Development of Microneedle Granules and the Application in Drug Delivery

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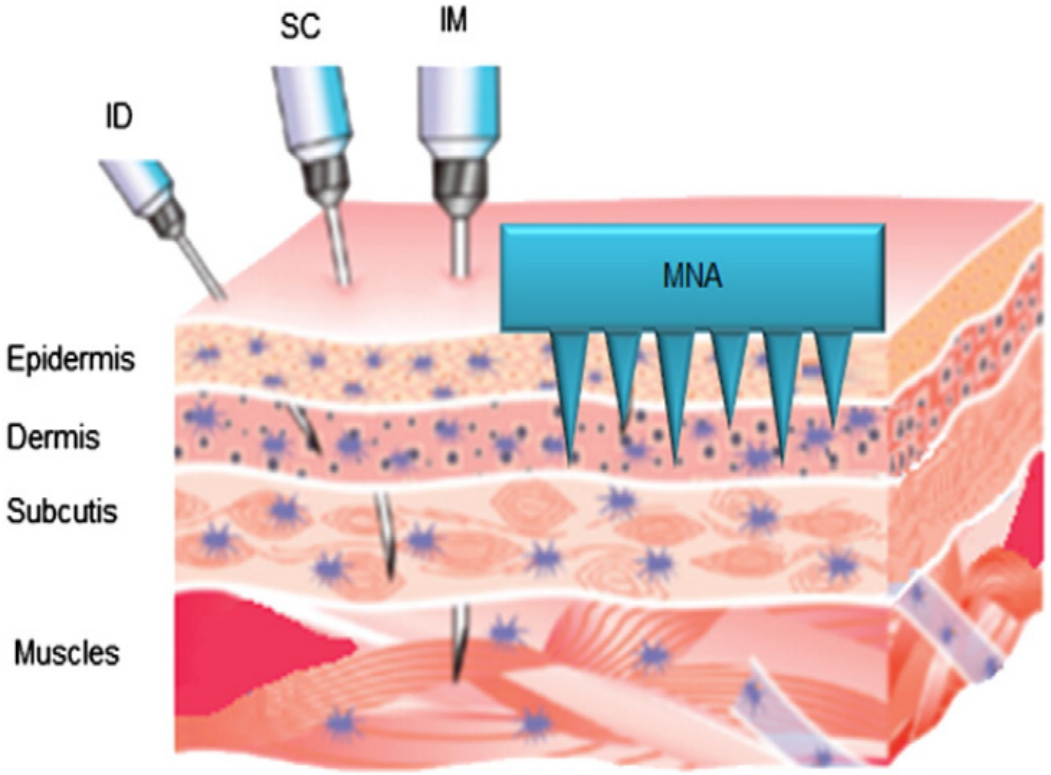
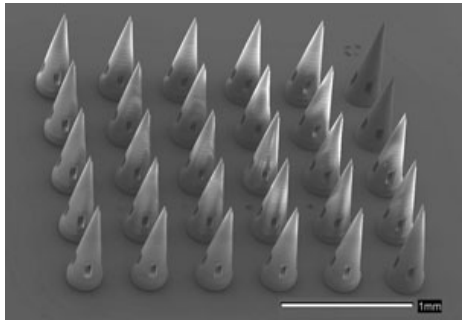
Microneedles

- Create transport pathways of micron dimensions to overcome stratum corneum
- Allow molecules of larger dimensions to readily permeate (e.g. peptides).Increase bioavailability up to 30%



Advantages of MN array over Hypodermic Needles

- Minimal pain
- Minimal invasiveness
- Self-administration
- Ideal for patient adherence



SEM image of microneedle

Indermun et al. Journal of Controlled Release (2014)
Ling M.H. & Chen M.C. Acta Biomater (2013)

