DEVELOPMENT OF AN INTRAORAL DEVICE FOR FACIAL MUSCLE RETRAINING AND ITS CLINICAL APPLICATION

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ABSTRACT

The aim of this work was to develop a facial neuromuscular retraining technique for cases of facial palsy, involving an easy-to use intraoral device that allows correcting abnormal neuromuscular patterns and improving esthetics.

Facial palsy is a motor alteration of multiple origin that results in facial asymmetry. Treatment remains controversial to date and includes, surgical anastomosis and decompressive and plastic surgery, corticosteroids therapy, injection of botulinum toxin, and administration of other medicinal drugs. Physical therapy involving electrical stimulation and feedback are also used to retrain facial muscles.

A removable thermopolymerized acrylic intraoral device with wrought wire clasps was developed and constructed.

The device was used on a patient with facial palsy who was instructed to wear it 4 times a day during 20 minutes and perform exercises in front of the mirror, trying to coordinate the action of the device with the smile movement on the unaffected side of the face.

Digital photographs of the patient were taken during smile movement and at rest with and without the device, and movements of the oral commissures were compared using specific software.

Results showed anatomic and nonanatomic indices of facial motion for the lower part of the face with the device to be 1.77 and 0 respectively.

The device improved facial symmetry during rest by opposing traction forces of the contralateral muscles, resulting in a better position of the filtrum during rest, and allowed the patient to exercise smile movements at home.

Key words: *facial palsy, rehabilitation, physical therapy, Bell`s palsy.*

DESARROLLO DE APARATOLOGÍA INTRAORAL PARA REENTRENAMIENTO DE LA MUSCULATURA FACIAL Y SU APLICACIÓN A UN CASO CLÍNICO

RESUMEN

El objetivo de este trabajo fue desarrollar una técnica de reeducación de la musculatura facial lesionada en cuadros de parálisis facial, por medio de una aparatología intraoral de sencilla manipulación para el paciente, que permita corregir patrones neuromusculares incorrectos y mejore la estética.

La parálisis facial es una alteración motora de múltiple etiología que resulta en una asimetría facial. Sus tratamientos actuales en constante discusión incluyen, cirugías de anastomosis, descompresivas y estéticas; terapia con corticoesteroides, toxina botulínica y otros medicamentos. Además se aplican terapias físicas con electroestimulación y feedback para reestrenar la musculatura facial.

Se diseñó y confeccionó un aparato intraoral removible de acrílico de termopolimerización y retenedores de alambre forjado según técnica de laboratorio convencional.

Se aplicó a un caso clínico de parálisis facial instalando el sistema e indicando el uso diario, 4 veces al día, realizando ejercicios frente al espejo durante 20 minutos cada vez, tratando de coordinar la acción del aparato con la sonrisa del lado sano.

Se tomaron fotografías digitales de la paciente en reposo y sonrisa con el sistema puesto y sin el sistema y se compararon los movimientos comisurales con software.

Se observó que el índice de movimiento anatómico para la porción inferior de la cara fue de 1,77 y el índice de movimiento no anatómico para la porción inferior de la cara fue de 0 (con el sistema instalado).

El dispositivo utilizado mejoró la asimetría facial en reposo oponiéndose a la tracción de los músculos contralaterales logrando una mejor ubicación del filtrum en reposo, permitiendo que el paciente practique en su casa movimientos simulatorios de una sonrisa.

Palabras clave: *parálisis facial, rehabilitación, terapia física, parálisis de Bell.*

INTRODUCTION

Facial palsy is a motor nerve alteration of multiple origin that results in different degrees of facial asymmetry depending on the history and severity of the lesion. The anatomic site of the motor nerve lesion allows differentiating central or supranuclear, nuclear, and peripheral or intranuclear facial palsy. The course varies widely ranging from almost total recovery to complete permanent lack of movement on the affected hemiface. Facial palsy is described in the American Medical Association Guides to the Evaluation of Permanent Impairment (1).

Facial palsy interferes with communication and development and therefore has great psychosocial impact (2, 3).

