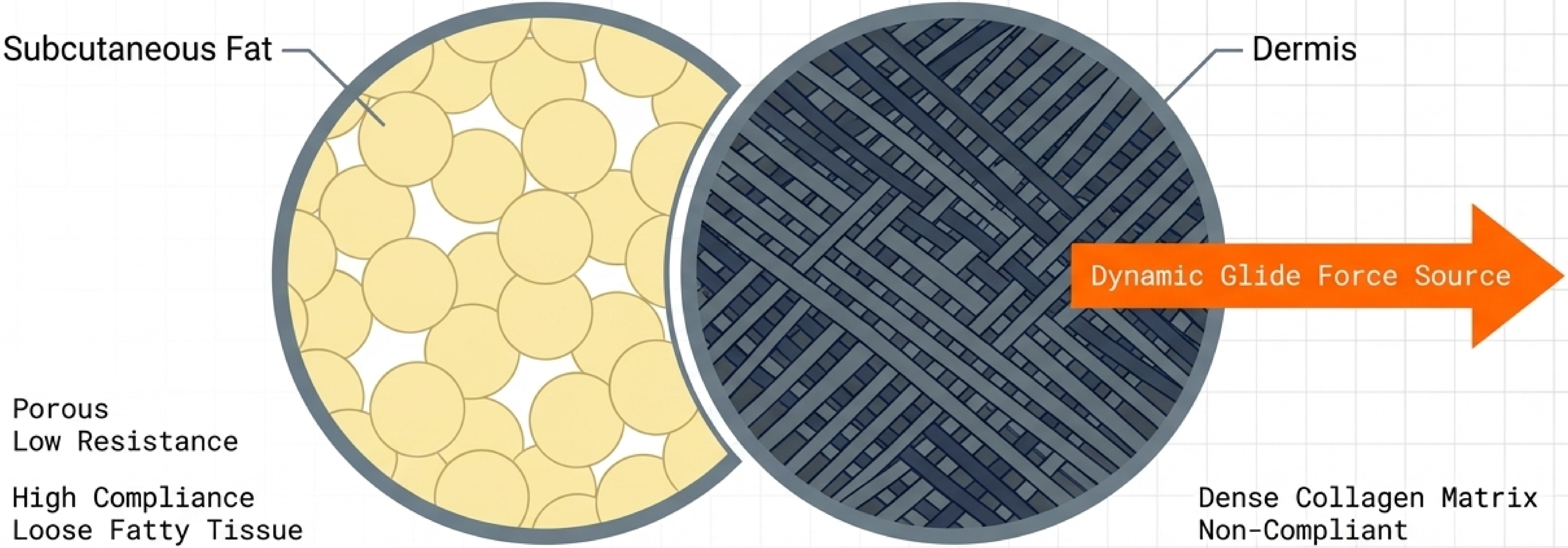
The Physics of Intradermal Delivery

Overcoming Glide Force with Nanoneedle Engineering

Precision Clinical Biomechanics Dossier

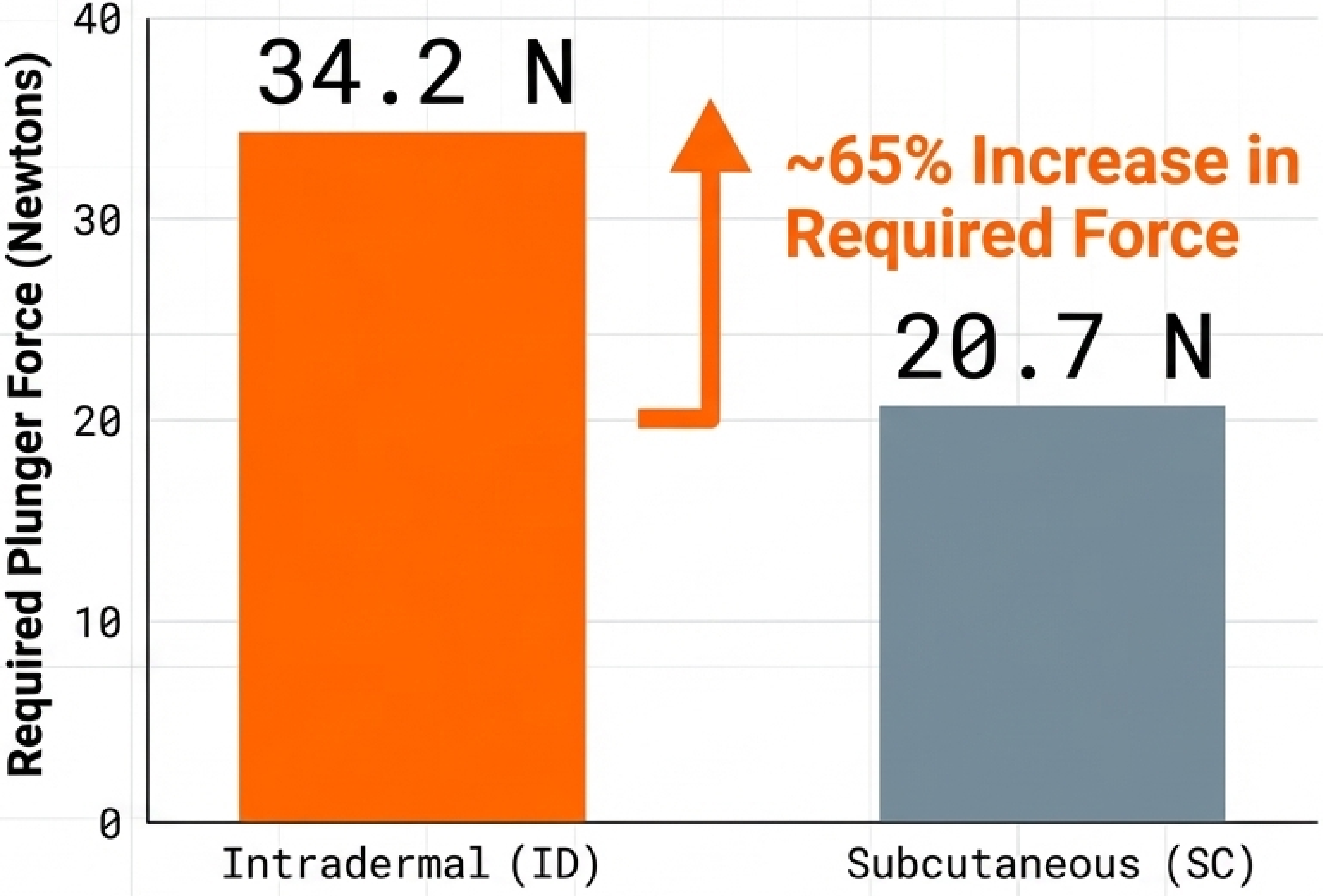
The Intradermal Paradox

CLINICAL PRECISION ENGINEERING



> Unlike loose fatty tissue, the dermis actively resists fluid expansion, creating substantial back-pressure that acts as a hydraulic "brake" on injection flow.

