



# Preoperative analysis of upper lip in patients with upper cleft lip/palate before lip repair

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**Background:** The postoperative morphological appearances vary widely patients with unilateral cleft lip with or without cleft palate (UCL/P), whether it is complete or incomplete cleft. The main reason of bilateral lip asymmetry after cleft lip surgery lies in the lack of personalized measurement and design before surgery. In this study, we aim to individually investigate areas of the upper lip on cleft and non-cleft sides in patients with unilateral cleft lip with or without cleft palate (UCL/P).

**Methods:** Ninety-two patients with UCL/P (group 1: <1 year, group 2: 1–2 years) were included in the study. Group 1 included 37 patients with incomplete UCL/P and 29 with complete UCL/P; group 2 included 11 and 15 patients, respectively. The total area of the upper lip on the cleft side (Q8) was divided into Q3, Q4, and Q5 (further divided into a1 and a2), and the upper lip on the non-cleft side (Q7) was divided into Q2 and Q1 (further divided into A1 and A2). Area ratios between the cleft and the non-cleft sides were calculated, and certain parameters were tested for correlations with these ratios.

**Results:** Values of Q8/Q7 were partially overlapped between patients with complete and incomplete UCL/P. Significant correlations were noted between differences in height of the philtrum column (a–h) and the prolabial area ratio between the cleft and the non-cleft side (Q3/Q2) ( $P=0.032$ ). Moreover, a significant correlation was noted between a1/A1 and the ratio of the lateral labial area between the cleft and the non-cleft side (Q5/Q1) ( $P=0.001$ ).

**Conclusions:** The conventional classification of unilateral cleft lip as incomplete and complete does not completely and accurately reflect individual malformations. Therefore, it is necessary to analyze unilateral cleft lips individually to determine the repair technique and to predict postoperative outcomes.

**Keywords:** Upper lip; cleft lip; philtrum column; prolabial area

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## Introduction

According to available literature, morphological appearances immediately after surgery and the further development

of upper lips vary widely among patients with unilateral cleft lip with or without cleft palate (UCL/P), based on complete or incomplete nature of the cleft, even when performed by the most experienced surgeons. Few studies

**Table 1** Linear parameters measured in the present study

Linear parameters	Definition
Line a	Height of philtrum column on non-cleft side
Line b	Height of philtrum
Line c	Width of upper lip on the non-cleft side
Line d	Distance between alar base and ipsilateral commissure on the non-cleft side
Line e	Distance between the central point and the peak point of Cupid's bow on the non-cleft side
Line f	Width of nasal floor on the non-cleft side
Line g	the distance between the central point and Peak point of Cupid's bow on the medial part of cleft side
Line h	height of philtrum column on the cleft side
Line i	Distance between the peak point of Cupid's bow and the end point of the vermilion on the medial part of cleft side
Line j	Width of nasal floor on the medial part of cleft side
Line K	Width of upper lip on the cleft side
Line L	the distance between alar base and ipsilateral commissure on the cleft side

have quantitatively analyzed (1,2), whereas others have qualitatively described (3–6), such differences. In addition, postoperative morphological appearance of lips was better in some patients with complete UCL/P compared with those with incomplete UCL/P, even when the most experienced surgeons operated using a single technique (7). In terms of surgical technique, Nakajima suggested that methods designed for repair of complete unilateral cleft lips should not be used to repair incomplete unilateral cleft lips (8), while Chowdri suggested that either technique can be used for repair of unilateral cleft lips (9).

A major reason for the lack of postoperative morphological symmetry in cases of unilateral cleft lip is the characteristic differences in lips among patients before surgery. Conventionally, cleft lips are classified as complete and incomplete, which is too general to accurately reflect the wide variations observed in cleft lip cases. Therefore, in order to resolve this issue, we evaluated areas of the upper lip in individual patients based on geometric principles.

The aim of the present study was to report basic information regarding labial areas before primary

cheiloplasty, differences in labial areas between cleft and non-cleft sides among patients, changes in growth area ratios between cleft and non-cleft sides, and parameters that are significantly correlated with these ratios.

We present the following article in accordance with the STROBE reporting checklist (available at <http://dx.doi.org/10.21037/atm-21-1424>).

## Methods

### *Patients and photo data acquisition*

Patients with UCL/P enrolled in this study were from Nanjing Stomatological Hospital (Nanjing, China). The present study included 92 Chinese babies with UCL/P (48 incomplete cleft lips and 44 complete cleft lips). Sixty-six of them were aged <1 year old (group 1) and 26 of them were aged 1–2 years old (group 2).

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by ethics board of Nanjing Stomatological Hospital (No. YW-2000NL-002) and informed consent was taken from all individual participants.

Linear data of the upper lip were directly obtained from the face when a baby received general anesthesia immediately before surgery. Major landmarks were defined according to Farkas' description (10).

