Physiology

Demonstration of the Human Hair Shaft as Transmitter/Receiver of Electromagnetic Forces

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Background: Prior research demonstrated that via a novel technique it was possible to obtain ex vivo hair tissues magnetic profiles based on microscopic nano-sized iron particles detected by Prussian Blue Stain (PBS). The present study demonstrates that magnetic signals emitted by both the *ex vivo* and *in vivo* hair follicles could penetrate glass barriers.
Methods: Two different versions of Prussian Blue Stain were used, one utilizing Potassium Ferrocyanide (Fe_2) the second Potassium Ferricyanide (Fe_3). Both were mixed with nano-sized iron particles (2000 nm in diameter). Ex-vivo human hairs were "sandwiched' between glass slides (SDW) containing either PBS Fe_2 or PBS Fe_3 solutions with added iron particles. The SDW was covered by a second SDW consisting of two coverslips containing the same two solutions. In addition, the coupled SDWs were placed directly on the author's forearm and stably maintained for 4 hours. All specimens were viewed and digitally recorded via a video microscope interfaced with an Apple computer system.
Results: After the solutions in the SDWs had evaporated, the hair shafts of the *ex-vivo* and *in vivo* hairs showed replicate images through the glass barriers constructed by iron particle aggregates and associated PBS crystals detected inside the SDW.
Conclusions: The human hair shaft has intrinsic electromagnetic properties producing replicate Images when transmitted through a very thin (0.13 mm in thickness) glass barrier. Ancillary experiments showed that static electricity could alter these effects.

Bioelectromagnetism | *In Vivo* Hair Shaft | *Ex-vivo* Hair Shaft | Electromagnetic Forces | Glass Barrier Penetration | Static Electricity

Introduction

Prior research demonstrated that via a novel technique [1], it was possible to obtain ex vivo hair follicular tissue magnetic profiles [2]. That optical visualization technique relied on optical microscopy and utilizes iron nanoparticles that detected by Prussian Blue Stain. Also previously it was shown that said magnetic signals emitted by the *ex vivo* hair follicles could penetrate glass barriers [3], the electromagnetic radiation emitted by the hair follicles had been documented as the electromagnetic imaging of subdermal human hair follicles was recently reported i*n vivo* [4]. In the present report, this area of research is expanded to the detection also *in vivo* of the hair shaft proper electromagnetic radiation detected and penetrating a glass barrier.

Materials and Methods

As published, the methodology for preparing the iron nanoparticles solutions with diamagnetic and paramagnetic properties has been previously described. A diamagnetic solution is obtained by mixing with Potassium Ferrocyanide. Conversely, a paramagnetic solution is obtained by mixing with Potassium Ferricyanide. The nano-sized iron particles are harvested as previously described [1]. Briefly, a fine iron particle solution was prepared by mixing several grams of powdered iron filings (Edmond Scientific, Co., Tonawanda, NY) in 200 cc of deionized water. After standing for several hours the supernatant was carefully decanted for sizing of the iron particles. The particle size and distribution of the particles from the supernatant was determined using dynamic light scattering (DLS) and the zeta potential using phase analysis light scattering by a Zeta potential analyzer (ZetaPALS, Brookhaven Instruments Corp, Holtsville, NY). For sizing, 1.5 ml of the solution in de-ionized water was scanned at 25°C and the values obtained in nanometers (nm). A similar aliquot of the fine iron particle solution was scanned for 25 runs at 25°C. for determining zeta potentials. Zeta potential values were displayed as millivolts (mV). Using a transfer pipette, aliquots of the solution containing the iron particles (mean particle size, 2 microns) were combined with Prussian Blue Stain (2.5% potassium ferrocyanide or potassium ferricyanide and 2.5% hydrochloric acid.

Procedures

A slight variation of the technique published in reference [3] was used as follows: On top of a clean 25x75x1mm glass slide (Globe Scientific # 1301), one slide coverslip (Fisher brand 12-545-F 25x50x0.13 mm) was centered.