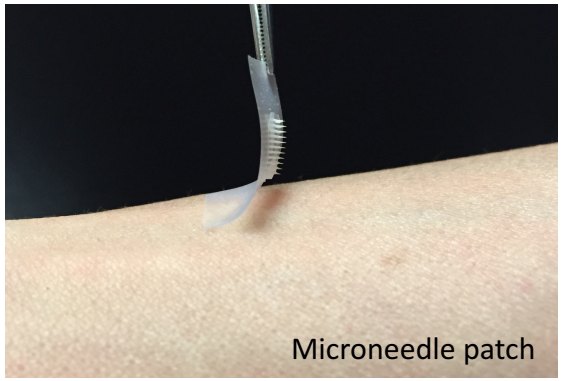
Monkare et al. Journal of Controlled Release (2015)
Kochar et al. International Journal of Nanomedicine (2012)

Shortcomings of Current Microneedles for Transdermal drug delivery

- Microneedles only fabricated on flat planar surfaces, which will lead to incomplete insertion. (*Microneedle patch, microneedle stamp*)

  *Human skin is undulating and curved around body parts

- Limited area (*Microneedle patch, microneedle stamp*)



Microneedle patch

Microneedle stamp

- Infection (*Derma roller*)

  *The most serious side effect of derma roller. Need to make sure that clean and disinfect derma roller after each use, to remove bacteria that could potentially cause infection

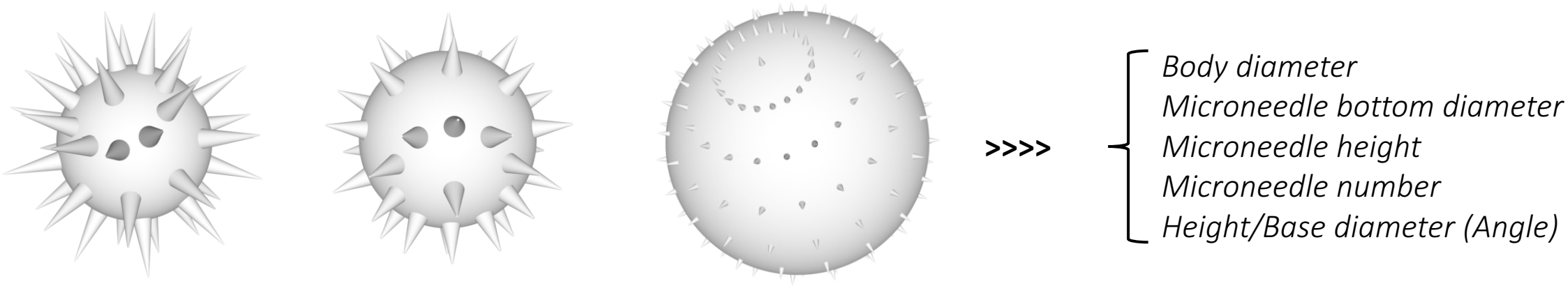
Derma roller

Cai et al. European Journal of Pharmaceutics and Biopharmaceutics (2015)
Lahiji et al. Nature Scientific Reports (2015)

The concept of Microneedle Granule

- **Bio-inspired structure**

  Microneedle granule is a new designed microneedle arrays with thorny sphere architecture , which the out layer of is decorated by spikes. Size of granule body and needles on the sphere can be varied at the designing stage.

