Technical Note

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# Newly Designed Immediate Scalp Electrode for Emergency Electroencephalography

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**ABSTRACT**

We design a novel scalp electrode for use in urgent situation in the emergency room. The electrode is made of elastomer/polypropylene material with excellent conductivity and has a Kenzan shape, which does not require shaving or degreasing of the scalp. The novel scalp electrode enables us to immediate electroencephalography (EEG) in the emergency room.

*Key words:* EEEG, Electrode, Emergency EEG, Material

## Introduction

In the measurement of electroencephalography, it is essential to keep the electrodes in close contact with the scalp. Therefore, it is necessary to apply shaving, degreasing of scalp, and taping to each electrode, which are factors becoming obstacles the use of electroencephalography examination in emergency room. We study the shapes and materials of electrodes that does not require shaving or degreasing so that electroencephalography measurement in emergency can be performed more easily.

## Material and Method

We use 3-D printer, da Vinci Jr.1.0 3 in 1 by XYZ PRINTING.Co. Japan, to make several candidate shape of electrode. In recent trend of EEG electrode for man-machine interface development, numerous candidate shapes of scalp electrode have been proposed in the literature[1-3]. Many of them consists of the combination of bio-plastic electrode and electromagnetic conductive gel. We tested several candidate materials for electrode and conductive gel with special reference to Japanese Standard of Biological Safety for Medical Equipment (2012).

## Result

By modeling numerous candidate shapes of scalp electrode in the literature 1)-3), we developed multi-spike electrode, which is similar to the shape of Kenzan as supporting device of cut flowers in Japanese flower arrangement (Figure 1).

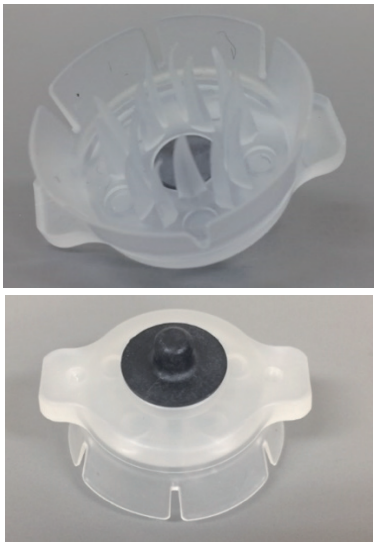

**Fig 1. Prototype of Kenzan shaped electrode made of hyper conductive elastomer.**

Bottom view: left and top view: right. Black area of top view is Ag-AgCl tip.

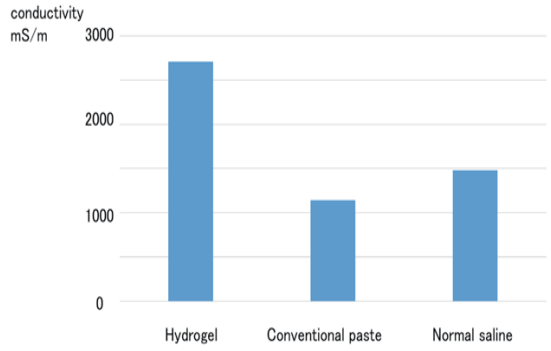


**Fig 2. Conductivity of hydrogel, conventional EEG paste and normal saline (mS/m).**

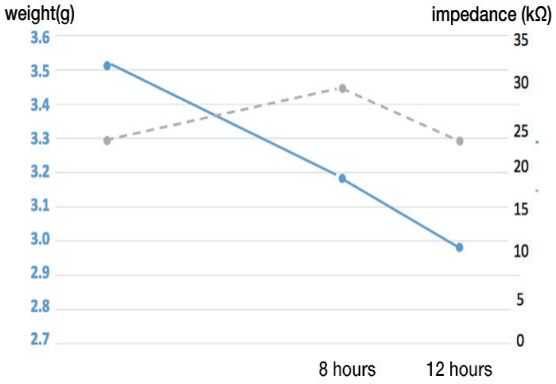


**Fig 3. Sequential change of weight and impedance of hydrogel material.**

As a material for gel, we compared hydrogel, conventional EEG paste and normal saline (Fig.2) and concluded that hydrogel is suitable for new electrode.

As next step, we tested the sequential change of weight and impedance of hydrogel material. After 12 hours, weight of the hydrogel reduced about 10% and impedance (k Ω ) was almost same (Fig.3).

Then, the candidate combination of electrode tip and gel was measured and concluded the combination of Ag-AgCl and hydrogel is suitable for new electrode (Fig.4).

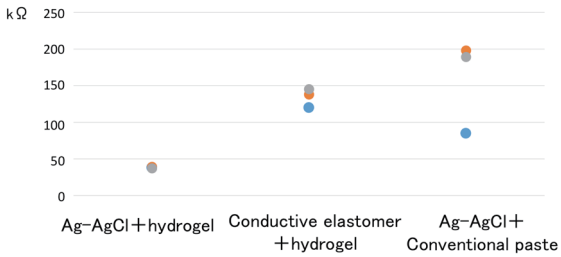


**Fig 4. Impedance of the candidate combination of electrode tip and gel (kΩ).**

Sequential change (Impedance) of new electrode with Kenzan shaped conductive polymer, Ag-AgCl tip and hydrogel is measured in volunteers within 2 hours (Fig.5), without shaving or degreasing of scalp.