Quantifying Resistance: ID vs. SC Delivery



Impact Box

Data Source: Porcine Model Biomechanics.

The force differential is the primary cause of:

1. Injection variability
2. Risk of “overshoot” (depth error)
3. Operator tremor

The Cilurzo Injectability Framework

1. Break-Loose Force (PBF)

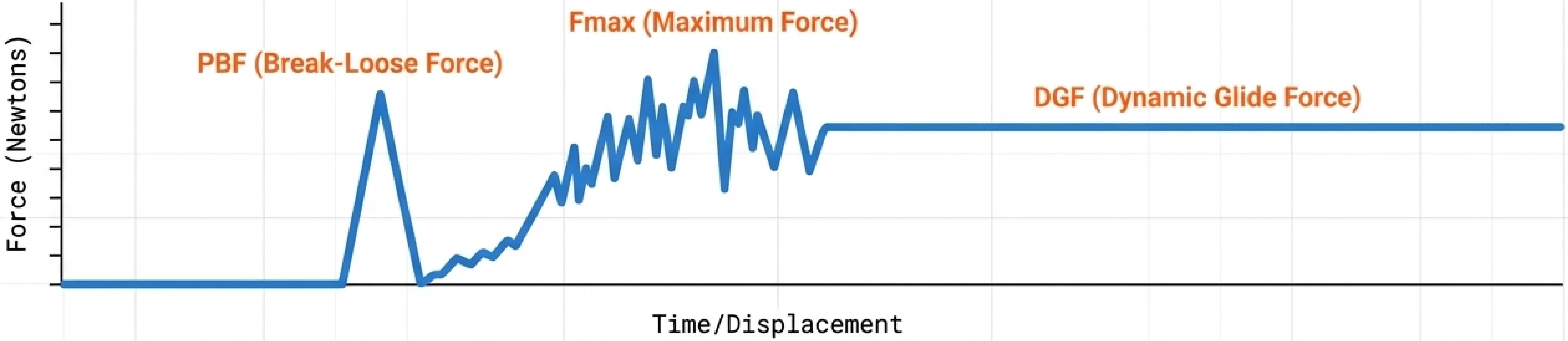
Peak force to overcome static friction.

2. Maximum Force (Fmax)

Peak resistance influenced by tissue back-pressure.

