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ARTICLE

A simple computerised technique for estimating resting lip position and symmetry

Nigel Tapiwa Mabvuure[a], Stefan Klimach[b], Marc-James Hallam[c] and Charles Nduka[d]

[a]St Andrews Centre for Plastic Surgery, Chelmsford, UK; [b]Royal Derby Hospital, Derby, UK; [c]Plastic Surgery Department, Aberdeen Royal infirmary, Aberdeen, Scotland, UK; [d]Department of Plastic Surgery, Queen Victoria Hospital, East Grinstead, UK

ABSTRACT
The angle between the commisure–commisure and the endocantus–commisure lines (CCE angle) is approximately equal to the contralateral angle. A computerised technique for assessing the gross symmetry and position of the lips by comparing left- and right-sided CCE angles was developed. This study established (1) the repeatability of computerized CCE angle measurement; (2) mean CCE angle magnitudes in healthy controls and suggest a "normal" reference range. Two authors independently measured CCE angles on frontal repose facial photographs of 104 volunteers on three separate occasions using facial analysis software. Twenty right-sided hemifaces with the largest CCE differences were then mirrored in the sagittal plane to produce symmetrical photographs. Measurements were repeated by a single author. There was high agreement of angle measurements between authors (inter-rater ICC of 0.89) and within each authors' repeated measurements (intra-raters ICCs of 0.85 and 0.77). Differences in the mean right and left-sided CCE angles in controls were small but statistically significant (82.4° and 81.7°, respectively, mean absolute difference 2.2 ± 1.7°, $p < 0.05$). The mean absolute differences had a skewed distribution. The 2.5th and 97.5th centiles were therefore set as limits of the range of asymmetries which could be regarded as "normal" (95% reference range, or 95% reference interval): 0.2°–6.2°. Measurements of opposing CCE angles in symmetrical mirrored images were similar (82.4° versus 82.3°, mean absolute difference 0.6°, $p > 0.05$). In conclusion, computerised CCE angle measurement is highly repeatable and may be a useful tool with which to assess gross resting lip symmetry.

Abbreviations: ECCE: endocanthus–cheilion–cheilion–endocanthus; ICC: intraclass coefficients; SMILE: Scaled Measurement of Improvement in Lip Excursion system; 2D: two-dimensional; 3D: three-dimensional

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Introduction

Dynamic facial reanimation aims to improve both the symmetry and coordination of movement in paralysed faces. Resting symmetry is usually the predominant, natural and most visible facial expression perhaps because it is effortless and does not require muscle activation. Improved resting symmetry may also benefit patients by hiding dynamic asymmetries when a patient does not wish to reveal them, reducing unwanted attention. Many patients report anxiety that official documents including passports, visas and identification cards, which usually require photographs of the face at rest, may be constant reminders of asymmetries.

Lip asymmetry is particularly visible due to their central facial location and expressiveness. Non-surgical options for treating lip asymmetry include fillers and neurotoxins, such as in facial palsy. Surgical procedures such as facial reanimation and cleft lip surgery affect symmetry by either directly altering the shape of the lips or indirectly through static suspensions and dynamic tissue transfers. Current measures of symmetry following these treatments can be over-simple (e.g. surgeon estimation based on a Likert-scale) or can be detailed but expensive, risky, or too complex (e.g. computed tomography and 3D imaging) for routine clinical use.

The authors developed a potentially user-friendly, easy to use, computerized and time-saving technique for quantifying static lip symmetry. This was inspired by a thriving facial palsy practice and an observation that the contralateral angles formed by the commisure–commisure and endocanthus–commisure lines (CCE angles) were grossly equal in people with no history of facial asymmetry or pathology (Figure 1). Furthermore, the endocanthus–endocanthus line also appears symmetrical to the commisure––commisure line. Given these relationships and the relative immobility of the endocanthus, CCE angle asymmetry may represent asymmetry of lip position too. This study aimed to determine the magnitude and symmetry of CCE angles in healthy volunteers and to establish the repeatability of measuring them using facial analysis software.