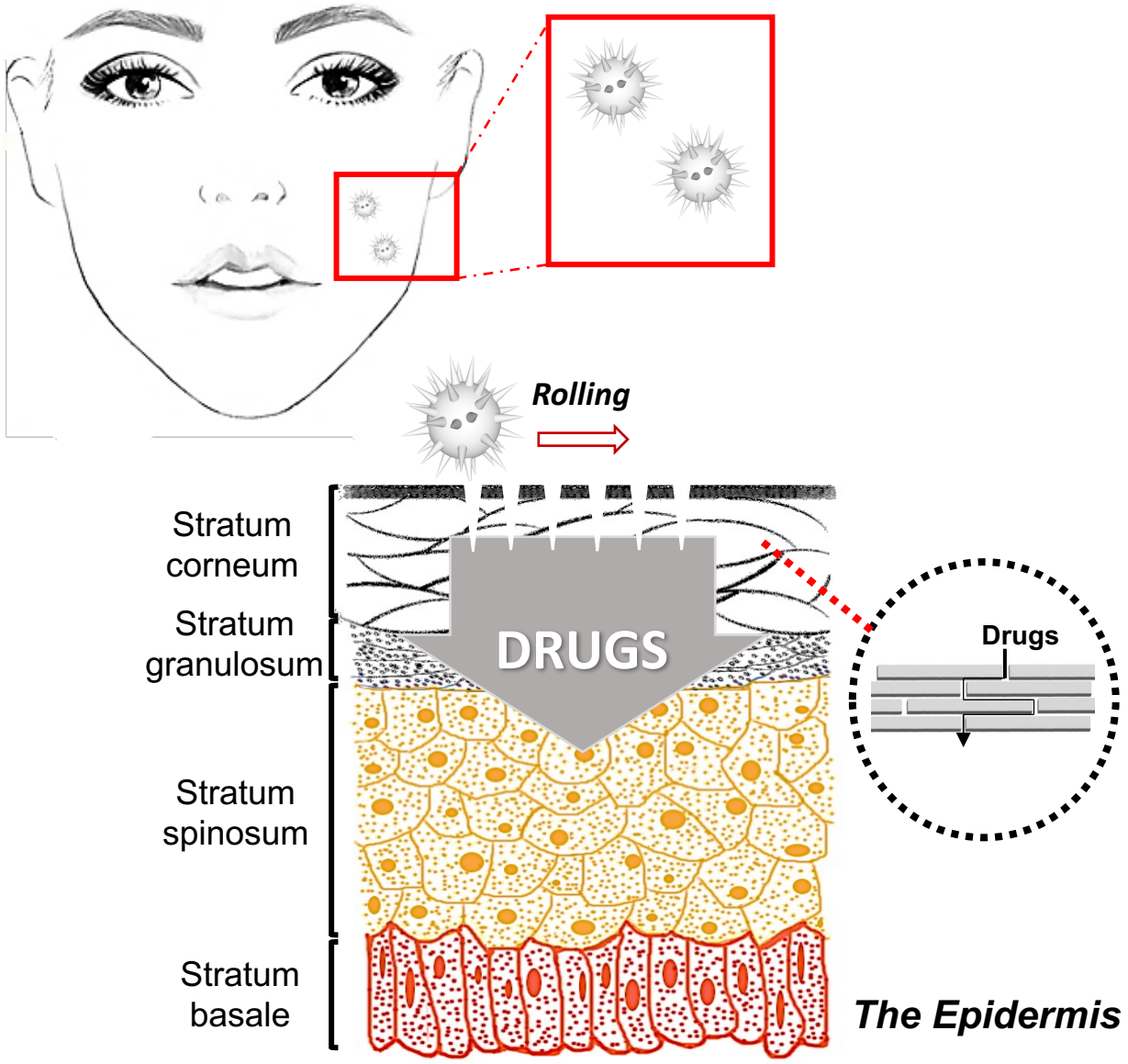


Microneedle Granule Computer Aided Design

Applications

Topical application/ Transdermal Drug Delivery

- Microneedle granule can be applied to **most of the topical used drugs and cosmetics** (e.g. essential oils, essence). Sterile microneedle granules could be kept in separated packaging and **disposed after use**. On a per-use-case, massage the skin with the granules to create micro channels before or after drugs/cosmetics applied.



Advantages

- Self-administrated easily on the skin without the limitation of skin condition (non-flat surface), moving direction and working area;
- The sterile microneedle granules could be kept in separated packaging and disposed after using to reduce the infection risk;
- The size the granule body, the microneedle dimension can be adjusted at the designing stage;
- The material can be selected to meet the requirement of drugs and physiological condition.