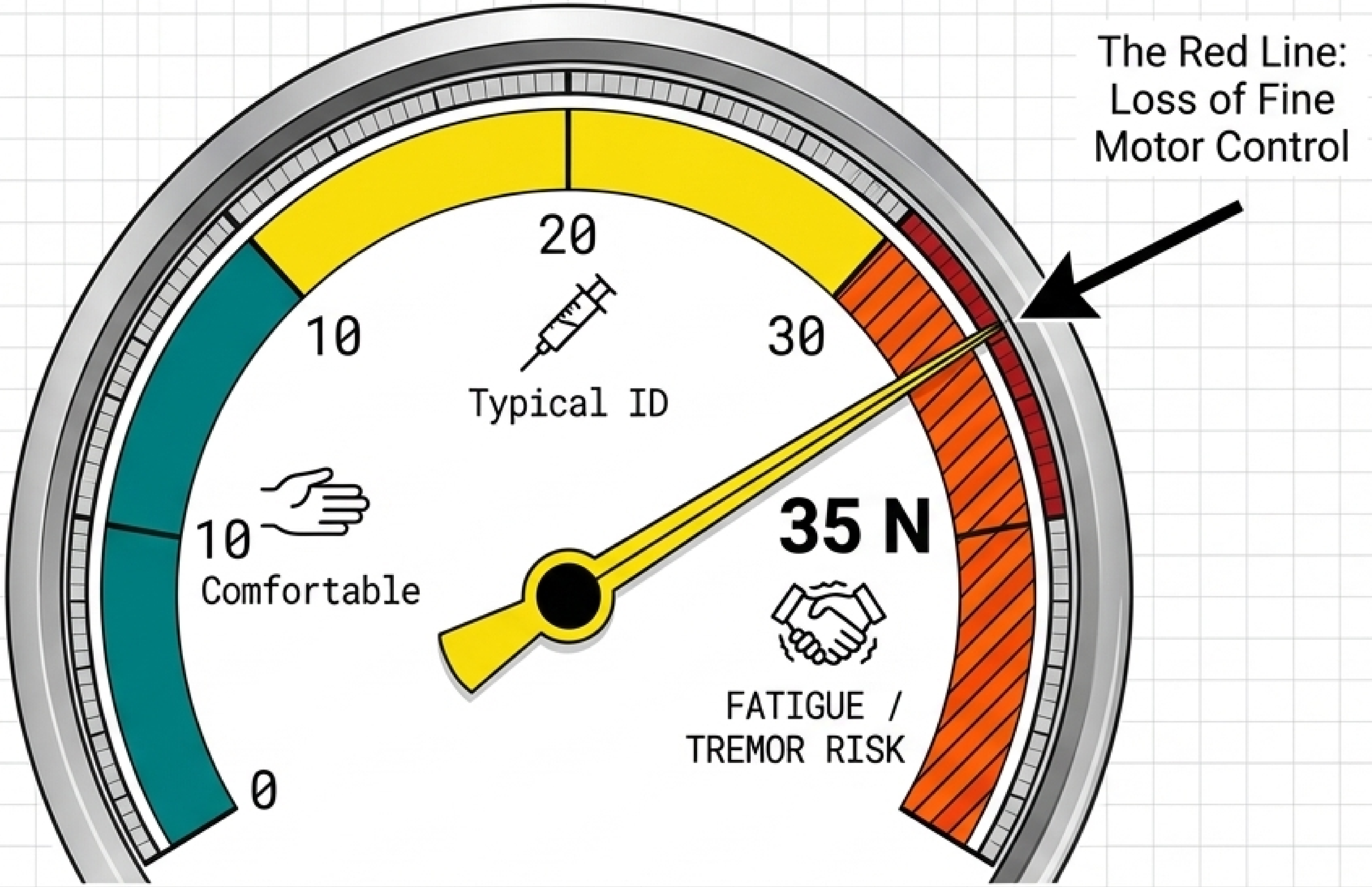
3. Dynamic Glide Force (DGF)

Sustained effort causing operator fatigue.



Core Insight: Dynamic Glide Force (DGF) is the sustained mechanical ‘enemy’ of the operator that must be engineered out.

The Engineering Threshold: >35 N Warrants Re-evaluation



Clinical Risks

Forces approaching the 34.2 N dermal average inevitably lead to:

- Operator tremor and hand fatigue
- Loss of depth control
- “Overshoot” into subcutaneous tissue
- Unnecessary tissue trauma

Optimization Lever 1: Syringe Geometry

Hydraulic Advantage is Exponential

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Mathematical Law: F = P * A
Force increases exponentially
with barrel diameter.
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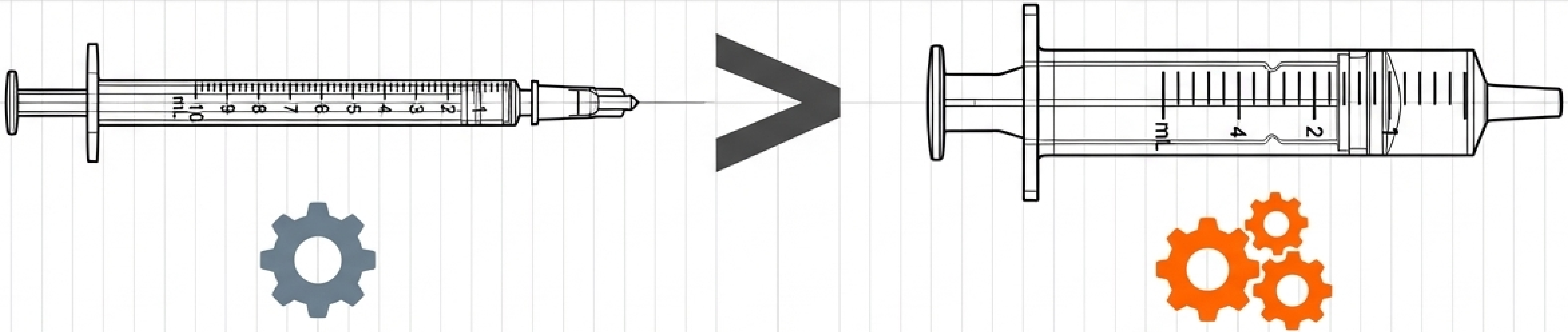
1 mL (6.3mm ID) 3 mL (10mm ID)