Methods

This study was approved by the Individual Research Project committee at Brighton and Sussex Medical School.

Resting frontal facial photographs of 104 volunteers (78 female, 26 male) [1] with no history of facial pathology or surgery were identified from the department's research database. A single author measured both CCE angles in controls on three occasions, each 5 days apart (Visualization, Analysis, Measurement (VAM) v2.8.2, Canfield Scientific Inc., Fairfield, NJ). Photographs were uploaded in turn and a mouse-controlled, circular cursor was

CONTACT Nigel Tapiwa Mabvuure n.mabvuure@doctors.org.uk St Andrews Centre for Plastic Surgery, Chelmsford, UK

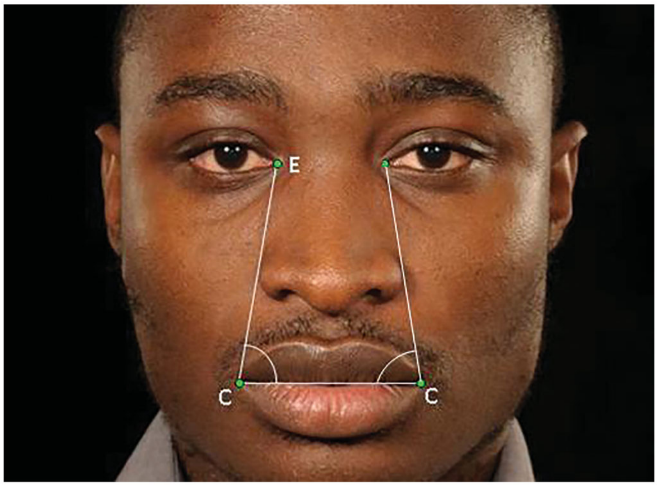

Figure 1. Standardised facial photograph of a subject with no history of facial pathology. The angle between the commisure–commisure and the endocantus–-commisure lines (CCE angle) is approximately equal to the contralateral angle.

used to select both commissures and the canthus using VAM. Landmark selection could be improved by zooming in and/or reducing the size of the cursor. Selections could also be altered as required. The software then automatically computed the magnitude of angles formed at the intersection of the two lines (CCE angle). A second author independently performed the same measurements to establish inter-rater repeatability.

Twenty right-sided control hemifaces were then mirrored in the sagittal plane (Microsoft PhotoShop) to produce symmetrical photographs in which the measurements described above were repeated by a single author (Figure 2). This software contains utilities to mirror photographs. Twenty controls with the largest left-to-right differences were selected. Mirrored photos were expected to produce symmetrical CCE angle measurements i.e. no statistical difference between the two measurements. Confirming this expectation would increase confidence that findings in controls were true differences i.e. low measurement error.

Statistical analysis

Average unilateral CCE angle sizes were calculated from the three repeated single-author measurements. Mean measurements were used in subsequent analyses. Mean absolute differences were calculated by subtracting the smaller angles from the larger angles so that the differences were positive numbers. *T*-tests were used to test the significance of CCE asymmetries in controls. *T*-tests were also used to compare control and mirrored photo measurements. Inter- and intra-rater repeatability were analysed using intraclass coefficients (ICCs). Significance was set at $p < 0.5$.

Results

There was high agreement of angle measurements between authors (inter-rater ICC of 0.89) and within each authors' repeated measurements (intra-raters ICCs of 0.85 and 0.77).

Differences in the mean right- and left-sided CCE angles in controls were small but statistically significant (82.4° and 81.7°, respectively, mean absolute difference $2.2 \pm 1.7°$, $p < 0.05$). The mean absolute differences had a skewed distribution. The 2.5th and 97.5th centiles were, therefore, set as limits of the range of asymmetries which could be regarded as "normal" (95% reference range, or 95% reference interval): 0.2°–6.2° [2]. Measurements of opposing CCE angles in symmetrical mirrored images were similar (82.4° versus 82.3°, mean absolute difference 0.6°, $p > 0.05$).

