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Modified Use of Costal Cartilage in Asians for the Correction of Nostril Asymmetry in Unilateral Secondary Cleft Lip Nasal Deformity

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Background: Weak alar cartilage and lack of soft tissue on the cleft side are considered to be the main critical factors leading to the asymmetry of bilateral nostrils. The costal cartilage can provide strong structural support and can be used to maintain long-term stability of nostril shape after surgical correction. With the advancement in rhinoplasty techniques, the application and understanding of costal cartilage in cleft lip nasal deformity is still on going. Herein, we present our technique of applying costal cartilage to provide nostril support and correct asymmetry in Asian patients with unilateral secondary cleft lip nasal deformity.

Methods: Ninety-seven patients who underwent nostril asymmetry correction from January 1, 2013, to October 31, 2018, were analyzed retrospectively. Modified integrative alar cartilage strut and diced nostril augmentation with costal cartilage were implemented to improve the collapsed and flat cleft-side nostril. The release and restoration of muscle and bone were also performed when required. Surgical outcomes were analyzed based on the comparison of nostril parameters, the shape and contour, and symmetry of bilateral nostrils after surgery. During postoperative follow-up, the patients' satisfactions with the corrective outcomes were also investigated.

Results: All patients received the corrective operations with complete survival of all implanted cartilages. The nostril width was narrower in postoperative group ($P < 0.05$). The nostril height and long axis angle were higher postoperatively ($P < 0.05$). After correction, the proportion of moderate type increased from 13.4% to 80.4%, whereas the proportion of horizontal type decreased from 86.6% to 17.5%. The symmetry score on the nostril parameters manifested the rate of high score (AS >3) in postoperative groups were 84.5%, 93.8%, and 87.6% for width, height, and angle of the long axis, respectively. They were higher compared with those of preoperative group (0%). More than 95% of the patients were satisfied with the overall aesthetic outcome of the surgery.

Conclusions: Through ameliorating its constructive technology and optimizing its filling form, the modified use of costal cartilage displayed excellent correction effects in the width, height, and long axis angle asymmetry of Asian patients' nostril. Precise and comprehensive rhinoplasty technique is the cornerstone for achieving satisfactory long-term aesthetic outcomes, especially in severe cases, such as secondary cleft lip nasal deformity.

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Nostril asymmetry is the most common clinical characteristic of patients with unilateral cleft lip nasal deformity. The typical manifestation of this kind of deformity is flattened and collapsed cleft-side nostril, accompanied by an increase base width and decreased height. Dysplasia, deformity, and even anatomic absence of the alar cartilage on the cleft side are considered the most critical factors that cause asymmetry of the nostrils.

Although the incidence of cleft lip is very frequent in Asian populations, effective correction of the deformed nostril seems unattainable due to an inadequate understanding of the specific procedure for rhinoplasty.[1] The timing of the first surgery and nonstandard sequential treatment processes are the main dilemmas to be dealt with when patients are treated for nostril asymmetry. Inadequate initial treatment always leads to an unexpected surgical scar contracture and tissue deficiency, which exacerbates the difficulty in the repair of nostril deformity. With the capability of providing strong structural support, costal cartilage grafts can be used to maintain long-term stability of the nostril shape after surgical correction.

Lateral crura strut graft is a classical rhinoplasty technique used to reenforce the weak lateral crural cartilage and to correct the contour of the nostril by converting the concave lateral crura into a convex shape.[2,3] As the depressed nostril base might easily cause recurrence of the nostril asymmetry, the materials used to fill the underlying base framework should provide an adequate, solid, and stable foundation, especially in severe cases.[4] Although the costal cartilage has been used for rhinoplasty of the cleft lip in previous reports, continuous improvement, scientific evaluation, and repeated verification in a relatively large sample size are essential in such a complex repair process to improve the aesthetic effect.[5–7] Therefore, in this study, we used the costal cartilage to strengthen the cleft-side alar cartilage and to raise the nostril. We evaluated the aesthetic outcomes using a standardized scoring system.

METHODS

A retrospective review of electronic medical records was conducted at our institution, which identified 97 patients who underwent correction of the alar cartilage and nostril asymmetry from January 1, 2013, to October 31, 2018. The group comprised 62 men and 35 women with a mean age of 21 years (range = 15–33 years). None of the patients had undergone a previous rhinoplasty. Informed consents were obtained before the surgery. The study was approved by the Clinical Research Ethics Committee of West China Hospital of Sichuan University.

Surgical Procedures

After the induction of general anesthesia, open inverted V-shaped skin incision lines were made. The position of the normal philtrum ridge

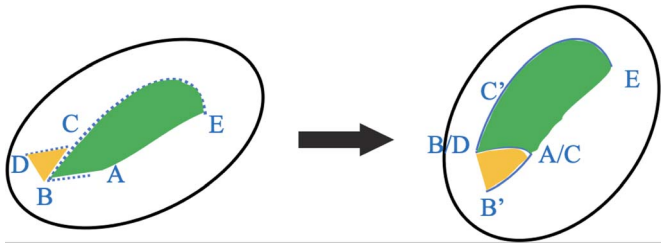

FIGURE 1. The mucous was cut along ABCE line and the mucosal flap (green) was rotated toward cephalic side, which leaded AB line outwards and upward and caused point B to point D and point A to point C. The BCD mucosal flap (yellow) was used to repair the defect after advancement of ABCE flap (green).

