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Statistical Evaluation of The Cleft Lip Nose Deformity Image

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Abstract- **Cleft lip is a congenital deformity condition with separation of the two sides of the lip and causes nose deformity. Evaluation of surgical corrections and assessment of prognosis in nose deformity depend mainly on doctor's subjective judgment. Development of an objective assessment tool in evaluation of the cleft lip nose deformity patients will help in advancement and evaluation of surgical techniques. Therefore, our study aimed on quantitative assessment of a cleft lip nose deformity by comparing following parameters gathered from a photographic image of a cleft lip patient: (1) angle difference between two nostril axes, (2) center of the nostril and distance between two centers, (3) overlapped area of two nostrils and (4) the overlapped area ratio of two nostrils. Assessment results of the nose deformity were statistically analyzed with evaluation results from three highly experienced plastic surgeons. In addition, regression model was developed using correlation relationship and factor analysis of parameters from the results of image analysis**

Keywords- **Cleft lip, nose deformity, nostril**

I. INTRODUCTION

Cleft lip is one of the most common congenital deformities in craniofacial region. Cleft lip isolates patients from the society due to resulting nose deformity. Recent developments in surgical techniques have improved quality of life for patients with severe cleft lip nose deformity and made easier for patients to get closer to the society. Although there are many reports on the results of primary surgery and secondary corrections of cleft lip and nose deformity, the results are very subjective and have no standards. In most cases, the results are evaluated into scale of 3 or 5 such as excellent, good, fair, poor, and bad [1,2]. These reports have been lacking objectivity in evaluating new technique or procedure and may produce discrepancies in analysis of the results.

Nose deformity from a cleft lip causes diverse deviations in nostril, nasal septum and alar. The evaluation of this complex and diverse deviations has been dependent on only subjective judgment, which can be effected by time and space. Therefore, determination of the surgical procedure type or the time of surgery based on the reported results may lack universal validity. There have been efforts to evaluate surgical results of the cleft lip subjectively [3-7]. However, most cases have been limited to comparative observations of evaluations between highly experienced doctors and laypersons on previously determined artificial scale.

Development of an objective assessment tool in evaluation of the condition of cleft lip nose deformity patients may help in advancement and evaluation of surgical techniques. Nevertheless such objective assessment method does not exist yet [3]. Hence, this study analyzed diagnostic factors helpful in subjective evaluation of cleft lip nose deformity by examining factors such as nostril angle, distance between nostrils and overlapping area using the cleft lip nose deformity images.

II. METHODOLOGY

A. Analyzing factors in nose deformity evaluation

Cleft lip nose deformity can be determined by visual inspection of the symmetry of both nostrils. The asymmetry of nostrils was analyzed and compared using differences in angle, area and distance between the two nostrils as shown in Fig. 1 by reflecting one side onto the other. Under the assumption that right nostril is normal and left nostril is abnormal, each angle, area, and distance is defined as following.

- S1(2) : Area of (ab)normal nostril
- C1(2) : Center of (ab)normal nostril
- θ1(2) : Angle of (ab)normal nostril axis
- S1' : Area of symmetric normal nostril with nasal septum as symmetrical axis
- C1' : Center point of symmetric normal nostril with nasal septum as symmetrical axis
- θ1' : Angle of symmetric normal nostril with nasal septum as symmetrical axis
- S3 : Overlapping area of S1 and S2
- D1 : Distance between normal nostril and abnormal nostril
- D2 : Distance between symmetric nostril to the normal side and abnormal nostril
- D3 : Distance between symmetric nostrils

Because of nasal septum as a symmetric axis, obtained symmetrical angle and nostril area are θ1 = θ1'and S1 = S1', respectively. Above measured values can be used in

analyzing nasal asymmetry with consideration to the following analyzing factors.

1) Symmetry of the nostril angle :

① |θ1–θ2| : Difference in angles of normal nostril and abnormal nostril. In normal, θ1 = θ2, |θ1–θ2| becomes 0 when normal.

② θ1/θ2 : Ratio between nostril angles of normal and abnormal side. Of the two angles, ratio of smaller value to the larger is calculated. In normal, θ2 = θ1. Hence, θ2/θ1 becomes 1 when normal.

2) Symmetry of the nostril position: Depending on the magnification degree of the image, same distance may have variations when measured and differences may occur interpersonally. Accordingly, asymmetry should be determined using the ratio between distances rather than the actual distances measured. D2 and D3 are distances proportional to abnormal values, while D3 signifies the distance between symmetric nostrils. Therefore, following 3 ratios of distance can be calculated.

① D1/D3
② D2/D3
③ D2/D1

In normal, D1 = D3 and D2 becomes close to 0. Hence, D1/D3 = 1 and D2/D3 = D2/D 1 = 0 in normal case.

3) Symmetry of the nostril area:

① S2/S1 : Ratio of area between normal and abnormal nostril
② S3/S1 : Ratio of normal nostril and overlapping area
③ S3/S2 : Ratio of abnormal nostril and overlapping area
④ S3/(S1+S2) : Normalization of overlapping area
⑤ S3/(S1+S2-S3) : Normalization of overlapping area

In normal, S1 = S2 and S3 becomes close to 0. Hence, S2/S1 = 1 and other factors become close to 0 in normal case.

B. Evaluation

This study was based on analysis of images obtained from 86 patients who underwent nose deformity corrective surgery at the department of plastic surgery of Yonsei University College of Medicine. 3 plastic surgeons subjectively evaluated the images 3 times each using 100 percentile scales in interval of 10, while 3 laypersons analyzed images 3 times each as well using a developed analysis program. Then, statistical regression equation was extracted by analyzing the correlation relationship and regression analysis on doctor evaluation score and each of the 9 parameters as mentioned above section. Image analysis program was developed using the LabView6.1 (National Instruments, USA).

