AN ELECTROMYOGRAPHIC STUDY OF THE ORBICULARIS ORIS
MUSCLE OF CEREBRAL PALSYED SPASTIC HEMIPLEGICS

By

Robert R. Buckley

Submitted to the Faculty of the Graduate School in
partial fulfillment of the requirements for
the degree, Master of Science in Dentistry
Indiana University, May, 1961.
TABLE OF CONTENTS
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>Spastic Hemiplegia</td>
<td>2</td>
</tr>
<tr>
<td>Electromyography</td>
<td>3</td>
</tr>
<tr>
<td>REVIEW OF LITERATURE</td>
<td>4</td>
</tr>
<tr>
<td>Anatomy</td>
<td>6</td>
</tr>
<tr>
<td>Innervation of Orbicularis Oris</td>
<td>7</td>
</tr>
<tr>
<td>The Motor Unit</td>
<td>8</td>
</tr>
<tr>
<td>Innervation Ratio</td>
<td>9</td>
</tr>
<tr>
<td>Motor Unit Action Potentials</td>
<td>9</td>
</tr>
<tr>
<td>Fibrillation</td>
<td>10</td>
</tr>
<tr>
<td>Stretch Reflex</td>
<td>11</td>
</tr>
<tr>
<td>The Mechanism of Conduction</td>
<td>12</td>
</tr>
<tr>
<td>STATEMENT OF PROBLEM</td>
<td>16</td>
</tr>
<tr>
<td>METHODS AND MATERIALS</td>
<td>17</td>
</tr>
<tr>
<td>Selection of Patients</td>
<td>17</td>
</tr>
<tr>
<td>Materials Used to Record Action Potential</td>
<td>19</td>
</tr>
<tr>
<td>Method</td>
<td>21</td>
</tr>
<tr>
<td>Instructions to the Patient</td>
<td>28</td>
</tr>
<tr>
<td>PRESENTATION OF DATA</td>
<td>32</td>
</tr>
<tr>
<td>DISCUSSION</td>
<td>45</td>
</tr>
<tr>
<td>SUMMARY</td>
<td>47</td>
</tr>
<tr>
<td>CONCLUSIONS</td>
<td>48</td>
</tr>
<tr>
<td>REFERENCES</td>
<td>49</td>
</tr>
<tr>
<td>BIBLIOGRAPHY</td>
<td>52</td>
</tr>
<tr>
<td>VITA</td>
<td></td>
</tr>
<tr>
<td>ABSTRACT</td>
<td></td>
</tr>
</tbody>
</table>
LIST OF FIGURES
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Action potential recorded between inside and outside giant squid axon.</td>
<td>15</td>
</tr>
<tr>
<td>2.</td>
<td>Grass Polygraph Model 5A.</td>
<td>23</td>
</tr>
<tr>
<td>3.</td>
<td>The muscles of the face are shown with eight electrodes in place over the lips.</td>
<td>25</td>
</tr>
<tr>
<td>4.</td>
<td>Calibration procedure for Grass Polygraph Model 5A</td>
<td>27</td>
</tr>
<tr>
<td>5.</td>
<td>A general view of the surface electrode used in this study.</td>
<td>30</td>
</tr>
<tr>
<td>6.</td>
<td>The patient is seated in the examining room ready to be tested.</td>
<td>31</td>
</tr>
<tr>
<td>7.</td>
<td>The electromyograms of a normal individual (A), and a spastic left hemiplegic (B), are presented following the commands (1) relax, (2) teeth together, and (3) bite hard.</td>
<td>33</td>
</tr>
<tr>
<td>8.</td>
<td>An electromyographic record of activity in the orbicularis oris muscle during a voluntary swallow is shown for a normal individual (A), and for a left spastic hemiplegic (B).</td>
<td>35</td>
</tr>
<tr>
<td>9.</td>
<td>Involuntary swallowing during straw drinking of water is shown electromyographically for a normal individual (A), and left spastic hemiplegic (B).</td>
<td>37</td>
</tr>
<tr>
<td>10.</td>
<td>Voluntary activity in the orbicularis oris muscle was recorded when the lips were held together voluntarily and is shown in the electromyogram of a normal individual (A), and a left spastic hemiplegic (B).</td>
<td>39</td>
</tr>
</tbody>
</table>
LIST OF TABLES
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. The age, sex, race, and date of examinations are shown for all individuals studied. The hemiplegic side of involvement for the spastic group is designated by right or left.</td>
<td>16</td>
</tr>
<tr>
<td>II. The muscle activity of the orbicularis oris when the lips were at rest is presented to show areas of greater or lesser electrical activity as recorded on the electromyogram of each individual included in the study.</td>
<td>41</td>
</tr>
<tr>
<td>III. The muscle activity of the orbicularis oris when the lips were engaged in voluntary swallowing on command is presented to show areas of greater or lesser electrical activity as recorded on the electromyogram of each individual included in the study.</td>
<td>42</td>
</tr>
<tr>
<td>IV. The muscle activity of the orbicularis oris when the lips were engaged in straw drinking of water accompanied by involuntary swallowing is presented to show areas of greater or lesser electrical activity as recorded on the electromyogram of each individual included in the study.</td>
<td>43</td>
</tr>
<tr>
<td>V. The muscle activity of the orbicularis oris when the lips are held together on command is presented to show areas of greater or lesser electrical activity as recorded on the electromyogram of each individual in the study.</td>
<td>44</td>
</tr>
</tbody>
</table>
ACKNOWLEDGEMENTS
ACKNOWLEDGEMENTS

The author wishes to express his grateful appreciation to all those who have contributed to this study.

The critical examination of data, advice, guidance, and review of this paper by Dr. Ralph E. McDonald, Chairman of the Pedodontic Department, was invaluable.

Dr. Charles Bonsett provided the inspiration, professional guidance and technical assistance, and equipment which made this study possible. His staff, headed by Dr. Benjamin Abreu and including Dr. Sami El-Beheri and Mrs. Beatrice Thompson, was patient and helpful throughout the course of the investigation.

