# Mechanical Spring-Loaded Pinch Roller Device for Precision Guidewire Torque Transmission in Endovascular Procedures

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**ENDOTORQUE MEDICAL**

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## Background and Clinical Need

⚙ Control Issues — 25% of procedures report torque control issues [1].

✋ Usability Burden — Frequent regripping and two-hand use slow procedures [2, 3].

↘ Device Failure — 16.5% failure in challenging aortic arches [1].

Current torque devices **lack control, precision, and usability,** affecting procedural efficiency and increasing risk of vessel damage.
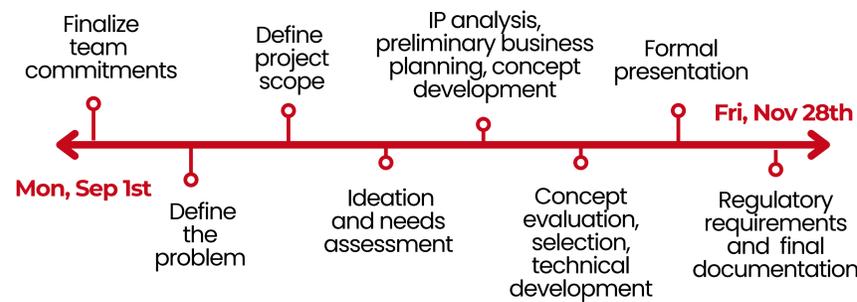
## Mission Statement

EndoTorque Medical aims to **enhance procedural efficiency** in interventional surgical procedures by integrating torque control and improved usability into a one-handed device for endovascular teams.

## Project Timeline

**Project received: Tuesday, August 5th, 2025**

- Existing torque devices are currently classified as Class 1 Medical Device.
- The concept for the new device will be a Class 2 Medical Device.

Finalize team commitments

Define project scope

IP analysis, preliminary business planning, concept development

Formal presentation

**Fri, Nov 28th**

**Mon, Sep 1st**

Define the problem

Ideation and needs assessment

Concept evaluation, selection, technical development

Regulatory requirements and final documentation

## Design Inputs

| Action | Metric | Target Specs |
|---|---|---|
| Reduce vessel injury risk | Max torque applied | ≥ 0.08 N·m for 30s w/ no slip |
| Provide controlled rotation | Rotational accuracy | Rotational backlash < 1° |
| One-handed repositioning | Reposition time | ≥ 90% tasks done one handed |
| Compatible with workflow | Guidewire compatibility | 0.010–0.038 in diameter |

## Device Concept and Design
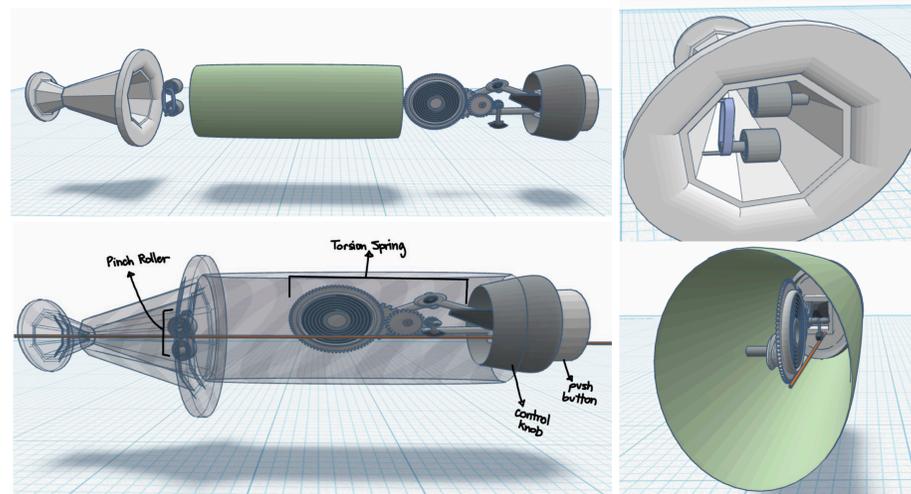


**Figure 1.** 3D model illustrating the torsion-spring gear mechanism (bottom right) that provides energy to drive the guidewire, and the pinch-roller interface (top right) that reduces slippage and alignment for the wire. The control knob and push-button are integrated for torque release.