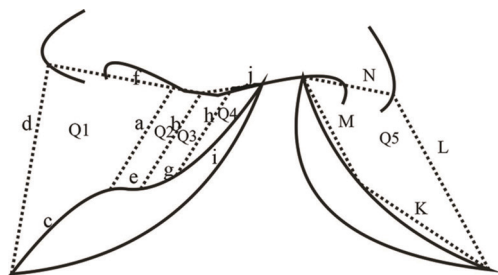
### *Grouping and calculation*

For the purpose of the present study, we divided the upper lip into the cleft and the non-cleft side according to line b, which connects the midpoint of the Cupid's bow and the midpoint of the base of the columella. Certain linear parameters were measured and certain areas were calculated (*Tables 1* and *2*, respectively). *Figure 1* shows these parameters.

Based on the geometry of the patients' lips, the area on the non-cleft side (Q7) was divided into Q1 and Q2, and that on the cleft side (Q8) was divided into Q3, Q4, and Q5. The area of the lateral lip on the cleft side (Q6) included Q4 and Q5. To compare Q8 and Q7, we assessed Q3/Q2 and (Q4 + Q5)/Q1 in each patient. On comparing the lateral lip between the cleft and the non-cleft side, Q4 was significantly less than Q1 and Q5, so Q4 could be ignored, and the lateral lip comparison was simplified to Q5/Q1. Q1 was further divided into A1 and A2, and Q5 was further divided into a1 and a2 (*Figure 2*). Certain parameters were

**Table 2** Areas calculated in the present study

Parameters of area	Definition
Q1	Area of lateral lip on non-cleft side
Q2	Area of prolabial on non-cleft side
Q3	Area of prolabial on the cleft side
Q4	Area of lateral lip on the medial part of cleft side
Q5	Area of lateral lip on the lateral part of cleft side
Q6	Area of lateral lip on the cleft side (Q4+Q5)
Q7	Area on the non-cleft side (Q1+Q2)
Q8	Area on the cleft side (Q3+Q4+Q5)
A1	Area of lateral part of Q1
A2	Area of medial part of Q1
a1	Area of lateral part of Q5
a2	Area of medial part of Q5

**Figure 1** Schematic representation of linear and area parameters used in the present study.

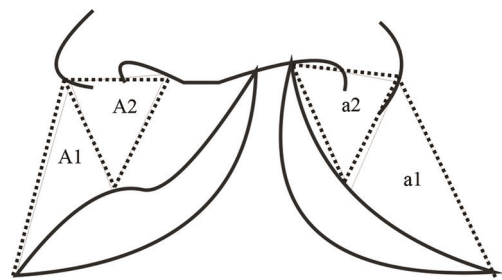
tested to determine correlations among these area ratios.

### Statistical analysis

Statistical analysis was conducted using the SPSS version 11.0 (SPSS, Chicago, IL, USA). Mean values of the 2 age groups, as well as mean values of the 2 types of cleft lip (complete and incomplete), were compared using Student's *t*-test. The linear correlation coefficient *R* and *P* values were calculated to describe correlations.  $P < 0.05$  indicated a significant difference.

### Results

Areas of Q1–Q8 are summarized in *Table 3*. In general, the

**Figure 2** Further division of Q1 and Q5 (Q1 was further divided into A1 and A2, and Q5 was divided into a1 and a2).

mean area of the non-cleft side was significantly larger than that of the cleft side in both age groups and in both types of cleft lip ( $P < 0.05$ ). Individual analysis revealed that the range of Q8/Q7 varied widely (45–112%). In fact, Q8 was larger than Q7 in certain cases. Moreover, values of Q8/Q7 partially overlapped between patients with complete and incomplete cleft lip (*Table 4*).

In total, Q8/Q7 was  $< 80\%$  in 54 (19 incomplete and 35 complete) cases (*Table 4*), 5 of the patients' Q8/Q7 was  $< 60\%$  who had complete cleft lips. Q8/Q7 was  $> 90\%$  in 18 (16 incomplete and 2 complete) cases; 9 of the patients' Q8/Q7 was  $> 100\%$  who had incomplete cleft lips. Furthermore, we observed a trend that Q8/Q7 reduced with growth, that is, the discrepancy between the cleft and the non-cleft side increased significantly with growth (*Table 4*).

Regarding prolabium, a significant correlation ( $R = -0.710$ ,  $P = 0.032$ ) was noted in the linear discrepancy between lines *a* and *h* (*a*–*h*) and Q3/Q2 (*Figure 3* and *Table 5*). In addition, a significant correlation ( $R = 0.97$ ,  $P = 0.001$ ) was observed between a1/A1 and Q5/Q1 (*Figure 4* and *Table 6*). No significant correlation was noted among the other parameters.