Particular appreciation is extended to Dr. Charles J. Burstone who originally suggested the subject.

The author also wishes to express his appreciation to Mr. Richard Scott, Mrs. Gloria Spray, and Mrs. Thelma Olson for their technical assistance in the preparation of the illustrations.

Miss Anita Sliominski, Coordinator of the Cerebral Palsy Clinic, was helpful in the selection of patients included in this study and in the final review of the paper.

The author is also appreciative of the help of his secretary, Mrs. Fred Buehl, and his wife who diligently typed and retyped this paper.
INTRODUCTION
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During the past four years more than 700 individuals were examined and treated at the Cerebral Palsy Dental Clinic at Indiana University Medical Center. Among the group were 136 patients with spastic hemiplegia. According to Angle's classification of occlusion, 40 had Class II occlusion, 3 had Class III occlusion, and the remaining 93 had Class I occlusion. Further investigation revealed that thirteen individuals had a moderate to severe openbite with a tendency for the openbite to be greater on one side of the dental arch. Another eleven of the 136 had a posterior crossbite involving one or more teeth. Two individuals had an anterior crossbite. The question arose as to the cause of the malocclusion. What forces were acting on the teeth and supporting structures which might contribute to a deformity of the dental arches? Was it tongue thrust that produced the openbite or was it that the lips failed to counteract the forces of the tongue? Did the muscles on one side of the face exert greater forces on the teeth resulting in a unilateral crossbite?

The purpose of this study was to examine a limited area of the face circumscribing the orbicularis oris muscle to determine if each side of the face functions similarly during prescribed functions both voluntary and involuntary. It is possible to detect any differences in muscle activity electromyographically. Therefore, a study was undertaken to examine bilaterally muscle activity of the orbicularis oris in this manner.
Spastic Hemiplegia

Magoun and Rhines described a patient who had suffered a cerebral vascular accident resulting in the paralysis of voluntary movement of the left arm and leg. The muscles of the involved side were not limp and flaccid. The stiffly extended leg did not bend when the weight of the body was upon it, and efforts to move the arm from its flexed position met with resistance. The deep reflexes of the involved side, if elicited, were more active than normal, and sustained tension, suddenly begun, would produce repeated muscle contraction called clonus. Therefore, the symptoms of increased resistance to manipulations, hyperactive deep reflexes, and clonus— together constituted spasticity. The clinical description by Magoun and Rhines for this one individual parallels that of the 136 spastic hemiplegic cerebral palsied individuals, from which seven patients were selected for this study. The etiology, however, of the spastic patients may vary since a number of causes are ascribed to cerebral palsy.

Hemiplegia implies that the condition is lateralized to one-half of the body according to Perlstein. He further described spasticity as an involvement of an upper motor neurone with a hyperactive stretch reflex present in the spastic muscle. The stretch reflex indicated an increased tendency of the muscle to contract when it was passively stretched rapidly. The reflex was not present when the muscle was passively stretched slowly. Electromyographically the stretch reflex could be recognized as a marked increase in the amplitude and spread of the normal action current of the muscle.
Electromyography

Electromyography is the tracing of electrical activity in muscle. Resting muscle fibers have a positive charge on the outside and a negative charge on the inside. When the polarity is reversed, an electrical current is produced and the muscle is activated. The activity is relayed by means of an electrode to the amplifiers and then recorded. The electrode may be an insulated needle, the end of which is uncoated and penetrates the muscle fiber or a flat circular piece of metal, approximately one centimeter in diameter, placed on the surface of the skin over the muscle to be tested. Electrical continuity is assured by means of a NaCl paste placed under the surface electrode. The electrical activity of the muscle may be recorded on the cathode ray oscilloscope, with an audio unit, or with an ink writer on a moving paper track. The electromyograph makes it possible to study the function of several muscle groups simultaneously. One can, therefore, ascertain the function of any specific muscle and obtain a permanent record of its activity at rest or during use.
REVIEW OF LITERATURE
REVIEW OF LITERATURE

Moyers, Pruzansky, and Porzy studied facial, cranial, and cervical pain associated with dysfunctions of the occlusion and articulation of teeth. In cases of longstanding occlusal interferences, the tempororal and probably external pterygoid muscles were reflexly stimulated to reposition themselves away from the area of premature contact. Jarabak also found this to be true. He used an interocclusal splint to remove occlusal interferences. Upon removal of the splint spasms recurred. Moyers used an onlay on a maxillary left cuspid to show changes in the occlusal equilibration will improve occlusion. Shpuntoff and Shpuntoff found a characteristic centric relationship of the jaws in 215 normal adults and that when one of the muscles of mastication was at rest, the others were at rest. Zwemer compared five cleft palate patients with normal interocclusal clearance and found that with an increase in interocclusal clearance there was a marked increase in the action potential of the temporal and masseter muscles upon closure to contact. Restoration of natural interocclusal levels restored the amplitude response to the normal range.
examined and studied the buccinator, masseter, and mylohyoid muscles in normal and atypical swallowing patterns. He described two types of swallowing: one, the atypical visceral swallow in which the teeth were separated and there was marked activity of the buccinator and circumoral muscles and increased activity in the lower lip. He compared this with the second normal somatic swallow in which there was marked masseteric contraction and little circumoral activity.

Tulley carefully reviewed the work of Whillis, Rix, and Gwynn-Evans and concluded that the masseter forcibly contracts at the mylohyoid stage of the normal swallow to fixate the mylohyoid arch. The atypical swallowing behavior is similar to the infantile sucking pattern and is a peristaltic type of activity that is automatic or visceral in behavior. Tulley further stated that in the normal teeth together swallow the circumoral muscles played very little part.