Discussion

These results show that there was normal variation in the symmetry of resting lip position, as shown by CCE angle asymmetry in healthy controls ($p < 0.05$). They also show that measuring these angles using facial measurement software was repeatable.

The finding that measurements in mirrored images were similar (mean 0.6° difference) suggests that CCE asymmetries in controls were not due to measurement error alone. This supports previous findings that people with no history of facial pathology or surgery are not perfectly symmetrical [3,4] for multifactorial reasons [5,6]. The right hemiface is usually larger in terms of inter-landmark distances [7]. Differences of 1–5 mm or 4–12% between left and right hemi-faces are regarded normal [8,9]. The point at which asymmetry becomes "abnormal" is largely dependent on both surgeon and patient's subjective thresholds [10]. The proposed normal CCE angle magnitude reference range of 0.2–6.2° is therefore a potentially significant advance because it adds objectivity to pre and postoperative workups for a wide range of indications.

This technique was developed to assess gross static symmetry and resting lip position. It is only appropriate for the assessment of repose photographs, in part, because this pose is highly repeatable during follow up visits [11,12]. It is not suitable for assessing symmetry in dynamic animation as these poses are less repeatable and require more complex measures. Such complex techniques may be impractical in busy clinics and in developing countries. There are other computerized measures, such as the Scaled Measurement of Improvement in Lip Excursion (SMILE) system, which aim to simplify and quantify symmetry assessments [13]. The authors favour systems with the simplest interface to encourage wider clinical uptake [14].

All measurements are prone to measurement error. The comparability of serial measurements using this system depends on the comparability of photo standards between visits. The potential bias in non-standardized photos is well recognized [15,16]. All photos were taken in standardized conditions by professional medical photographers using published guidelines [17,18]. Clinicians using this technique clinically should also ensure photographic standards between any two comparisons are similar.

The presence of variability of repeated measurements both within and between raters shows that there is inherent measurement error. However, the high ICCs show that this error was low enough to increase confidence that measurements were accurate. Measurement error was even present in mirrored photos either due to imprecision in mirroring (Figure 2) or in landmark selection. However, the finding of an insignificant mean absolute difference of 0.6° ($p > 0.05$) in supposedly symmetrical images suggests that this technique is indeed sensitive to changes in symmetry. If the negligible level of asymmetry in mirrored photos was taken as the inherent error of this technique and subtracted from measured asymmetries in controls, residual asymmetry in some healthy controls is likely "true" and within the suggested normal range.

Measurement precision was further improved by using the endocanthi as the basis for angle calculations. The accuracy of computerized anthropometric measurements is a function of the accuracy of on-screen landmark selection. Basing serial measurements on landmarks which changeable positions reduces precision. Endocanthi are minimally affected by gravity or age-related

