Comparative Analysis of Electrodes used in Neuromuscular Electrical Stimulation Therapy for the Treatment of Dysphagia

Testing and analysis performed by:

Weddendorf Design, Inc

8103 Valley View Drive - Huntsville, AL 35802

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Weddendorf Design, Inc Electrode Comparative Analysis

Purpose:

This document has been created to demonstrate a comparison of performance between the eSWALLOW USA electrodes, the VitalStim® Therapy electrodes and the Columbia Scientific Series 600 electrodes.

The intent of our testing and analysis is to provide an honest and fair comparison of the strengths and weaknesses of each brand of electrodes based on the two key measurements of performance important to the treatment of dysphagia; dispersion and impedance.

There has been a significant amount of misinformation circulated in an effort to frighten or mislead Speech Pathologists regarding the use and effectiveness of electrodes. The following test has been designed to allow medical professionals to compare the performance of three manufacturers and draw their own conclusions.

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Impedance:

Because impedance is the most often used method of measuring the performance of electrodes we began our comparison by testing the impedance or resistance of each of the three brands of electrodes.

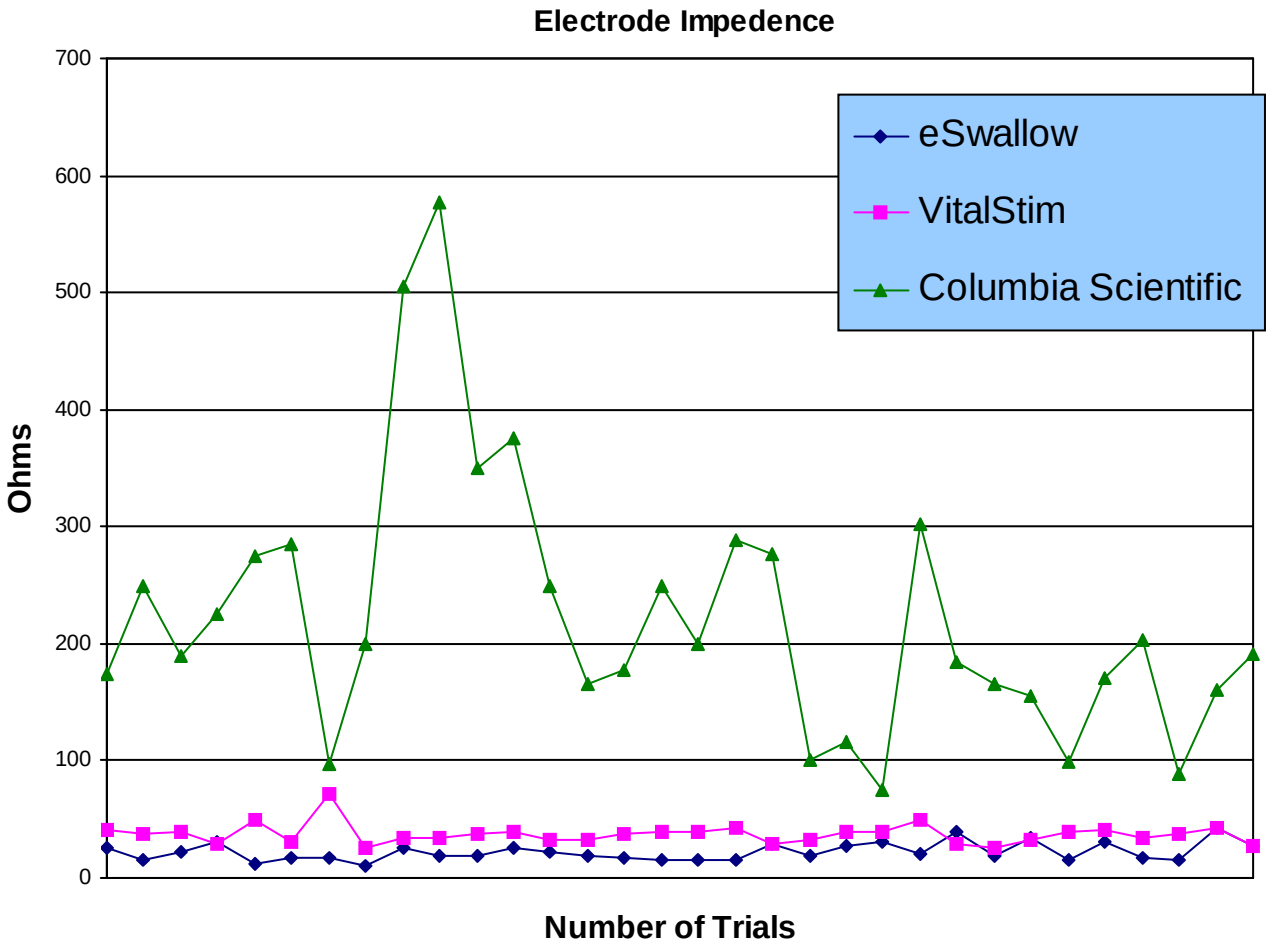
32 electrodes from each manufacturer were randomly selected for testing. 32 trials were conducted in which the resistance of each electrode was measured. All measurements were taken using a standard Ohmmeter. The results of the tests are depicted in the table below. The unit of measure is Ohms.