Schlossberg found supralaryngeal activity directly correlated with malocclusion and the mentalis muscle was more active in patients with Class II, Division I occlusion than in normal occlusion. Baril and Moyers studied the temporalis muscles and some of the facial muscles on 24 thumb or finger sucking children. The dominant muscle was either the orbicularis oris or the mentalis muscle. The findings in regard to swallowing were similar to Tulley's. He could not observe a relationship between retained visceral swallowing and thumb-sucking and could not establish a cause-effect relationship between the thumb habit and muscle pattern.
Anatomy:

The muscle tested in this study was the orbicularis oris. It is the sphincter of the mouth and extends upwards almost to the nose and downwards to the transverse groove on the skin midway between the chin and red portion of the lips according to Grant. Four slips, the incisive bands, arise from the incisive fossae of the upper and lower jaws and turn laterally into the orbicularis oris. They help to purse and to pout the lips. Five other muscles converge on the angle of the mouth where they blend with the orbicularis oris. They are:

1. Levator Anguli Oris - Caninus
2. Zygomaticus Major - Smiling muscle
3. Risorius - Grinning muscle
4. Depressor Anguli Oris
5. Platysma - Posterior fibers

Attached to the upper lip is the Quadratus Labii Superius with three heads of origin: angular, infraorbital, and zygomatic. On the lower lip is the Depressor (Quadratus) Labii Inferioris, whose medial border meets and decussates with that of its fellow above the transverse groove of the lip. This leaves a triangular space occupied by the mentalis muscle. The buccinator retracts the angle of the mouth and this is the antagonist of the orbicularis oris. It acts in blowing, sucking, and chewing. The buccinator extends anteriorly into the upper and lower lips and blends with the orbicularis oris. The upper and lower fibers pass directly into the upper and lower lips, but the intermediate
fibers decussate behind the angle of the mouth, the upper fibers passing into the lower lip and the lower fibers passing into the upper lip.

**Imnervation of Orbicularis Oris:**

All muscles of facial expression, except one, the Masseter, are innervated by the cranial nerve, the motor nerve of the face. The facial nerve is composed of motor and sensory fibers. There are special sense fibers of taste to the anterior two-thirds of the tongue and parasympathetic, motor secretory, fibers to the salivary and lacrimal gland. Three of its branches supply muscles associated with the orbicularis oris:

1. Zygomatic branch — supplies the muscles of the infraorbital region.
2. Buccal branch — supplies the buccinator muscle and orbital region.
3. Mandibular branch — supplies the lower lip and chin.

The motor fibers from the motor nucleus of VII in the caudal portion of the pons loop around the nucleus of VI (Internal Gem) and leave the skull by a long route through the petrous portion of the temporal bone. Parasympathetic fibers originate in the superior salivatory nucleus in the pons. The sensory fibers arise from unipolar cells in the geniculate ganglion. The motor nucleus receives crossed and uncrossed fibers from the cortico-bulbar tract, extra pyramidal tracts, and tectospinal.
tracts and reflex connection from the nucleus of the tractus solitarius and nucleus of the spinal tract of the trigeminius. The facial muscles below the forehead receive only contralateral cortical innervation (crossed corticobulbar fibers); however, the frontalis muscle receives bilateral cortical innervation and is, therefore, not paralyzed by the lesions involving one motor cortex of its pathways according to Chusid and McDonald.

**The Motor Unit:**

Scherrington designated the motor unit as the final common pathway of the nervous system. It is the basic motor element of the reflex arc and consists of an anterior horn cell of the spinal cord and the group of muscle fibers which it innervates. The anterior horn cell consists of dendrites, the cell body (perikaryon), axon, and end plate (which contains muscle fiber nuclei). The dendrites ramify throughout the grey matter of the spinal cord, receiving impulses from many posterior roots and from all levels of brain and cord. The cell body contains nucleus and nucleolus, and other elements in its cytoplasm, such as neurofibrils, Nissl substance, Golgi apparatus and Carotinoid pigments. The motor neuron is made of dendrites, cell body, and axon. Fixed neurons contain conspicuous neurofibrils which are the basis of conduction and are structural entities of the living cell. Fulton stated that all nerve cells and axons contain neurofibrils but that the dendrites exhibit the simple structure of colloidal protoplasm with obvious morphological organization.
Innervation Ratio:

The innervation ratio refers to the proportion of nerve to muscle fibers. In the extensor longus digitorum the ratio is 1:165; in the soleus 1:120. In muscle designed for more discrete movement, such as the extracocular muscles, the ratios are much smaller. No ratios have been established in humans and it is believed likely that muscles which have an extensive representation in the motor area of the cortex have smaller innervation ratios than those which do not. It has been found that a single anterior horn cell was capable of developing an average of 30 grams of tension.

Motor Unit Action Potentials:

Fulton made a comprehensive survey of the work of Denny-Brown, Kugelberg, and Skoglund, et al., related to the motor unit. He stated that a mild degree of stretch applied to a tendon, cats soleus muscle, caused a regular sequence of small electrical deflections at the rate of 5 to 7 waves per second. When the stretch was slightly increased, there appeared a second group of action potentials which discharges at a different frequency rate than that of the first group. The secondary action potentials were evoked by the activity of additional anterior horn cells. The frequency of motor units generated varied with the amount of stimulus.

A concentric needle electrode has been used to record from human limb muscles; in which the action potentials were found
to be monophasic, diphasic, triphasic and occasionally polyphasic. The duration varied between 5 and 10 milliseconds. The action potentials were short in duration and complex in form, and were recorded from muscles of the face. No electrical activity, except fibrillation, (which is a sign of denervation) could be recorded from voluntary muscle when it was completely relaxed. The duration form of action potentials in normal humans muscle in 30 cases, 10 women and 20 men, all between the ages of 20 and 42 included 100 observations in the facial muscles where extreme limits of 0.8 to 6 milliseconds were found. The motor units of the face had a complex organization because there was overlapping of the distribution of the terminal axon network. This caused poorly integrated multiple fiber potentials to appear. Marinacci stated that a simple normal motor unit has a wave form 1 to 6 spikes, a magnitude from 100 to 300 micro volts and a duration from 5 to 10 milliseconds. However, the extreme is from 2 to 16 milliseconds with a frequency of 5 to 30 waves per second. The discharge of the motor unit produced a sharp thumping sound on the audio unit.

