Smart Medical Devices: Nano-enabled Sensors, Electronics, and On-demand Drug Delivery

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Outline

• Introduction

• Closed loop smart medical devices

• Smart dressing for the wound care management:
  o Smart closed-loop wound dressing
  o Biotextile wound dressing for drug delivery
  o Microneedle based wound dressing

• Conclusion
Introduction

Current approach: Regular screening
• Expensive
• Inhibit early screening
• Inaccuracy
Closed-loop Smart Devices

- Smart platform transmits healing factor information via Bluetooth to a mobile device which uploads the data to a cloud.
- Healthcare providers can remotely monitor healing and modify treatment if necessary.
Problem: Chronic Wounds

Chronic wound treatment places a heavy cost and resource burden on the health care system, costing over $50 billion annually in the US.

25% of infected chronic wounds lead to amputation. Chronic wounds are the leading cause of non-traumatic limb amputation.
- **pH, oxygen, and proinflammatory cytokines** are key markers for monitoring of wound healing.
- **Antibiotics, growth factors, and immune regulating drugs** are essential.
Current dressings:
- Maintain moisture balance
- Remain in place but not adherent to wound bed
- Minimize shear, friction, skin irritation, and additional pressure

Continuous monitoring and treatment is not available.
Smart Flexible Wound Dressing

Smart Textile Dressing

- An active wound dressing was fabricated using composite fibers with a core electrical heater covered by a layer of hydrogel containing thermo-responsive drug carriers.
- This biotextile dressing can deliver biomolecules with a pre-determined spatial and temporal delivery ability.


Smart Microneedle-based Dressing

- VEGF-laden PLGA
- Hollow needles
- Heater layer
- Biosensor
- Needle-based bandage
- Electronic board
- Wound bed
- Exudate

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Highlighted Results

Day 1 | Day 5 | Day 7 | Day 13 | Day 15 | Day 19
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Negative Control

Topical

MNA

P. Mostafalu, et al. (2019). *science advances*
Conclusion

- A better treatment outcome, clinical practice should decide about “what”, “when”, and “where” you should deliver a drug.
  - Sensors allow that what kind of treatment should be delivered.
  - Electronic system can be used to readout the data and make the decision when the treatment should be applied.
  - Stimuli responsive drug delivery enables electronic system to adjust the treatment.