J. Phys. Ther. Sci.
25: 515–519, 2013

Review

Evaluation and Grading Systems of Facial Paralysis for Facial Rehabilitation

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Abstract. [Purpose] We investigated the availability of facial grading systems for the evaluation of facial nerve functions including both of traditional and computer-based approaches. An accurate and reliable studies on facial grading systems is needed for constructing a standard system, which is desired by the medical professions all over the world, for evaluating how much the patients suffering from facial paralysis. [Methods] We searched for articles related to facial grading systems using online databases such as Pub Med, Elsevier, IEEE, Springer, and the ACM digital library. Studies selected to be include were based on following criteria: a) in English language; b) published from 1955 to 2012; and c) considered both bilateral and unilateral facial palsy resulting from any causes. [Results] Thirty-two articles were identified in the search, and we present an overview and explanations of various traditional and computer-based methods for accessing facial nerve function for facial rehabilitation. [Conclusion] Studies of facial grading systems cannot be compared easily as facial grading systems have their own advantages and disadvantages. We expect that this review will provide the clinicians and researchers a brief overview of the facial grading systems which have been used and assist in the development of a standard one.
Key words: Facial paralysis, Facial rehabilitation, Facial grading system

(This article was submitted Sep. 24, 2012, and was accepted Nov. 20, 2012)

INTRODUCTION

Individuals with facial paralysis not only suffer from asymmetry of their face, but also have difficulty in performing activities such as eating, drinking, and are unable to pronounce specific words or sounds. They will have impaired physical function and psychosocial distress related to their physical appearances[1)]. Some possible causes of facial paralysis are birth, trauma, neurologic syndromes, infection and idiopathic causes[2)].

Rehabilitation is necessary for patients to regain their normal lives in the social, educational, and occupational life. It will leads to the improvement of relationships with family and the community by reducing stress, educational failure, and antisocial behavior. In facial rehabilitation, it is the most important part is to know how much a patient suffers from facial paralysis, and a comprehensive standard measurement of the degree of facial paralysis is required. A standard grading system has not yet been developed, even though it is very important for medical professionals in rehabilitation to measure the level of paralysis accurately. They also need to define its severity, following the progression of patients and compare the results of interventions. Secondary defects such as synkinesis, contracture, and hemi-facial spasm, which may affect facial appearances and function variably, is also need to be considered in facial assessment[3)].

Little is known about various grading systems which have been used to evaluate facial nerve function. Both approaches required the patient to perform some activities such as puckering, closing the eyes, and showing the teeth. In traditional approaches, subjective judgments are being made by clinicians with reference to medical indexing systems whereas the computer-based approaches are objectively assess the facial measurement by using image processing and classification methods.

METHODS

A thorough search of articles was carried out using online databases such as PubMed, Elsevier, IEEE, Springer, and the ACM digital and some keywords related to facial paralysis and facial grading systems. Studies selected for this review fulfilled the following criteria: a) in English language; b) published between 1955 and 2012; and c) consideration of bilateral and unilateral facial palsy resulting from any causes. Thirty-two articles were identified and a review was conducted of those articles. Figure 1 shows the details of the articles selection procedure for this review paper.

RESULTS

In 1955, the first traditional grading system was introduced by Botman and Jongkees[4)]. It was a simple five-category scale for evaluating the degree of facial paralysis, which ranging from 0 (normal) to IV (total paralysis). A

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secondary defect contracture is considered to be total paralysis.

House and Brackmann[5], however, considered this inappropriate since they believed there is no development of secondary defects in total paralysis. House has reviewed the existing grading systems and divided them into three categories: gross, regional and specific. Gross category is descriptive, and attempts to classify patients in a simple and practical way, but does not give the specific details on the patient's facial function[6]. Examples of gross grading systems are those of Botman and Jongkees[4], and Peitersen[7]. Regional category grading systems considers the different areas of facial nerve function separately, and then adds these scores for a final score. Examples of grading systems in this category are those of Lewis and Adour-Swanson[8], and Yanagihara[9] grading system. Specific category grading systems focused more on specific items of various functions of facial nerves, by using 'yes' or 'no' questionnaires and includes secondary defects.

