Assessment of the aging human skin with a unilateral NMR scanner

Elad Bergman[1], Yifat Sarda[1], Noa Ritz[2], Edmond Sabo[2], Reuven Bergman[2], and Uri Nevo[1]
[1]*Biomedical Engineering, Tel Aviv University, Tel Aviv, Israel, Israel,* [2]*Departments of Dermatology and Pathology, Rambam Health Care Campus and The Bruce Rappaport Faculty of Medicine, Technion, Haifa, Israel, Israel*

Purpose

This study aimed to develop an affordable method for evaluation of skin aging and sun damages to the skin using a portable unilateral NMR scanner.

Introduction

In young skin, most water is bound to proteins, mainly collagen and is characterized by very short relaxation times [1]. As the skin ages (both chronologically and due to exposure to the sun), the relative fraction of bound water drops, while the fraction of free water increases (having much longer relaxation times). This is an outcome of the reduction in collagen content and of additional age related mechanisms. In this work skin was scanned using a portable unilateral stray-field scanner that is used mainly for non-destructive testing but never used for clinical purposes [2].

Methods

To detect chronological aging, skins of 9 female volunteers of different ages were scanned, and reference biopsies were made. The skin was measured in a sun protected area, the flexor region of the forearm. The sun protected area was also used as a baseline to recover the superimposed damage caused to the sun exposed region (extensor region). Scans were based on high resolution profiling for quantification of three basic relaxation coefficients (T1, T2 and ADC). Scans were performed with the NMR-MOUSE scanner (Magritek, NZ) operating using a permanent magnet in 0.3 T with a stray field gradient of 7 T/m, and equipped with a surface RF coil. Following a scout scan, a longer T2 measurement was applied, and bi-exponential analysis was performed on the acquired data. Analysis of T2 was based on bi-exponential fitting to detect changes in both the tightly bound water and the free water. .

Results

Figure 1 presents a depth profile (intensity and T2, mono-exponential fit) providing means to locate the different skin layers, and specifically the upper-reticular dermis (region 3, figure 1). The measurement was then focused only on this region of interest, which was found to be the most sensitive to both chronologically aging and sun-exposed aging.

The T2 analysis showed a remarkable and consistent reduction in the fraction of the short T2 with age (Figure 2a). This reduction was complemented by an increase of the long relaxation time itself, among the older subjects (Figure 2b). These two parameters can be combined to produce an aging fingerprint parameter. The results from the extensor region maintain the same chronological kinetics that characterized the flexor area: a reduction in the short relaxation fraction (f) and an increase in the long T2 component (T_{2s}). However, on top of this, a further reduction in f and an increase in T_{2s} values was noticeable with age. This reduction is attributed to sun damage, and was indeed absent in most young volunteers. .

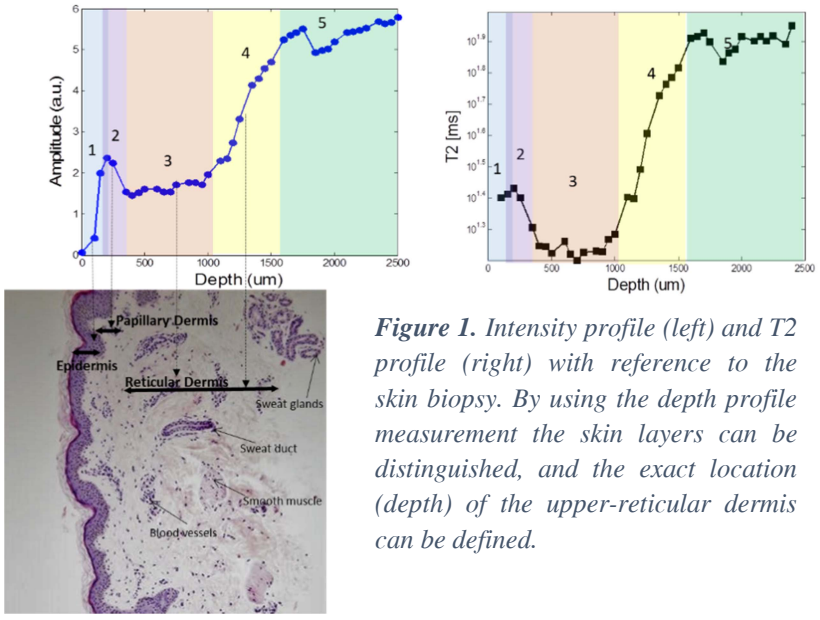

Figure 1. *Intensity profile (left) and T2 profile (right) with reference to the skin biopsy. By using the depth profile measurement the skin layers can be distinguished, and the exact location (depth) of the upper-reticular dermis can be defined.*

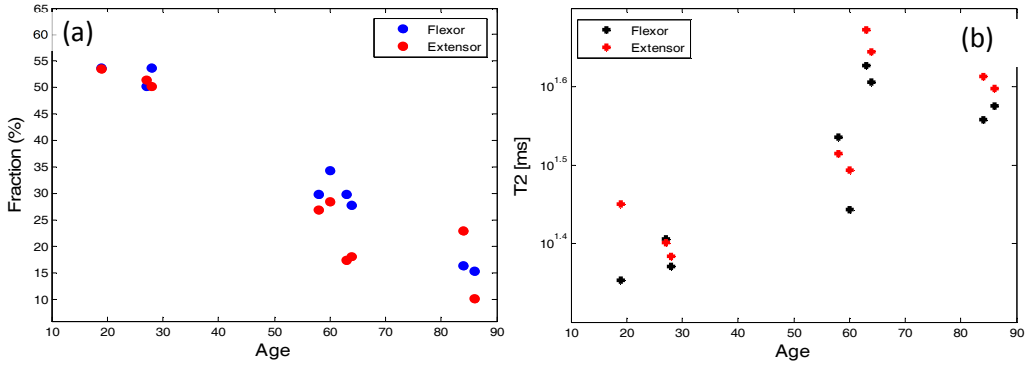

Figure 2. The fraction of the short relaxation component **(a)** and the long T2 relaxation time (b) as a function of age, (bi-exponential analysis) in the flexor (blue) and the extensor (red).

Conclusion

These results are in agreement with the decline of the collagen content, and the increase in the free water content with aging. The results suggest that a portable unilateral scanner can be developed to serve as a tool for characterization of skin aging and of sun damages caused to the skin

References

[1] Bittoun J. *et al.* NMR Biomed. (2006) 19: 723–730; [2] Blumich B. *et al.* Prog. Nucl. Magn. Reson. Spectrosc. (2008) 52: 197–269.