Both the lack of movement and nonphysiologic and physiologic motion have been used to evaluate the severity of facial palsy (4). Physiologic (anatomic) and nonphysiologic (nonanatomic) motion is determined by the direction of movement of one area in relation to the orientation of the muscle or group of muscles that produce the movement. For example, an upward and backward movement of the oral commissures is caused by the greater zygomatic and Santorini's muscles. Thus, if an imaginary point on the lip commissure follows the direction of these muscles the resulting motion is anatomic, whereas if it doesn't the resulting motion is nonanatomic.

Treatment strategies remain controversial to date and comprise two approaches: surgical and non-surgical. Surgical therapy includes anastomosis, nerve decompression and plastic surgery and is indicated in cases of non-inflammatory complete paralysis caused by traumatic or surgical severing of the nerve (5).

Nonsurgical treatment includes administration of corticosteroids because of their strong anti-inflammatory effect (this therapy is not widely accepted in pediatrics). Therapy combining corticosteroids and acyclovir is under study due to their potentially synergistic effect, but it is still not widely accepted. Gangliosides are currently being analyzed on account of their anti-inflammatory and neuroreparative effect. Botulinum toxin is recommended for spasm and postparalysis synkinesis (6). The use of acupuncture for motor recovery is also being evaluated (7). The use of electrical stimulation in facial palsy rehabilitation is controversial, but it is applied in postparalysis synkinesis to send information to the central nervous system. Visual and auditive feedback has also been used to correct muscular patterns (8).

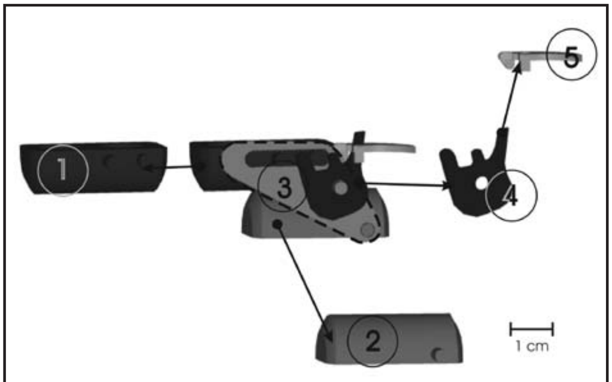

Fig. 1: Assembled device (middle) and each splint / plate separately. 1- Upper anchor splint; 2- Lower anchor splint; 3- Inner sliding plate; 4- Outer sliding plate; 5- Commissure wing.

The aim of this study is to present a facial muscle retraining technique involving an easy-to-handle intraoral device, used on a patient with facial palsy.

MATERIALS AND METHODS

A removable intraoral device for facial neuromuscular retraining was designed for a patient presenting Grade VI facial palsy on the House-Brackman scale.

Front and side view photographs of the patient were taken in resting position and maximum smile in order to study smiling movement. Location of the unaffected oral commissure in relation to the teeth was determined in both positions (as reference for the technician). Finally, plaster casts were made (showing landmarks indicating commissure position) and registrations were performed to mount casts on a semi-adjustable articulator.

The device is made of thermopolymerized acrylic using wax models and following conventional dental laboratory techniques. It has two anchor splints and two sliding plates that constitute the primary mechanism, and a commissure wing, which together with the outer sliding plate, forms the secondary mechanism.

ANCHOR SPLINTS

Two removable thermopolymerized acrylic splints serve as anchor splints: an upper splint extending from tooth 1.4 to tooth 1.7, and a lower splint from tooth 4.4 to tooth 4.7. The splints have 2 wrought wire clasps and an occlusal surface to ensure retention and allow the maxillae to move freely.

The upper splint (US) (Fig.1) has two 1cm long acrylic projections perpendicular to the center of the vestibular aspect of teeth 1.4 and 1.5 respectively. The projections are approximately 4 mm in diameter so as to provide them with sufficient tensile strength to endure mild tension forces.

The lower splint (LS) has only one similar projection at the level of tooth 4.4 (Fig. 2).