1x Work 3x More Work

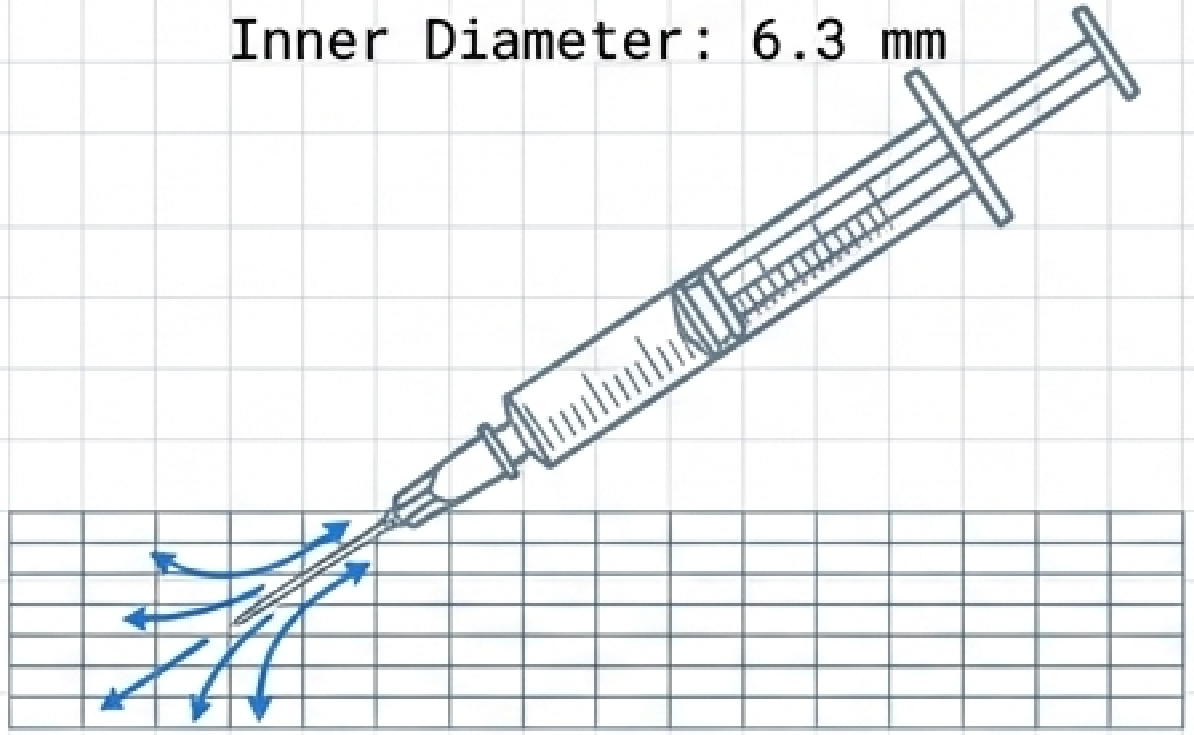
Reducing barrel diameter provides massive mechanical advantage against dermal back-pressure. Syringes ≥ 5mL immediately cross the >35 N failure threshold.