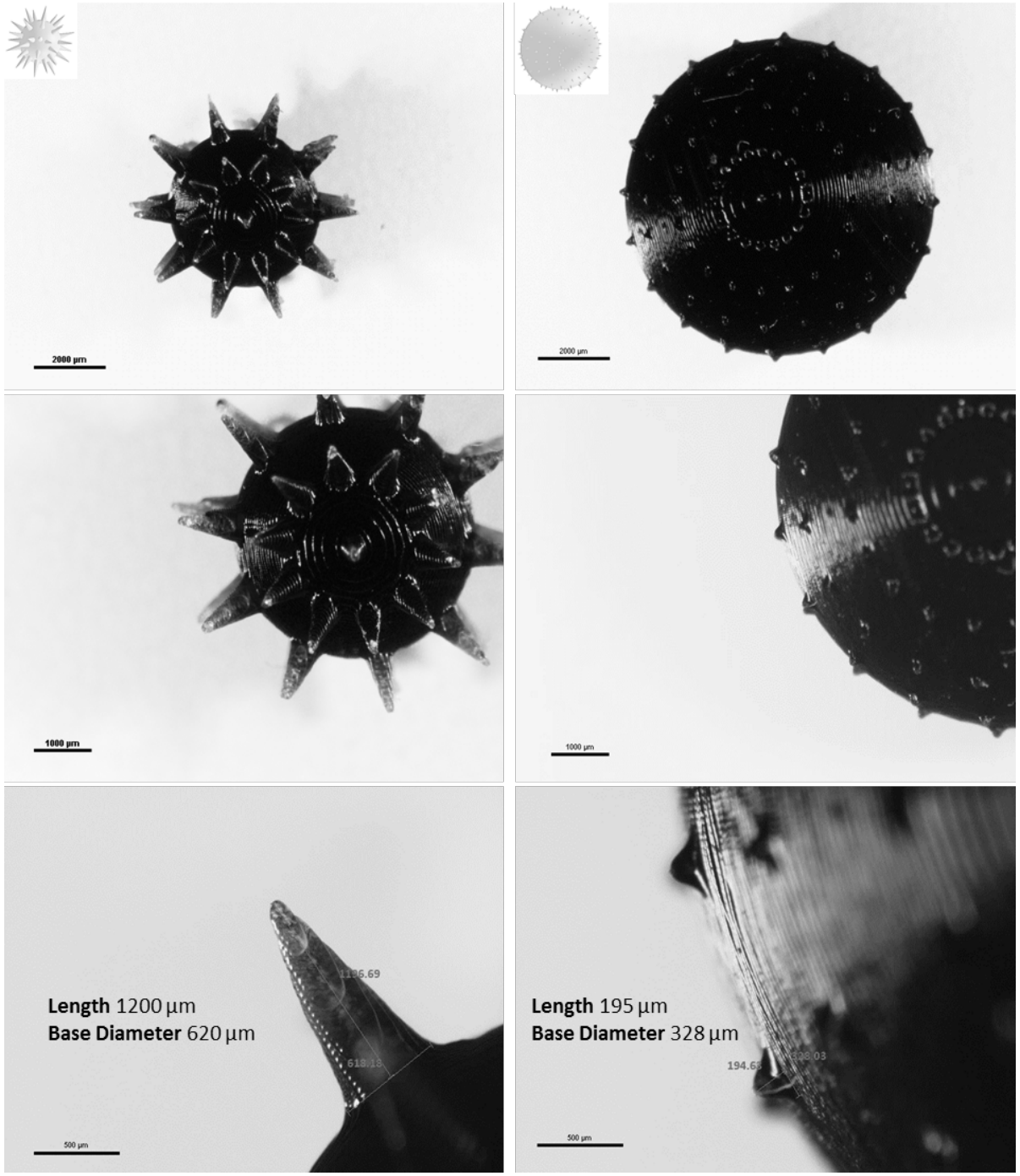


Figure 1. Two kinds of microneedle granules in different sizes of body and microneedle dimensions by 3D printing.

