



Degradation Mechanism Induced by Psoriasis in Human Fingernails: A Different Approach

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TO THE EDITOR

Nail psoriasis has a significantly negative impact on patient life quality (Dogra and Arora, 2014; Martínez-García et al., 2014).

This study is focused on understanding the degradation mechanism induced by psoriasis in human fingernails. The chemical structure, elemental composition, and surface morphology of healthy and psoriatic fingernails were compared using spectroscopic and imaging methods: attenuated total reflection-Fourier transform infrared spectroscopy, X-ray photoelectron spectroscopy, energy-dispersive X-ray spectroscopy, and scanning electron microscopy.

Fingernail clippings from 23 patients with psoriasis and 20 healthy donors were investigated (Supplementary Materials and Methods online) after obtaining written informed consent and approval by Ethics Committee of “Grigore T. Popa” University of Medicine and Pharmacy following Declaration of Helsinki protocols. Understanding the degradation mechanism can allow an early diagnosis, before high damage occurs. With noninvasive techniques, we identified differences in the molecular structure and elemental composition of keratin from psoriatic nails.

The molecular changes in the secondary structure of keratin were studied by analyzing the amide I region ($1,700\text{--}1,600\text{ cm}^{-1}$) in attenuated total reflection-Fourier transform infrared spectroscopy spectra; this region is sensitive to changes in secondary structures (Srisayam et al., 2014). After spectra deconvolution, the amide I regions of healthy and psoriatic nails (Figure 1a) were compared. The four components of the secondary structure were attributed to β -sheet, random coil, α -helix, and β -turns (Sakudo et al., 2009; Srisayam et al., 2014). Regardless of age or gender, a significant

reduction of α -helix content coupled with an increase of β -sheet and random coil content was observed in psoriatic fingernails (Table 1). Nails are hard α -keratins, which abound in α -helix (Bragulla and Homberger, 2009), and a decrease in α -helix destabilizes the nail proteins (Sakudo et al., 2009). On the other hand, the β -sheet increase is due to keratin misfolding in amyloid-like fibrils—intermolecular β -sheets involved in protein aggregation (Balzani et al., 2012; Campioni et al., 2010). We can conclude that the damage produced by psoriasis in fingernails is associated with the α - β transition followed by a β -sheet-mediated protein aggregation. Moreover, the random coil increase is indicative of protein denaturation (Sakudo et al., 2009).

In addition, attenuated total reflection-Fourier transform infrared spectroscopy spectra showed absorption bands at $1,170$ and $1,040\text{ cm}^{-1}$ (Figure 1b), which are specific to the S-O bonds of the cysteic acid unit. Increased band intensity in psoriatic fingernails indicates that certain changes also occur in the disulfide bridges (--S--S--) of cystine units. --S--S-- bridges are degraded in psoriatic fingernails, first by reduction to thiol groups (--SH) and then by oxidation to sulfite groups ($\text{--SO}_3\text{H}$) (Supplementary Figure S1A–C online) (Oguri et al., 2012). This destabilizes the healthy nail matrix. Cysteic acid is normally present in healthy nails, as a part of sulfur amino acids (Ogura et al., 1962; Strzelczak et al., 2013), but a higher concentration of S-O bonds in psoriatic nails is indicative of nail matrix degradation (Figure 1c).

Energy-dispersive X-ray spectroscopy data (Supplementary Table S1 online) contain both elements with significant statistical differences ($P < 0.05$), such as oxygen (O), sulfur (S), and phosphorous (P), and elements without

significant differences ($P > 0.05$), such as carbon (C) and nitrogen (N). The data confirm that the degradation process in psoriatic nails occurs by the conversion of disulfide bridges into sulfate groups, and/or into hydrogen sulfite and other volatile compounds (Supplementary Figure S1D online). This explains the decreased S content and the increased O content. The loss of S is sustained by the increased C/S ($P = 0.0318$) and N/S ($P = 0.0077$) ratios in psoriatic nails compared with healthy ones. Nail keratin also contains low concentrations of P (up to 0.18%), but an abnormally low content is more likely to be the result of a disease (Berndt and Kumar, 2009).

X-ray photoelectron spectroscopy results are consistent with energy-dispersive X-ray spectroscopy data, showing higher C and O contents and lower N and S contents in psoriatic nails (Figure 1d, Supplementary Table S2 online). X-ray photoelectron spectroscopy identifies the chemical structure by high-resolution spectra. The C1s high-resolution spectra, for both healthy and psoriatic fingernails (Figure 1e), were deconvoluted into five peaks, which can be seen in Supplementary Table S3 online. The concentrations of C-N and C-S bonds decrease in psoriatic nails, as the molecular structure of keratin is affected. As stated before, S is present because of the cystine, cysteine, and cysteic acid. A closer inspection of the S2p spectra (Figure 1f, Supplementary Table S3) confirms that the reduction of --S--S-- bridges to --SH groups. Some of these are subsequently transformed into sulfite groups. The peaks for S=O and S-OH bonds, which indicate the presence of cysteic acid, were increased in psoriatic fingernails, whereas the S-S peak was decreased. In conclusion, the damages caused by psoriasis to the cystine disulfide bridges determine the appearance of a higher concentration of cysteic acid.

We also investigated healthy and psoriatic nails with scanning electron

Abbreviations: C, carbon; N, nitrogen; O, oxygen; P, phosphorous; S, sulfur

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