In EEG electrode standard in Japan 2002, impedance of electrode in clinical use is proposed less than 30k Ω . In all volunteer, impedance of new electrode shows the practicality for clinical use.

Finally, standard test of cell toxicity, primary skin irritation and sensitization (Klingman maximization test) by Japanese Standard of Biological Safety for Medical Equipment (2012) demonstrated no cell toxicity, no skin irritation and no sensitization.

## Discussion

Recent development of man-machine interface technology, several type of EEG electrodes for commercial use. In medical field, Lepola P4 reviwed commercially available EEG template, EEG caps and emergency electrode sets (Fig.6).

All of commercially available unit uses Ag-AgCl in electrode material and several kind of gel/cream. 7 of 11 unit requires skin abrasion and all unit has hairy area related problem.

The Kenzan shaped electrode requires no shaving or degreasing of the scalp with low and stable impedance within 120 minutes for emergency use in emergency room.

## Conclusions

We developed the new electrode especially for use in emergency room. The electrode requires no shaving or degreasing of the scalp and demonstrate low impedance within 120 minutes. Using this electrode, we can perform EEG measurement more easily and more frequently.

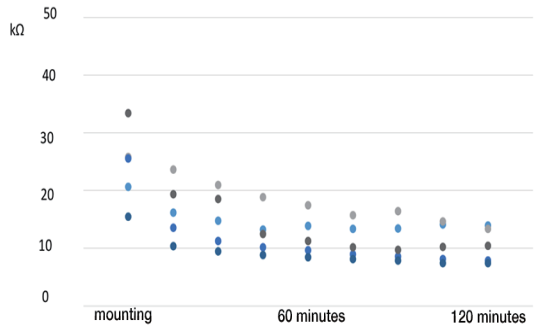


**Fig 5. Sequential change of impedance of new electrode on scalp without shaving or degreasing.**

| Name | Type | Number of electrodes | Electrode material and type | Recommended electrolyte | Supplier | Weaknesses A | B | C | D | E |
|---|---|---|---|---|---|---|---|---|---|---|
| **BraiNet** | Template | 14-21 | Ag/AgCl passive | EC2 cream collodion glue | Jordan NeuroScience, Inc. | x | x | x | x | x |
| **Neuroband** | Template | 2-19 | Sn or Ag/AgCl passive | ElectroMist gel | Dr. Diane Brain Health | x | x | x | x | x |
| **EazeNet** | Template | 19 | Ag/AgCl passive | Gel pre-attached | Hydrodot, Inc. | x | | | x | x |
| **MultiCap** | Cap | 21 | Ag/AgCl passive | ECI electrode gel | GVB-geliMED KG | | x | x | x | x |
| **EasyCap** | Cap | 19-40 | Ag/AgCl passive | Abrassive gel (Abrylat 2000) | EASYCAP GmbH | | x | x | x | x |
| **EasyCap Active** | Cap | 19-40 | Ag/AgCl active | SuperVisc Hydrogel | EASYCAP GmbH | x | | | x | x |
| **QuickCap** | Cap | 19-256 | Sn, Au, Ag/AgCl passive | QuikCell Hydrogel | Compumedics USA Inc. | | x | x | x | x |
| **WaveGuard** | Cap | 21-256 | Ag/AgCl passive | Gel | ANT Neuro | | x | x | x | x |
| **BrainCap** | Cap | up to 256 | Ag/AgCl passive | Various | Brain Products GmbH | | x | x | x | x |
| **ActiCap** | Cap | up to 64 | Ag/AgCl Active | SuperVisc Hydrogel | Brain Products GmbH | x | | | x | x |
| **StatNet** | Set | 18 | Ag/AgCl passive | Gels pre-attached | Hydrodot, Inc. | | | | x | x |

*A = Separate electrodes, B = Separate gel/paste, C = Skin abrasion needed, D = Hairy area related problems, E = Need to move the head during setup*

**Figure 6. Examples of commercially available EEG Template, EEG caps and emergency electrode sets.**

## References


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## 要　旨

# 救急脳波測定のための新たな脳波電極の開発

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脳波の測定において、電極を頭皮に密着させることが重要である。そのために剃毛や脱脂、テーピングを各電極に施す必要があり、緊急時や時間外診療において脳波検査の普及を妨げる要因となっている。我々は、緊急時の脳波測定をより簡易に行えるように、剃毛や脱脂を必要としない電極の形状と素材を検討し、新たな素材の組み合わせによる剣山状の形態の新たな電極を開発した。この電極は、頭髪の前処置が不要であり安定した電気的性能を持つ。本電極の商品化により、救急外来での意識障害患者に対する脳波測定の機会が増えると予想される。

**キーワード：脳波 , 電極 , 救急脳波 , 素材**

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