# Optical Coherence Tomography and High-frequency Ultrasound for Skin Imaging - Multimodal Imaging on the Rise

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## Introduction

New multimodal imaging techniques provide visualization of tissue morphology within the skin including layers of the epidermis and dermis without being invasive, which is beneficial for applications in preclinical research and, even more so, in clinical diagnosis. Furthermore, imaging approaches that generate objective, qualitative and quantitative datasets ensure reproducible and accurate results, reasoning their increasing use and supporting the development of machine learning-based assessments that can assist classical examination in the clinics. Within the framework of this study, two commonly used imaging techniques in dermatology, optical coherence tomography (OCT) and high-frequency ultrasound (HFUS), have been evaluated and contrasted regarding their applicability to image skin tissue morphology and quantify intradermal structures *in vitro* and in a preclinical model in murine skin *in vivo*.

## Methods

The accuracy and reproducibility of both methods were assessed in *ex vivo* experiment utilizing standardized precision glass spheres, followed by an *in vivo* experiment using 21 female BALB/c mice and a standardized model for intradermal volumes based on the injection of predefined soft tissue filler volumes. The acquired data of the OCT and HFUS recordings were analyzed in terms of penetration depth, resolution and contrast. In addition, the anatomical landmarks of the B-scan images of both OCT and HFUS were compared with histology.

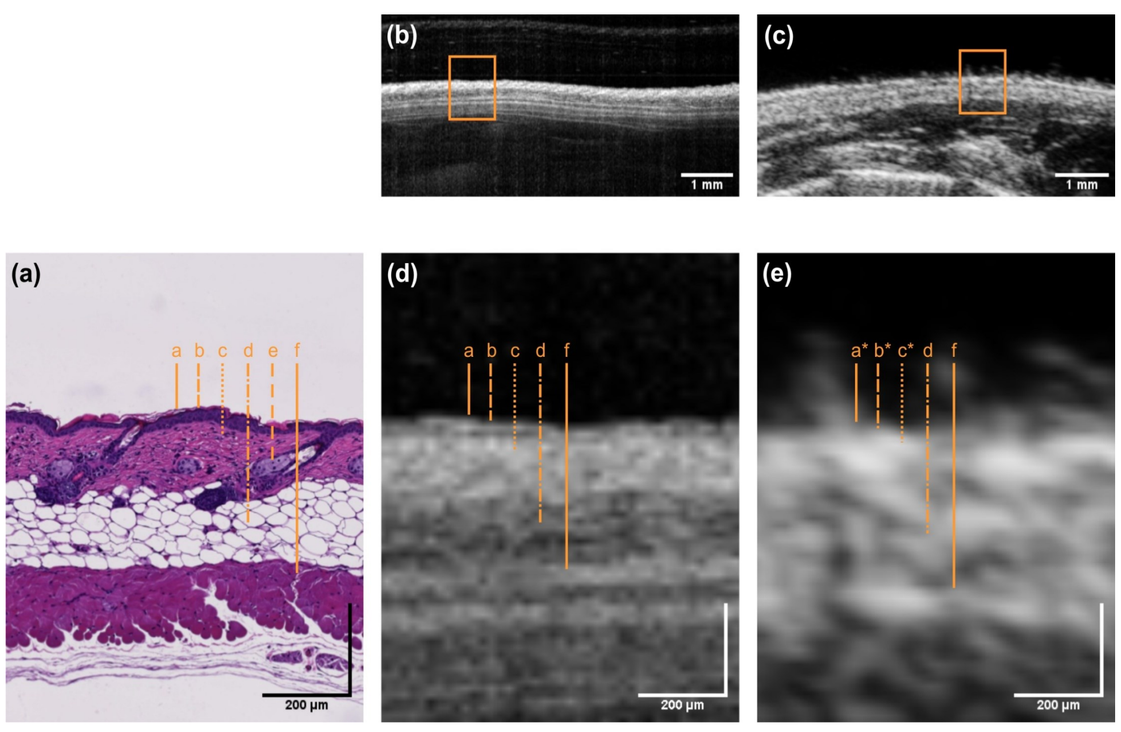


**Figure 1.** Representative cross-sections of unpigmented mouse skin from BALB/c mice acquired by (b) OCT and (c) HFUS and the matching (a) histological section that was stained with H&E. The magnified cross-sections as marked by the orange rectangles are shown in (d,e). Dashed orange lines in image (a,d,e) refer to the following skin layers: (a) epidermis, (b) papillary dermis, (c) reticular dermis, (d) subcutis, (e) sebaceous glands and hair follicles and (f) muscle. The skin layers that are marked with letters with an asterisk indicate structures that are not detectable in the HFUS images.