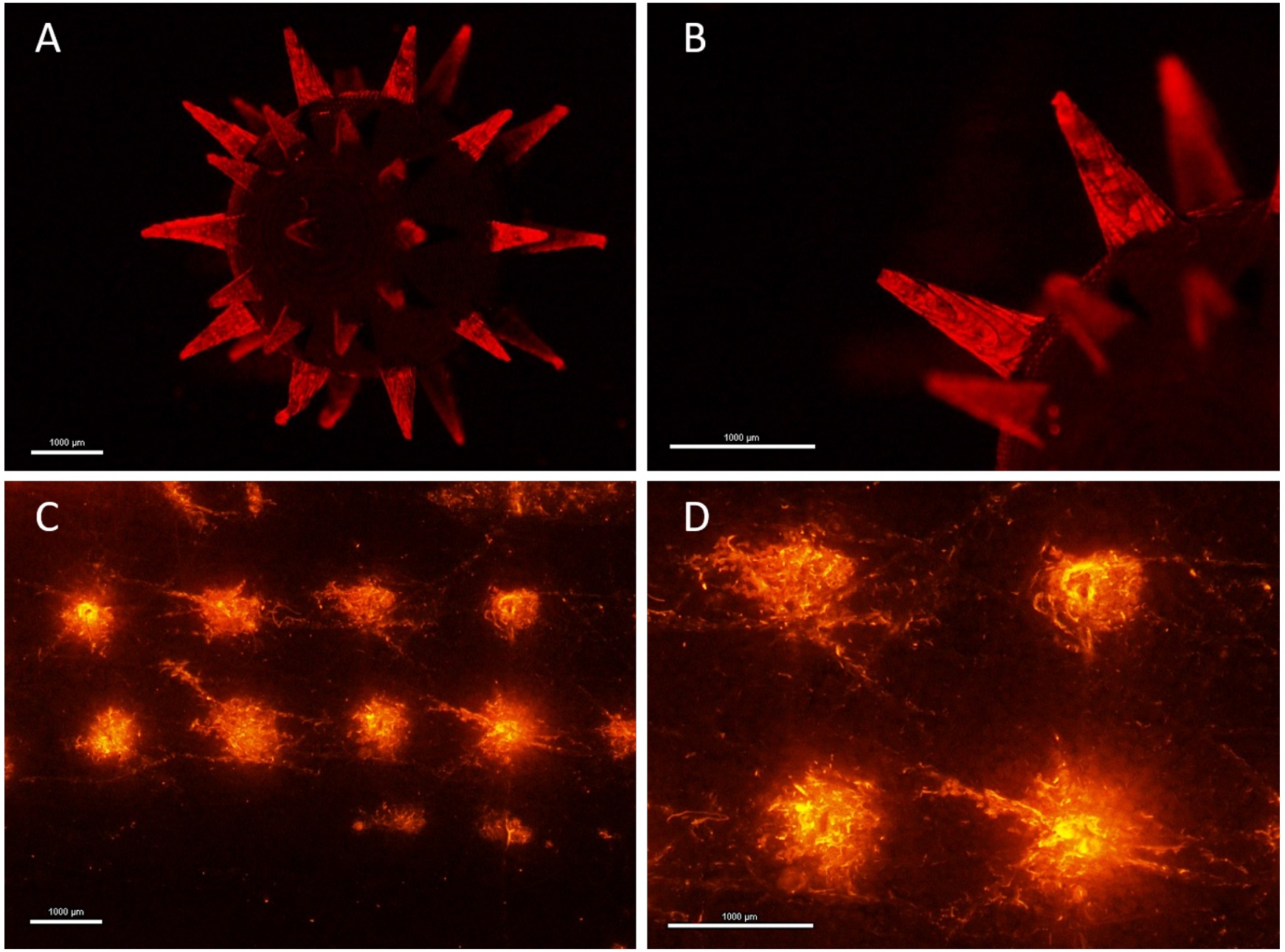


Figure 2. Microneedle staining and Human cadaver skin penetration. (A-B) Before insertion, Sulforhodamine B (0.2% w/v) was stained on the microneedle granule surface and administered to human cadaver skin. (C-D) Fluorescence micrograph of human cadaver skin after one time rolling and insertion of microneedle granule, showing the delivery of the coated Sulforhodamine B.