Fibrillation:

Fibrillation can be readily distinguished from motor unit action potential by its sound. Fibrillation produces a sharp click whereas motor unit action potentials are heard from the loud speaker as a low pitched sound. Fibrillation is not visible in muscle covered by intact skin other than in the
denervated muscle of the tongue. The phenomenon of fibrillation which is spontaneous, continuous, rhythmical contraction occurs in denervated muscle. Any voluntary muscle that has been denervated fibrillates actively 21 days after nerve interruption. It denotes that healthy muscle tissue is still present and in one case was known to persist 54 years. Fibrillation is increased by:

1. Prostigmine
2. heat
3. massage
4. electrical stimulation
5. use of paretic limb
6. administration of thyroid extract

Fibrillation is decreased by:

1. low temperature of extremity examined
2. quinine or quinidine medication
3. curare
4. immobilization of denervated muscle
5. poor circulation
6. thyroid insufficiency
7. morphological change — fibrosis

Stretch Reflex:

Reflex tonus is confined to those muscles which maintain the animal in an erect posture. It has been observed that by setting a decerebrate animal on its feet it will stand reflexly.29
The extensor reflexes, unlike the flexor, are primarily concerned in resisting the action of gravity and are thus the basic postural reflexes of the body, for in the upright posture gravity tends to cause flexion of the body, joints such as the ankle, knee and hip, and the extensor muscles resist this flexion by active contractions. The resistance develops through the operation of a specific reflex known as the myotatic or stretch reflex. The receptors of the stretch reflex are proprioceptors lying in the fleshy region of the muscle itself and the balance of evidence indicates that the muscle spindles are the active endings.

Evidence of the reflex character of the stretch cones through study of its inhibition and from the fact that dorsal root section or anterior root section completely destroys the reaction. When an extensor muscle contracts, its opposing flexor muscle relaxes. This is the principle of reciprocal innervation which is a basic pattern of the spinal reflexes. Decerebrate rigidity is simply reflex standing. Severance of the posterior nerve roots destroys it, but local anaesthesia of the tendon itself has no effect upon the reaction. Therefore, the reflex results from stretch of the muscle itself.

The Mechanism of Conduction:

Work with electrodes has demonstrated conclusively that potential differences are developed across a thin membrane situated at the surface of the cell. Elliott\textsuperscript{31} reported that a long
capillary tube of 100 microns in diameter has been inserted centrally inside 500 micron squid axons for distances up to 3 centimeters. Another electrode has been developed which is only about .5 microns in diameter at its tip and can be inserted transversely into nerve or muscle fibers without causing appreciable damage or twitching.

In the classical form of the membrane theory of nervous conduction it is assumed that depolarization of the resting membrane by local circuit action resulted in a loss of its selective permeability properties and caused a collapse of the membrane potential. It has recently become increasingly clear that the process must be more complex than a simple breakdown of the membrane, since it has been established that the potential actually reverses in sign during the passage of an impulse, and does not merely fall toward zero. Reversal of the membrane potential during activity was first demonstrated in squid axons but was later shown to occur in frog muscle, in medullated muscle and in mammalian cardiac muscle. It is apparently a general characteristic of most excitable tissue. The sodium hypothesis is one of the most satisfactory explanations of the overshoot of the action potential. According to this hypothesis the membrane becomes highly and specifically permeable to sodium ions during the rising phase of the action potential, so that sodium enters faster than potassium can leave, and reversed potential is established. After the peak of the action potential has been reached, the membrane again becomes more permeable to potassium ions than to sodium.
ions, allowing potassium to diffuse outwards and restore the potential of its original resting value. The immediate transmission of the impulse is thus the exchange of a small quantity of sodium and potassium. Apparently the active depolarization is due to the entry of sodium ions and changes in the external sodium concentration have a large effect on the action potential. Furthermore, the rate of rise of the action potential in squid axons was dependent on the external sodium concentration which is consistent with the idea that the potential change is caused by a sodium entry, Figure 1."
Figure 1. Action potentials recorded between inside and outside giant squid axon. Time Marker 500 cycles/second. The Vertical scale indicates the potential of the internal electrode in millivolts, the sea water outside being taken at zero potential.

From J. of Physiology, 1945, p. 183.
STATEMENT OF THE PROBLEM
STATEMENT OF THE PROBLEM

This study was undertaken to discover whether or not the lips function symmetrically in cerebral palsied individuals with spastic hemiplegia. To determine this it was necessary to ascertain the bilateral function of the lips of normal individuals. The lips may be regarded as consisting of the orbicularis oris musculature as innervated by the Cranial Nerve VII.

An attempt was made to require each patient to execute a series of commands which would induce both voluntary and involuntary function of the lips. No attempt was made to establish a normal function of the lips for any given command except to establish bilateral functional symmetry or asymmetry of the orbicularis oris musculature.

It was felt that by studying the function of the lips in an abnormal population, one could learn something of lip function in the normal population. Therefore, a method was devised to prove or disprove that the right and left side of the upper and lower lips function symmetrically during any given activity.
METHODS AND MATERIALS
Selection of Patients:

Fourteen children with Class I occlusion according to Angle were selected for this study. The sample consisted of seven normal individuals with clinically good occlusion and seven cerebral palsied spastic hemiplegics - Table I.

The control group included four girls and three boys with an age range of eight years zero months to 13 years six months and all were Caucasian. The spastic group included six boys and one girl with an age range of nine years seven months to sixteen years eleven months. Three of the boys in this group were Negro; the remainder of the group was Caucasian. Four of the spastic group were right hemiplegics and three were left hemiplegics.

