Eyelid tissue characterization using photoacoustic imaging

John Albinsson[1], Ulf Dahlstrand[1], Rafi Sheikh[1], Johanna Berggren[1], Magnus Cinthio[2], Malin Malmsjö[1], [1] Department of Clinical Sciences - Ophthalmology, Lund, Sweden, [2] Department of Biomedical Engineering, Lund, Sweden

Background, Motivation and Objective

The eyelids are susceptible to a number of skin cancers which are challenging to excise radically without sacrificing excessive healthy tissue. Photoacoustic (PA) imaging is an emerging non-invasive biomedical imaging modality that could potentially be used for intraoperative micrographic control of the surgical margins of eyelid tumors. In this study, excised human eyelid tissue was characterized using PA as a first step in the development of this technique.

Statement of Contribution/Methods

Twelve full-thickness samples from nine healthy patients and one sample with suspected basal cell carcinoma (BCC) were analyzed *ex vivo* using a Vevo LAZR-X multimodal imaging system (FUJIFILM VisualSonics Inc., Toronto, ON, Canada) equipped with an ultrasound linear array transducer MX400 with a central frequency of 30 MHz and a bandwidth of 22-55 MHz. Two-dimensional PA images were acquired using 59 wavelengths in the range 680 nm to 970 nm, to obtain the spectral signatures of skin, orbicularis oculi muscle, tarsal plate and BCC. Three-dimensional volumes were collected using a stepping motor. Regions of interest were carefully chosen in the ultrasound B-mode image to only include one type of tissue in each. Mean spectral signatures were calculated for healthy tissue types using MATLAB R2018b (MathWorks Inc., Natick, MA, USA) and spectral unmixing was performed to visualize chromophore distributions using Vevo LAB 3.1.0 (VisualSonics Inc.).

Results/Discussion

The mean PA spectra could be used to differentiate the orbicularis oculi muscle from the two other healthy structures ($p<0.05$) (Fig. 1A). The spectra from the skin and the tarsal plate were more similar in appearance. The results also show promise to use PA imaging for differentiating healthy and diseased tissue and to be able to determine if a tumor has been radically excised or not. Figure 1B shows a BCC tumor indicated in purple. The arrow points at tumor growth at the edge of the excised tissue and thus a non-radically excised BCC. This study has for the first time characterized healthy and diseased eyelid tissue, paving the way for intraoperative micrographic control of the surgical margins of eyelid tumors.

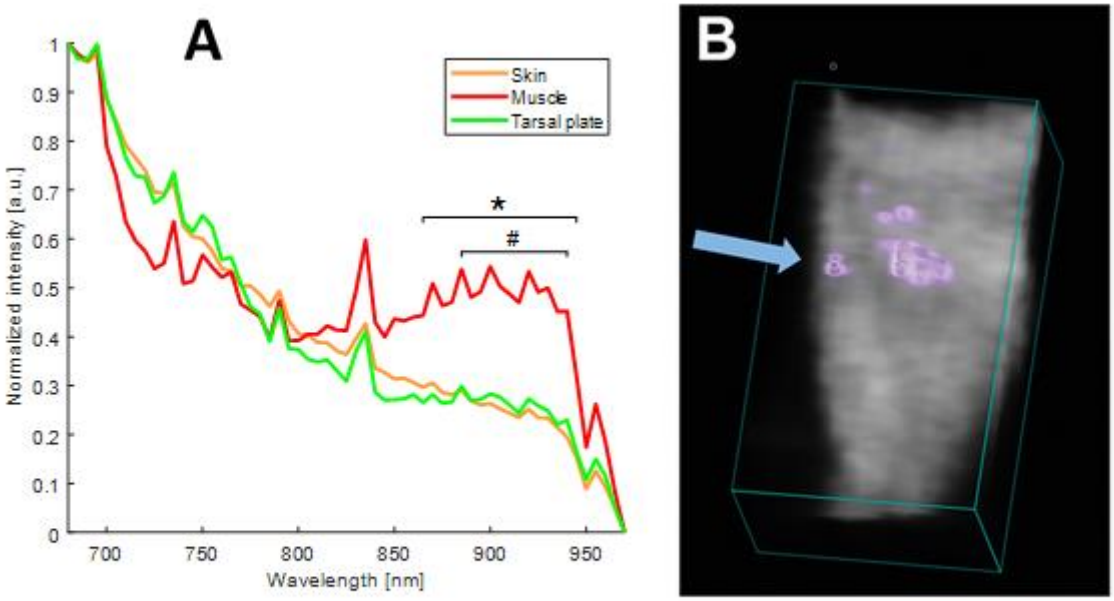

Figure 1: A) Mean normalized spectral response from the three types of healthy tissue. Significance at $p<0.05$ between Muscle and Skin (#) or Tarsal plate (*). B) Suspected basal cell carcinoma (BCC) marked by purple in the excised tissue. The arrow indicates an area with suspected BCC at the edge of the sample.