Characterisation of the skin barrier defect in atopic dermatitis using in vivo ATR-FTIR molecular spectroscopy

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INTRODUCTION

• A defective skin barrier is the underlying cause of atopic dermatitis/eczema (AD), a common inflammatory skin condition1.
• This skin barrier defect is characterized by:
  • Abnormal differentiation leading to a defective cornified envelope9.
  • Decreased levels of natural moisturizing factor (NMF) leading to increased dryness and elevated stratum corneum (SC) pH2,3.
  • Increased degradatory proteolytic activity4.
  • Altered composition and conformation of the lipid lamellae, leading to reduced permeability barrier function5,6.
  • Mutations affecting the FLO gene, encoding the structural protein filaggrin, confer a skin barrier defect and increase the risk of developing AD (strongest risk factor identified to date).
  • Components of NMF are derived from filaggrin catabolism7,8.
  • Neonates who go on to develop AD already display a skin barrier defect, even before the development of clinical signs9.
  • A growing body of evidence suggests that topical emollient therapy to ameliorate the skin barrier defect can prevent the initial onset of AD by 50% and prevent the re-emergence of established AD10,11.

METHODS

In a cohort of 56 adult patients with AD, and a control group of 20 volunteers with healthy skin (no skin conditions or atopy), the clinical and biophysical properties of six different skin sites (cubital fossa, volar forearm, wrist, back of hand, palm, and lower leg) were assessed using the techniques listed below (Figure 1 and Table I).

Figure 1: The test sites and equipment

OBJECTIVE: To compare the molecular structure of the skin of AD patients to the skin of healthy controls non-invasively using a fibre-based FTIR device.

RESULTS

Figure 2: Top: Mean ATR-FTIR absorbance spectra collected at the cubital fossa for healthy participants (blue line), all AD patients (red line), and severe AD patients with clinical signs at the test sites (grey line). Bottom: Difference spectra (Healthy – all AD).

Figure 3: ATR-FTIR absorbance at 1350 cm⁻¹ correlates significantly with HPLC determined SCNMF levels in healthy participants on the volar forearm. Pearson’s r=0.7705, p<0.0001.

Figure 4: Surface SC NMF levels quantified by ATR-FTIR at different anatomical locations in healthy participants and patients with AD. Asterisks indicate significant differences identified using a t-test.

Figure 6: ATR-FTIR determined NMF levels on the cubital fossa stratified by the severity of AD. A one-way ANOVA reported a significant difference between the groups. Asterisks indicate the results of a Tukey post-test. Mean ±SEM displayed.

Table I: The study population

Table II: Correlations between ATR-FTIR determined NMF levels and skin properties

REFERENCES


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CONCLUSIONS

ATR-FTIR is a useful technique for the rapid and non-invasive characterization of the skin barrier defect in AD.

Figure 5: SC NMF levels quantified by ATR-FTIR on the volar forearm before and during tape-stripping in healthy participants and patients with AD. Tape-stripping was performed to quantify NMF levels at deeper levels within the SC. A two-way ANOVA reported significant differences between the groups (post-test results not shown).

Figure 8: Correlation between stratum corneum NMF levels and lipid structure. Lipid structure was determined according to a previously published protocol. 11 PHWM, full width at half maximum – a spectral feature associated with lipid membrane lateral chain packing. A highly ordered orthorhombic state (toward FWHM of 12) is associated with optimum permeability barrier function (TEWL).