3D Printed Microneedles for Transdermal Drug Delivery

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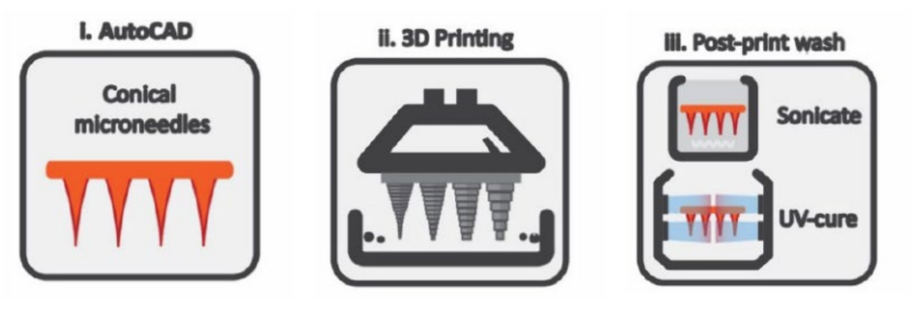


Introduction

- The transdermal drug delivery system (TDDS) provides a non-invasive route for systemic and local delivery of drug which avoids first-pass metabolism and improves patient compliance.
- As the main skin barrier, the stratum corneum significantly limits therapeutic permeation; microneedles (MNs) bypass this by forming painless microchannels that facilitate drug transportation.
- Conventional MN fabrication methods (e.g., molding, lithography) have limited design flexibility and may require complex, multi-step processes.3D printing offers precise, customizable, and rapid fabrication of MNs.
- In this study, we used 3D printing to build hollow MNs, providing a straightforward method for MN fabrication and TDDS.

Experimental Procedure and Characterisations

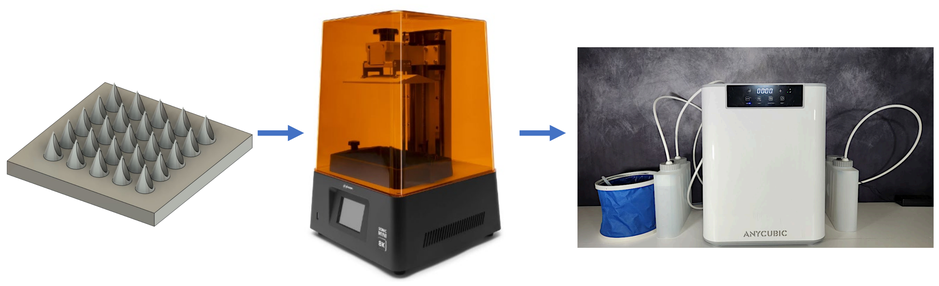


Fig. 1. 3D printing processes: Autodesk model design, 3D printing, sonication, and post-curing.

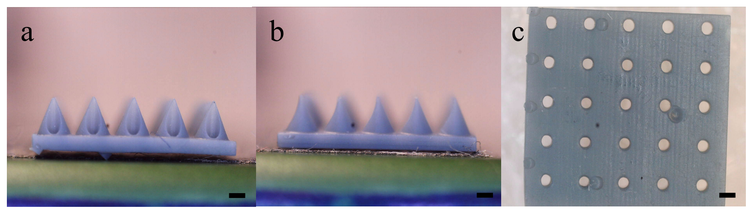


Fig. 2. Optical microscope images of hollow MNs: (a) front view, (b) side view, and (c) back view. Scale bar = 500 µm.

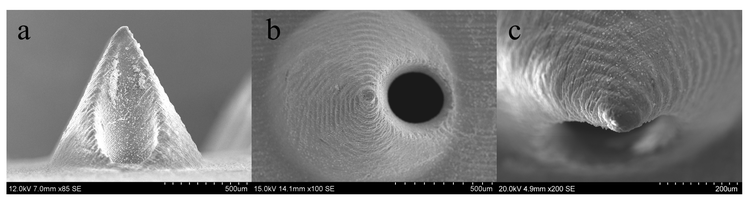
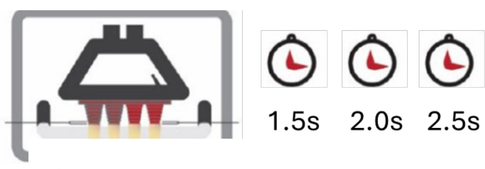


Fig. 3. SEM images of hollow MNs: (a) front view, (b) top view, and (c) tip.