Trial #	eSWALLOW USA	VitalStim®	Columbia Scientific
1	25	**41**	**175**
2	15	**37**	**250**
3	22	**39**	**190**
4	31	**29**	**225**
5	12	**49**	**275**
6	17	**31**	**285**
7	17	**72**	**97**
8	10	**25**	**200**
9	25	**35**	**505**
10	18	**35**	**577**
11	18	**38**	**350**
12	26	**40**	**375**
13	23	**33**	**250**
14	19	**32**	**166**
15	17	**38**	**177**
16	15	**39**	**250**

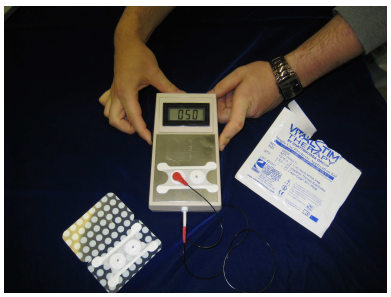
Trial #	eSWALLOW USA	VitalStim®	Columbia Scientific
17	15	**40**	**200**
18	15	**42**	**289**
19	29	**29**	**277**
20	18	**33**	**101**
21	27	**39**	**116**
22	31	**39**	**75**
23	21	**50**	**302**
24	40	**29**	**185**
25	19	**25**	**166**
26	35	**33**	**156**
27	16	**39**	**99**
28	31	**41**	**170**
28	17	**35**	**203**
30	15	**37**	**88**
31	43	**42**	**160**
32	28	**28**	**191**

	eSWALLOW USA	VitalStim®	Columbia Scientific
Average Impedance	**22.18**	**37.3**	**222.6**

Weddendorf Design, Inc Electrode Comparative Analysis



Columbia Scientific 600 Series electrode. Tested impedance of 505 Ω



VitalStim® electrode. Tested Impedance of 50 Ω

eSWALLOW USA electrode. Tested Impedance of 16 Ω

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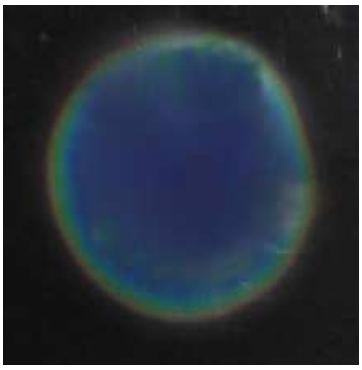
Electrode Comparative Analysis

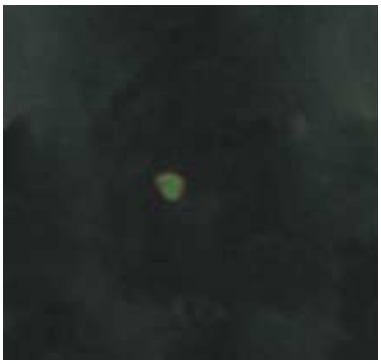
Dispersion:

Each manufacturer's electrodes were tested to see how evenly electrical current is dispersed across the surface of the electrode. The test was conducted with the aid of a conductive, illuminating thermal membrane. As current passes from the electrode to the membrane, a small amount of heat is produced. The areas of higher current produce more heat. A visual inspection of the membrane reveals the areas of greater current flow. Blue indicates greater current flow, yellow and red indicate lesser current flow.

VitalStim® Electrode - Crescent shape dispersion pattern.



eSWALLOW USA Electrode - Circular dispersion pattern covers the surface of the electrode.