No limitations were placed on age, sex or race since the only purpose of the study was to determine if any differences in activity existed between the right and left sides of the orbicularis oris muscle.

Patients were selected who were able to travel to Indianapolis, Indiana, for repeated examinations. The group of cerebral palsied patients was limited to those with spasticity and involvement on one side only - hemiplegics.
Table 1. The age, sex, race, and date of examination are shown for all individuals studied. The hemiplegic side of involvement for the spastic group is designated by right or left.
### Table I.

#### Group #1 - Control

<table>
<thead>
<tr>
<th>Name</th>
<th>Age</th>
<th>Sex</th>
<th>Race</th>
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<th>Involvement</th>
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<tr>
<td>Richard Coy</td>
<td>10 6</td>
<td>M</td>
<td>W</td>
<td>11/11/60</td>
<td>None</td>
</tr>
<tr>
<td>Kathryn Coy</td>
<td>13 6</td>
<td>F</td>
<td>W</td>
<td>11/11/60</td>
<td>None</td>
</tr>
<tr>
<td>Janet Garvelis</td>
<td>8 0</td>
<td>F</td>
<td>W</td>
<td>11/11/60</td>
<td>None</td>
</tr>
<tr>
<td>Linda Manning</td>
<td>9 10</td>
<td>F</td>
<td>W</td>
<td>9/29/60</td>
<td>None</td>
</tr>
<tr>
<td>James Scalf</td>
<td>13 6</td>
<td>M</td>
<td>W</td>
<td>10/28/60</td>
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</tr>
<tr>
<td>Rocky Tapscott</td>
<td>8 0</td>
<td>M</td>
<td>W</td>
<td>11/4/60</td>
<td>None</td>
</tr>
<tr>
<td>Vera Tapscott</td>
<td>10 0</td>
<td>F</td>
<td>W</td>
<td>11/4/60</td>
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#### Group #2 - Cerebral Palsied - Spastic Hemiplegics

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<thead>
<tr>
<th>Name</th>
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<th>Sex</th>
<th>Race</th>
<th>Exam Date</th>
<th>Involvement</th>
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<tr>
<td>Walter Bland</td>
<td>16 11</td>
<td>M</td>
<td>C</td>
<td>2/3/61</td>
<td>Left</td>
</tr>
<tr>
<td>Karen Bravard</td>
<td>9 7</td>
<td>F</td>
<td>W</td>
<td>2/10/61</td>
<td>Right</td>
</tr>
<tr>
<td>David Hergenroether</td>
<td>9 11</td>
<td>M</td>
<td>W</td>
<td>2/10/61</td>
<td>Left</td>
</tr>
<tr>
<td>Mike Nolan</td>
<td>14 11</td>
<td>M</td>
<td>W</td>
<td>9/30/60</td>
<td>Left</td>
</tr>
<tr>
<td>Donald Privett</td>
<td>12 2</td>
<td>M</td>
<td>W</td>
<td>9/15/60</td>
<td>Right</td>
</tr>
<tr>
<td>Herman Russell</td>
<td>15 7</td>
<td>M</td>
<td>C</td>
<td>1/27/61</td>
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<tr>
<td>William Stantley</td>
<td>14 6</td>
<td>M</td>
<td>C</td>
<td>2/3/61</td>
<td>Right</td>
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Materials Used to Record Muscle Action Potential

The Polygraph

In this investigation a six channel Polygraph, Grass Model 5A, was used to obtain an objective record of the action potential of the muscles under evaluation. The Polygraph was a commercial instrument used to record blood pressure, oxygen tension, respiration, muscle action potential, heart rate, and other physiological data. It consisted of:

1. driver amplifier
2. chart driving mechanism
3. writer and oscillograph units
4. base line position control
5. sensitivity control
6. calibration control
7. integrating unit

A brief description of each mechanism of the Polygraph follows:

1. Driver amplifier: The Model 5A was a push-pull, two stage, direct coupled amplifier with a differential input. Its primary function was to amplify signals from the polygraph preamplifiers sufficiently to drive the direct writing oscillograph. It also supplied voltage to operate its associated preamplifier. The sensitivity of the combined amplifier and oscillograph was adjustable from 40 to 400 microvolts per centimeter of pen deflection. Normal sensitivity with preamplifiers was 100 microvolts.
per centimeter. Calibration of the Driver and Oscillograph was a plus or minus 200 microvolts direct current signal.

2. Chart driving mechanism: The chart drive provided 9 speeds of 100, 50, 25, 5, 2.5, 1, .5, and .25 millimeters per second. Accuracy was better than 1%. Speed was changed by a push and turn of the instant shift control knob. The chart was 50 millimeters in width for each channel. Curvilinear paper was used to provide true coordinate recording. The basic chart speed used was 25 millimeters per second.

3. The writer unit: It contained the chart drive mechanism, the oscillograph units which drive the pens, and the electrical damping circuits for the oscillographs. The muscle action potential was recorded on moving paper by a stylus, 5 inches in length, which was driven by an oscillograph unit connected to each amplifier. Each pen was connected by plastic tubing to an ink well of nigrosine ink which was especially recommended for use with the polygraph.

Formula for nigrosine ink is:

1000cc distilled water
50cc glycerin
10cc alcohol or chloroform
20gm ink crystals

Mix ingredients and filter thoroughly.

There was also an indicator center pen which was connected to a manually operated push button device. It was used to indicate the beginning of each command given the patient.
4. Baseline position control: This was used to set each pen to a position corresponding to a zero input from the preamplifier. This adjustment was made with the Polarity-cal-use switch in one of the two calibrate positions. The baseline could be set anywhere within a plus or minus 25 millimeters from the centerline of the chart. A dial lock prevented accidental changing of the baseline.

5. Sensitivity Control: This allowed control of Driver Amplifier amplification. A dial lock prevented accidental changing of the sensitivity. Each channel had a sensitivity control for both the electromyograph and the integrator and a separate sensitivity control for the integrator only.