The ≤ 3mL Imperative

Optimal Solution

1-mL Syringe

Inner Diameter: 6.3 mm

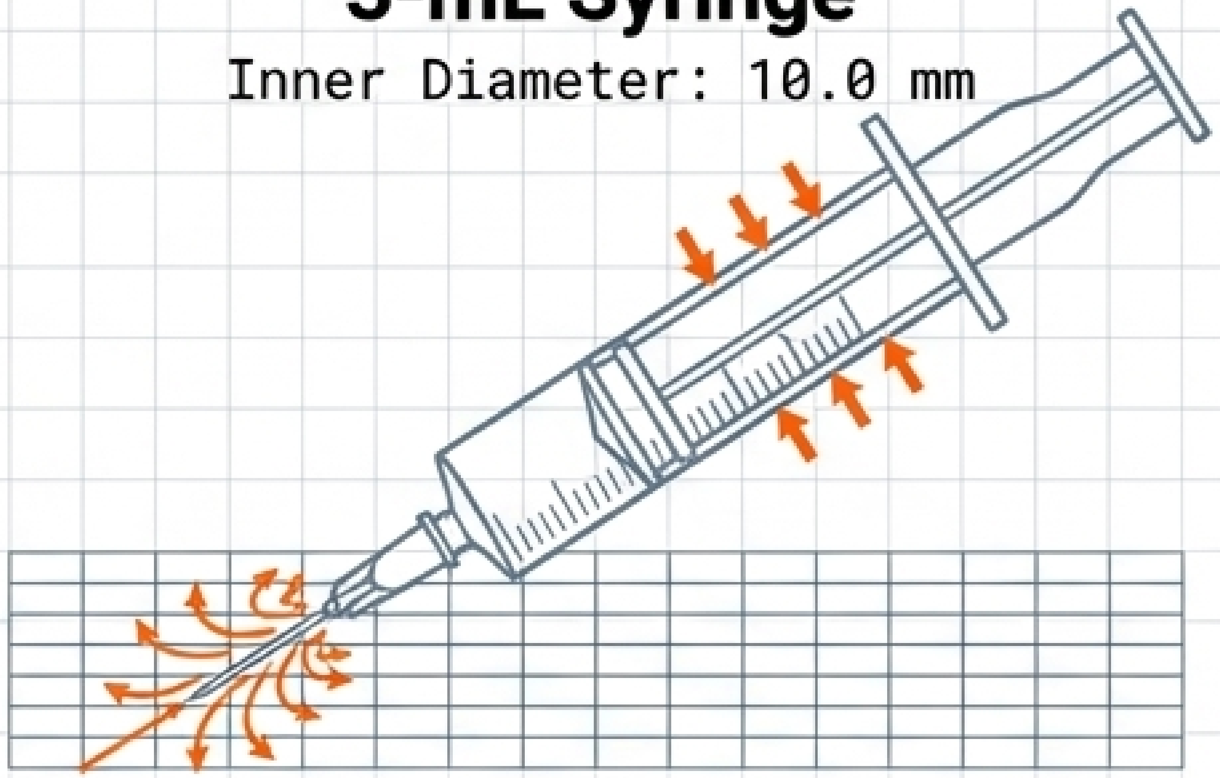


Provides maximum hydraulic leverage against dermal back-pressure. Best choice for flawless delivery.

Maximum Viable Limit

3-mL Syringe

Inner Diameter: 10.0 mm



The upper limit for manageable intradermal therapy. Requires optimization of other variables to prevent clinician fatigue.

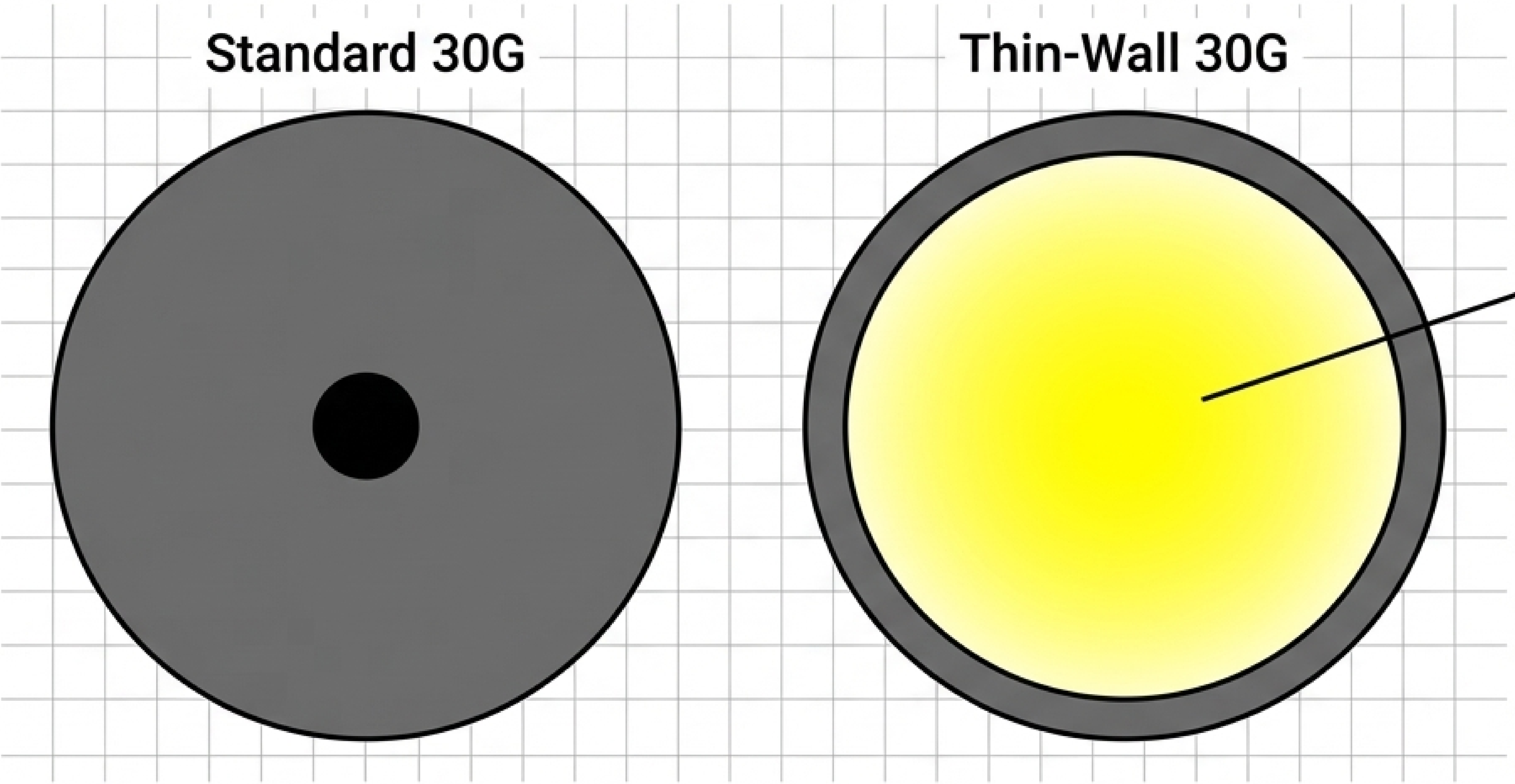
Synthesis: Achieving an optimal injection requires a syringe volume of 3mL or less to offset the dermal resistance that causes larger syringes to fail.