**Relevant Technical Model:**

$$T_{spring} = K_\theta \theta$$

$$N = \frac{K_\theta \theta}{L}$$

$$T_{max} = \mu N r$$

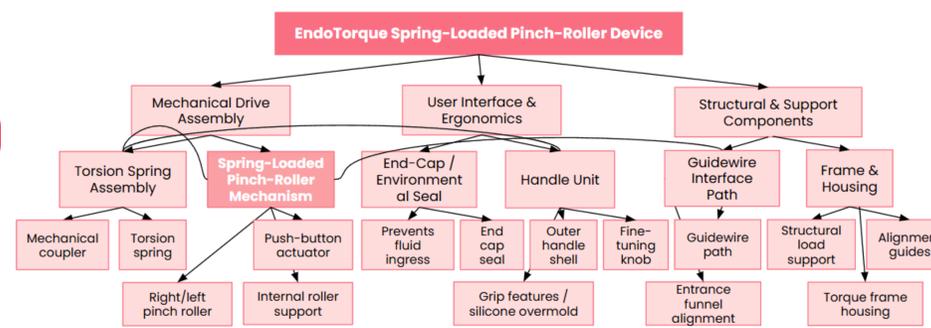$$p = \frac{N}{A_{contact}} \leq P_{allow}$$

Variables:
- $K_\theta$: torsion spring stiffness
- $\theta$: spring twist under button actuation
- $L$: lever arm from spring to roller contact
- $N$: roller normal force
- $\mu$: roller–wire friction coefficient
- $r$: effective roller radius
- $A_{contact}$: roller–wire contact area
- $P_{allow}$: allowable pressure for guidewire coating

The technical model predicts how torsion-spring preload generates roller normal force, which determines the maximum frictional torque transmitted to the guidewire without slip or coating damage.

## Product Architecture

**EndoTorque Spring-Loaded Pinch-Roller Device**

- Mechanical Drive Assembly
  - Torsion Spring Assembly
    - Mechanical coupler
    - Torsion spring
  - Spring-Loaded Pinch-Roller Mechanism
    - Push-button actuator
    - Right/left pinch roller
    - Internal roller support
- User Interface & Ergonomics
  - End-Cap / Environmental Seal
    - Prevents fluid ingress
    - End cap seal
    - Outer handle shell
    - Fine-tuning knob
    - Grip features / silicone overmold
  - Handle Unit
- Structural & Support Components
  - Guidewire Interface Path
    - Guidewire path
    - Entrance funnel alignment
  - Frame & Housing
    - Structural load support
    - Alignment guides
    - Torque frame housing

Architecture shows the key mechanical, user interface, and support subsystems that enable controlled guidewire rotation.

## QR Codes

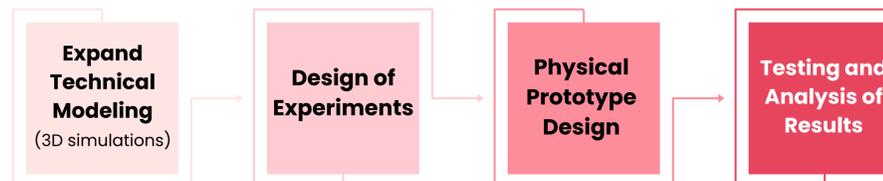Gantt Chart · House of Quality · Product Architecture · Design for Manufacturing · Product Specifications · References

## Manufacturing Cost

| Component | Est. Unit Cost |
|---|---|
| Housing | $2.00–$3.00 |
| Internal Frame | $1.00–$1.50 |
| Pinch Rollers | $0.80–$1.20 |
| Torsion Spring | $0.40–$0.80 |
| Button/Knob/Seal | $0.50–$0.80 |
| Assembly | $0.30–$0.90 |
| Total | $6–$8 |

## Product Specifications

| Specification | Target Value |
|---|---|
| Torque Transfer | ≥ 2.0 N.cm |
| Roller Grip Coefficient | ≥ 0.8 μ |
| Spring Torsional Stiffness | 0.05 – 0.08 N·cm/° |
| Actuation Force (Push Button) | ≤ 5 N |
| Device Weight | 50 - 60g |
| Housing Material | Medical-grade polymer (ABS / PC) |

## Design Status and Future Work

**Expand Technical Modeling** (3D simulations) → **Design of Experiments** → **Physical Prototype Design** → **Testing and Analysis of Results**

## Acknowledgements