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A computer-aided method of measuring nasal symmetry in the cleft lip nose

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SUMMARY. **Objective assessment of the results of cleft lip and nose surgery is necessary to quantify differences between alternative surgical techniques. A previously described method of measuring facial asymmetry has been modified to allow a comparison of differently treated cleft noses (radical nasal correction versus no nasal correction).**

Standardised, inferior view photographs of 10-year-olds were obtained from patient records. These were projected, traced, digitised and analysed using a BBC microcomputer. A method of excluding the ill-defined nasal baseline by obtaining a mirror-image of the upper nasal perimeter is described. The method has a high degree of inter and intra observer reproducibility.

The objective assessment of the results of surgery is a necessary method of auditing results of alternative methods of treatment. There have been many reports of different types of cleft lip and palate repairs in the literature; some differ by only small technical points, but a fundamental division between these repairs is the timing of any nasal correction. No objective study has previously been reported comparing the late (10-year-old) results of radical primary nasal correction with no nasal correction.

The nose and nostrils have been objectively evaluated by a variety of reported methods.

Anthropometry (Lindsay and Farkas, 1972) provides measurement both directly from live subjects and indirectly from photographs and facial masks (Huddart, 1971). Nasal features measured, such as the length and width of the nose, alar length, columella width and deviation, and alar base dislocation are combined with the use of standard anatomical points (*e.g.* subalare, subnasale).

An advance is the combined used of standardised photographs and radiographs—"analytic morphograms"—to provide digitised soft tissue and skeletal outlines of the nose (Hodgkinson and Rabey, 1986).

Moire conturography (Kawai *et al.*, 1977) provided additional three dimensional data but has not been used as the basis of assessment of the nose and nostrils.

Fourier analysis is one method of curve and waveform assessment which has been used to describe the human nostril (Goto and Katsuki, 1990). This method maps a curve from a defined centre point and uses the length of serial arcs to obtain information about the curve (Fig. 1).

In this study the curve method of measuring asymmetry was used, as previously described (Coghlan *et al.*, 1987): this measures the difference between the two sides of the nose or nostril by reflecting one side onto the other.

This paper describes the methods applicable to the results reported by Laitung *et al.* (1992). Some preliminary results of this work have been previously presented (Coghlan *et al.*, 1990).

Materials and methods

Definitions

The definitions used in this and the associated paper, Laitung *et al.* (1992), are given in Figure 2.

Photographic records

A standard inferior photographic view was obtained by tilting the subject's head back to bring the alar domes to a level below the eyebrows but above the canthi. These views must have had either both canthi, both upper eyelids or the pupils clearly visible in order for a horizontal plane to be constructed. When the head is tilted too far back the lower lip obscures the alar bases and if it is not tilted far enough back the skyline of the alar domes does not appear.

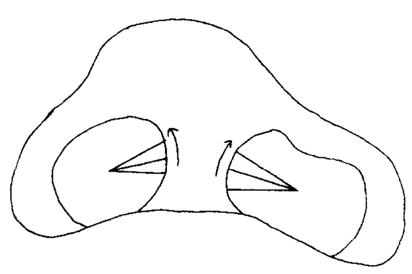

Fig. 1

Figure 1—Example of the technique of Fourier analysis. Details about the outline of a nostril can be obtained by plotting a series of arcs from a centre point to the outline. These values can be used as a comparison with the other side and with other nostrils (Goto and Katsuki, 1990).

