Central Venous Catheter Guidewire Management Device

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Background

Central Venous Catheter (CVC) Kits are used in emergency medicine to rapidly deliver fluids and medications to patients in critical care. The catheter is advanced into the patient's Jugular vein over the guidewire, using the guidewire as a track.

Clinical Problem:
When CVC placement fails, clinicians face challenges re-inserting the guidewire through the tip of the management device. The guidewire can become bent or slippery from ultrasound gel and blood, making handling difficult and delaying the procedure. This can elevate the risk of patient complication, extend procedural time and patient discomfort, and increase medical waste and healthcare costs.

- Placement failures account for **20.4%** of CVC complications
- Tissue perforation accounts for **23.4%** of patient complications.
- Re-insertion is common, minimizing procedural delays is crucial

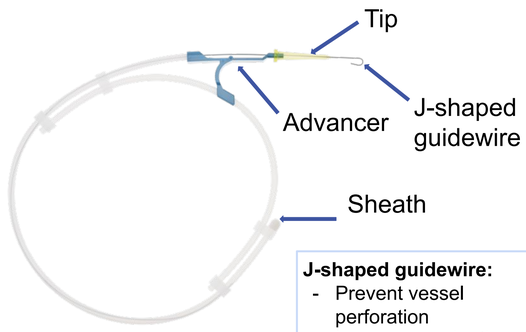


Figure 1: Teleflex® Marked Spring-Wire Guide with Arrow Advancer

J-shaped guidewire:
- Prevent vessel perforation
- Improves navigation
- Better feel resistance within the vein

Objectives

- Improve guidewire re-insertion efficiency
- Lower reloading times with updated design
- Maintain compatibility with current CVC kits and procedures
- Ensuring easy one-handed handling of guidewire.

Prototyping

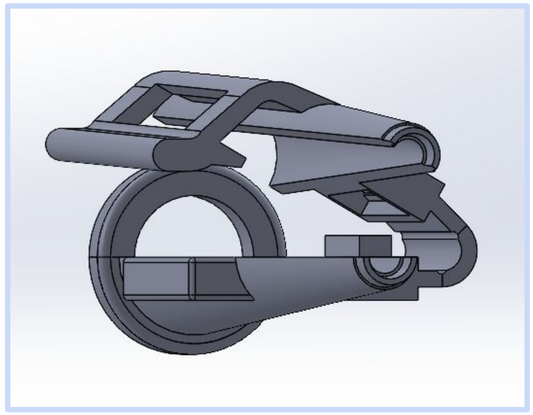


Figure 2: Final tip CAD model with snap-clip feature

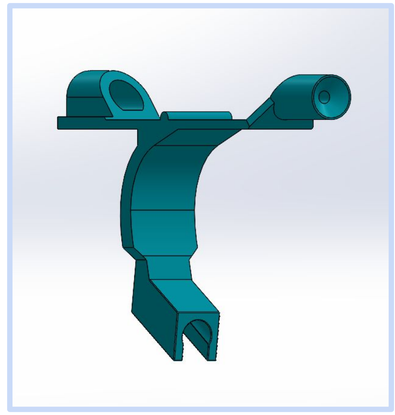


Figure 3: CAD drawing of the final design of the Advancer

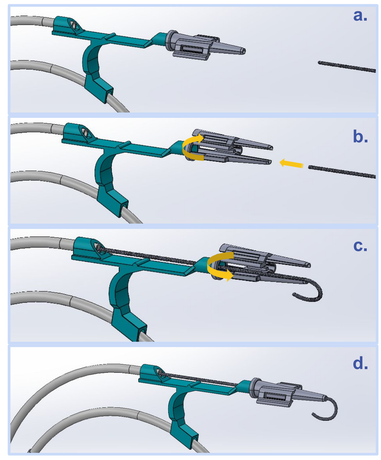
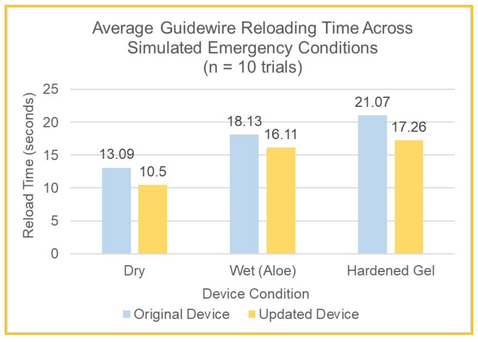
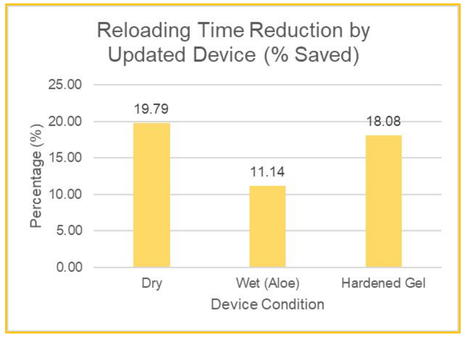


Figure 4: Functional CAD assembly of the updated tip design. **(a)** Closed tip, **(b)** tip opens, **(c)** guidewire reloaded, **(d)** tip closed.

Results





Modifications

Tip:
- Split-body design to expose wider advancer opening
- Snap-Clip Mechanism → pull back to open, release and snap closed
- Thin connector piece
  - flexible, intended for limited reuse (<5 times)
- Wedge-and-cavity feature for precise alignment

Advancer:
- Increased re-insertion point diameter from **2 mm to 4.5 mm**
  - Original geometry maintained

Methods

CAD Design in SolidWorks
- Produce 3 variations of solution
- 4 rounds of prototyping
- Iterative process
- Integrated clinician feedback

Finite Element Analysis in SolidWorks
- Validate structural integrity
- Analyze stress concentrations and identify weak points
- Improve geometry selection

3D Printing via Terrapin Works
- Advancer in TPU (current material)
- Tip in Resin
  - PC (current material) printing unavailable; local costs excessively high
- PC vs Resin
  - High strength, low cost, smooth surface finish, rapid prototyping flexibility

Clinician Usability Testing at University of Maryland Medical Center Trauma Simulation Lab
- Clinical feedback and testing under realistic conditions
- Select final design

Student Usability Testing at Leidos Innovation Lab
- Informal testing to refine prototypes

Future Work

Incorporate clinician feedback and assess adoption potential in clinical settings

Evaluate manufacturing feasibility, cost barriers, and of large-scale production options

Analyze marginal utility and pursue partnerships for device development and patent submission

Ethical Implications

Patient Safety
Minimize tissue trauma

Testing Strategy
UMMS Lab Simulation

Stakeholders
Clinicians, Patients, Hospitals, Device Distributors, Manufacturers

References

1. AW-04225 - Teleflex Incorporated - Vascular Access Product Catalog. (n.d.). https://www.teleflexvascular.com/products/aw-04225
2. DeLuca, J., Doynow, D., Grondin, J., Lockhart, E., & Lareau, S. (2023, November 15). *Ultrasound gel alternatives in an austere environment*. Wilderness & Environmental Medicine. https://www.sciencedirect.com/science/article/abs/pii/S1080603223001783#:~:text=Physicians%20who%20rated%20the%20control,supplement%20(87.5%25)%20as%20sufficient.
3. Teja B, Bosch NA, Diep C, et al. Complication Rates of Central Venous Catheters: A Systematic Review and Meta-Analysis. *JAMA Intern Med*. 2024;184(5):474–482. doi:10.1001/jamainternmed.2023.8232