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Three-dimensional superimposition for patients with facial palsy: an innovative method for assessing the success of facial reanimation procedures

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Abstract

Facial palsy is a severe condition that may be ameliorated by facial reanimation, but there is no consensus about how to judge its success. In this study we aimed to test a new method for assessing facial movements based on 3-dimensional analysis of the facial surfaces. Eleven patients aged between 42 and 77 years who had recently been affected by facial palsy (onset between 6 and 18 months) were treated by an operation based on triple innervation: the masseteric to temporofacial nerve branch, 30% of the hypoglossal fibres to the cervicofacial nerve branch, and the contralateral facial nerve through two cross-face sural nerve grafts. Each patient had five stereophotogrammetric scans: at rest, smiling on the healthy side (facial stimulus), biting (masseteric stimulus), moving the tongue (hypoglossal stimulus), and corner-of-the-mouth smile (Mona Lisa). Each scan was superimposed onto the facial model of the "rest" position, and the point-to-point root mean square (RMS) value was automatically calculated on both the paralysed and the healthy side, together with an index of asymmetry. One-way and two-way ANOVA tests, respectively, were applied to verify the significance of possible differences in the RMS and asymmetry index according to the type of stimulus ($p = 0.0329$) and side ($p < 0.0001$). RMS differed significantly according to side between the facial stimulus and the masseteric one on the paralysed side ($p = 0.0316$). Facial stimulus evoked the most asymmetrical movement, whereas the masseteric produced the most symmetrical expression. The method can be used for assessing facial movements after facial reanimation.

Keywords: facial palsy; facial reanimation; stereophotogrammetry; 3D-3D superimposition

Introduction

Facial palsy is a severe condition that has several causes and may be a complication or expected outcome of specific operations on the cranial base and brain.[1]

Facial paralysis greatly affects the quality of life of affected patients, both clinically and socially.[2,3] At present, surgical facial reanimation is based on providing a new neu-

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ral stimulus, and the hypoglossal and masseteric nerves are the most commonly used.[4,5] The masseteric nerve, and less so the hypoglossus, partially change their function (smiling without clenching the teeth) – so called cerebral adaptation[6] – though their original function still provides the maximal stimulus: smiling plus clenching the teeth or pushing with the tongue against lower incisors leads to a wider movement.

This type of smile is seldom spontaneous, however, as only the facial nerve can be activated by emotions.[1] Often one or more branches of the contralateral healthy facial nerve can therefore be used to evoke a "qualitative" improvement of facial expression through the "cross-face" nerve grafts.[7]

Surprisingly at present there is no method that is the "gold standard" for assessing the restored facial functions.[2] Traditional methods for verifying the improvement of facial activity are clinical classifications such as the House-Brackmann scale,[8] which is easy to use but provides only qualitative evaluations and is observer-dependent.[9,10] An attempt to introduce a world-wide assessment method is the e-FACE evaluation proposed by the Harvard facial paralysis team.[11] It is being adopted by many other teams, and has the great merit of permitting comparisons between units – the draw-back is still the lack of objectivity because it is based on observers' evaluations.

With time and the introduction of modern 3-dimensional acquisition of images and elaboration systems, procedures in the sensitive field of facial palsy have been reported, through the 3-dimensional analysis of patients' faces.[2,12,13] However, existing studies have so far analysed the facial movements almost only through the dislocation of landmarks, which has limited the evaluation to selected points. However, now the 3-dimensional analysis of faces allows research workers to make more detailed analyses (for example, through the recording and superimposition of 3-dimensional facial models and calculation of point-to-point distances between all the facial surfaces). This approach has already been reported in different types of research.[14,15]

In this study we report a new method for assessing the success of facial reanimation surgery through 3-dimensional recording and superimposition; the results may enable clinicians to develop new objective and quantitative methods useful in maxillofacial surgical practice.

Patients and methods

Data were collected for 11 subjects (mean (range) age 58 (42–77) years) who had unilateral facial palsy, in most of cases following excision of an acoustic neurinoma (Table 1). The mean (SD) time between the facial nerve being affected and the operation was 11 (3) months, while between operation and 3-dimensional analysis it was 24 months (10) months. All patients were treated between 2013 and 2016 by a single operation based on triple innervation: end-to-end masseteric to temporofacial branch neurorrhaphy, side-to-end hypoglossus to cervicofacial branch neurorrhaphy, and two cross-face sural nerve grafts (end-to-end at the proximal coaptation and end-to-side at the distal one).

Before data were collected, all patients were given a detailed description of the procedure and signed an informed consent form that had previously been approved by the ethics committee of the University of Milan Medical School in accordance with the standards of the 1964 Declaration of Helsinki. No procedure was invasive, dangerous or painful, and involved minimal discomfort.

A series of 50 reference points were marked on each face according to a set of landmarks already described elsewhere.[16,17] Each patients face was scanned five times by stereophotogrammetry (VECTRA-3D®: Canfield Scientific, Inc., Fairfield, NJ). The first scan was taken in the "rest" position, and then scans were taken during a posed "smile" that was evoked by the three functional manoeuvres recognised as stimuli for the corresponding nervous connections (smiling on the healthy side for the cross-face procedure, biting for masseteric neurorrhaphy, and pushing with the tongue against the lower incisors for hypoglossal neurorrhaphy). Finally, they were requested to produce the most natural corner-of-the-mouth smile (Mona Lisa) using all the strategies that they had learned.

Table 1
Clinical data of the 11 patients selected for the study. The preoperative House–Brackmann score was six for all patients.

Sex	Age (years)	Diagnosis	Time between lesion and operation (months)	Time between operation and 3D analysis (months)	Postoperative House–Brackmann score
Female	60	Acoustic neurinoma	14	15	2
Male	49	Acoustic neurinoma	10	14	3
Male	69	Acoustic neurinoma	13	43	3
Female	52	Acoustic neurinoma	13	29	2
Male	59	Acoustic neurinoma	6	22	2
Male	77	Acoustic neurinoma	8	23	2
Female	53	Car accident	18	13	3
Female	43	Acoustic neurinoma	10	19	2
Female	68	Acoustic neurinoma	10	14	2
Female	42	Acoustic neurinoma	13	32	2
Female	68	Neoformation of the petrous portion of temporal bone	10	35	3

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