C.L.I.N.C.H.: Controlled Laminar-shear for INtegumentary Closure with Hemostatic film

A Minimally Traumatic, Biogel-Assisted Wound Closure Device

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Abstract

C.L.I.N.C.H. (*Controlled Laminar-shear for INtegumentary Closure with Hemostatic film*) is a wound-closure concept that leverages controlled superficial laminar shear of the epidermis, combined with simultaneous deposition of a biodegradable, platelet-supportive biogel film, to achieve rapid, sterile, and minimally traumatic wound sealing. By inducing shear at 50 µm to 150 µm depth, the device forms a natural lap-joint between wound edges without puncture trauma. A voice-coil actuator provides a 0.3 mm reciprocating stroke while a piezo stack delivers sub-millisecond tangential impulses, applied in a controlled stitch or lattice pattern at 0.25 mm to 0.40 mm spacing. The biogel film establishes a diffusion barrier, concentrates platelets for hemostasis, and biodegrades harmlessly over time. This white page outlines the rationale, mechanism, parameters, and performance targets for an open engineering prototype suitable for bench validation.

1 Background and Rationale

Conventional closure methods (sutures, staples, cyanoacrylate adhesives) can cause secondary trauma, have limited sealing strength under motion, or require skilled time-intensive application. The epidermis exhibits a predictable susceptibility to *superficial laminar shear* without vascular injury. C.L.I.N.C.H. harnesses this property to create secure lap-joint closures when paired with a biocompatible sealing medium.

2 Core Mechanism

2.1 Biological Principle

The epidermis can be predictably delaminated at 50 µm to 150 µm depth using tangential shear while preserving dermal capillaries. This forms a superficial "failure plane" that can be overlapped to create a mechanical lap joint.

2.2 Mechanical Translation

- **Actuation:** Voice-coil for ± 0.15 mm stroke (0.3 mm total); piezo stack for sub-ms tangential impulses (0.02 N s to 0.05 N s per tap).
- **Pads:** Silicone (Shore 00: 40–70) with micro-ridges (pitch 80 µm to 200 µm, height 50 µm to 120 µm, oriented ± 15–30° to wound line).
- **Stitch pitch:** 0.25 mm to 0.40 mm along the margin; optional lattice cross-links every 0.8 mm to 1.2 mm at ± 30–45°.
- **Normal pressure:** 20 kPa to 60 kPa pre-load to anchor shear plane while avoiding bruising.

3 Biogel Composition

- **Film thickness:** 50 µm to 150 µm continuous layer; **margin bead** 0.3 mm to 0.6 mm wide $\times$ 0.2 mm to 0.4 mm high.
- **Candidates:** Fibrin–collagen hybrid; chitosan hydrogel (0.5–1%); PEG–alginate blends (low swelling).
- **Optional reinforcement:** Electrospun PLGA micro-web embedded in gel for 5–10$\times$ lap-joint toughness.
- **Gel modulus:** 1 kPa to 10 kPa for flexible sites; up to 50 kPa for high-tension areas.

4 Operational Sequence

1. Irrigate and debride wound per standard care.
2. Apply biogel film along wound edges.
3. Align and clamp jaws with 20 kPa to 60 kPa normal pressure.
4. Traverse at 4 mm s^{-1} to 8 mm s^{-1}, actuating taps at 10 Hz to 20 Hz (matching 0.25 mm to 0.40 mm pitch).
5. Optionally apply lattice cross-links every 0.8 mm to 1.2 mm at ± 30–45°.
6. Hold for 15 s to 30 s to allow gel set; apply breathable protective drape.

5 Performance Targets

- **Shear depth:** 50 µm to 150 µm.
- **Edge gapping:** $<$0.3 mm after 1000 flex cycles at $\pm 10\%$ strain.
- **Burst pressure:** $>2\times$ adhesive-only controls.
- **Closure time:** $<$60 s for a 3 cm laceration.
- **Hemostasis:** No bleeding in 95% of closures at proper settings.

6 Feasibility and Manufacturing

C.L.I.N.C.H. can be prototyped using commercially available voice-coils, piezo stacks, and medical-grade hydrogels. Pad micro-textures can be cast in platinum-cure silicone from SLA-

printed molds. Candidate gel materials have prior surgical use, simplifying biocompatibility and regulatory pathways.

7 Potential Applications

- Field and military medicine
- Pediatric and cosmetic surgery
- Remote and austere environments
- Veterinary medicine

8 Prior Art Differentiation

Unlike sutures and staples, C.L.I.N.C.H. avoids puncture trauma. Unlike adhesive-only closures, it achieves superior mechanical strength through micro lap-joints generated by controlled epidermal shear, combined with an immediately applied biogel film and optional lattice sealing pattern. No existing system combines these features in a single pass.

9 Open Source Commitment

Design files (pad CAD, actuator firmware), gel formulations, and test protocols will be released on GitHub under an open license following Zenodo publication, enabling collaborative refinement and field adaptation.

10 Acknowledgments

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References

A curated bibliography on epidermal shear biomechanics, surgical adhesive performance, hydrogel tissue adhesives, and lattice sealing methods will be provided in the repository.