Optimization Lever 2: Needle Lumen

The Thin-Wall Paradox

Poiseuille's Law:

Flow Resistance $\propto \frac{1}{r^4}$

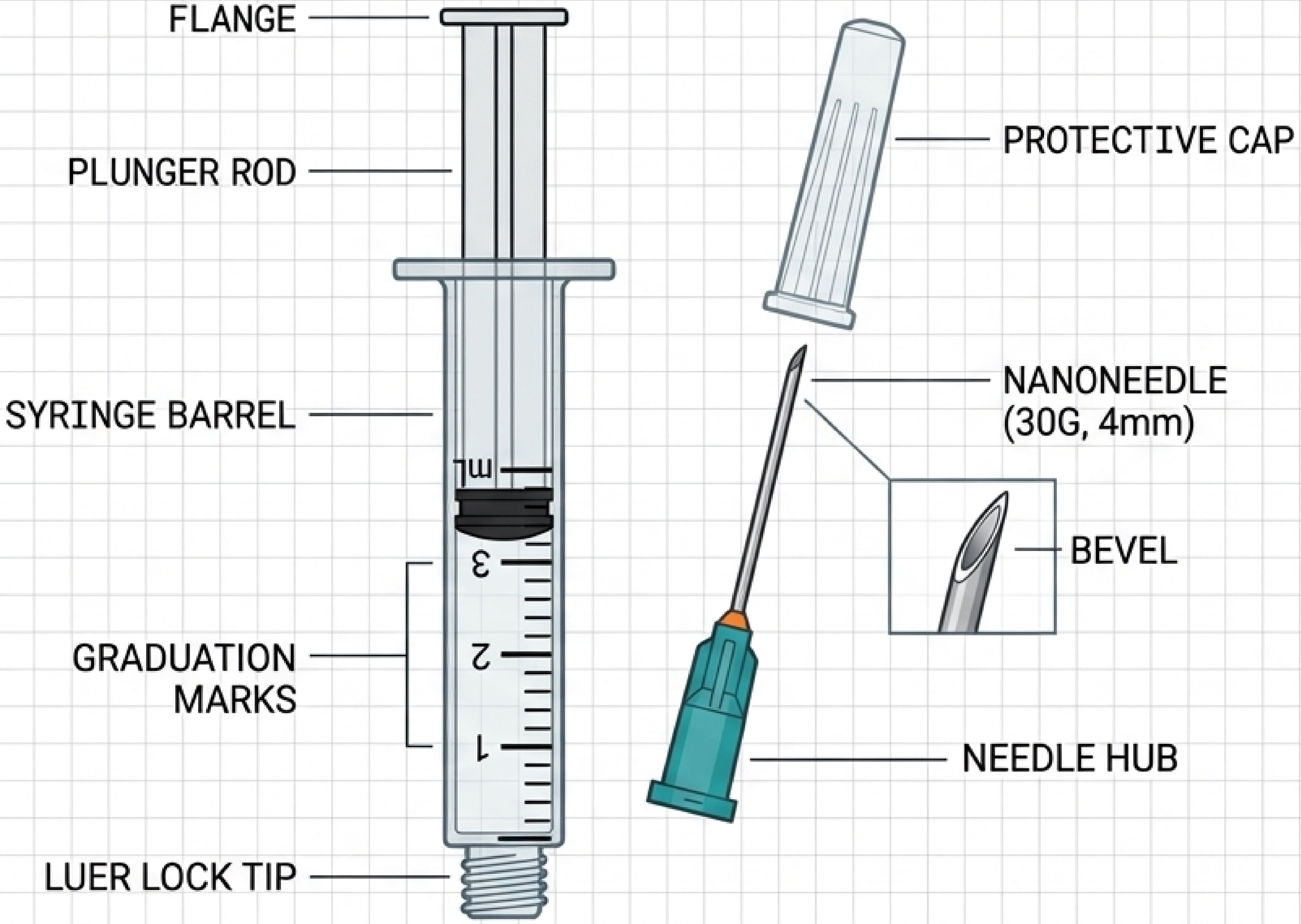


Internal diameter effectively 27G, creating exponential flow improvement without increasing external pain.

Core Insight: The Newtons involved in the glide force **decrease exponentially** with a **wider internal needle diameter.**

THE NANONEEDLE INNOVATION

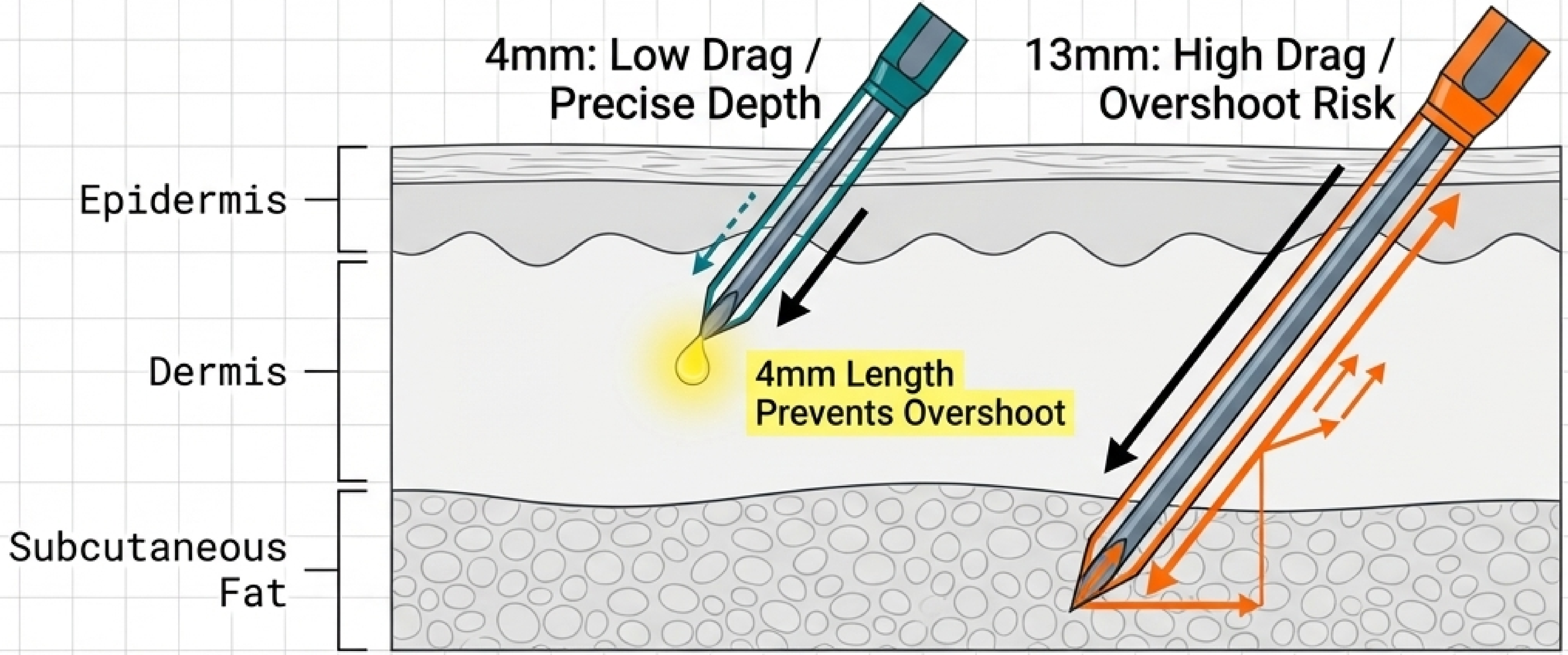
Synthesizing Fluid Dynamics with Hardware



- **External Profile:** 30-gauge (minimizes trauma)
- **Internal Profile:** Proprietary "Thin-Wall" widened lumen
- **Connection:** Luer Lock (prevents leakage under extreme dermal back-pressure)

Technical Callout: This unique geometry fundamentally alters biomechanics, bypassing flow resistance within the dense dermal lattice.

Optimization Lever 3: Needle Length & Drag



Bernoulli Principle: Resistance is proportional to length. 4mm needles mathematically reduce DGF friction and mechanically prevent the operator from overshooting the 1–2 mm dermal depth.