Results and Discussion

3D printing parameters



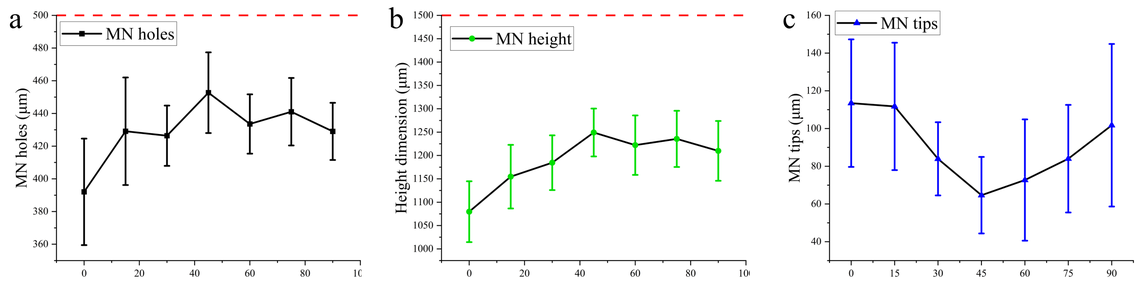


Fig. 4. Dimensions of MN (a) holes, (b) height, and (c) tips influenced by printing angles. Red dashes are the designed dimensions [1].

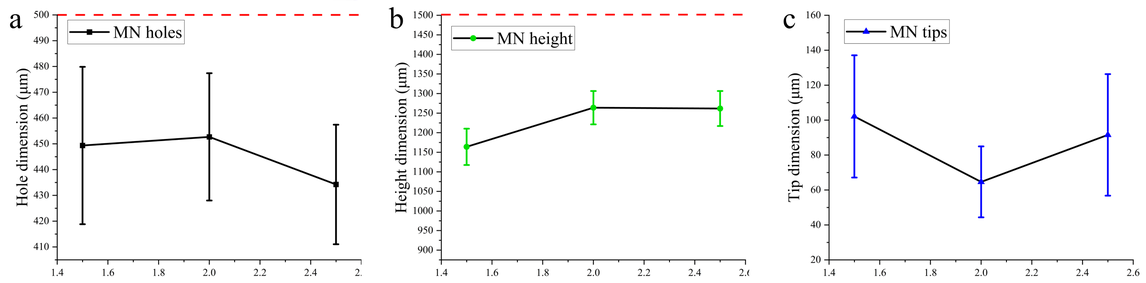


Fig. 5. Dimensions of MN (a) holes, (b) height, and (c) tips influenced by exposure time. Red dashes are the designed dimensions [1].

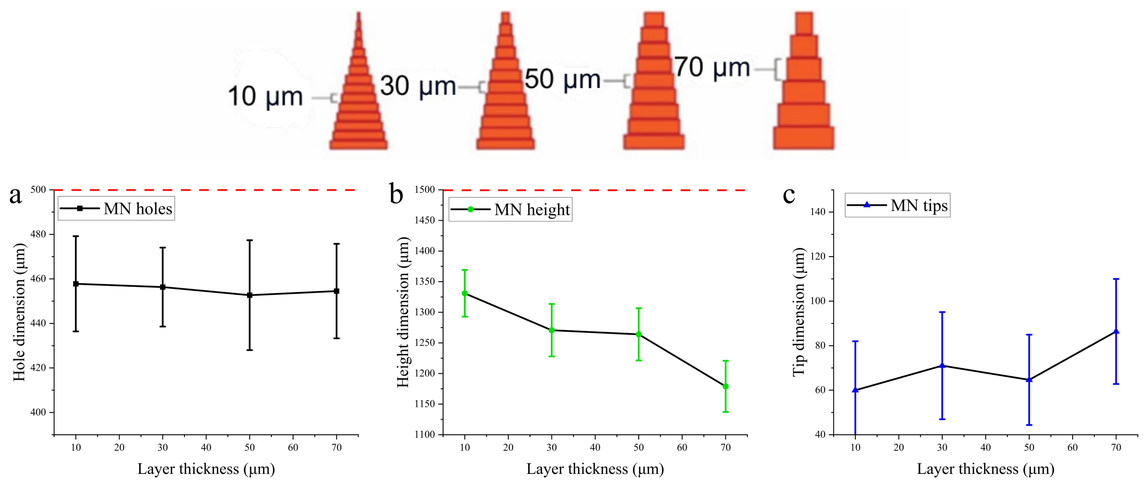


Fig. 6. Dimensions of MN (a) holes, (b) height, and (c) tips influenced by layer thickness. Red dashes are the designed dimensions [1].

