Characterizing the microcirculation of atopic dermatitis using angiographic optical coherence tomography.

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Background

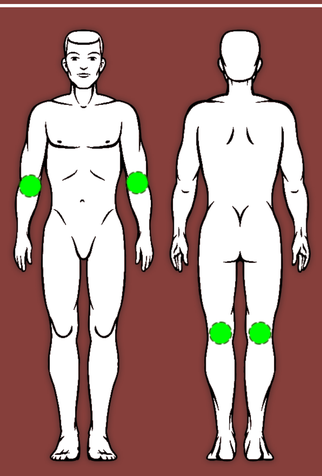
- **Atopic dermatitis** (AD - Eczema); an inflammatory condition of the skin, currently affects ~10.5%[1] of the population, representing a significant quality of life impairment.
- AD is typically graded externally using clinically visible symptoms such as erythema, excoriation and lichenification. However **subclinical** abnormalities within the skin provide key information about the condition even past the point of clinical remission.[2]
- The microcirculation presents several key subclinical metrics, which have potential to be correlated with AD progression and used to quantify response to treatment.

Aims

1. **Utilise** angiographic optical coherence tomography (OCTA) to capture and compare the morphology of microcirculation within both healthy skin and skin affected by AD.
2. **Extract** quantitative subclinical metrics from the datasets. In particular, the use of OCTA to robustly measure the degree of epidermal thickening (Hyperplasia) in AD.

Methods

- **Pilot study participants:**
  - 5 **healthy** volunteers with Fitzpatrick skin type between I-III and no history of chronic skin disease.
  - 5 **AD** volunteers with Fitzpatrick skin type between I-III, and mean severity (EASI) of 8.5 ± 3.3.
- **Scan sites selected as common sites of adult AD:**
  - Left/right cubital fossa (Inner elbow).
  - Left/right popliteal fossa (Rear of the knee).
- **4x4x2mm OCTA volumes (N=10) captured non-invasively from each skin site using a clinical Vivosight OCT scanner.[3]**



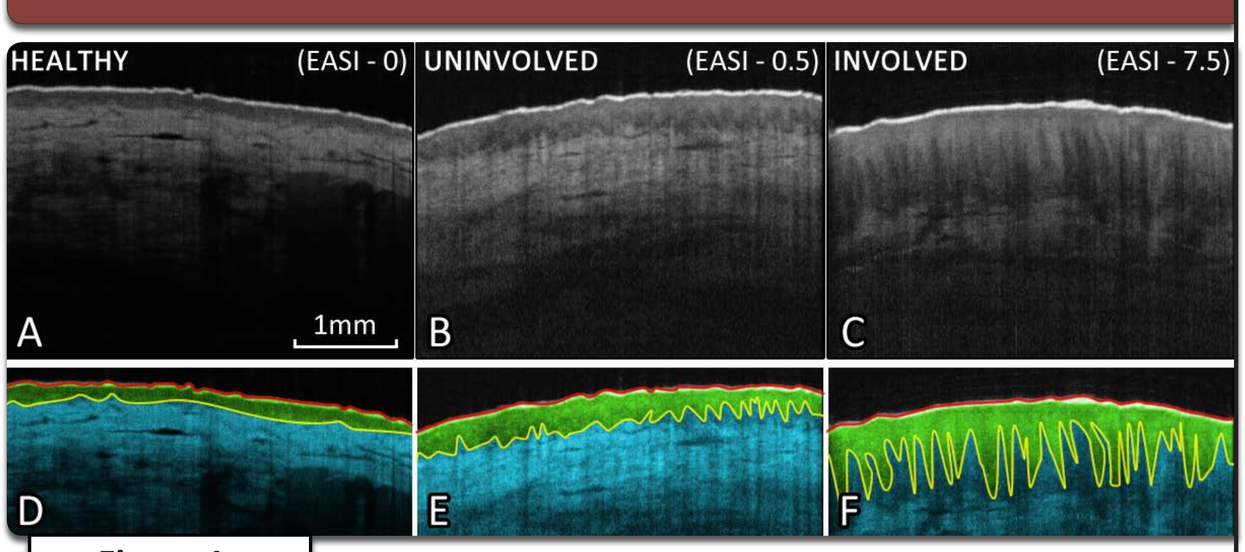


Figure 1 — **Structural OCT views of skin changes resulting from AD.**

Notably, subclinical abnormalities are present even at unaffected AD sites **(B)**.

A) OCT image captured from a healthy subject, showing clear delineation of the epidermis and dermis. **B)** OCT image captured from an uninvolved site on an eczema patient, showing slightly extended rete-pegs and an undulating dermal-epidermal junction (DEJ). **C)** OCT image captured from an involved site on a different eczema patient, showing what appears to be psoriasiform hyperplasia (Long thin epidermal papillae/rete-pegs).

D-F) Manually segmented skin layers. The **red-line** is the skin surface / stratum corneum layer. **Green colouration** represents the epidermis, the **yellow-line** is the DEJ and **blue colouration** represents the dermis.