## Results

Optical coherence tomography provided visualization of the murine skin in greater detail, and, because of the superior resolution, enabled to depict even single skin layers. The volumetric assessment of the deposits recorded *ex vivo* by OCT (7.9 ± 0.3 µl) and HFUS (7.7 ± 0.5 µl) showed a good agreement and a high accuracy when compared with the administered volume of 7.98 ± 0.8 µl. *In vivo*, OCT revealed a higher precision (relative SD: 26% OCT vs. 42% HFUS) for the quantification of the intradermal deposits, whereas HFUS offered a higher penetration depth allowing for imaging of deeper structures.

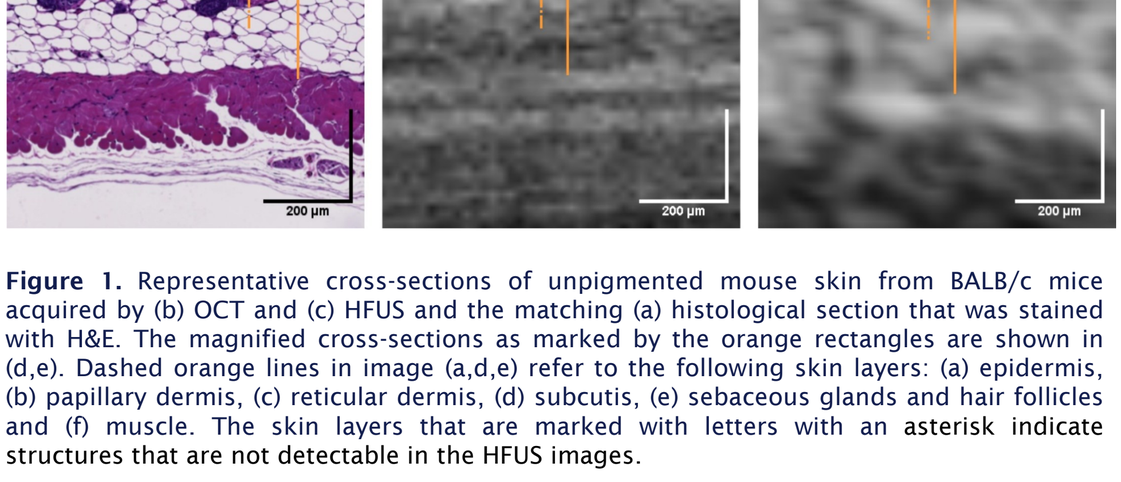


**Figure 2.** Evaluation of the volumes of the soft tissue filler deposits. (a) Bland-Altman plot, (b) box plot and (c) histogram contrasting data acquired via OCT and HFUS imaging.