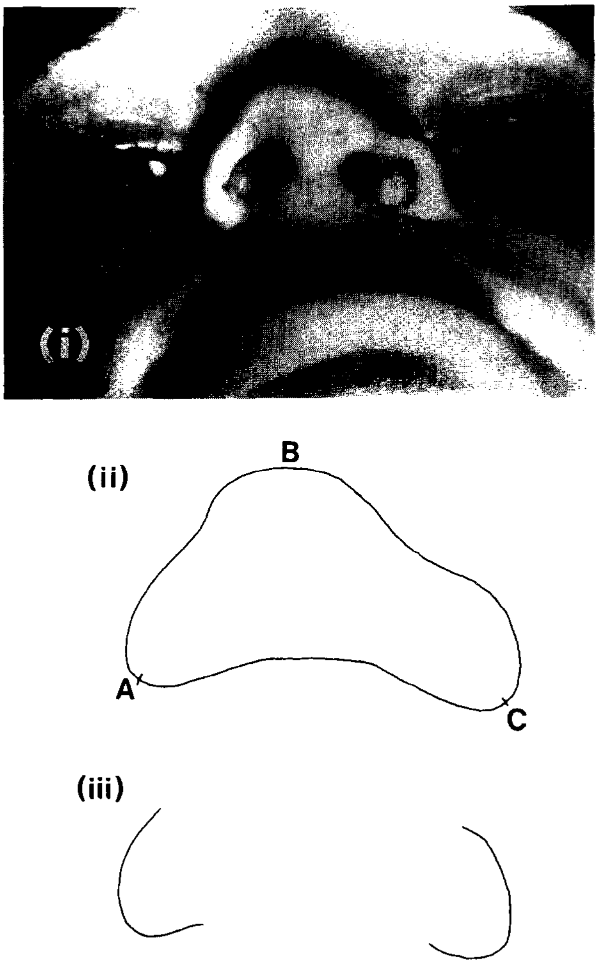

Fig. 2

Figure 2—The definitions used in this and the accompanying paper, Laitung *et al.* (1992), are illustrated as follows: (i) Photograph (inferior view) of a patient's repaired cleft lip and nose. (ii) Tracing taken from (i). Upper nasal perimeter (A–B–C) and interalar base (A–C). (iii) Tracing to illustrate the alar margins.

Subjects

All of the subjects were aged 10 ± 1 year, and had been born with unilateral, complete cleft lip and palates. The subjects were divided into three groups, radical nasal correction, no nasal correction and controls as described in the accompanying paper, Cussons *et al.* (1992).

All three sets of slides or prints (62 in total) were rephotographed to produce colour slides with the base of the nose appearing as 12 ± 1 mm on a 35 mm film. All were placed in similar mounts, randomly sorted and numbered and then sealed in a slide carousel.

Projection method

The back projection system previously described (Coghlan *et al.*, 1987) was simplified in use and design. A zoom-lensed slide projector was focused directly on a screen to produce a magnification such that the distance between the most lateral borders on the nasal outline was 20 ± 1 cm. If larger tracings were made, difficulty was experienced in following the tracing outline with the crossed-wire cursor which would be deflected by the edge of the digitising pad. Smaller images were more likely to conceal real differences between the original and reflected images.

To exclude any inter observer error all 62 slides were traced by one operator (JKGL). The reproducibility of the tracings was established for this observer. Where there was difficulty defining an outline, a group decision (all three authors) was taken. The observers were unaware of the trial group from which the slide was taken.

Digitising the tracings

The level of magnification described for the nasal outlines did not produce a sufficiently large nostril image for accurate tracings to be performed on the digitising pad. Thus all the nostril tracings were enlarged 1.65 times using an optically accurate photocopier.

When tracing the projected slides the largest source of error in reproducibility was drawing the interalar base. This was to be expected as this is not a defined line or angle in life (Fig. 3). To correct for this inaccuracy a new method of representing the nasal outline was used, involving the construction of a mirror image. In all of the slides the clearest area of the nasal outline was that of the domes and lateral alar margins. To produce an image based upon this part of the outline, two perpendicular lines were drawn from the horizontal plane to form tangents to the most lateral borders of the alar margins on each side (Fig. 4(i)). A new horizontal was constructed where these tangents intersected the alar margins (Fig. 4(ii)). The upper nasal perimeter was then reflected about this axis (Fig. 4(iii)) thereby forming a complete figure, necessary for the computer analysis. This reflected image could be redrawn with a high level of accuracy.

Computer method

The curve method of feature analysis previously described was used on a BBC model B microcomputer. Briefly the method of computer analysis was as follows: the original outline was reflected about the first axis of symmetry and the reflected shape superimposed upon it (Fig. 5). The computer divides the left hand side (from the observer's viewpoint) of the original curve with sixteen equidistant points, and then for each of these points the computer finds the distance to the nearest part of the reflected curve. Thus 16 distances are calculated for each axis of symmetry, representing the distances of separation of the original and reflected curves. The reflections are repeated up to 40 times in different axes to determine the best axis of symmetry. A highly symmetrical feature where the original and reflected curves fit together well will be detected by low separation distances; the more asymmetrical the feature, the larger the separation distances. The sequence is repeated for the right hand curve of the original outline.

Early results of reproducibility established that practice was required at digitising the tracings and errors were minimised using one operator, thus all the tracings were digitised by one author (BAC).

Fig. 3

Figure 3—Two photographs of the same patient. (i) Inferior view of the nose, two lines have been drawn between the alar bases, either could represent the interalar base. (ii) Frontal view of the nose, the same two lines are seen to be widely separated and the enclosed envelope represents the limits of potential error in the concept of the interalar base.