6. Calibration: The amplifiers are calibrated at the factory for a standard deflection sensitivity of 200 microvolts per 2 centimeter of pen deflection. In this study a deflection of 100 microvolts per one centimeter was desired to record the amplitude of the muscle action potential and the Polygraph was so standardized.

7. Integrating Unit: The electrical output from each amplifier as it passed through the integrator produced a record in which only the peak amplitude of the muscle action potential was recorded. Each channel had a selector switch for electromyographic or integrated electromyographic output. A baseline was established for the integrator and the Polygraph was calibrated for this procedure as it had been in obtaining the electromyogram.
Pick up electrodes: Surface electrodes were used to pick up action potentials. Each electrode consisted of an insulated copper wire approximately 90 centimeters in length tipped with a metal disc approximately one centimeter in diameter. The other end of each electrode was connected to the Polygraph by means of a small jack and plug. There were eight pick up electrodes and a ninth electrode which was used to ground the Polygraph and eliminate 60 cycle interference produced by electrical wiring in the recording area.

A general view of the Polygraph used in this investigation is shown in Figure 2.
Figure 2. A general view of the Grass Model 5A Polygraph.
Four channels were used to record electrical activity in the orbicularis oris muscle on paper moving at 25 millimeters per second.$^{32}$
Method:

Each patient was seated in a wooden chair in the non-shielded examining room. Four channels of the six channel 33 Polygraph, Grass Model 5A, were used to record action potential of the orbicularis oris muscle of each of the fourteen individuals included in the study. The lips were divided into four quadrants and two surface electrodes were placed over each quadrant of the orbicularis oris muscle. No skin preparation was necessary. The surface electrode was held in position with celloidin which was dried with compressed air. Care was taken not to permit any celloidin to get between the metal disc and the skin. The perimeter of the disc was sealed with celloidin. Sodium chloride paste was placed next to the skin through a hole in the center of the disc to assure electrical continuity. A total of eight electrodes were placed to record muscle activity in the right upper lip, left upper lip, right lower lip and left lower lip. A ninth electrode was used to ground the equipment and was previously discussed. The placement of surface electrodes was in the following manner and is shown in Figure 3.

Electrode #1 was placed on the right upper lip just medial to the corner of the mouth and approximated the vermilion border of the upper lip.

Electrode #2 was placed on the right upper lip just distal to the distal border of the philtrum and approximated the vermilion border of the upper lip.

Electrode #3 was placed on the left upper lip just distal to
Figure 3. The muscles of the face are shown with all eight surface electrodes in position over the orbicularis oris muscle. The ground electrode is #9. The drawing is taken from Grant's Method of Anatomy.
the distal border of philtrum and approximated the vermillion border of the upper lip.

Electrode #4 was placed on the left upper lip just medial to the corner of the mouth and approximated the vermillion border of the upper lip.

Electrode #5 was placed on the right lower lip just medial to the corner of the mouth and approximated the vermillion border of the lower lip.

Electrode #6 was placed on the lower right lip immediately inferior to electrode #2 and approximated the vermillion border of the lower lip.

Electrode #7 was placed on the left lower lip immediately inferior to electrode #3 and approximated the vermillion border of the lower lip.

Electrode #8 was placed on the left lower lip just medial to the corner of the mouth and approximated the vermillion border of the lower lip.

Electrode #9 was the ground electrode. This was placed in the center of the left cheek of the face.

The polygraph was calibrated before and after each recording session for each patient. The gain of each amplifier was set at 100 microvolts per centimeter of pen deflection and the paper was set at 25 millimeters per second for each individual, Figure 4.
Figure 4. A sample record is shown of the method of calibrating each channel of the Polygraph. Each channel was calibrated at 20, 50, 100, 200, and 500 microvolts with the gain of each amplifier set at 100 microvolts per one centimeter of pen deflection.
100 microvolts = 1 centimeter = 1
Time = 25 millimeters per second =

Right upper lip

Time signal line

Left upper lip

Right lower lip

Left lower lip

20 mv* 50 mv* 100 mv* 200 mv* 500 mv*

(*) = microvolt
Instruction to the Patient:

The following instructions were given to each patient during which time electrical activity in the orbicularis oris was recorded electromyographically.

1. Relax.
2. Teeth together — just till they touch.
4. Relax.
5. Swallow.
6. Wet your lips with your tongue.
7. Relax.
8. Swallow.
9. Stick out your tongue.
10. Relax.
11. Swallow.
12. Lips together.
13. Relax.
14. Lips apart.
15. Relax.
16. Drink water through a straw on the command, and swallow 3 times.
17. Say the letter M.
18. Say the letter C.
19. Say the letter P.
20. Open your mouth.

22. Say the letter O - and hold it.

The entire sequence of commands were executed and recorded twice on the electromyograph. Following this procedure the Polygraph was set on the integrator to record peak amplitude only of the orbicularis oris muscle activity. The results of the integrated records are not included in this study.

Figure 6 shows a patient as he was seated in the examining room with the electrodes in place.
Figure 5. A general view of the surface electrodes used in this study. The metal surface electrode is approximately one centimeter in diameter.
Figure 6. A patient is shown seated in the examining room during a recording session with the eight surface electrodes in position over the orbicularis oris muscle. The ground electrode is attached to the left cheek.
PRESENTATION OF DATA
PRESENTATION OF DATA

Representative samples of the electromyogram records obtained for both a normal and a spastic individual were removed from the original electromyogram. They were carefully studied to detect any differences in function that existed between the right and left halves of the orbicularis oris muscle.

Four different activities are presented.

1. Lips at rest.
2. Voluntary swallow.
3. Involuntary swallow during straw drinking.
4. Lips together.

Figure 7 shows the electromyogram of a normal individual (A), and a spastic left hemiplegic (B), when the lips were relatively quiet. Each patient was asked to bring his teeth together lightly followed by the request to bite hard. For the normal individual no differences in function could be detected between the right and left halves of the orbicularis oris muscle. The lips were relatively inactive during this sequence of commands and practically no muscle activity could be detected when the lips were at rest.