The splints provide the system with anchorage, and are designed to allow the full range of mandibular

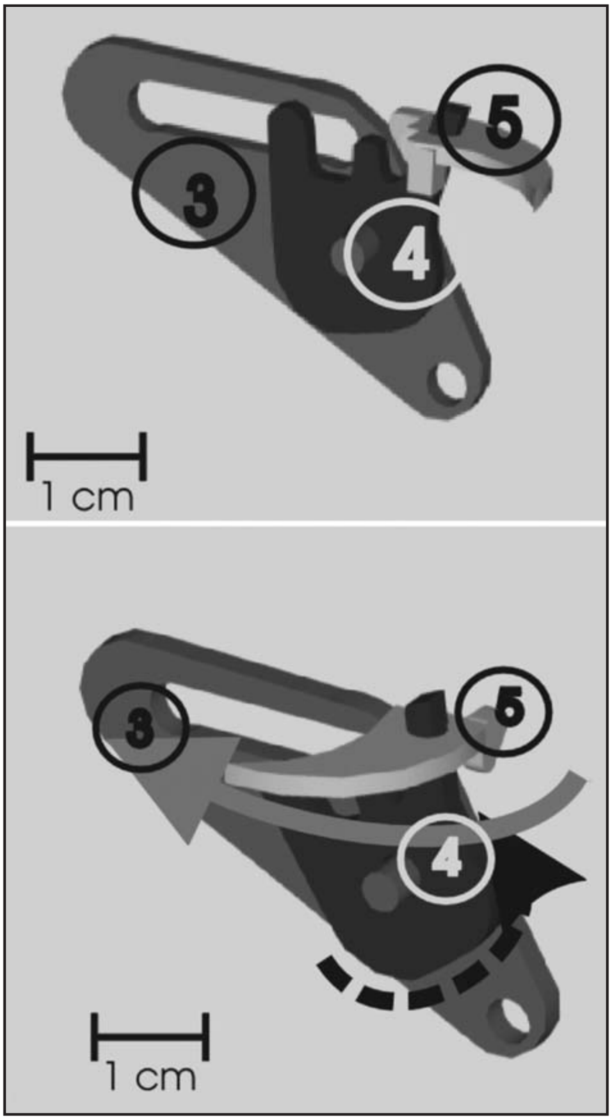

Fig. 2: Inner (3) and Outer (4) sliding plates and Commissure wing (5). Primary mechanism (dotted arrow); secondary mechanism (full line arrow). Top: in resting position. Bottom: during movement.