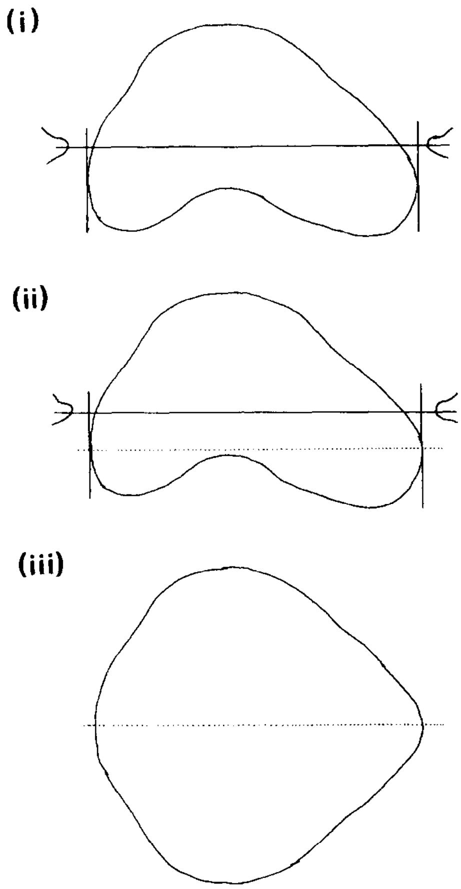

Fig. 4

Figure 4—Steps required to form the reflected upper nasal outline from the original tracing, thus excluding the indistinct interalar base. (i) The horizontal plane between the two internal canthi is used to drop two perpendicular lines to form tangents to the most lateral points of the alar margin on each side. (ii) A new horizontal (dotted) was constructed where these tangents intersected the alar margin. (iii) The upper nasal perimeter was then reflected about this horizontal axis, thereby forming a completed figure.

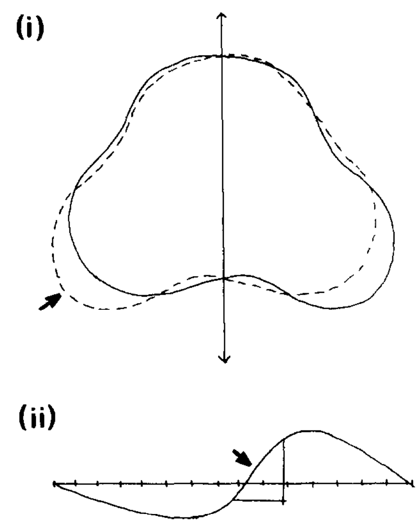

Fig. 5

Figure 5—(i) The original nasal outline (solid line) has been reflected about the first axis of symmetry and the reflected outline (dashed line) has been superimposed on it. (ii) The cumulative sum graph plotting the asymmetry of the left hand curves. The maximum slope of the graph, measured in angles of degree, represents the area of greatest asymmetry (arrowed), see text for calculation.

Statistical analysis

A series of 16 numbers was produced for each axis of symmetry; each series represented the separation distances of the original and reflected images. A non parametric statistical method of analysing these numbers is the use of cumulative sums (Woodward and Goldsmith, 1964). The mean of the 16 separation distances is calculated and then each distance is individually compared with the mean value and the difference between the two is plotted on a graph (Fig. 5(ii)). Any trends from the mean value are detected

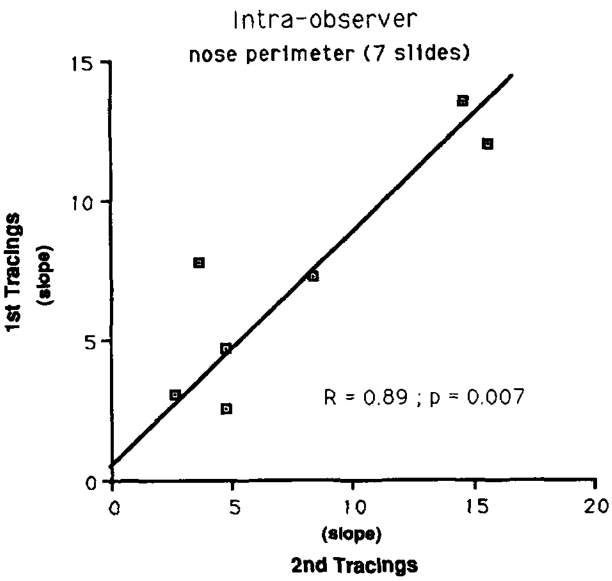

Fig. 6

Figure 6—Graph plotting the results of the same observer retracing seven different slides and then each is separately digitised and analysed and the results, in the form of the slope values, compared using regression analysis.