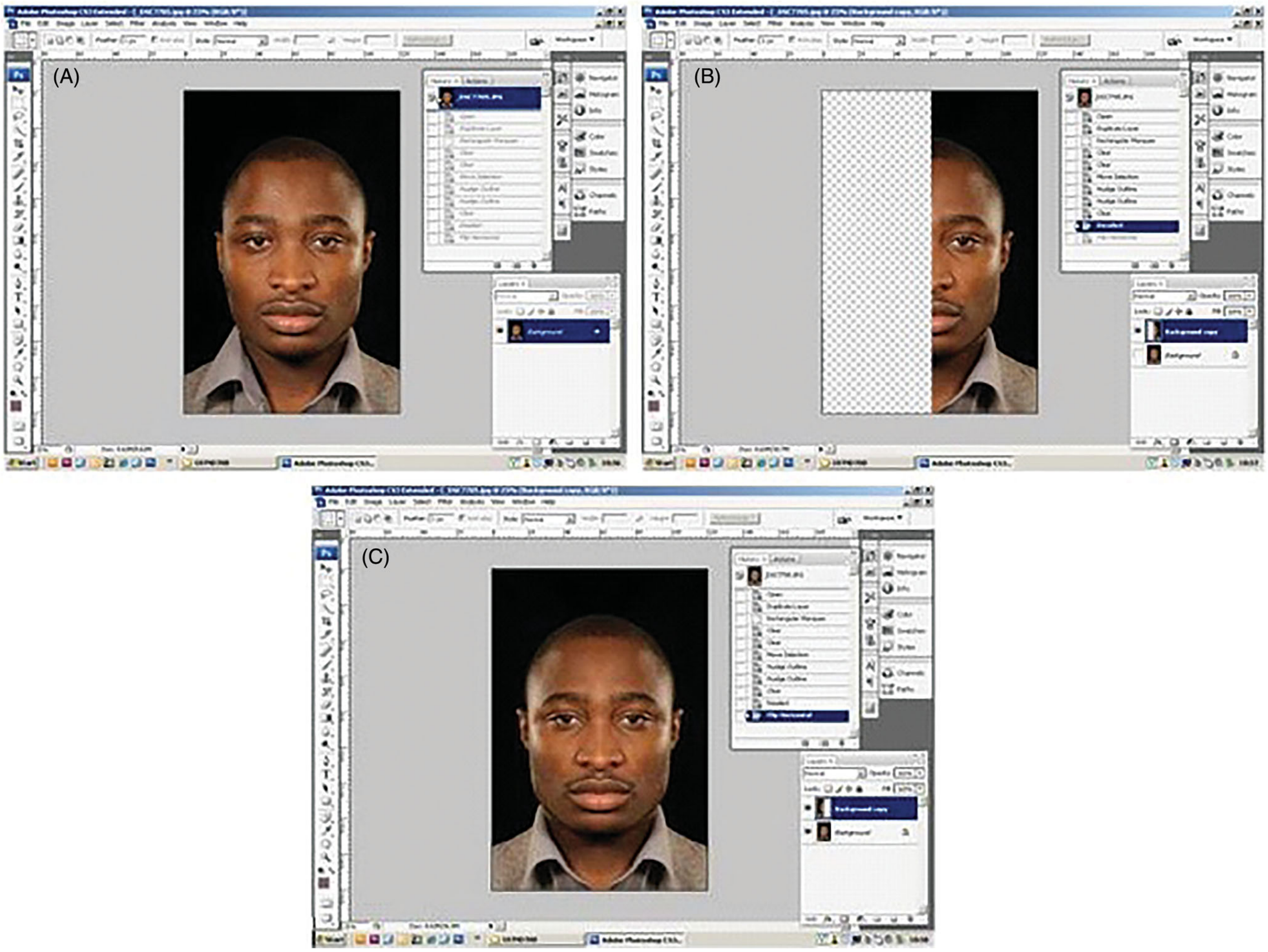

Figure 2. Creation of a mirror image. (A) The frontal facial photo is divided into two hemifaces using MS Photoshop's utility which selects the midsagittal line. The left hemiface is deleted to give image (B). Image B is rotated by 180° about its mid-sagittal axis to give a symmetrical image (C).

changes [19]. Changes in CCE angle relationship are therefore more likely due to differences in the position of the mobile commisures, and, therefore, more specific for lip asymmetry. Previous studies showed that selection of endocanthi on photos has an error of less than 1 mm along each of the three coordinate axes [20].

Notwithstanding these potential limitations, the described technique is relatively accessible. Many free and commercial photo-editing software already contain utilities to measure angles so would not require additional expenses for most users. The process of uploading photographs, selecting landmarks and computing angles is relatively quick and with VAM does not require much processor power.

Despite this speed and ease of use, this technique is not designed to replace current grading scales. Rather, it may be appropriate for it to be incorporated into existing scale systems to increase their objectivity. For example, instead of a surgeon subjectively grading mouth symmetry as part of the Sunnybrook Facial Grading System, CCE angles could be used to provide more objective data.

Conclusion

In conclusion, CCE angle measurement has high inter- and intra-rater repeatability as an assessment of lip symmetry in repose. A difference in CCE angle magnitude, at rest, of 0.2–6.2° is normal in healthy faces. This simple and cheap technique has utility in assessing the lip symmetry and position in patients with facial palsy.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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