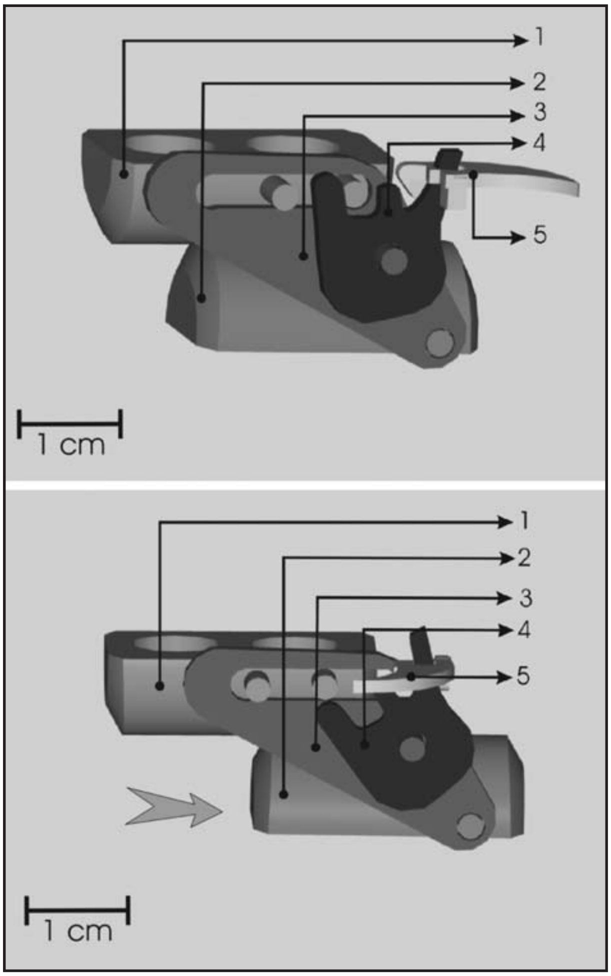

Fig. 3: 1- Upper anchor splint; 2- Lower anchor splint; 3- Inner sliding plate; 4-Outer sliding plate;; 5- Commissure wing. Top: in resting position. Bottom: during movement.

movements (opening, protrusion, laterotrusion). Both splints have an occlusal surface in order to facilitate protrusive movement of the mandible.

SLIDING PLATES AND MECHANISMS

The primary mechanism consists of another two 2 mm thick thermopolymerized acrylic plates that we have termed Sliding Plates. They are placed between the cheek and the vestibular aspect of the teeth (sagittal plane). The one closest to the teeth is the Inner Sliding Plate (ISP) (Fig. 3). It has a slot running lengthwise below its upper edge, through which the projections of the upper anchor splint are inserted allowing for anteroposterior movement, and a projection in the center that functions as the rotation axis of the primary mechanism. The Outer Sliding Plate (OSP) (Fig. 4) is placed adjacent to the ISP. It has a hole in the middle into which the projection of the ISP is inserted when the device is assembled. It has two projecting ends at the top between which the US projections are placed, functioning as the teeth of a gear mechanism, and an anterior projecting end that functions as the rotation axis of the secondary mechanism.

The last plate of the device is the oral Commissure Wing (CW) (Fig. 5); it is the only part of the system that goes outside the mouth to enable traction of the commissure.

The wing has a hole into which the anterior projecting end of the OSP is fitted; the most anterior part must exert traction forces on the commissure when

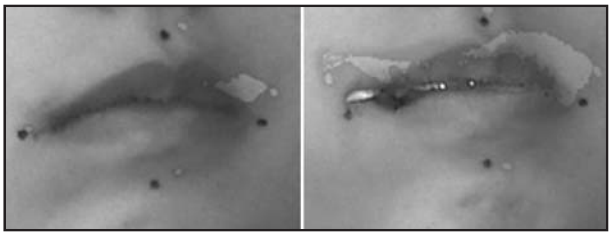

Fig. 4: Photographs of the patient. Black dots show points in resting position. White dots show points during smile movement. Left: without the device. Right: with the device.

Fig. 5: Resting position without the device (left) and with the device (right). Note the change in symmetry.

Fig. 6: 1- Smile without the device (left) and with the device (right).

the patient activates the system and must mimic the unaffected commissure as closely as possible during rest.

Thus, when the patient moves the mandible forward all the components, except the US, move forward together with the mandible, activating the primary rotation mechanism (sagittal plane) due to the action of the projecting ends of the OSP between the US projections. Simultaneously, this movement causes the CW to come in contact with the anterior edge of the ISP thus activating the secondary mechanism, which rotates on a horizontal plane.

Temporary stoppers were used throughout the entire test period so as to evaluate the functioning of the device and perform necessary adjustments prior to final assembly.

Clinical Application

The device was first used on a female patient aged 18 years with a 2 year and 8 month history of facial palsy due to trauma to the skull and brain and cerebral edema following a car accident.

Electromyographic Recordings

Electromyography of the orbicularis oculi, frontal muscle, and orbicularis oris showed lack of electrical activity. Facial nerve function was Grade VI on the House Brackman scale, and anatomic and nonanatomic indices of facial motion for the lower part of the face were 0 and 0.34 respectively.

The patient and her mother were informed about the study and both gave their written consent.

The device was placed and the patient was instructed to use it 4 times a day and perform exercises in front of a mirror during 20 minutes each time, trying to coordinate the action of the device with the smile movement on her normal side.