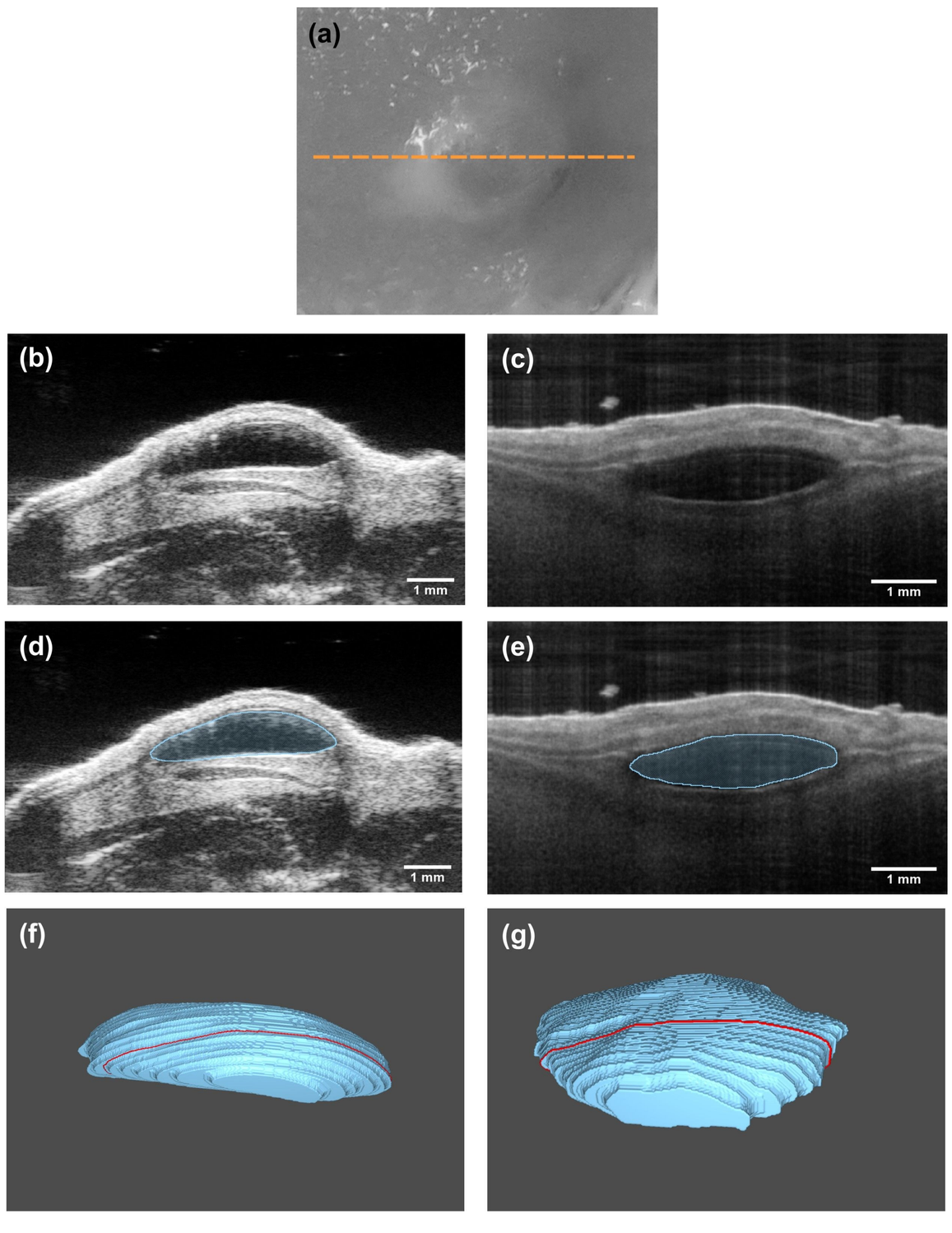


**Figure 3.** Exemplary images of soft tissue fillers in mouse skin, depicting the same filler volume acquired with OCT and HFUS. (a) Photograph of the skin area at the dorsum of the mouse that comprises the soft tissue filler volume. The dashed line in orange shows the position of the cross-sections acquired by (b) HFUS and (c) OCT. The images of (d) HFUS and (e) OCT show representative examples of results of the automatic segmentation algorithm, which was applied for determination of the volumes. Images (f,g) show 3D representation of intradermal volumes as obtained *in vivo* via HFUS and OCT, respectively.

## Conclusion

The findings of this study indicate that multimodal imaging combines the strengths and advantages of each technique and compensates the other methods drawbacks and limitations. Optical coherence tomography offers a high resolution and greater precision for quantitative assessments, whereas HFUS provides a high imaging penetration depth. Both techniques enable accurate quantification of the injected soft tissue filler volumes. The combination of both can provide valuable information of morphologic features, not only in healthy skin, but can be also utilized for the assessment of tumors or other dermal pathologies in a clinical setting and in preclinical research, alongside with the evaluation of treatment success.

## References

Schuetzenberger, K. et al. Comparison of optical coherence tomography and high frequency ultrasound imaging in mice for the assessment of skin morphology and intradermal volumes. Sci. Rep. 9, 13643, https://doi.org/10.1038/s41598-019-50104-4 (2019).