One drop of the potassium ferrocyanide solution + iron particles was delivered and sandwiched (SDW) by a second coverslip. The same procedure was performed with potassium ferricyanide in solution. Masking tape was used to secure the edges of the coverslip SDWs centered on the glass slide. Then, a flat area showing conspicuous hairs in the forearm was selected and the main glass slide was then secured (with the coverslip SDW facing the skin). Four hours later the SDW was carefully separated (from the main slide), Images viewed on a video microscope (Celestron LCD Digital Microscope II Model # 44341, Torrance California), photographed and were downloaded into an Apple computer system.

Ancillary Experiments

To test the effect of static electricity (triboelectric effect) a balloon (8" in diameter when inflated) was rubbed against wool and applied to the SDW containing the hair shaft. Only a 25x75x1mm SDW was used and placed on a table top.

Results

After the sandwiched (SDW) solution had evaporated, replicate photographic images of the forearm hairs (flatten by the glass slide assembly) formed by the aggregated iron particles and associated Fe_2 and Fe_3 crystals were seen inside the SDW (Figures 1 and 2).

Conflict of interest: No conflicts declared.

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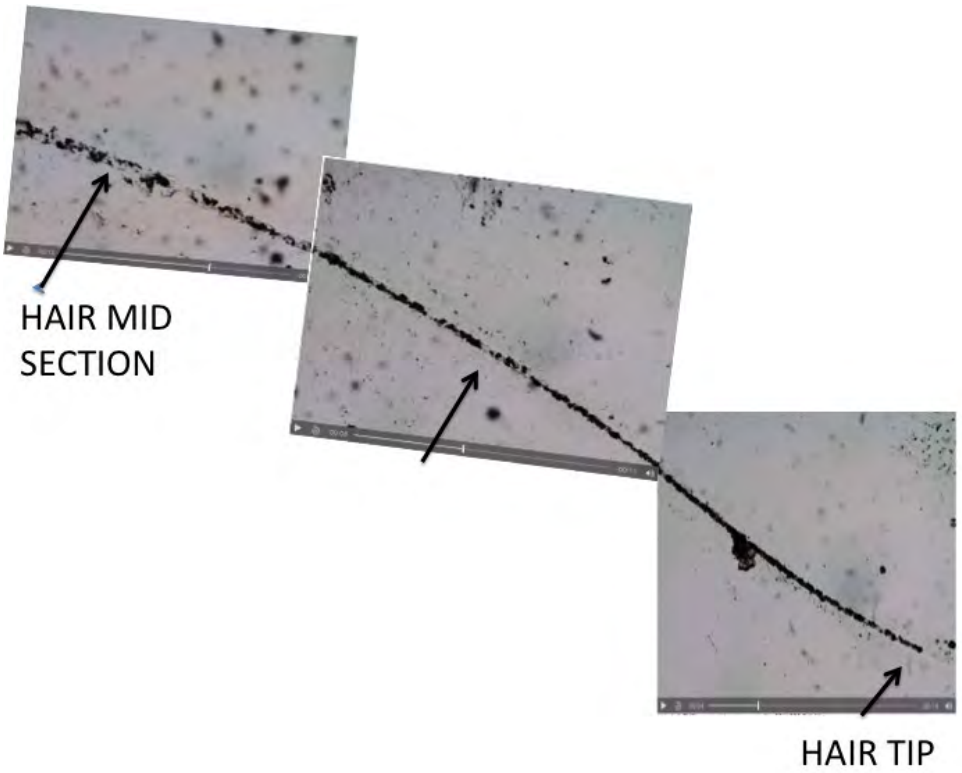

Figure 1. Collage of sequential video images showing the replicated hair shaft outline created by EMFs from an *in vivo* human hair penetrating a glass barrier. This collage image of SDW consisting of two slides coverslips (25x50x0.13 mm) and interstitial PBS Fe2 2K that was secured over author's forearm and undisturbed for 4 hours. Arrows denote partial hair shaft outline seen gradually increasing in diameter towards the mid-section. X4 Magnification.

