Magneto-Trichography: Magnetic Fields Produced by Human Hair Follicles

Sheraz Khan [1,2] and David Cohen [2,3,4]

[1]Dept. of Neurology, [3]Radiology, Massachusetts General Hospital, Harvard Medical School, Boston, USA
[2]Athinoula A. Martinos Center for Biomedical Imaging, Massachusetts General Hospital, Boston, USA
[4]Francis Bitter Magnet Lab, , Massachusetts Institute of Technology, Cambridge, USA

Introduction

We have transformed the 204 planar gradiometer outputs of our Elekta MEG system so that DC (direct current) in the head can be directly seen online. The DC is seen as a map of arrows, looking down on the head. That is, we have performed an online inverse solution to approximately show the source DC. Because the gradiometers see only short range, we are insensitive to distant disturbances. We are therefore limited in sensitivity only by internal gradiometer noise, about 0.4 pT/cm in a bandwidth of 0-4 Hz. We are especially sensitive to DC in the scalp.

Such measurements have been reported[1] many years ago by one of us, but measured by only a 2-channel system, at only one location at a time. In that report, an attempt to see the DC sources in the brain was masked by an unforeseen DC in the scalp. This source was hair follicles, activated by mild pressure on the scalp. We have now benn re-doing those early measurements, but this time using our advanced display.

Our goal here is 2-fold: 1. This DC from hair follicles can mask the important detection of DC from the brain, therefore must be well-understood in order to be subtracted away; 2. DC in the human body is increasingly of interest because it has a role in healing and probably in signalling, so all aspects should be understood, including hair-follicle signalling.

Methods

For a measurement, the subject's head is first positioned outside the helmet, and the arrows are zeroed. Then the subject puts his or her head into the helmet, and the new arrows are seen and recorded, perhaps in 3 seconds. Because we are detecting the gradients only, we lose that part of B_z which is uniform across the detecting coils; but this part of B_z can only be made by a distant source, of no interest, so we have lost nothing of value. Our method is useful because it is rapid, using only a single in-out motion. No Signal Space Projection (SSP) is used.

Ideally, we want the arrows to perfectly mimic the currents in the head, so we would see the actual current flow. To do this, we have used a number of transformations. But we have attained that goal only very approximately. Using an actual element iΔl as the source at the helmet surface, we obtain the map shown in Fig 1.

The side lobes are unwanted, and are only an artifact of our transformations; a more complex source of current, made up of such elements, will be distorted by these lobes. However, to a crude first approximation, this display does show the actual current. As a further check, we have measured simple current configurations such as a wire, and a continuous sheet, an a wet mdsel of the scalp. These arrowmaps show that the principle holds up, that these maps roughly show the actual underlying currents.

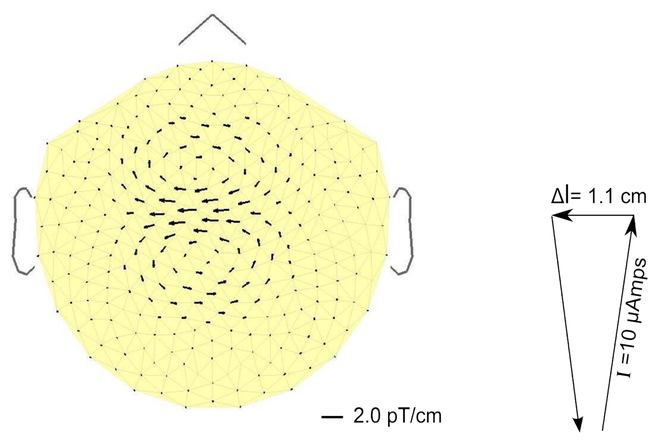

Fig.1. On-line arrowmap due to a test current element, iΔl=11μamp-cm. This is placed tight against the helmet inside, about 20mm from the closest detection coil. The current element is here enlarged for clarity.

Results

By now we have looked at the follicle DC during about 30 recording sessions of the head, from about 15 subjects, including both men and women, and two alopecia subjects (diseased follicles hence no hair). Results generally confirm the head findings of the old MIT report[1], that pressing on the scalp generates DC from healthy follicles; and diseased follicles show no DC whatever. We tried to influence the signal by creating an "ion wind" in the scalp, by passing an external DC from ear-to-ear, surprisingly to no effect.

We here show,in Fig. 2, typical results from one male adult subject with healthy hair. The upper head, not touching anything, shows some DC flowing, typical of all subjects, but at this time we have only partially discovered the sources of this non-hair DC (some from the mouth). The lower four heads are typical of young men and women with healthy hair, shaved or not. The direction of the largest (source) currents, always opposite to the slant of the hair exiting the scalp, confirming that the DC is due to hair follicles. The rise and fall times of the signals are of the order of a second or less. The magnetic gradients and fields are larger than most reported DC levels from the brain.