### Discussion

UCL/P is the most common deformity in newborn infants with cleft lip or palate (11). Some attempts have been made to describe the complicated deformity of UCL. Although several studies have described classifications of UCL based on length of the cleft (12–14), previously published studies describing other preoperative features of cleft lip are limited (15,16). Individual analysis is important to evaluate the degree of malformation, to select the appropriate repair technique, and to predict postoperative morphological outcomes.

**Table 3** Mean areas of Q1–Q8

Group	Non-cleft side (mm <sup>2</sup> )			Cleft side					No. cases
	Q1	Q2	Q7	Q3	Q4	Q5	Q6	Q8	
Group 1 (<1 year old)									
Incomplete UCL	138.72	24.97	163.67	21.20	10.16	111.53	121.67	142.89	37
Complete UCL	157.38	25.34	183.72	21.40	10.50	106.58	117.08	138.48	29
Group 2 (1–2 years old)									
Incomplete UCL	149.78	28.34	178.6	23.17	8.88	94.45	103.33	126.5	11
Complete UCL	146.65	30.10	176.8	23.920	8.53	95.72	104.25	128.2	15

UCL, unilateral cleft lip.

**Table 4** Values of Q8/Q7

	No. cases	Group 1							Group 2							
		60%	69%	79%	89%	99%	>100%	No. cases	60%	69%	79%	89%	99%	>100%		
Incomplete UCL/P	37	0	0	6	5	10	7	9	11	0	1	2	5	3	0	0
Complete UCL/P	29	0	4	10	11	4	0	0	15	1	0	6	3	3	2	0

UCL/P, unilateral cleft lip with or without cleft palate.

Anthropometry is a useful tool to assess soft tissue anatomy of the upper lip, and also provides clinicians with quantitative information regarding malformed structures and regions (17,18). Various methods are used to assess cleft lip deformities, such as anthropometry (19), casts (20), photographs (21,22), video imaging (23,24), 3D computed tomography (25,26), and 3D laser scanning (27,28). In the present study, we performed measurements on live subjects because it is a simple, non-invasive technique with minimal equipment cost. Moreover, the scope for error during measurement is limited when a baby is under general anesthesia.

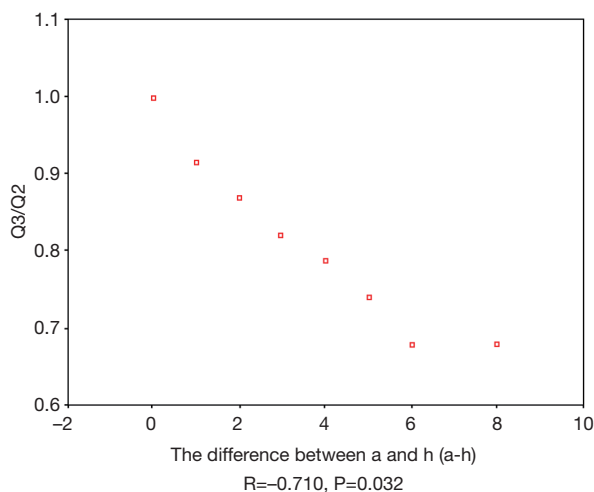
Available literature suggests that measurements, such as distance, angle, ratio, area, and volume are related to the evaluation of UCL (29,30). We selected area as the measurement tool, because it is the most appropriate parameter to reflect tissue defects and tissue malposition (31,32). We calculated area according to geometric principles.

Even when operated by surgeons with limited experience, the postoperative morphological appearance of some patients with complete UCL/P were better than that of some patients with incomplete UCL/P. Regardless

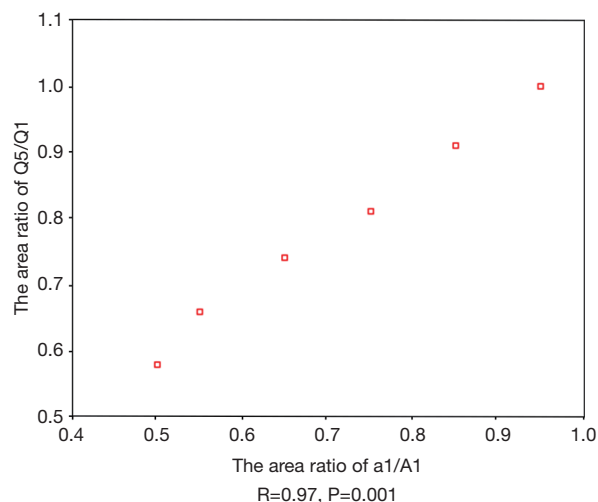
of the type of conventional classification of cleft lip used, postoperative appearances of different lips varied widely following the same surgical technique. Therefore, conventional classification was insufficient to accurately reflect various characteristics of cleft lip, and therefore, complete evaluation of UCL is warranted.