The House-Brackmann (HB) grading system[10] proposed in 1983 has been adopted as the North America Standard for the evaluating on of facial paralysis. It was modified by the addition of the measurements determining by measuring the upwards (superior) movement of the mid-portion of the top of the eyebrow and the outwards (lateral) movement of the angle of mouth. It assesses the five facial expressions[11]. The assigning of grading of paralysis which has been ranges from grade I (normal) to grade IV (no movement) based on clinical observation and subjective judgement, is made. In 2002, Peitersen has modified the HB system to produce the Peitersen Grading System[3] as shown in (Table 1).

The HB system in 1985 is summarized in Table 2. It has been recognized as the universal standard for grading facial paralysis by the Facial Nerve Disorders Committee of the American Academy of Otolaryngology-Head and Neck-Surgery (AAO-HNS). Clinicians were encouraged to convert their existing grading system to the HB system when reporting their results[3]. However, the HB system has failed to gain worldwide acceptance. It has been criticized for being not having sufficient in sensitivity to document clinically significant changes[12 13]. HB system offers some a single-figure description of facial function, and it is easy to use. Many of the current grading systems of facial paralysis have used the HB system as their reference in presenting their works[14–18].

In 1986, an objective method was proposed by Burres and Fisch for measuring the distances between specific facial landmarks at rest and five standard expressions. It has compares the affected side of the face with the normal side by using photographs and still video images[19]. It analyses the symmetry and global function of the face in an objective and quantitative form[20], and has the advantage of eliminating observer bias and subjectivity. It uses a 100-point scale, with higher scores indicating less impairment and handicap[20]. One advantage of the Burres-Fisch system over the HB system is the latter allows finer distinction of functions because LMI is a continuous graded scale. However, the Burres-Fisch method is a time-consuming and an arduous

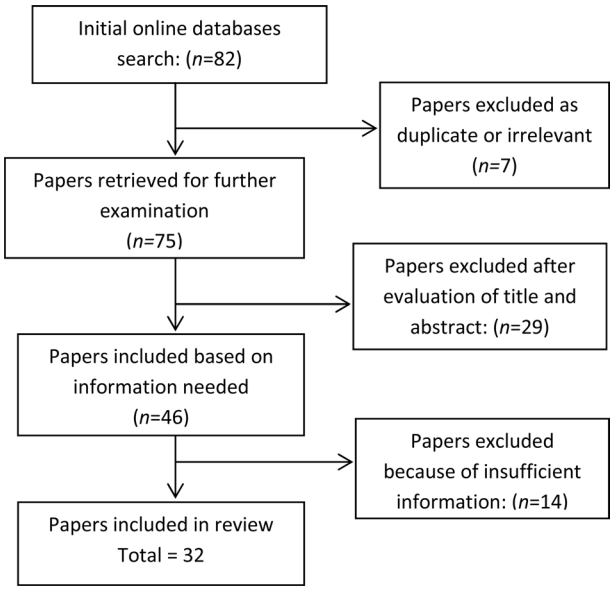

Fig. 1. Illustration of studies selected

Table 1. Peitersen grading system

Grade	Degree of Palsy	Description of palsy
0	None	Normal function
I	Slight	Only visible when patient grimaces
II	Moderate	Visible with small facial movements
III	Severe	Function just visible
IV	Complete	No function

Table 2. House-Brackmann grading system (summarised)

