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Original Article

Accuracy of generic mesh conformation: The future of facial morphological analysis

A. Almukhtar [a], B. Khambay [b], X. Ju [c, d], J. McDonald [d], A. Ayoub [e, *]

[a] Scottish Craniofacial Research Group, Glasgow Dental School, University of Glasgow, Glasgow, UK
[b] Institute of Clinical Sciences, College of Medical and Dental Sciences, The School of Dentistry, University of Birmingham, Birmingham, UK
[c] Medical Device Unit, Department of Clinical Physics and Bioengineering, NHS Greater Glasgow and Clyde, Glasgow, UK
[d] Glasgow Dental School, University of Glasgow, Glasgow, UK
[e] MVLS College, Medical School, University of Glasgow, Glasgow, UK

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ABSTRACT

Three-dimensional (3D) analysis of the face is required for the assessment of changes following surgery, to monitor the progress of pathological conditions and for the evaluation of facial growth. Sophisticated methods have been applied for the evaluation of facial morphology, the most common being dense surface correspondence. The method depends on the application of a mathematical facial mask known as the generic facial mesh for the evaluation of the characteristics of facial morphology. This study evaluated the accuracy of the conformation of generic mesh to the underlying facial morphology. The study was conducted on 10 non-patient volunteers. Thirty-four 2-mm-diameter self-adhesive, non-reflective markers were placed on each face. These were readily identifiable on the captured 3D facial image, which was captured by Di3D stereophotogrammetry. The markers helped in minimising digitisation errors during the conformation process. For each case, the face was captured six times: at rest and at the maximum movements of four facial expressions. The 3D facial image of each facial expression was analysed. Euclidean distances between the 19 corresponding landmarks on the conformed mesh and on the original 3D facial model provided a measure of the accuracy of the conformation process. For all facial expressions and all corresponding landmarks, these distances were between 0.7 and 1.7 mm. The absolute mean distances ranged from 0.73 to 1.74 mm. The mean absolute error of the conformation process was 1.13 ± 0.26 mm. The conformation of the generic facial mesh

* Corresponding author. Glasgow University, 378 Sauchiehall Street, G2 3JZ, UK.
E-mail address: ashraf.ayoub@glasgow.ac.uk (A. Ayoub).

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is accurate enough for clinical trial proved to be accurate enough for the analysis of the captured 3D facial images.

Introduction

At present, the analysis of three-dimensional (3D) facial images has generally been limited to linear and angular measurements between anatomical landmarks. The operator usually identifies and digitises a set of landmarks that result in a 3D landmark configuration, which is then used for analysis. The limited number of accurately identifiable landmarks does not allow a comprehensive analysis of the facial morphology.

To overcome this problem, the concept of a 'generic mesh' was introduced.[1] The use of generic meshes for analysing biological geometry has previously been reported.[2,3] A generic mesh can be thought of as a 'simplified symmetrised facial mask' that contains a known number and distribution of points or 'vertices'. The triangles or 'faces' formed by these vertices are indexed or ordered within the file structure. The generic mesh can be used to standardise the number and distribution of vertices for images of the same individual and between individuals. Using the process of 'conformation', the generic facial mesh can be 'wrapped' around any facial image depending on several anchoring landmarks, whilst the remaining points are mathematically fitted or elastically deformed to maintain the surface topography of the original 3D image.

The conformation process on the preoperative and postoperative 3D facial images produces two meshes, which have the same number of vertices and triangles. Each vertex represents a corresponding point on the pre- and post-operative conformed meshes. The accuracy of the conformation process of the generic facial meshes will determine the precision in relating the corresponding facial points for the analysis. A recent study assessing the accuracy of conformation of a generic mesh for the analysis of facial soft tissue changes reported that the method was valid but the accuracy of the conformation was higher towards the middle of the face than towards the peripheral regions.[4] The study was limited to six anatomical facial regions, namely left cheek, right cheek, left upper lip, philtrum, right upper lip and chin regions, and did not investigate the accuracy of the conformation of the facial mesh at peripheral regions including forehead, eyes and gonial angle region. This is essential when using generic meshes to analyse pan-facial changes, especially at peripheral regions, i.e. assessing the changes of the mandibular gonial region following orthognathic surgery or global facial growth.

Aims

This pilot study evaluated the pan-facial accuracy of conformation of a generic mesh.

Materials and methods

Approval was obtained from the Research ethics committee, MVLS, University of Glasgow Ref: 200150025. Six males and four healthy female adult volunteers with no history of facial deformity or previous surgery in the facial region were recruited and consented to participate in the study.

Participant preparation

Prior to 3D image capture, participants were instructed to wear a head cap (figure 1) and then 34 2-mm-diameter self-adhesive, non-reflective black markers (Diamonte, Apparel accessories Ltd, Guangdong, China) were positioned on each subjects' face using an application tool (Pick-it-up vacuum