In the present study, among incomplete cleft lip cases, the area on the cleft side was much less than that on the non-cleft side in some cases, with Q8/Q7 being <60%. Conversely, among complete cleft lip cases, the area on the cleft side was similar to that on the non-cleft side in some cases, with Q8/Q7 being >90%. This would perhaps explain why sometimes postoperative appearance in incomplete cleft lip cases was worse than that in complete cleft lip cases.

We thought it was inappropriate to attribute the cleft lip to tissue defects alone in group 1 patients, because in some of these patients, areas on the cleft side were larger than those on the non-cleft side, with Q8/Q7 being up to 112%. However, in group 2, there were no cases of the cleft side area being larger than the non-cleft side area. Notably, rapid growth occurs between 1 and 2 years of age (33), and the inconsistent growth between the cleft and the non-cleft



**Figure 3** The correlation between a-h and Q3/Q2 in the present study. x axis means the *t*-test value of a and h, where a is the height of philtrum column in the non-cleft side and h is the height of philtrum column in the cleft side. Pair *t*-test is performed on a and h values of all samples. The y axis is the Q3/Q2 ratio, where Q3 is the area of the philtrum in the cleft side and Q2 is the area of the philtrum in the non-cleft side.



**Figure 4** The correlation between a1/A1 and Q5/Q1 in the present study. x axis means the ratio of a1/A1. The lines between the alars and the lip peaks divide Q1 into A2 of the nasal base area and A1 of the lateral labial area, and divide Q5 into A2 of the nasal base area and A1 of the lateral labial lip, respectively. Y axis is the ratio of Q5/Q1, where Q1 is the area of lip in the non-cleft side and Q5 is the area of cleft lip in the cleft-side.

**Table 5** Relationship between a-h and Q3/Q2

a-h (mm)	No. cases	Q3/Q2 (%)
0	1	100
1	10	91.7
2	22	86.8
3	19	82.2
4	24	78.9
5	11	74.4
6	4	67.5
7	0	0
8	1	68.0.

**Table 6** Relationship between a1/A1 and Q5/Q1

a1/A1	No. cases	Q5/Q1 (%)
<50%	3	57.68
51-60%	18	65.7
61-70%	17	74.26
71-80%	14	80.85
81-90%	5	91.43
>90%	0	≥100

side between 1 and 2 years of age would aggravate the area discrepancy. Cleft lip can therefore be gradually attributed to tissue defects with growth.

A significant correlation was observed between values of a-h and Q3/Q2 ( $R=-0.710$ ,  $P=0.032$ ). Moreover, a significant correlation was noted between a1/A1 and Q5/Q1 on the lateral lip ( $R=0.97$ ,  $P=0.001$ ).

Based on geometric principles, the quadrilateral Q2 was organized by lines b, a, and e, and the upper width of the

prolabium on the non-cleft side, while the quadrilateral Q3 was organized by lines b, h, and g, and the upper width of the prolabium on the cleft side. Line a was shared by Q2 and Q3. Based on our design and observations, line e was equal to line g, and the upper width of the prolabium did not differ significantly between the cleft and the non-cleft side. Therefore, the only variable between Q2 and Q3 was the difference between lines a and h (a-h). This would explain the significant correlation observed between values of a-h and Q3/Q2.

The lateral lip comparison could be simplified to Q5/Q1 as we mentioned earlier. Q1 was further divided into

A1 and A2, and Q5 was further divided into a1 and a2. No significant differences were noted between a2 and A2 ( $P>0.05$ ) in both complete and incomplete cleft lip patients. Hence, the comparison between Q5 and Q1 could be further simplified to a1/A1. This would explain the significant correlation observed between a1/A1 and the area ratio of the lateral lip.

Based on the results, parameters that reflect area ratios between the cleft and the non-cleft sides were meaningful. With the help of these parameters, we can approximately estimate the level of tissue defect, as well as postoperative appearance. Moreover, we can analyze which part of the upper lip (prolabial or lateral lip) is the primary causative factor for deformity and select the appropriate treatment approach.

Several studies have assessed the effects of a single repair technique or the skill of a single surgeon based on postoperative appearance (34-36). This method may not be appropriate because discrepancies of areas between the non-cleft and the cleft side among patients before repair are different. Preoperative appearance can influence postoperative morphology.

## Conclusions

The traditional classification of unilateral cleft lip cannot completely and accurately reflect the degree of individual deformity. In this paper, we innovatively use the form of computing area to personalize the evaluation of unilateral cleft lip, based on geometric principles, in order to identify repair techniques and predict postoperative outcomes.

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## Footnote

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*Ethical Statement:* The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by ethics board of Nanjing Stomatological Hospital (No. YW-2000NL-002) and informed consent was taken from all individual participants.

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