The Synthesiis: **Achieving a 6-Fold Force Reduction**

Standard

3mL to 5mL Syringe
+
30G / 13mm Needle
=
32.4 N

Near Failure Threshold
(High Fatigue)

82% Reduction in Effort

Optimized

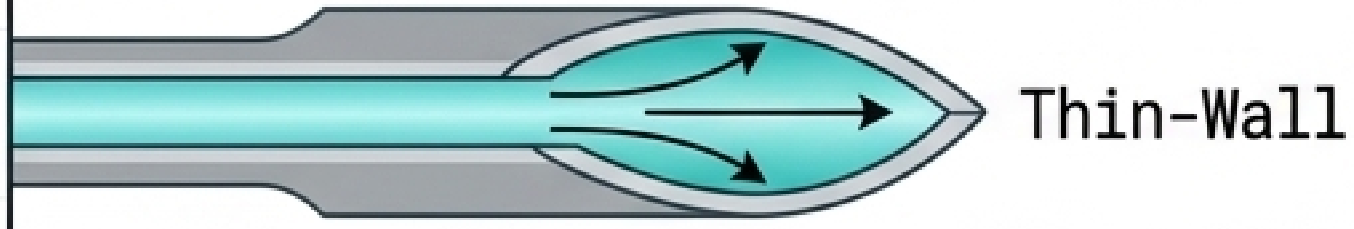
1mL or 3mL Syringe
+
30G / 4mm Nanoneedle
=
5.7 N

Effortless Operation

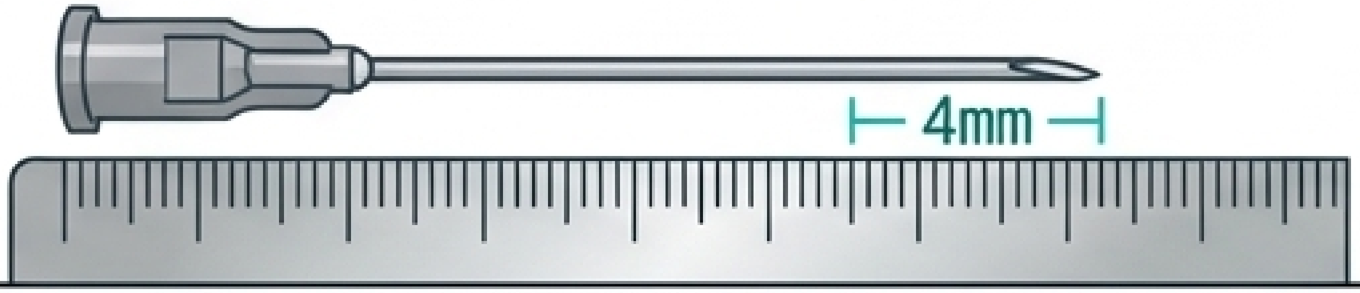
Source: Oh et al. Data.

Summary of Engineering Best Practices

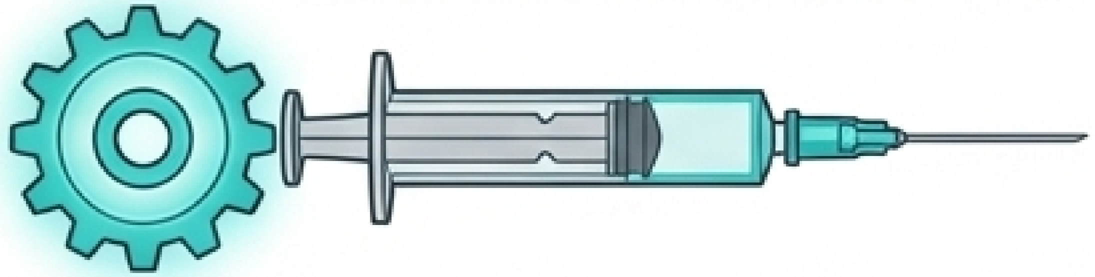
Geometry: Use ≤ 3mL syringes (avoid ≥ 5mL to maintain hydraulic advantage).



Lumen: Utilize “Thin-Wall” tech to leverage Poiseuille’s Law ($1/r^4$).



Length: Standardize on 4mm length to reduce Bernoulli drag and prevent overshoot.



System: The Nanoneedle integration solves the 34.2 N Intradermal Paradox.

The perfect injection is not art.
It is engineering.

AMA References

1. Cilurzo F, Selmin F, Minghetti P, et al. Injectability evaluation: an open issue. AAPS PharmSciTech. 2011.

2. Oh SM, Lee Y, Lee JH, Oh M. Investigating the mechanisms of intradermal injection for easier "skin booster" treatment. Plast Reconstr Surg Glob Open. 2024.

3. Verwulgen S, Beyers K, Van Mulder T, et al. Assessment of forces in intradermal injection devices. Pharm Res. 2018.