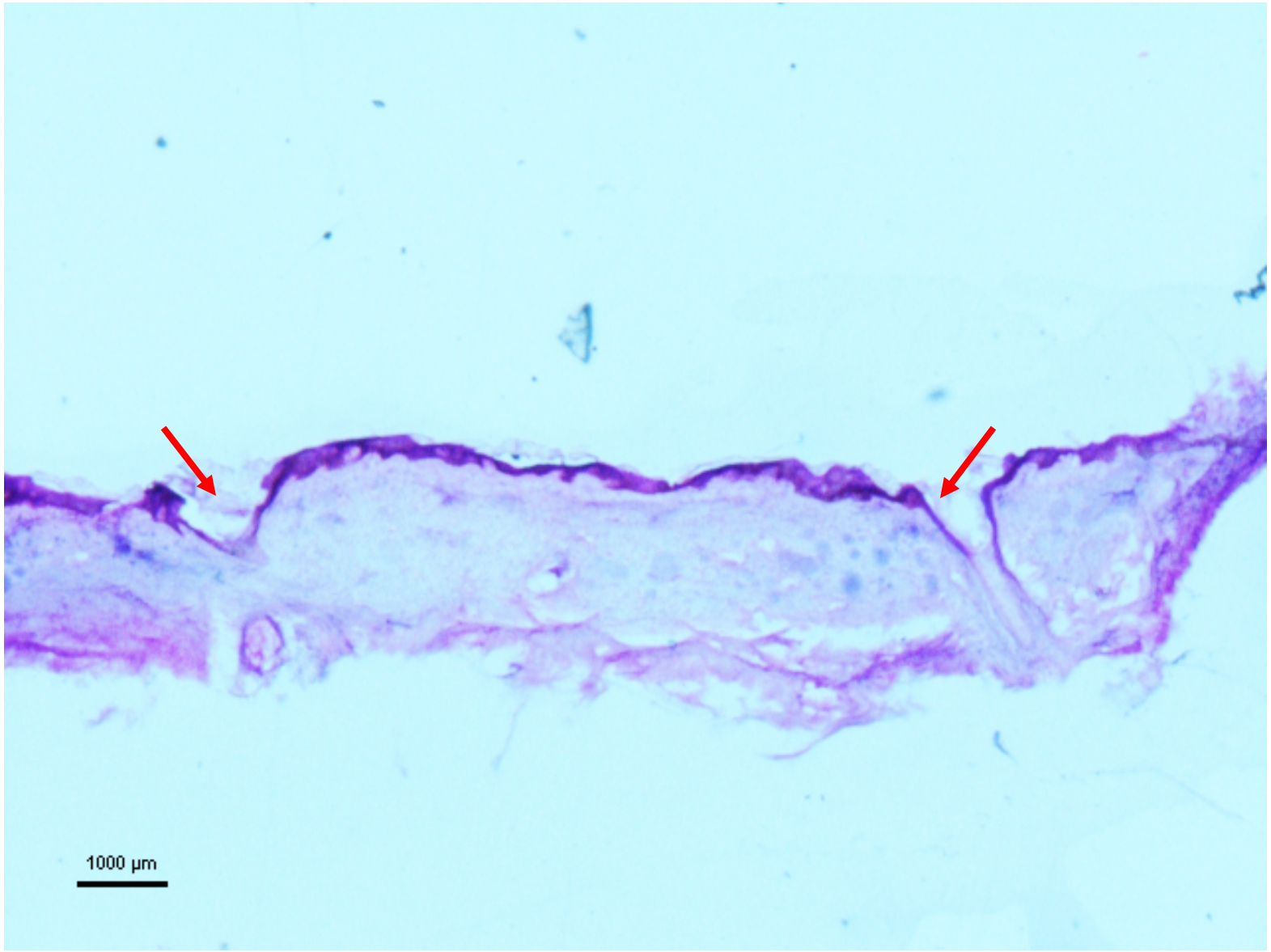


Figure 3. Histological section of human cadaver skin stained with hematoxylin and eosin after microneedle granule treatment. The red arrows indicate microneedle holes.