Hair Stimulation with Pulsed Electric Fields

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Purpose:
Alopecia affects more than half of the population worldwide.[1] Current therapeutic options including minoxidil and finasteride are minimally effective, expensive, and require daily use to avoid recurrent alopecia. Hair transplantation is expensive, minimally effective, and leads to donor site morbidity.

Pulsed Electric Fields (PEF) create transient vasoconstriction followed by vasodilation.
We have evidence that PEF stimulate hair follicles and we hypothesize that this stimulation shifts the hair cycle from resting telogen to active anagen. The objective of this study is to prove that PEF stimulate hair growth in a dose-dependent manner, and to optimize treatment parameters.

Methods:
Sprague Dawley rats were shaved and treated with PEF using two $1cm^2$-contact electrodes. Three treatment and three control sites were tattooed onto the dorsum of each rat. Following the taguchi experimental design, a range of low-dose parameters were investigated: 30, 90, 270-Volts; 100, 300, 900-pulses; and 10, 90, 270us pulse length.

Animals were euthanized 1-month after treatment and tissue was harvested for histological analysis. The percent of anagen follicles per treatment site was calculated. Taguchi analysis was performed to rank parameters.

Results:
We prove that PEF shift the hair cycle from telogen to anagen, resulting in dense patches of hair. The optimal dose tested was 270V, 300pulses, and 270us pulse length duration, which induced a 5.05-fold increase in anagen follicles at treated sites as compared to controls. Treated sites demonstrated 45.55±18.07% of follicles in anagen, contrasting 9.02±6.00% of follicles in the anagen phase at control sites (p=0.0008). A dose response was demonstrated among the tested parameters.

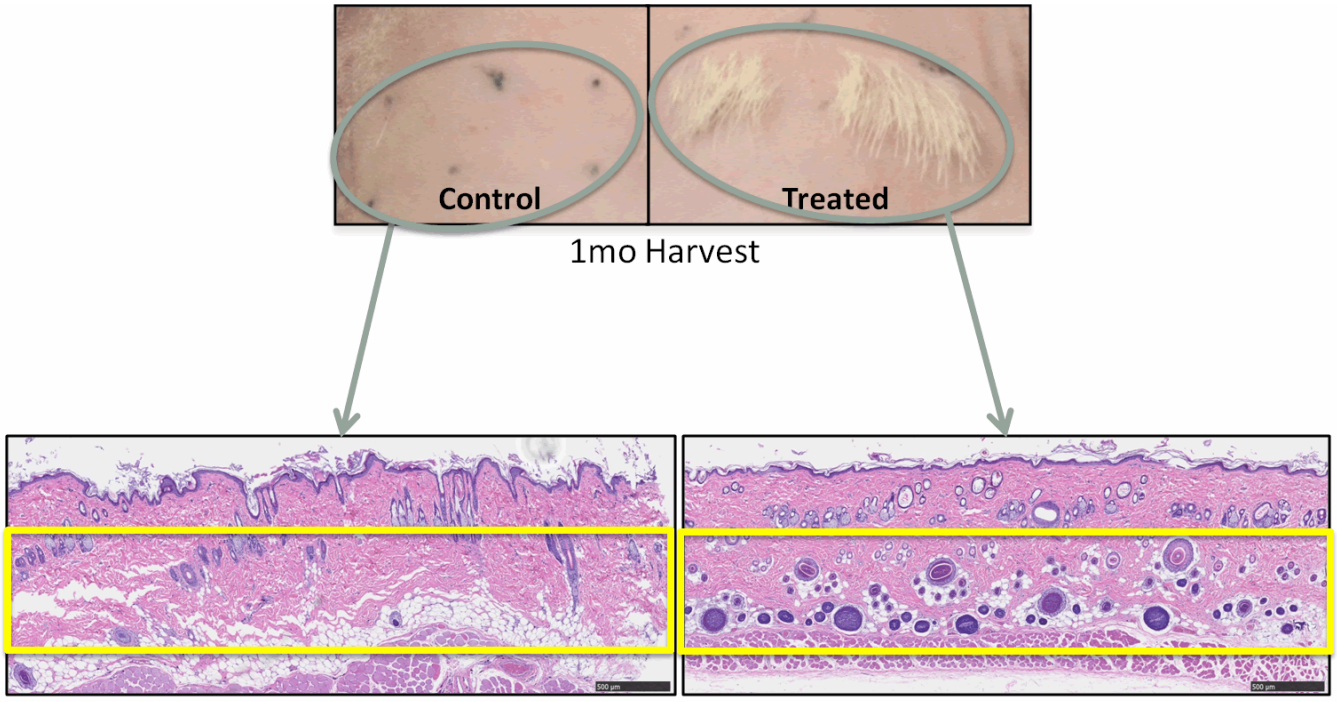
Additionally, the taguchi analysis generated the following rank: voltage, pulse length, and number of pulses, demonstrating that voltage has the greatest effect on anagen stimulation. Digital photography correlated with histological findings, revealing defined patches of hair at treated sites distinctly contrasting untreated skin (Figure 1).

Conclusion:
PEF shifted hair follicles from resting telogen to active anagen, and voltage was the most influential parameter. A single treatment at 270V, 300pulses, and 270us pulse length, lead to a 5.05-fold increase in anagen follicles at treated sites.

Additional studies are needed to evaluate duration of results, effect of multiple treatments, and mechanism of action. In conclusion, we showed that low-dose PEF effectively stimulate hair follicles in a rat model.

References:
1. P. Avci, G. K. Gupta, J. Clark, N. Wikonkal, and M. R. Hamblin, "Low-level laser (light) therapy (LLLT) for treatment of hair loss," *Lasers Surg Med,* vol. 46, pp. 144-51, Feb 2014.

Figure Legend:
Figure 1. Gross photography of control vs. PEF-treated sites with corresponding histology. Dense patches of well-demarcated hair growth at treated sites with increased anagen follicles as compared to controls.


Control
Treated
1mo Harvest
Control
(paucity of anagen follicles)
Treated
(many anagen follicles)