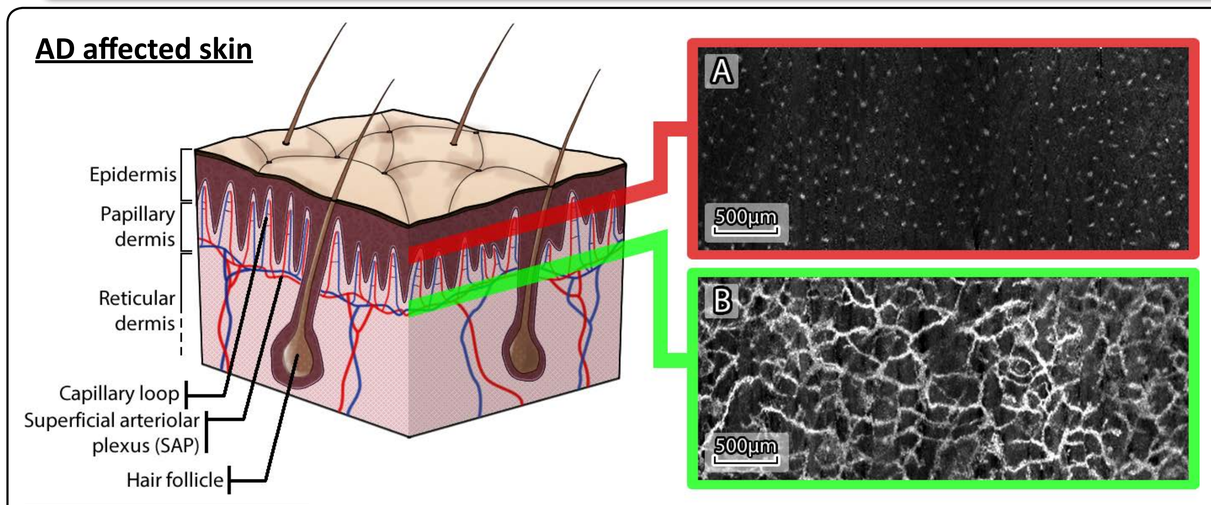


Figure 2 — **Method of quantification for epidermal thickness using OCTA.**

Distinct vessel morphologies of the capillary loop tips (A) and superficial arteriolar plexus (B) allow for a robust estimation of epidermal thickening. With the depth (A) being a lower bound, and (B) being an upper bound.

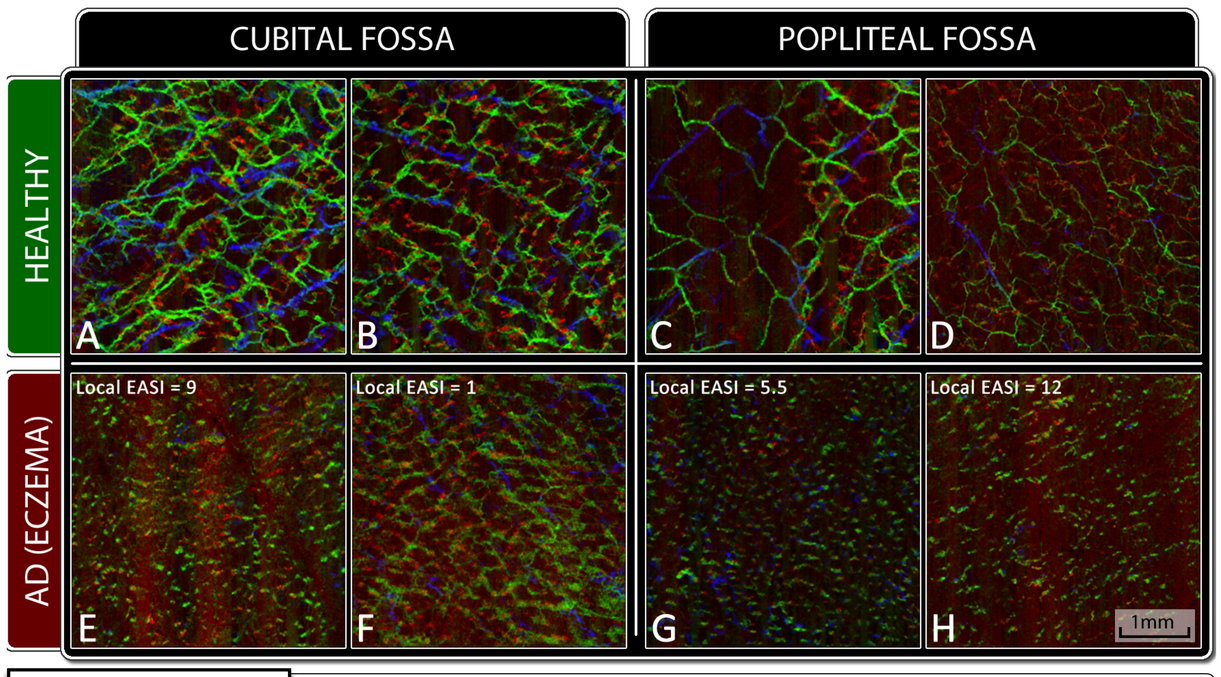


Figure 3 — **Depth resolved *en-face* OCTA images of both healthy & AD skin**

Top row) Volumes acquired from healthy volunteers at both skin sites. **Bottom row)** Volumes acquired from AD patients at both skin sites. Colours correspond to depth beneath the skin surface:

Red colouration = 39-117µm **Green colouration = 117-195µm** **Blue colouration = 195-273µm**

Capillary loops are visible on both healthy/AD datasets as red/green dots. The SAP is typically visible between 117-195µm for healthy volunteers but is generally absent in cases of AD, suggesting it is deeper in the tissue.

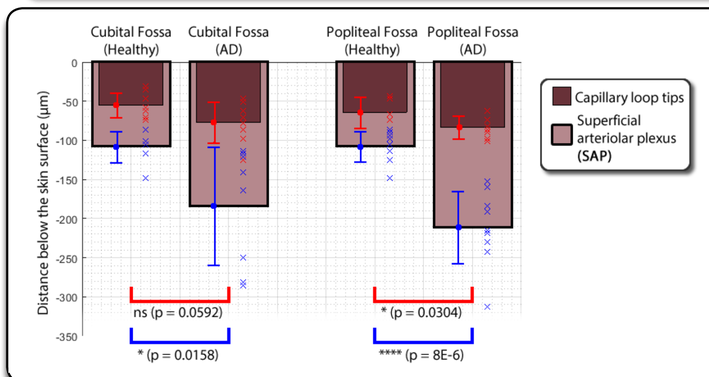


Figure 4

Comparison of capillary loop depth and SAP depth as a function of AD.

A significant increase in SAP depth was measured for AD volunteers at both sites. Comparatively capillary loop depth only increased by a small amount at both sites in cases of AD. These results are indicative of epidermal psoriasiform hyperplasia such as that seen on figure 1C.

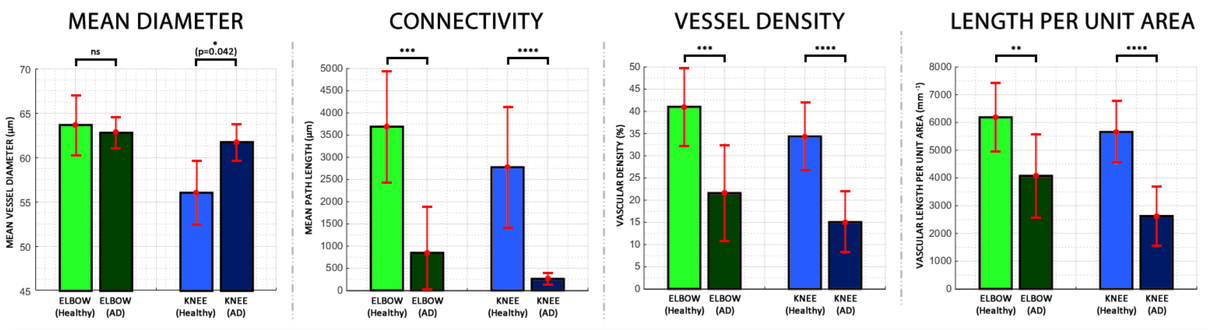


Figure 5 — **Variation in quantitative vessel parameters as a function of AD.**

Metrics were acquired automatically from maximum intensity projections of the entire visible OCTA volume.

- Significantly **higher** mean vessel diameter at the popliteal fossa in AD volunteers. Likely indicative of inflammation.
- **Lower** vessel connectivity for AD patients at both sites. Suggesting incomplete vessel linkages within the plexus.
- Significantly **lower** vessel density **and** length for AD patients at both sites.
  - Both of these metrics suggest that less vessels are within the field of view (0-300µm depth) for AD cases.

Conclusions

- Structural measurements of epidermal thickness are challenging in AD patients due to a lack of contrast at the DEJ. OCTA offers a robust alternative method for quantifying the degree of epidermal hyperplasia through consideration of the vascular layers.
- OCTA is able to differentiate between healthy and AD skin through comparison of automatically extracted vessel metrics, including: diameter, length and connectivity.
- Current work is expanding this study to look at the correlation between clinical score (EASI) and many of the discussed subclinical abnormalities measurable with OCTA. Futhermore, these metrics will be correlated with measures of skin barrier function.

For more information, please consult the following paper:

R. Byers *et al*, "Characterizing the microcirculation of atopic dermatitis using angiographic optical coherence tomography," SPIE BiOS, 2017.

References and Acknowledgements

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2. T. S. Tang et al, "Are the concepts of induction of remission and treatment of subclinical inflammation in atopic dermatitis clinically useful?" J. Allergy Clin. Immunol. (2014).
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