Detection of titanium nanoparticles in the hair shafts of a patient with frontal fibrosing alopecia

Editor

Frontal fibrosing alopecia (FFA) is a lymphocyte-mediated primary cicatricial alopecia closely related to lichen planopilaris.[1] Over time, the number of FFA reports has increased continuously, suggesting the implication of yet unidentified environmental factors. Several studies based on questionnaires have pointed out that leave-on facial skin care products, especially sunscreens, could be implicated in FFA.[2] Here, we report the detection of titanium dioxide (TiO_2) along the hair shafts of a patient presenting FFA.

The patient was a 73-year-old woman who presented with typical FFA characterized by a frontotemporal hairline regression and eyebrow loss (Fig. 1a, b). There was no manifestation of nail, mucosal or cutaneous lichen planus. A biopsy was per-formed in an active area of the temporal frontline, showing ostial hyperkeratosis and perifollicular fibrosis with gigantocellular reaction, as well as a reduced number of hair follicles. Her past medical history was unremarkable, but she reported the application on a daily basis of a sunscreen containing nanoparticles of TiO_2 during the last ten years to prevent skin photoageing.

A physicochemical characterization of the patient's hair was performed with scanning electron microscopy (SEM) coupled with energy-dispersive X-ray spectroscopy (EDX). Two plucked hairs were analysed using SEM, which showed the presence of micrometre scale abnormal deposits on the hair surface (Fig. 1c, d). The EDX analysis of these deposits pointed out the presence of silicium, sulphur, chlorine, calcium and titanium (Fig. 1e, f). These findings are in line with the literature,[3] except for the presence of titanium. In a second phase, a finer analysis of the particles containing titanium was performed with micro-X-ray fluorescence spectroscopy. This technique evidenced a large aggregate of 0.5- to 1-μm-sized titanium particles associated with smaller (<=0.5 μm) titanium particles on the hair surface. The EDX microanalysis confirmed the presence of a fluorescence peak corresponding to exogenous titanium in these abnormal deposits (Fig. 1g). The strong intensity of this peak (up to 200 counts/50 ms) reflects a high concentration of titanium along the patient's hair shafts.

TiO_2 is the most widely used white pigment in the world. It has a wide range of applications, from paint to food colouring, and is also used in cosmetics and skin care. Due to its properties of UV blocking, TiO_2 is extensively used in sunscreens. The potential toxicity of TiO2 is an important public health concern as TiO_2 is classified by the International Agency for Research on Cancer (IARC) as an IARC Group 2B carcinogen. Concerning the skin, it is still debated whether TiO_2 does or not penetrate the stratum corneum, but it has been clearly demonstrated that it can deposit in the follicular orifice.[4] To date, there are no available data concerning the impact of TiO_2 cutaneous exposure on hair growth. However, the detection of TiO_2 along the hair shafts of our patient raises the question of a possible implication of TiO_2 in FFA pathogenesis via an allergic process. This hypothesis is based on the fact that lichen planus, which is a close or even the same entity as FFA, can be a consequence of metal sensitization, especially for oral lichen planus in association with dental implants containing nickel, iron or zinc.[5] Moreover, there are several reports of contact dermatitis or granulomatous reactions induced by TiO_2 upon its use in pacemakers, hip prostheses or osteosynthesis, showing that TiO_2 can be a target allergen for T-cell lymphocytes.[6] Further studies are needed to confirm this potential link.

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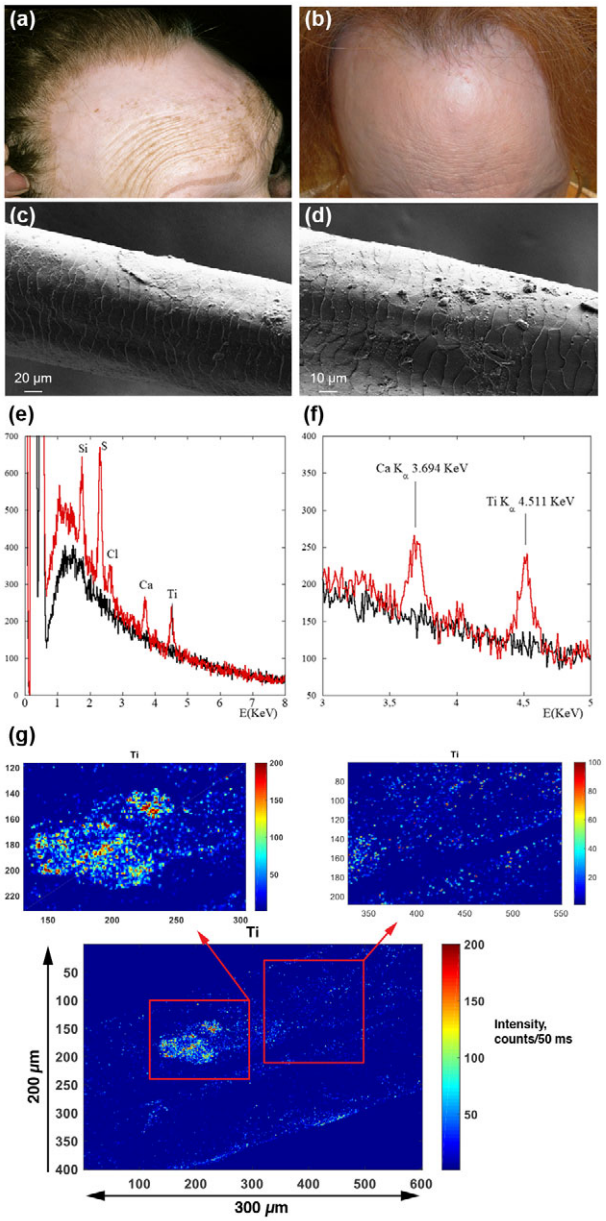


Figure 1 Clinical features and physicochemical analysis. Clinical features of the patient (a, b). Typical frontal fibrosing alopecia characterized by a hairline regression (a) associated with eyebrows loss (b). (c, d) Conventional SEM images of a patient's plucked hair showing the presence of micrometre scale abnormal deposits, scale bar 20 µm (c) and 10 µm (d). (e, f) The EDX data (black support, red abnormal deposit) identify the presence of silicium (EK_α = 1.740 keV), sulphur (EK_α = 2.305 keV), chlorine (EK_α = 2.622 keV), calcium (EK_α = 3.694 keV) and titanium (EKα = 4.511 keV) in the abnormal deposit present at the hair surface (g). Micro-X-ray fluorescence spectroscopy: high 500 nm resolution distribution maps of Ti within the two measured hair samples.