Grade	Descriptions	Characteristics
I	Normal	Normal facial function in all areas
II	Slight Dysfunction	Slight weakness on close inspection, very slight synkinesis, complete eye closure with minimal effort, slight mouth asymmetry
III	Moderate Dysfunction	Obvious, but not disfiguring difference between the sides, noticeable but not severe synkinesis, contracture, hemi-facial spasm, complete eye closure with maximum effort
IV	Moderate Severe Dysfunction	Obvious weakness and/ or disfiguring asymmetry, incomplete eye closure, asymmetric mouth with maximum effort
V	Severe dysfunction	Only barely perceptible motion, incomplete eye closure, slight mouth movement
VI	Total paralysis	No movement

process, which takes approximately 20 minutes and it is not suitable to be used as a practical tool for busy clinicians. It is not user-friendly and it is difficult to estimate the degree of dysfunction of facial function in severe paralysis and mild paralysis[13]. Secondary defects cannot be measured and this method lacks the ability to make simultaneous recordings in different facial regions.

Nottingham grading system[13] has simplified the Burres-Fisch method which is summarized in Table 3. It measures the movements of four points of three facial expressions. Some claimed this system offers a more objective, practical[21], and unbiased assessment, and recommended it as an accurate objective system for rapid assessment of facial nerve function in clinical practice[13]. However, the Nottingham system does not take into account the possible normal variance in facial expressions between halves of the face. Besides, it cannot used to assess on bilateral facial paralysis because the system compares the affected side with the unaffected side[21].

In Japan, the Yanagihara grading system as summarized in Table 4, is widely used for evaluating facial nerve function[22]. It is unweighted and does not take into account the secondary effects. A doctor has awards the scores to 10 different facial expressions performed by patients. Each expression is subjectively evaluated by a doctor on a four-point scale. The maximum total score is 40. The total score indicates the severity of patients. A score, which ranges from 0 to 8, indicates as complete paralysis and a score ranging from 36 to 40 is considered as normal[17]. Although the Yanagihara system is a powerful diagnostic method, the score is strongly dependent on doctors' subjective evaluation and is consequently considered less accurate.

The Sunnybrook (Toronto) Facial Grading System (SFGS) is viewed has having advantages ahead compared to the other assessments in clinical use. As shown in (Table 5), it measures three components, which consist of resting asymmetry (0 to 4; 4 is the most asymmetrical), symmetry of voluntary movement (scored from 0 to 5; 5 is the most symmetrical) and synkinesis (0 to 3; 3 is the worst). A perfect score of 100 points represents normal facial symmetry[17]. The Sunnybrook system is found to be easy and quick, and can be used as an alternative to the other existing grading systems by adding objective measurements and additional defects[23].

The Stennert-Limberg-Frentrup Scale (SLFS) is generally utilized in German medical practice[24], and the scores for paralysis and secondary defects are separated. The paralysis scores is obtained by summing scores of the normal side in resting tone in four regions of face with scores of six motility assessments during voluntary movements. A score of 0 is awarded for similarity with the normal side, and a score of 1 is awarded for significantly worse than the normal side.

Recently, several computer-based methods have been proposed for assessing facial paralysis, since providing the clinicians with an objective and quantitative measurement of paralysis is very important. For example, the maximum static response array (MSRA) assesses facial expressions by measuring the displacement from a standard model. This method measures the amplitude of standard facial movements by comparing the facial photos taken at rest and at maximum contraction. MSRA method is labour-intensive, time-consuming, and subject to inter-observer error because it needs the placement of markers and identification of marker's position[25].

Some researchers used 3D expression models[26], but some consider that 2D information is more than sufficient for facial expressions. Other researchers are concentrating on processing methods of images or video databases[27]. Some methods use the placement of markers in computer systems. By means of image processing, only marked places on the face are extracted, and then movement of these marks is quantitatively analyzed[28].

Some researchers have concentrated on tracking or measuring some parts of face such as the mouth, lips and eyes. For example, an automated face image analysis (AFIA) system has been proposed to track the movement of the lips. This system provides automated head stabilization generating stabilized face images for tracking. AFIA was originally created to detect, extract, and recognize emotion and paralinguistic expressions and it has been used in clinical studies to differentiate subtle changes in facial movement after interventions[29].