The electromyogram of the spastic individual also showed little or no muscle activity when the lips were at rest.

It was not possible to detect a difference in function between the right and left side of the lips when they were at rest; although the electromyogram of the spastic individual generally showed greater activity than did the record of the normal individual.
Figure 7. The electromyograms of a normal individual (A), and a spastic left hemiplegic (B), are presented following the commands (1) relax, (2) teeth together, and (3) bite hard. The muscle examined was the orbicularis oris. There was little or no muscle activity detectable in either individual. Some baseline instability is noted in the record of B.
(A) Normal

Right upper lip

rest teeth together  bite hard

time signal line
25 mm = 1 second

Left upper lip

Right lower lip

Left lower lip

100 mv* = 1 centimeter  (*) = microvolt
(B) Left spastic hemiplegic

Right upper lip

rest teeth together bite hard

Time signal line
25 mm = 1 second

Left upper lip

Right lower lip

Left lower lip

100 mV* = 1 centimeter (*) = microvolt
Figure 8 records a voluntary swallow in a normal individual and a left spastic hemiplegic individual. Examination of the electromyogram of the normal individual revealed somewhat greater muscle activity in the lower lip but the activity was equally great on the right and left sides of the orbicularis oris muscle. For the spastic individual, however, greater muscle activity was recorded in the area of the left upper lip and the left lower lip; which corresponded with the side of involvement of the individual who was a left spastic hemiplegic.
Figure 8. An electromyographic record of activity in the orbicularis oris muscle during a voluntary swallow is shown for a normal individual (A), and for a left spastic hemiplegic (B). The muscle activity of A is fairly equal and symmetrical in the upper lip and also in the lower lip. However, in B, there is increased activity in the upper left lip and in the lower left lip.
(A) Normal Voluntary swallow

Right upper lip

Time signal line
25 mm = 1 second

Left upper lip

Right lower lip

Left lower lip

(B) Left spastic Hemiplegic Voluntary swallow

Right upper lip

Time signal line
25 mm = 1 second

Left upper lip

Right lower lip

Left lower lip

100 mv* = 1 centimeter

(*) = microvolt
The third activity studied was that of involuntary swallowing as each individual drank water through a straw. The electromyographic record of this activity of the orbicularis oris is shown in Figure 9, where a sample record of a normal individual and a left spastic hemiplegic are presented. There was little or no difference in function between the right and left halves of the orbicularis oris muscle in the normal individual. The degree of activity appeared to be about the same for the upper and lower lip.

The electromyogram of the left spastic hemiplegic showed evidence of greater muscle activity on the left side of the orbicularis oris muscle in both the upper and lower lip. There also appeared to be greater activity in the upper lip than in the lower lip during this procedure.
Figure 9. Involuntary swallowing during straw drinking of water is shown electromyographically for a normal individual (A), and a left spastic hemiplegic (B). The muscle studied was the orbicularis oris. In A, the muscle activity of the right and left upper is about equal — and it is also about equal in the right and left lower lip. There is increased activity in the orbicularis oris in both the left upper lip and left lower lip.
(A) Normal Inv oluntary swallow

Right upper lip

Time signal line
25 mm = 1 second

Left upper lip

Right lower lip

Left lower lip
100 mv* = 1 centimeter
(*) = microvolt

(B) Left spastic hemiplegic

Right upper lip

Time signal line
25 mm = 1 second

Left upper lip

Right lower lip

Left lower lip
100 mv* = 1 centimeter
(*) = microvolt
The fourth activity studied is represented in Figure 10

in which electrical activity in the orbicularis oris muscle

was recorded electromyographically when the lips were held
together on command. There appeared to be no difference in

function between the right and left halves of the orbicularis
oris muscle in the electromyogram of the normal individual —

although greater activity was observed in the lower lip than

in the upper lip in bringing the lips together. There was a

marked difference in the greater muscle activity record in

the left upper lip and left lower lip of the orbicularis oris

muscle.
Figure 10. Voluntary activity in the orbicularis oris muscle was recorded when the lips were held together voluntarily and is shown in the electromyogram of a normal individual (A), and a left spastic hemiplegic (B). There is increased muscle activity in the left half of the orbicularis oris of B — but there is little or no difference in activity between the right and left half of the orbicularis oris of A.
The Figures 7, 8, 9, and 10 have included sample records of three normal individuals and three spastic hemiplegic individuals with involvement in the left half of the body. Those spastic individuals who were included in the study and were right hemiplegics showed evidence of greater muscle activity in the right half of the orbicularis oris muscle in both the upper and lower lips. When the lips were at rest, little or no activity could be detected.

The electrical activity of the orbicularis oris muscle for all individuals included in the study is presented in table form to show differences in muscle activity when the lips are at rest, during voluntary swallowing, involuntary swallowing during straw-drinking and activity when the lips are together. They are:

Table II. Lips at rest.

Table III. Voluntary swallowing.

Table IV. Involuntary swallow during straw drinking.

Table V. Lips together.

The spastic individuals included in this study were examined neurologically at the Cerebral Palsy Clinic and it was not possible to detect any asymmetry in function of the orbicularis oris clinically.
Table II. The muscle activity of the orbicularis oris when the lips were at rest is presented to show areas of greater or lesser electrical activity as recorded on the electromyogram of each individual included in the study.
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<tr>
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</table>

(x) Similar electrical activity
(+) Greater electrical activity
(-) Lesser electrical activity
Table III. The muscle activity of the orbicularis oris when the lips were engaged in voluntary swallowing on command is presented to show areas of greater or lesser electrical activity as recorded on the electromyogram of each individual included in the study.
Table III.

