EEG Electrode Shape and Design Affects Skin Safety and Breakdown for Longer Studies

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INTRODUCTION

EEG Electrodes have been used for decades with very little attention being paid to the design or shape of the electrode and its impact on skin safety and health. As a matter of fact, even in the past few years when more attention than ever is being paid to skin health, breakdown and injury, the electrode design continues to be relatively dismissed and reported to have less impact on skin breakdown than the technique in which the electrode is used. The objective is to illuminate the effect of EEG electrode design on skin health while controlling for application techniques and patient risk factors.

- The results indicate the type, shape, surface area and relative pressure of each electrode type does indicate impact on skin health for longer term EEG Electrode applications.
- These results lead to further conversations regarding patient-specific customization using a more than one EEG Electrode shape on a single patient to assist in the reduction of skin breakdown and skin injury issues.

All electrodes used were single patient disposable electrodes.

- **Deep Cup:** Traditional 10mm EEG Electrode type with a large dome/cup area to hold substantial conductive material. This type traditionally has a thinner (less surface area) rim in contact with the patient skin.
- **Slim Cup:** This 10mm EEG Electrode type has a lower profile dome/cup area which holds less conductive material than the deep cup but has a broader/wider (larger surface area) rim in contact with the patient skin.
- **Webb™ Electrode:** This 10mm EEG Electrode is flat and has a waffle type design which holds the conductive material in place. This lead has no rim (largest surface area) in contact with the patient skin.
- **PressOn™ Electrode:** This electrode is flat with three small prongs which penetrate the skin approximately 1mm in depth. The PressOn was not applied on the skin as part of the project but was calculated for pressure values.

Objective

1. To compare the effect of different types and shapes of commercially available FDA Approved EEG electrodes on increased risk of skin breakdown and injury.
2. Eliminate the variability of technologist technique or patient difference to directly assess electrode shape impact.
3. Calculate pressure values per electrode type

RESULTS

1. Applied three different types of electrodes on the same subject skin area, by the same technologist, using the same application materials and technique.
2. The Deep Cup style with the thinner (smaller surface area) rim showed visible skin changes versus the slim (larger surface area) and the flat Webb™ (largest surface area) which had little or no visible identification after removal.
3. Surface area and relative pressure were linked with the smaller surface area having the highest relative pressure.

Figure 1. Skin Conditions following 74 hours of wearing Deep Cup, Slim Cup, and Webb electrodes. Images were taken immediately following removal (T=0 hrs), 6 hours after removal (T = 6 hrs), and 24 hours after removal (T=24 hrs).

Electrode Style	Surface Area in Contact with Skin (mm^2)	Estimated Force required to Hold Electrode on Scalp (N)	Relative Skin Pressure, Normalized to Slim Cup (AU)
Slim Cup	57.64	2	1.000
Deep Cup	43.14	2	1.336
Webb™	85.84	2	0.671
PressOn™	9.34	0.2*	0.617

*Note: The PressOn™ holds itself on the scalp without external force, however it does impart a minimal force, estimated here to be 1/10th that required to hold traditional electrodes.

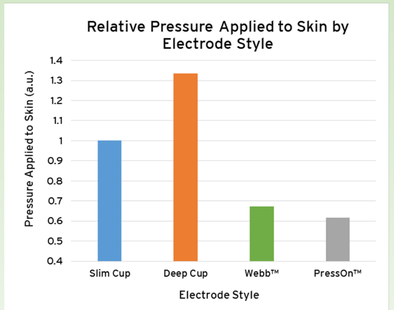

Figure 2 . The pressure applied to the skin for each electrode style is calculated by dividing the estimated force used to hold an electrode on the scalp by the surface area in contact with the scalp. Pressure values are normalized to the calculated Slim Cup pressure (set at 1.000 arbitrary units).

METHODS

1. Three different types of electrodes applied to the same subject using the same application technique, materials and technologist in an attempt to eliminate subjective differences involved in the application process.
   - Weaver NuPrep™ used to prep the skin
   - Weaver Ten20™ used as the conductive material
   - Mavidon™ Collodion used as the adhesive with gauze
   - Impedances recorded only at initial application- all were between 2K-5K Ohms.
   - All electrodes were Rhythmlink disposable EEG Electrodes
   - Electrodes (Deep Cup, Slim Cup, Webb™) applied for cont. 74 hours on left forearm with each electrodes 1.5 inches apart
2. Document 1) surface area, 2) force to hold electrode to scalp, and 3) relative pressure by electrode type

CONCLUSIONS

- Surface area and relative pressure were related with the smallest surface area reporting the highest relative pressure and the largest surfaced area reporting the lowest relative pressure when applied to the skin.
- Deep Cup has the smallest surface areas (rim) in contact with the skin and is the highest relative skin pressure.
- Deep Cup applies the most relative pressure when applied to the skin with the Slim Cup having lower relative pressure and a larger surface area.
- Webb™ and PressOn™ applies the least amount of relative pressure when applied to the skin.
- The data indicates the shape of a traditional style Deep Cup may increase risks for skin challenges/issues due to the small surface area and high relative pressure when applied.
- A larger patient study would assist to provide more significant conclusions.

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