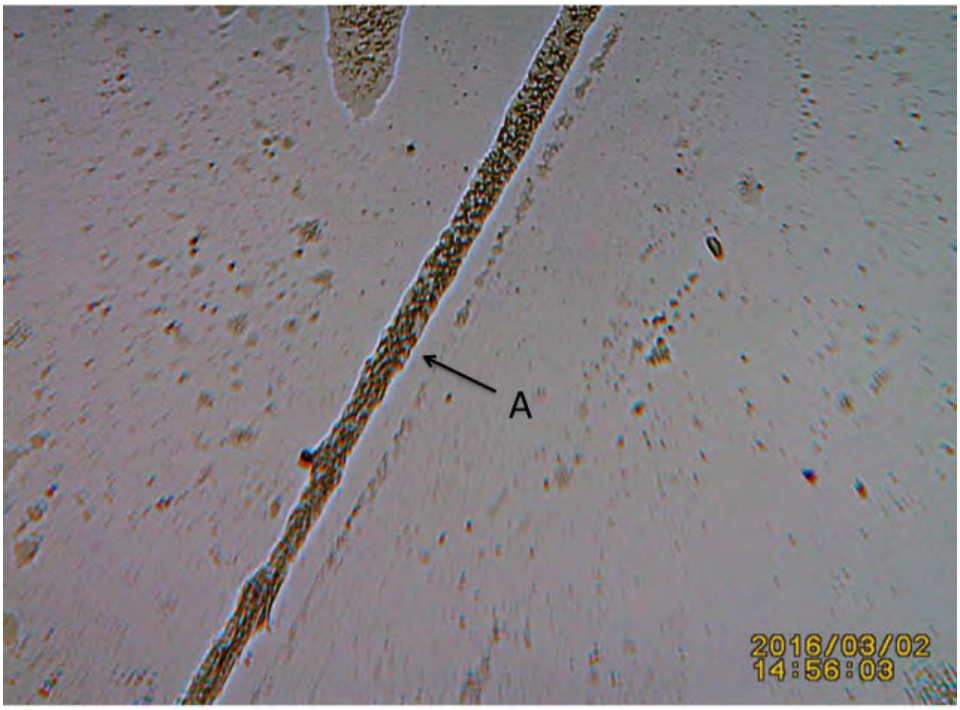

Figure 2. SDW Microphotograph of replicated *in vivo* hair shaft outline. Since a paramagnetic solution was used (Potassium Ferricyanide), please notice the homogeneity observed between crystals containing iron particles. This is attributed to the fact that in a paramagnetic, environment there are attractive EMFs. X10 magnification.