Table 3. Nottingham grading system

PART I :	Right	Left
Calculations from reference points		
Raise eyebrows: measure distance SO-IO		
Close eyes tightly measure distance SO-IO		
Smile: measure distance LC-M		
Sum		
$X/Y \times 100 = \%$	$= X$	$= Y$
PART II :		
Hemifacial spasm	Absent	Present
Contractures	Absent	Present
Synkinesis	Absent	Present
PART III :		
Does your eye water when you eat?	No	Yes
Is your eye drier than before?	No	Yes
Have you noticed a change in taste?	No	Yes

Table 4. Yanagihara grading system

	Scale of five rating				
1 At rest	0	1	2	3	4
2 Wrinkle forehead	0	1	2	3	4
3 Close eyes normally	0	1	2	3	4
4 Close eyes forcefully	0	1	2	3	4
5 Close eyes on involved side	0	1	2	3	4
6 Wrinkle nose	0	1	2	3	4
7 Blow out cheeks	0	1	2	3	4
8 Whistle	0	1	2	3	4
9 Grin	0	1	2	3	4
10 Depress lower lip	0	1	2	3	4

Jane and Tomas[15] have implemented a House-Brackmann scoring system based on individuals' ability to perform a symmetrical smile. The lateral movement of the outer corners of the mouth is measured. By using one image as the starting point, the distance between the corners of the mouth on this image and those on each of the subsequent images are measured. The average accuracy of this method is 87%.

An assessment has been made[30] of the results of a new computerized system, the Glasgow Facial Palsy Scale[24], in comparison with the traditional methods and the objective clinical scale, Stennert-Limberg-Frentrup Scale[24]. The Glasgow scale showed promising results and its proponents claim it is an accurate method for facial paralysis assessment. This scale used Facogram, a program which represents the HB system together with regional grades within a time that is acceptable for clinical practice[31]. This system however cannot be used for bilateral facial paralysis.

An algorithm named CEM algorithm has been used to detect facial paralysis in the early stage by using mouth parameter analysis. It measures the distance values from the nose center to the mouth edges and computes the value. Then, the level of paralysis from these values is identified. This proposed system should be further investigated, because it is only being tested with normal facial conditions and provides only an estimation of the degree of paralysis[32].

DISCUSSIONS

A brief overview of facial grading systems reported in 32 articles has been presented in this article, and it is the first organized, structured, and detailed review of both traditional and computer-based approaches are presented together. Although the traditional approaches are easier to use, computer systems offered many advantages, by providing clinicians the objective and accurate grading scores for facial rehabilitation. Computer-based systems can be used at home and do not require a professional to record the data, unlike the traditional approaches. Developing cost effective, real time applications and easy-to-use computer systems for facial assessment is still an area to look into of future research since to date; no standard system has been

Table 5. Sunnybrook grading system

Eye		No movement	Slight movement	Mild excursion	Movement almost complete	Movement complete	None*	Mild*	Moderate+	Severe++
Normal Narrow Wide										
Eyelid Surgery	**Brow Lift**	1	2	3	4	5	0	1	2	3
Cheeks (naso-labial fold)	**Gentle Eyes Closure**	1	2	3	4	5	0	1	2	3
Normal Absent	**Open Mouth Smile**	1	2	3	4	5	0	1	2	3
Less pronounced More pronounced	**Snarl**	1	2	3	4	5	0	1	2	3
Mouth Normal Corner drooped Corner pulled up/out	**Lip Pucker**	1	2	3	4	5	0	1	2	3
Resting symmetry score:		Voluntary movement score:					Synkinesis score:			
Voluntary Movement x 4 – Resting Symmetry Score x 5 – Synkinesis Score x 1 = Composite Score										

proposed. More details on existing facial grading systems should be collected to construct a standard one.

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