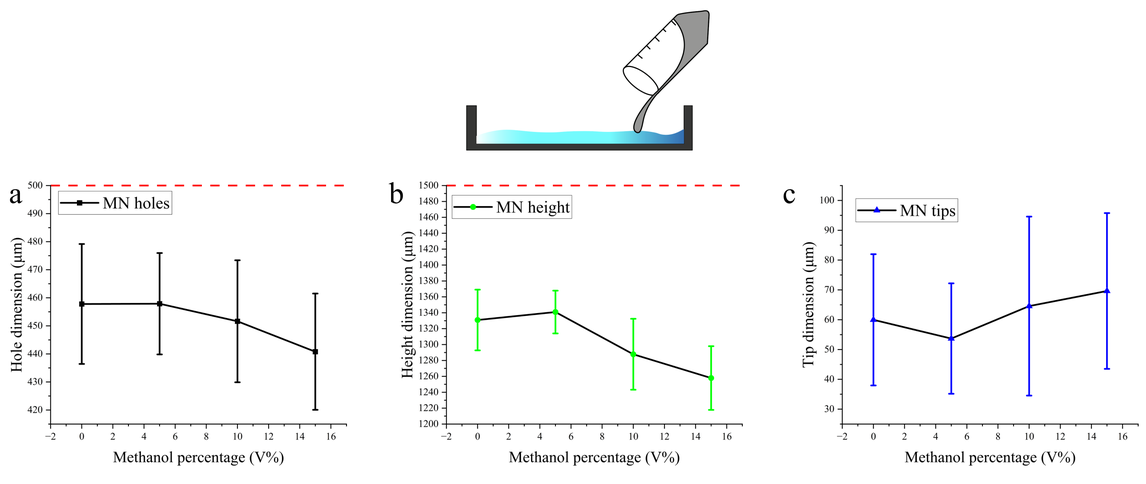


Fig. 7. Dimensions of MN (a) holes, (b) height, and (c) tips influenced by methanol dilution. Red dashes are the designed dimensions.

Skin penetration

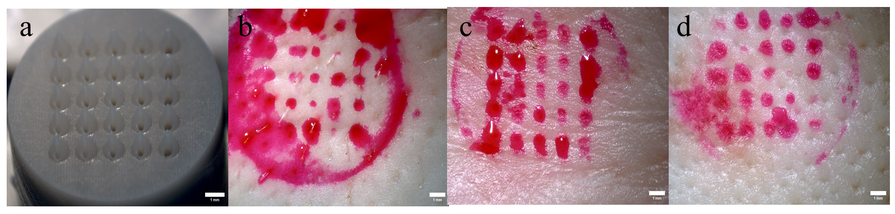


Fig. 8. Optical microscope image of the 3D printed MNs (a) used for skin penetration tests and pig skin (b, c, and d) after MN penetration by thumb pressure for 60s

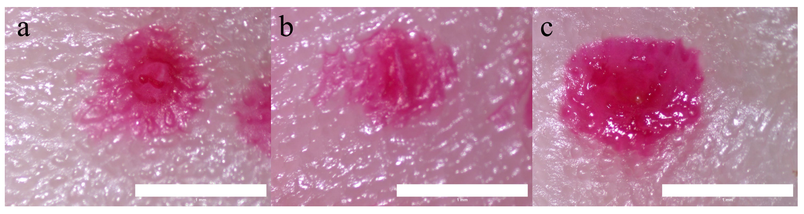


Fig. 9. Optical microscope images of pig skin (a, b, and c) after MN penetration by thump pressure for 60s.

Conclusion

- Benchtop 3D printer fabricated hollow MNs with high precision after parameter adjustment.
- The 3D printed hollow microneedle is capable of penetrating the outermost skin layer, the stratum corneum, thereby creating a conduit within the skin.

Acknowledgements

This research was supported by National Health and Medical Research Council (NHMRC) of Australia for Early Career Fellowship (GNT1143296) and the Australian Research Council (DP210100265). The authors acknowledge the supervision of Associate professor Tushar Kumeria.

References

1. Ali,…, Kumeria, 3D printed microneedles for the transdermal delivery of NAD+ precursor: toward personalization of skin delivery, ACS Biomaterials Science & Engineering, 2024