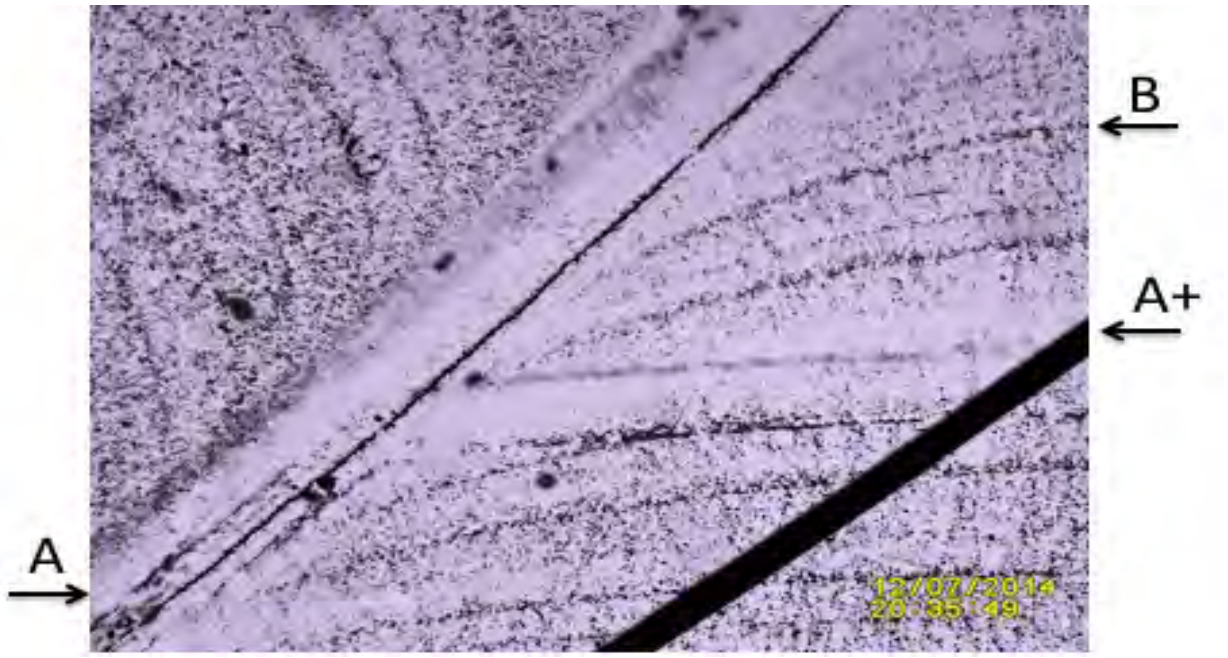

Figure 3. After evaporation. Microphotograph of hair shaft on slide top and imbedded in Potassium Ferrocyanide/Iron particle solution after exposure to static electricity. A= Empty trail caused by shifting shaft from original position attracted by the triboelectric effect A+= Shifted true shaft B= EMFs detected by iron particles resulting from exposure to static electricity. See text for details.

Two different patterns were observed, the first was the result of using the diamagnetic (Potassium Ferrocyanide solution). Diamagnetic meaning that there is repulsion by the hair shaft electromagnetic forces (EMFs) (Fig 1). The second pattern observed was from the paramagnetic solution (Potassium Ferricyanide). Paramagnetic meaning that the solution is attracted towards the magnetic source (Fig 2).

Ancillary Experiments

Ex vivo ancilalry experiment. The triboelectric effect (also known as triboelectric charging) is a type of contact electrification in which certain materials become electrically charged after they come into frictional contact with a different material. Rubbing glass with fur, or a comb through the hair, can build up triboelectricity. In these experiments, an inflated balloon was rubbed against wool to produce the static electric charging which was then applied to the slide containing the PBS Fe_3 solution as seen in Figure 3 below.

Discussion

This report extends and confirms our previous reports showing that EMFs are emitted from *ex vivo* samples of hair follicles [2], rodent whiskers [5] and plant parts [6]. The *in vivo* detection of EMFs by the hair shaft trough a thin glass barrier has important ramifications. The first being that it can be postulated that the shaft maintains magnetic profiles and are piezoelectric, i.e. convert EM oscillations to mechanical vibrations and vice versa. This places the hair shaft in a transmitter-receiver of EMFs category. We have seen the receiver property effect in triboelectric experiments, where rubbing an inflated balloon on a wool generated static electricity. In this instance the hair shaft shifted positions on the slide, and appears to act as a receiver (Fig 3). In this report, we have demonstrated that that the bioelectromagnetic signals from in vivo human hair shafts could penetrate glass barriers also behaving as a transmitter of EMFs.

Limitations

There is some question regarding whether the human hair shaft contains living cells (trichocytes/cornecytes) and whether there is residual metabolic activity in these cells [7, 8]. For the most part, the hair shaft is composed of keratin which is known to feature piezo-electric properties. Thus the EMFs which comprise the bioelectromagnetism could derive from either metabolic activity or from the phonon (vibrational) photon (electromagnetic) transduction processes.

Conclusion

The human hair shaft has intrinsic electromagnetic properties producing replicate Images when transmitted through a very thin (0.13 mm in thickness) glass barrier. Ancillary experiments showed that static electricity could alter these effects.

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