Evaluation Methods

In order to quantitatively assess results the studied points were marked on the patient's skin using a felt marker, and a 2 cm x1 cm reference scale served to calibrate the measurements. Three-mega pixel resolution photographs were taken using a digital camera placed on a tripod; the zoom was not modified during the sessions. The images were stacked using conventional image processing software in order to measure movement of each point. Anatomic and nonanatomic Indices of facial motion (4) were first determined without the device and then with the device (9). The determinations were repeated three times and the average was calculated and expressed in centimeters.

RESULTS

The movements recorded while wearing the device are shown in Table 1.

The anatomic index of facial motion represents the ratio of the sum of vector magnitudes on the affected side to the corresponding sum on the unaffected side.

TABLE 1. Results obtained with the device (expressed in cm)			
	Horizontal Movement	Vertical Movement	Distance
Right Commissure	1.12	0.68	0.79
Filtrum	0.18	0.26	0.32
Chin	0.49	0.10	0.50
Left Commissure	0.48	0.57	0.70

TABLE 2. Results obtained without the device (expressed in cm)			
	Horizontal Movement	Vertical Movement	Distance
Right Commissure	0.20	0.12	0.24
Filtrum	0.39	0.15	0.42
Chin	0.28	0.59	0.66
Left Commissure	0.50	0.25	0.56

Anatomic Index of facial motion:
Sum of vector magnitudes of anatomic motions on affected side / Sum of vector magnitudes of anatomic motions on unaffected side.
The sum of nonanatomic motions on the affected side equals zero.

Nonanatomic Index of facial motion:
Sum of Vector magnitudes of Nonanatomic motions on affected side / Sum of Vector magnitudes of anatomic movements on unaffected side.
The sum of anatomic motions on the affected side equals zero.

Vector = $\sqrt{x^2+y^2}$

The anatomic index of facial motion of the lower part of the face was 1.77, and the nonanatomic index of facial motion of the lower part of the face was 0, when using the device.
Table 2 shows movement of the four studied points during smile movement without the device.

DISCUSSION

The device used on this patient allowed exercising bilateral smile movements at home in addition to improving facial symmetry at rest, by opposing traction of contralateral muscles and consequently improving the position of the filtrum at rest. In the present case, the distance covered by the filtrum was similar with and without the device. However, movement was predominantly vertical when using the device and predominantly horizontal when smile movement was performed without it. As regards the oral commissures, use of the device prevented nonanatomic movement and allowed achieving anatomic movement of the right commissure (affected side) and did not hinder movement of the left commissure (unaffected side). The system offers mechanical opposition to the traction of the muscles on the opposite side as well as to gravity, so that muscle length is maintained and contraction force is adequate (10, 11).
It would seem that home exercise provides proprioceptive feedback to the cerebellum and somatosensorial cortex of the brain, and allows movement control associations with the adjacent primary motor cortex to be established and reinforced (12, 13, 14). Thus, neuroplasticity allows achieving some degree of recovery and correcting pathologic motor patterns (synkinesis). Detection of muscle afferent inputs generated by passive movement of the fingers has been reported (15).
The sensorimotor theory posits that recovery of movement includes re-learning how to initiate muscle activity during voluntary movements as well as knowing that the paralyzed limb is moving. Prognosis of the case presented here was bad since the patient had peripheral facial palsy and all electromyographic recordings indicated total denervation with no signs of re-inervation.
The observation time points used in this study are too short to detect neuromuscular changes. Nevertheless, we believe that home exercise and mechanical opposition to forces that tend to stretch the muscle excessively might contribute to avoiding facial deformity.
Bajaj-Luthra et al (4) found that anatomic and non-anatomic indices of facial motion tended to

1 and 0 respectively in healthy individuals as opposed to patients presenting facial palsy, who additionally showed a decrease in non-anatomic and an increase in anatomic indices of facial motion as recovery advanced. The present study only evaluated the smile movement and included only four points. The effectiveness of the device used on this patient must be further evaluated over longer time periods and on a larger number of cases. Nevertheless we consider that this device may contribute to physical rehabilitation therapy in cases of facial palsy or serve to complement other therapies that are currently being used.

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