

SHORT REPORT

Estimating the “Pull” on a Pullthrough Wire: A Pilot Study

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Objective: Pullthrough/body floss wires are used to track endovascular devices across tortuous aorto-iliac anatomy encountered during endovascular repair of abdominal or thoracic aortic aneurysms. The tension imparted on such wires is arbitrary and has never been quantified. This pilot study attempted to quantify the tension used to stiffen the floppy hydrophilic wires typically used in such a scenario.

Methods: Two linked experiments were undertaken, the first by tasking 13 blinded vascular surgeons (eight male, five female; mean age 36 ± 11 years, including nine trainees) with pulling a long floppy hydrophilic wire (Radifocus Guidewire M Stiff, Terumo UK, Bagshot, Surrey, UK) attached at the other end to a horizontally configured industrial scale (HDN-N Hanging Scale, Kern & Sohn GmbH, Balingen, Germany), to simulate what they individually felt was an “appropriate” tension; the second by using the derived average tensioning force to set up a pullthrough wire within a rigid life like aorto-iliac model to assess whether a test device (16F Sentrant Introducer Sheath, Medtronic Limited, Watford, UK) could be delivered over such a tensioned wire in both brachiofemoral and femorofemoral configurations.

Results: The mean tension exerted by the group on the wire was 38.3 ± 14.8 N (equivalent to 3.9 kgf). Pullthrough wire tensioning was undertaken by fixing one end and applying a 3.9 kg weight at the other. The test device was successfully deployed into the infrarenal aortic position and also across the aortic bifurcation, via brachiofemoral and femorofemoral pullthrough configurations, respectively.

Conclusion: Successful test device deliveries suggest that a minimum tension equivalent to almost 4 kgf applied to a floppy wire can provide “stiffening” to allow device tracking across tortuous aorto-iliac anatomy. More studies are needed to ascertain whether lower tensions can be applied; these results may help provide a platform for other such studies depending on configuration, aortic geometry, and device or wire/tension characteristics.

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INTRODUCTION

Severe aorto-iliac angulation (including aortic neck angulation) may exceed 60° ¹ and even 90° ^{2,3} and hamper tracking and delivery of endovascular devices during endovascular aneurysm repair (EVAR)⁴ or thoracic endovascular aneurysm repair.⁵ Pullthrough wires (PTWs; brachiofemoral/femorofemoral), also called “through and through” or “body floss” wires, are sometimes used to deliver endovascular devices across tortuous aorto-iliac anatomy⁴ or to hold sheaths in place, including iliac branch device delivery.⁶ The optimal tension used to “stiffen” these (typically floppy

hydrophilic) wires is based on “feel”, effectively drawing on experience to allow device delivery while preventing arterial damage;⁷ conversely, a PTW that is too slack will be ineffective in facilitating device tracking. Operators must also be cautious when deploying such wires across (shaggy) aortas with high thrombus/atheroma burden in order to minimise the recognised high risk of stroke in such scenarios.⁸ The arbitrary nature of tension applied is also emphasised by the fact that the senior operator can hand the ends of the PTW to junior colleagues in order to proceed with the primary objective, namely successful device deployment. Current studies have only examined wire stiffness characteristics in the non-tensioned state.⁹ This study attempted firstly to attempt to quantify the force used on floppy wires when tensioned (**Experiment 1**), and secondly to check whether the results can be translated into successful device delivery (**Experiment 2**) over a PTW, using a life like aorto-iliac model.

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REPORT

The study is presented with background detail of the apparatus used and the experiments conducted in sequence.

Apparatus

Radifocus Guidewire M Stiff (0.035" × 300 cm Terumo UK, Bagshot, Surrey, UK). This is a polyurethane/tungsten jacketed nitinol based guidewire with a proprietary hydrophilic coating¹⁰ and is appreciably less stiff than a designated stiff wire with a stainless-steel core such as the Lunderquist (Cook Aortic Interventions, Bloomington, USA), which is made of PTFE-coated stainless steel.¹¹

Industrial scale. The HDN-N Hanging Scale (Kern & Sohn GmbH, Balingen, Germany) is a battery-powered strain gauge based scale with external calibration facility and digital display capable of directly measuring tension that meets the requirements of the European Standard EN13155 (non-fixed load lifting attachments).