Group #1 - Control

<table>
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<th>Name</th>
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Group #2 - Cerebral Palsied Spastic Hemiplegics

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(x) Similar electrical activity  
(+ ) Greater electrical activity  
(- ) Lesser electrical activity
Table IV. The muscle activity of the orbicularis oris when the lips were engaged in straw drinking of water accompanied by involuntary swallowing is presented to show areas of greater or lesser electrical activity as recorded on the electromyogram of each individual included in the study.
**Table IV.**

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### Group #2 - Cerebral Palsied Spastic Hemiplegics

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(x) Similar electrical activity

(+) Greater electrical activity

(-) Lesser electrical activity
Table V. The muscle activity of the orbicularis oris when the lips are held together on command is presented to show areas of greater or lesser electrical activity as recorded on the electromyogram of each individual included in the study.
### Table V.

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**Group #2 - Cerebral Palsied Spastic Hemiplegics**

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<td>+</td>
<td>-</td>
<td>+ -</td>
</tr>
<tr>
<td>Herman Russell</td>
<td>+</td>
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<tr>
<td>William Stantley</td>
<td>+</td>
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(x) Similar electrical activity
(+ ) Greater electrical activity
(- ) Lesser electrical activity
DISCUSSION
DISCUSSION

The control group of normal individual showed little or no
difference in the electrical activity between the right and left
half of the orbicularis oris muscle either at rest or when the
lips were called upon to perform voluntary or involuntary func-
tions. This was true for the spastic group only when the lips
were at rest or not in use. When the orbicularis oris was en-
gaged in either voluntary or involuntary swallowing, there was
increased electrical activity in that half of the muscle which
corresponded with that involved side of the body. For right
spastic hemiplegics the right upper and lower lips were more ac-
tive than the left half of the lips; and for the left spastic
hemiplegics there was increased electrical activity in the left
half of the orbicularis oris. One may account for the increase
in activity in observing that an increased number of motor units
were called upon to perform the same amount of work as the non-
involved side.

Further study is needed in this area of muscular imbalance
of forces affecting the teeth since spastic cerebral palsied in-
dividuals may be involved in all four extremities, only the lower
extremities, or just in the upper half of the body. There are
many combinations of involvement that occur in spastic individuals.
To further complicate the problems, other types of cerebral palsy
may accompany spasticity - including athetosis which is associ-
ated with purposeless involuntary movement. Other types of cere-
bral palsy, namely tremor, rigidity, ataxia, or mixture of the
five types may occur in any one individual. Therefore, the problem is complicated and bears continuous study.
SUMMARY
The orbicularis oris muscle was examined electromyographically to determine any differences in muscle activity on the right and left side of the face. Included in the study were a group of seven cerebral palsied patients with spastic hemiplegia and a control group of seven non-cerebral palsied individuals. All fourteen subjects had Class I occlusion.

A six channel Polygraph Grass Model 5A was used in the study. Paired surface electrodes were placed over each quadrant of the orbicularis oris and electrodes were connected to four channels of the Polygraph. The paper speed was 25 millimeters per second and the gain of the amplifiers was calibrated at 100 microvolts per centimeter. The patients were requested to execute a series of commands which would necessitate voluntary and involuntary activity of the orbicularis oris. The commands involved: swallowing, holding the lips together, straw drinking, and others.

The results of the study demonstrated that in normal individuals the orbicularis oris functions symmetrically. However, in cerebral palsied spastic hemiplegics there is increased muscle activity in the orbicularis oris on the hemiplegic side. One may conclude from this finding that an imbalance of forces is present in the spastic individual acting on the dental arches of the spastic individual. Perhaps early bracing of primary teeth is indicated in these individuals to prevent serious malocclusions at a later age. Further study is needed in other areas of cerebral palsy to correlate the findings of the present study with such problems as tongue thrust and abnormal swallowing patterns.
CONCLUSIONS
CONCLUSIONS

One may conclude from the findings in this study:

1. In normal individuals the muscle activity of the orbicularis oris is very nearly equal and symmetrical during any given function involving the right and left half of the muscle.

2. When the orbicularis oris muscle is at rest and not in use in normal individuals little or no electrical activity is detectable.

3. Among spastic cerebral palsy hemiplegic individuals there is increased electrical activity in that half of the orbicularis oris muscle corresponding with the hemiplegic side of the individual during any given function involving the right and left half of the muscle.

4. When the orbicularis oris muscle is at rest and not in use among spastic cerebral palsy hemiplegic individuals little or no electrical activity is detectable and there is no asymmetry in activity. However, there may be some instability of the base line.
REFERENCES
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BIBLIOGRAPHY


Robert R. Buckley

Born in Washington, Pennsylvania, September 20, 1925.

Graduated West High School, Akron, Ohio 1943.

Graduated Akron University, Akron, Ohio B.S. 1949.

Graduated Butler University, Indianapolis, Ind. M.S. 1951.


Indiana University School of Dentistry, Graduate School 1957-1961.

PROFESSIONAL ORGANIZATIONS

Indianapolis District Dental Society

Indiana State Dental Society

American Dental Association

American Society of Dentistry for Children

Indiana State Society of Pedodontics

American Academy of Cerebral Palsy

American Academy of Dentistry for Handicapped
ABSTRACT

The orbicularis oris muscle of fourteen individuals including seven cerebral palsied spastic hemiplegics and seven normal individuals with Class I occlusion was examined electromyographically to determine any differences in muscle activity on the right and left side of the lips. The age range was between eight years and seventeen years. No limitations were placed on age, sex, or race since the purpose of the study was to determine any differences in activity between the right and left sides of the orbicularis oris muscle.

A six channel Polygraph Grass Model 5A was used with paired surface electrodes attached to each quadrant of the lips and connected to four channels of the Polygraph. When the lips were at rest, no muscle activity was detected for either group. When the lips were tested during voluntary swallowing, involuntary swallowing associated with straw drinking and holding the lips together, the activity was fairly equal and symmetrical in the normal group. However, in the cerebral palsied spastic hemiplegics, there was increased muscle activity in the orbicularis oris muscle on the hemiplegic side.