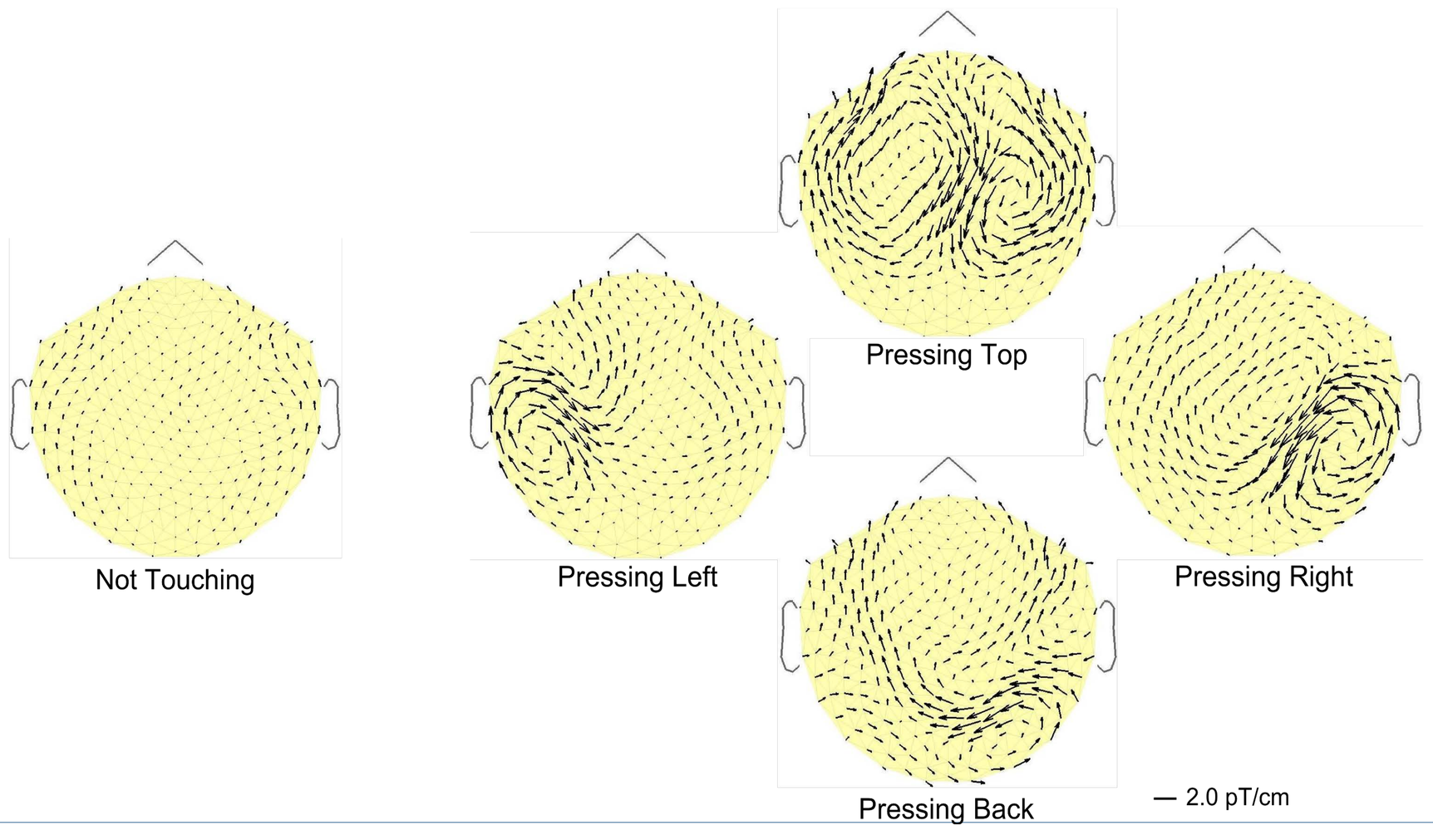

Fig. 2. Arrows roughly show the DC in the subject's scalp. Upper: head in, but not touching the helmet. Lower four: DC due to pressing different parts of the scalp against the inside of the helmet.

Conclusion

All our subjects with healthy hair show a strong DC flowing in the scalp when the hair follicles are pressed. Therefore in the many reported studies of DC from the brain itself, care must be taken that they are not instead seeing any DC from pressed hair follicles. All in all, we believe the source to be the arrector pili muscle, attached to each follicle. It was suggested that we call this phenomenon "magneto-trichography", where tricho is Greek for hair.

1. *Cohen D, Palti Y, Cuffin BN, Schmid S.J. Magnetic fields produced by steady currents in the body. Proc Natl Acad Sci 1980; 77:1447-51.*