Aortic model. A life size rigid acrylonitrile butadiene styrene (ABS) aorto-iliac model containing representations of an infrarenal abdominal aortic and common iliac aneurysms conforming to typical lengths and angulations (50° at the aortic bifurcation) was used;¹² the last representing a high tortuosity 130° angulation when applying a femorofemoral PTW trajectory.

Test device. A 16F Sentrant Introducer Sheath (Medtronic Limited, Watford, UK) was selected to be delivered over the PTW. This is a hydrophilic coated sheath that has a working length of 28 cm and thus could be delivered into the infrarenal position and also along a femorofemoral trajectory in the current experimental set up.

Data were collected numerically with pull forces/tension (newtons, N) recorded, and statistically analysed in Minitab 19.2 Statistical Software (Minitab LLC, Philadelphia, USA). For convenience, these forces are also presented later in kilogram force (kgf) equivalent (though not the SI unit for tension), and for practical application to the second experimental scenario.

Experiment 1

Thirteen vascular surgeons (eight male, five female; mean age 36 ± 11 years, including nine trainees) were blinded and asked to simulate what individually they felt was an "appropriate" tension, and were tasked with pulling a long floppy hydrophilic wire (Radifocus Guidewire M Stiff) attached at the other end to a horizontally configured industrial scale (HDN-N Hanging Scale).

Overall, mean tension exerted by the group was 38.3 ± 14.8 N (median 34.3 N), equivalent to 3.9 kgf (Fig. 1).

Experiment 2

Pullthrough wires were set up in the life like aorto-iliac model in both brachiofemoral and femorofemoral configurations; one wire end was fixed and a 3.9 kg weight

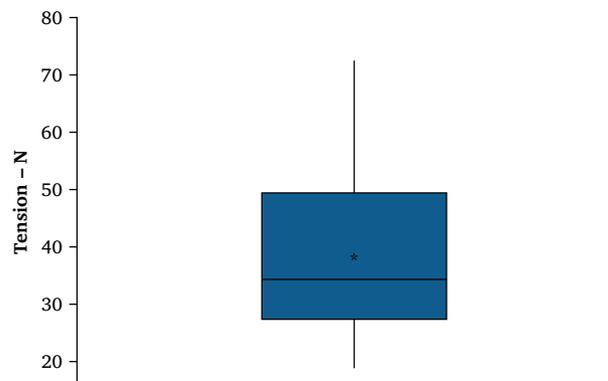


Figure 1. Box plot indicating the range of tensions applied by the test group of vascular surgeons (*mean tension of 38.3 N).



Figure 2. Successful test device delivery across highly tortuous anatomy (130° angle over the aortic bifurcation) over a femorofemoral pullthrough wire (tensioned using a 3.9 kg weight).

suspended from the other end to generate wire tension as obtained from the results in [Experiment 1](#). The test device (16F Sentrant Introducer Sheath) was successfully deployed into the infrarenal aortic position and also across the aortic bifurcation, via brachiofemoral and femorofemoral pull-through configurations respectively ([Video 1](#), [Fig. 2](#)).

DISCUSSION

In conclusion, successful test device deliveries suggest that a minimum tension equivalent to almost 4 kgf applied to a floppy wire can provide “stiffening” to allow device tracking across tortuous aorto-iliac anatomy. The study does not inform us whether lower tensions can be applied and still allow successful device tracking, the primary objective being to establish an initial working value in this context. These results may help provide a platform for other such studies depending on configuration, aortic geometry, and device or wire/tension characteristics. Understanding of such tensioning forces may also be hypothetically useful if an unmanned pullthrough wire is required, for instance when applying robotic technologies for EVAR with concomitant tortuous anatomy, though the scope for this is currently rather limited.

APPENDIX A. SUPPLEMENTARY DATA

Supplementary data related to this article can be found at <https://doi.org/10.1016/j.ejvsvf.2020.12.024>.

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