Columbia Scientific Electrode - Only a small portion of the electrode surface is conducting current.

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Summary Statement

Columbia Scientific:

1.) The Columbia Scientific electrodes performed poorly during the impedance test. The average impedance exceeded 220 ohms. This high impedance may result in weak or reduced effectiveness of the unit.

2.) The impedance test reflected a wide variance of resistance from electrode to electrode indicating possible inconsistency in materials and construction.

3.) The 1" diameter of the Series 600 electrode may make it more difficult to target the small muscles in the anterior portion of the neck.

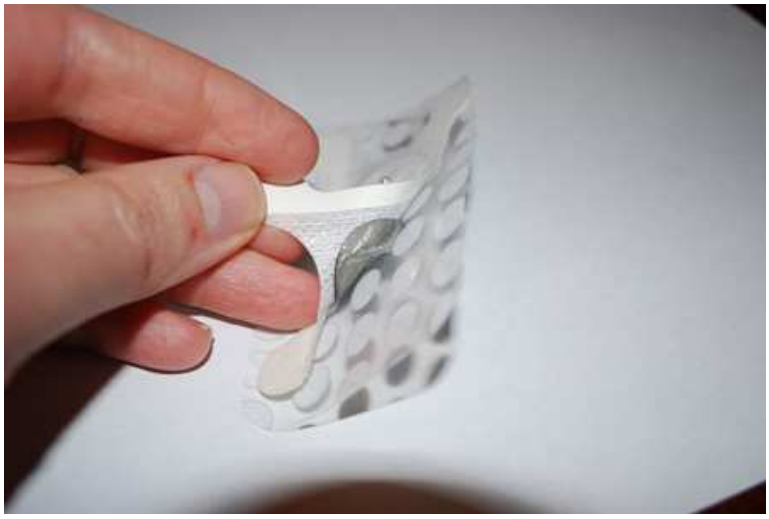
4.) The Series 600 displayed very poor dispersion. The only indication of current during these tests was directly at the point of termination of the lead wire. This result leads to a decrease in the effectiveness of each treatment.

VitalStim® Therapy Electrodes:

1.) The VitalStim electrodes performed consistently higher in impedance compared to the eSwallow electrodes. The average impedance of the VitalStim electrodes was 37.3 ohms as compared to an average of 22.2 ohms for the eSwallow electrodes.

2.) The dispersion test on the VitalStim electrodes proved erratic and often very spotty conductivity across the surface of the electrodes. Poor dispersion can result in hot spots, stinging and general discomfort to the patient. The lack of consistent dispersion makes it more difficult for the SLP to target the specific muscle group.

3.) The gel used on the VitalStim electrodes consistently separated or delaminated. This makes it impossible to reposition and in many cases the gel separated from the electrode when removing it from the liner. Replacing the gel after it separates caused a breakdown in the overall performance. Both impedance and dispersion were negatively impacted.



Example of VitalStim gel delaminating while removing electrode from liner.

Weddendorf Design, Inc Electrode Comparative Analysis

Summary Statement (continued)

eSWALLOW USA:

1.) The eSWALLOW electrodes consistently out performed both the Columbia Scientific Series 600 and the VitalStim electrodes in each phase of testing.

2.) The dispersion test revealed 100% coverage on every eSWALLOW electrode tested. Each test demonstrated a smooth, even current across the entire surface of the electrodes.

3.) The eSWALLOW electrodes generated the lowest resistance (impedance) of the 3 electrodes tested. This lower impedance enhanced the overall performance of the units and prolonged the life of the batteries.

4.) The eSWALLOW gel appears to be superior to either of the gels used on the VitalStim or the Series 600 electrodes. The eSWALLOW electrode can be applied, removed and reapplied 2, 3 or more times with no reduction in conductivity or dispersion. The eSWALLOW electrodes' adhesive properties also demonstrated a surprising resilience with significantly better adhesion. The gel used on the VitalStim electrodes repeatedly separated and made it difficult to reposition during testing.

5.) Our final observation related to the size or diameter of the electrodes. It was suggested in VitalStim literature that a smaller surface area was desirable in order to target the smaller muscle masses of the neck. The eSWALLOW electrodes measured slightly smaller in diameter then the VitalStim or the Columbia Scientific electrodes.

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