035″ Boston Scientific Starter (Boston Scientific, Natick, MA) wires (Fig. 5). Triple wire configurations of both the 0.014″ Asahi Grand Slam and 0.014″ Cook Approach Hydro ST exhibited a

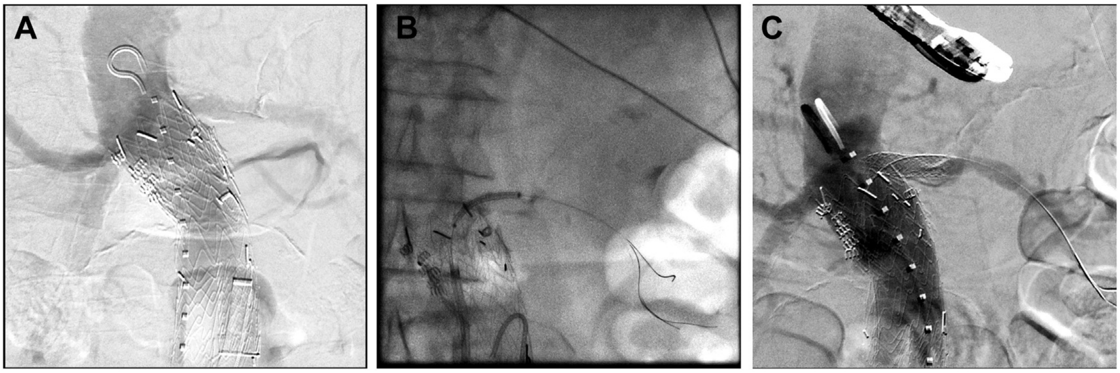

Fig. 4. Chimney for covered renal artery. **(A)** During placement of a proximal extension cuff, the left renal artery is partially covered. **(B)** Three 0.014″ Grand Slam wires are advanced over the cuff fabric and into the target renal artery. **(C)** Chimney graft is successfully deployed.

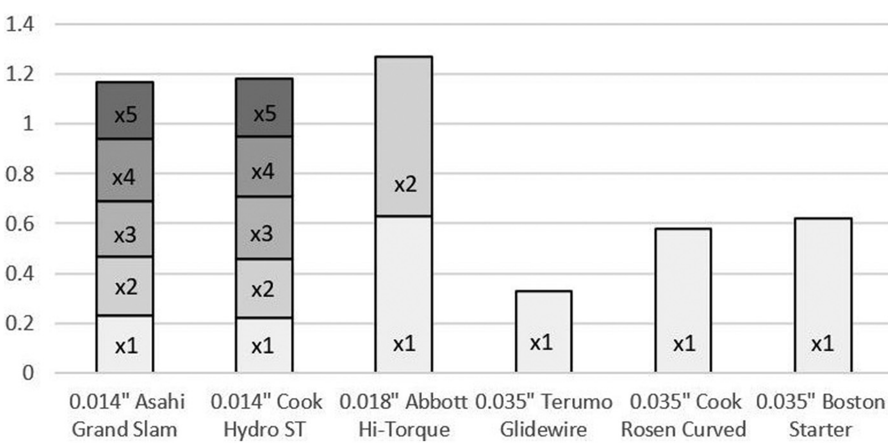

Fig. 5. Three-point bending stiffness of single, double, triple, quadruple, and quintuple configurations for 0.014″, single and double for 0.018″, and single for 0.035″ wires.

stiffness of 0.7 N/mm. Among the 0.035″ wires in single configuration, the largest stiffness was exhibited by 0.035″ Boston Scientific Starter wire at 0.61 N/mm. Both 0.014″ Asahi Grand Slam and 0.014″ Cook Approach Hydro ST wires in triple configuration exceeded the bending stiffness of all 0.035″ wires tested (Fig. 5). Furthermore, quadruple and quintuple 0.014″, and double 0.018″ wire configurations gain even greater bending stiffness, in the range of 0.93—1.21 N/mm.

DISCUSSION

Complex anatomy can lead to challenges in endovascular intervention, and may require innovative techniques to overcome. Our triple wire technique is a simple, off-the-shelf solution for situations where advancement of a stiff wire into a target vessel is not possible due to severe angulation or tortuosity. The underlying issue is a misalignment between the force vector from wire advancement and the target direction. Stiffer wires are not able to accommodate as much change in force vector direction as softer wires, and therefore tend to preferentially seek out straighter available paths rather than follow paths of high curvature. This even occurs in wires that have softer tips, different lengths of the softer tip, and different levels of stiffness of the main part of the 0.035″ wire. This leads to the ever-frustrating problem of the wire and catheter ‘‘kicking out,’’ and need for tedious recannulation.

The triple wire concept is similar to co-axial systems used in endovascular embolization procedures, where stepwise introduction of nested components leads to a gradual increase in support.[3] Although individual components are soft and trackable, the result is an extremely stable and supportive construction through which a variety of therapeutic endovascular devices can be passed.

We have applied the triple wire technique to a wide variety of clinical scenarios, with only a small representative sample described here. The technique is also useful for difficult target cannulation during fenestrated or branched aortic repair and navigation into supra-aortic branches through complex aortic arch anatomy, when traditional techniques have failed.[4,5]

The Asahi Grand Slam has proven to be an excellent wire for this purpose and is generally our first choice, but we have also successfully used the 0.014″ Approach Hydro ST and 0.014″ Hi-Torque Command (Abbott Vascular) wires. There does seem to be some advantage to using a nonhydrophilic wire though, as wire exchanges can be somewhat cumbersome over multiple, parallel hydrophilic wires. From our benchtop testing, three 0.014″ Grand Slam or 0.014″ Cook Approach Hydro ST wires are stiffer than a single 0.035″ Terumo Glidewire, Cook Rosen Curved, or Boston Scientific Starter wire. In cases where even more support is required, quadruple and quintuple 0.014″ wires, or double 0.018″ wires could theoretically be used for tracking stiffer devices.

CONCLUSIONS

The triple wire technique is a useful method for creating a stiff platform to deliver 0.035″-compatible endovascular devices through difficult anatomy. The technique is easily performed with off-the-shelf 0.014″ wires, and can be employed whenever a stiff 0.035″ wire will not track into position.

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