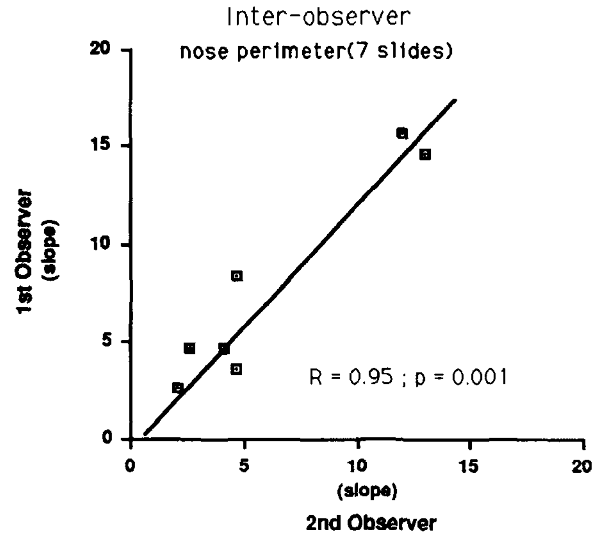

Fig. 7

Figure 7—Graph plotting the results of two different observers tracing seven different slides and then each tracing was separately digitised and analysed and the results, in the form of the slope values, compared using regression analysis.

and then represented as the slope or the angle of the cumulative sum. Thus the greater the slope of the cumulative sum the greater the angle of deviation from the mean value and the more asymmetrical the feature. The best axis of reflection for each feature was that which matches the original and reflected curves as closely as possible and forms the smallest slope value as measured by the cumulative sum.

Sensitivity of method

The method was assessed to establish the intra and inter observer level of reproducibility.

One observer re-traced seven different slides and then each tracing was separately digitised and analysed to obtain the objective measurement of asymmetry, the slope value, for each feature (Fig. 6). The results show a highly significant inter observer correlation ($R = 0.89$, $p = 0.007$).

Two observers each traced seven different slides and then each tracing was digitised and analysed (Fig. 7). The results show a highly significant intra observer correlation ($R = 0.95$, $p = 0.001$).

Discussion

A method of measuring asymmetry has been described that allows comparison of patients' noses and nostrils who have had a unilateral complete cleft lip and palate repaired by different surgical techniques. It provides an objective evaluation of the degree of asymmetry of the facial feature as it appears on a photograph. Existing systems such as anthropometry rely upon defining artificial ratios derived from combined measurements and these ratios are used to compare with other subjects. Neither these nor the more sophisticated analytic morphograms give any detail about the symmetry of the facial feature. For this type of assessment curve or waveform analysis such as Fourier analysis or the Bristol method of curve analysis is necessary.

Fourier analysis has only been applied to the assessment of nostrils where there is an opposite for comparison. The outline of the nose as seen from an inferior view would require modification of the standard Fourier computation.

The Bristol curve method is easy to use, requiring the minimum of training and practice. The computer equipment required is inexpensive, and the capacity is high; 10–15 tracings can be made and digitised within 1 h. Since completion of the study the computer program is now available for the IBM PC.

It is recognised that the subject material is taken from photographs and these represent just static, two-dimensional records. The use of three-dimensional images such as Moire conturography, possibly combined with video recordings of subjects at rest and talking would give the maximum information to assess the results of the lip and nose repair. However, this would require a prospective trial using as yet undeveloped equipment over a many year period.

The inferior view of the nose is not one commonly seen by the patient or on-lookers, but it was used as it provides the maximum amount of information about the results of surgical correction of the cleft nose deformity, namely the level of both alar domes, the slope of the alar borders, and the shape of the nostrils.

The use of mirror-images in curve analysis was a technique independently described by Lestrel *et al.* (1977). They assessed the distal human femur with Fourier analysis by reflecting the outline of the femur on itself to form a mirror image. The advantage of this technique in the nasal outline is to exclude the often ill-defined nasal baseline, although it is recognised that the mirror image reflection variably excludes part of

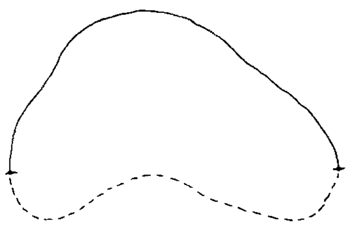

Fig. 8

Figure 8—Outline of an inferior view of the nose with the area dashed representing that part excluded from assessment by the use of mirror images.

the alar curve (Fig. 8) and this may be an important comparative feature.

The results of the inter and intra observer reproducibility support the Bristol method of curve analysis as a sensitive method of evaluating symmetry of the repaired cleft nose.

Ideally, to assess two separate methods of treating cleft lips and noses a prospective randomised trial would be required, where in one centre patients are treated by exactly the same methods except for the timing of the nasal correction. Sufficient patient numbers for statistical significance would be required and then patient follow-up would require regular photographic records. In the absence of such data a compromise with pooled data can be used.

The results of the computer analysis of the control faces and the two differently treated groups are reported in the following paper, Laitung *et al.* (1992).

Copies of the computer program and instruction manual are available from the authors for the BBC model B computer and the IBM PC.

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