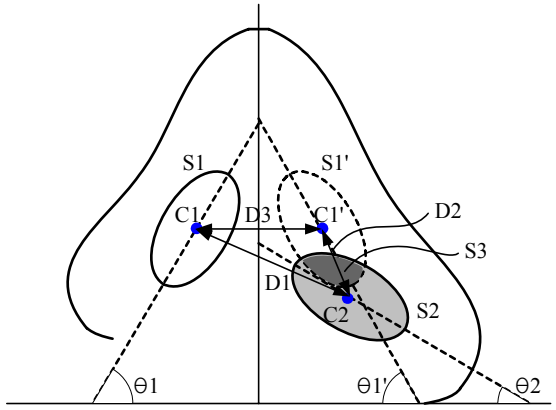

Fig. 1. Measurement values for evaluation of the nose deformity

III. RESULTS

Degree of agreement between doctors on evaluation scores was tested and the values with high degree of agreement were analyzed concurrently with 10 parameters. Kappa test was used to determine degree of agreement between doctors. Statistical values of less than 0.4 represent low degree of agreement, 0.4-0.75 represent average and greater than or equal to 0.75 represent high degree of agreement. Table I shows average degree of agreement between doctors. The values obtained from doctor 2 were excluded from further analysis due to statistical insignificance.

ANOVA test was performed on each of 3 trial measurements of 9 parameters performed by 3 laypersons to test for significant differences. There was no significant difference between 3 testers ($p > 0.05$) (Table II).

The average values of 10 parameters obtained from ANOVA test were then analyzed for correlation relationship with the average value of doctor evaluation score. The results of the analysis showed that D3/D1 and S2/S1 had p-values of 0.07 and 0.60, respectively and have no correlation to doctors' scores. The other 8 parameters had p-values of less than 0.001 and correlation coefficient ranged from -0.35 to 0.60.

The regression equation was formulated for 10 parameters according to the doctor evaluation score through the multiple regression analysis. The factors affecting the doctor evaluation score were extracted using regression analysis on 10 parameters and the resulting parameters were |θ1-θ2| and S3/(S1+S2).

TABLE I
STATISTICS BETWEEN DOCTORS ON AVERAGE OF 3 TESTS

Kappa Value	Doctor1	Doctor2	Doctor3
Doctor1	1.00	0.43	0.49
Doctor2	0.43	1.00	0.37
Doctor3	0.49	0.37	1.00

TABLE II
DESCRIPTIVE STATISTICS OF EACH PARAMETERS AND STATISTICS ON AGREEMENT OF 3 LAYPERSONS

	Mean	Standard deviation	p-value
|θ1–θ2|	17.29	11.46	0.08
θ1/θ2	1.75	2.00	0.24
D2/D1	0.13	0.07	0.05
D2/D3	0.14	0.08	0.22
D3/D1	0.99	0.20	0.86
S2/S1	0.97	0.37	0.34
S3/S1	0.62	0.29	0.73
S3/S2	1.71	0.84	0.66
S3/(S1+S2)	0.31	0.08	0.39
S3/(S1+S2-S3)	0.47	0.18	0.59

The regression equation was calculated as in (1).

$$\text{Doctor evaluation score} = 28.01 - 0.39(|\theta 1 - \theta 2|) + 112.23(S3/(S1+S2)) \quad (1)$$

Test on the goodness of fit, homogeneity in error, normality and independence of data in accordance with the regression model were all in 95% confidence interval. Analysis of correlation relationship between calculated scores using regression equation and doctor evaluation score yielded a result of 0.65 ($p < 0.001$) (Fig. 2).

IV. DISCUSSION

The evaluation of the cleft lip nose deformity has been dependent upon subjective observation of the doctors rather than being objective. This study analyzed nostril angle, distance and area to objectively and quantitatively evaluate cleft lip nose deformity. Consequently, this method allows even non-specialists to determine degree of nose deformity. Computer assisted assessment has several advantages such as non-invasiveness, easy to use, inexpensive and time efficiency. Moreover, it is easy to get digitized image due to the increased usage of high resolution digital camera recently. But further optimal analysis parameters should be developed to get more quantitative evaluation in the future study.

V. CONCLUSION

The results of regression equation confirmed that doctor evaluation score has high correlations with the score obtained from the regression equation. As a result of this study, degree of nose deformity was quantitatively assessed using images of cleft lip nose deformity patients.

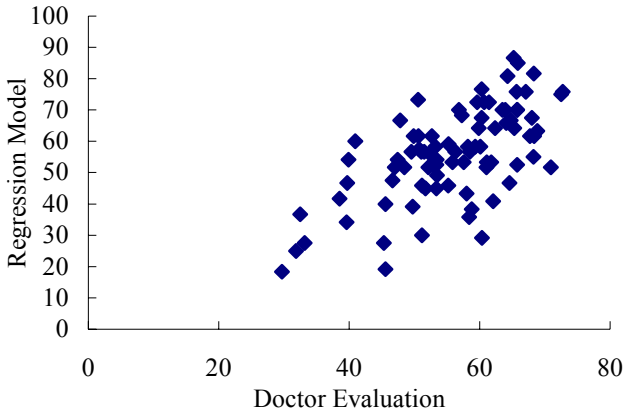

Fig. 2. Results of regression equation and the distribution of doctor evaluation score

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