and upper labial peak were marked as the basis for judging the degree of correction required during surgery. Both nostrils were measured again before the injection of local anesthesia using 1% lidocaine with 1:200,000 epinephrine. A skin incision was made and followed by the removal of the previous surgical scars. The first step was to correct the orbicularis oris muscle and alar muscles into their normal physiological positions. The reconstruction of the philtrum ridge, correction of the upper lip deformity, and adduction of the alae were sequentially completed. A costal cartilage graft measuring 3 cm in length was harvested through a minimally invasive incision. The costal cartilage was diced, and part of the cartilage was embedded in the base of the affected nostril and surface of the maxillary bone. The nasal mucosa on the cleft side was cut along the inferior margin of the lower lateral cartilage (LLC) to reach the caudal end of LLC. The caudal end of the mucosal flap was cut off and rotated toward the nose tip, and a Z-shaped flap was used to repair the defect caused by the mucosal advancement (Fig. 1). The stretch effect of the mucosa on the alar cartilage was reduced, and the genu of the affected side could be raised up simultaneously.

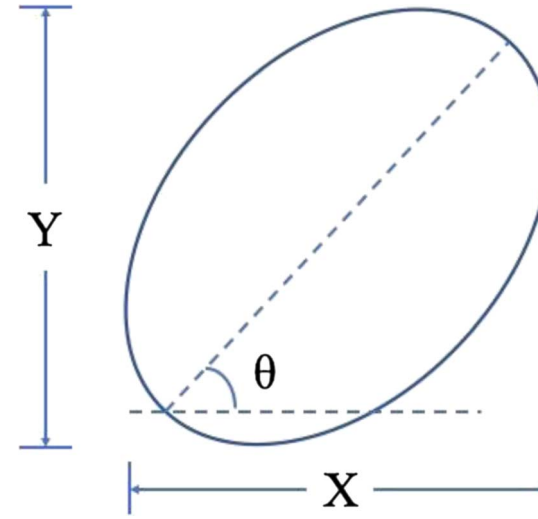

FIGURE 3. The parameters of nostril: width (X), height (Y) and long axis angle (θ). full color online

The remaining costal cartilage cortex was sculpted to form scaffolds that were used to reconstruct the alar cartilage and strengthen the septum and columella (Fig. 2). To simulate the normal morphology of the lateral, genu, and medial crus of the alar cartilage, the long arm of the reconstructed cartilage scaffold was maintained in a curled shape according to the inherent curvature of the costochondral cortex. The long arm was thinned to about 1 mm before implantation and suture. The short arm that was used to strengthen the septum, and columella was carved to a certain thickness and strength, especially in cases with poor development of the alar cartilage. The alar cartilage scaffold was fixed to the surface of the native alar cartilage by 5-0 polydioxanone synthetic

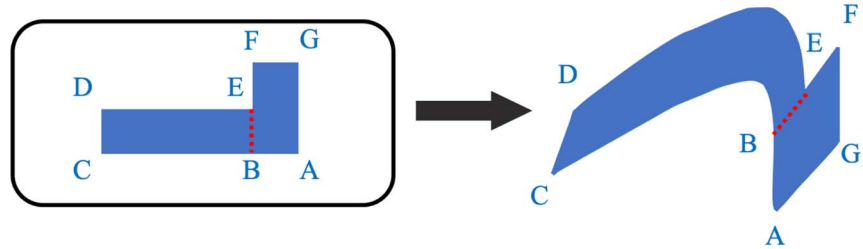

FIGURE 2. Excised cartilage grafts (above). The below left part shown how to cut off the graft (ABCDEFG) from costal cartilage (black box). The long arm (BCDE) of the graft was used to construct the lateral, genu and medial crus of alar cartilage. The short arm (ABEFG) was inserted to strengthen the septum and columella part (below right).

TABLE 1. Patient Satisfactory Score

	Satisfactory Score				
Question	**0**	**1**	**2**	**3**	**4**
1	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
2	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
3	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
4	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
5	Strongly disagree	Disagree	Neutral	Agree	Strongly agree

absorbable suture, and its shape and position were adjusted as required to make the alar radian close to the opposite (noncleft) side. Through scaffold construction, removal of redundant tissue, and tractional suture, the height, width, and symmetry of both nostrils were more consistent after continuous adjustment. Other existing deformities, such as dorsal hump, nasal septum, and bone deviation, were corrected at the same time. To further restore the nostril symmetry, partial excision of the soft triangular skin on the cleft side or reduction of the ala on the normal side could be performed if necessary. The skin incision was closed with 6-0 polypropylene, and a silicone tube was inserted to maintain the shape of the reconstructed nostril for at least 3 months.

Measuring the Nostril Parameters

The main nostril parameters were defined as below (Fig. 3):

Nostril width (X): The horizontal distance between the outermost and innermost borders of the nostril contour.

Nostril height (Y): The vertical distance between the highest and lowest points of the nostril contour.

Nostril long axis angle (θ): The angle formed by the long axis of the nostrils and horizontal reference line.

All measurements were performed by 2 different evaluators using a vernier caliper, before and after the surgery. All patients' preoperative photographs were obtained under a standardized submental-vertical view. Angle measurements were performed by two evaluators using Adobe Photoshop CC (Version 2017; Adobe Systems Inc, San Jose, CA). The long axis line of the nostril was first drawn between the most distant points of the nostril. Next, a horizontal reference line was constructed by connecting the bilateral inner canthus points and moved to the nasal base. To minimize the subjective and objective bias, measurements of both sides were completed on the same photograph. Based on the angle of axis of the nostril, all patients' nostrils were divided into horizontal ($\theta < 43°$), moderate ($43° \leq \theta \leq 49°$), and vertical ($\theta > 49°$) types.

Postoperative Evaluation

Evaluation criteria mainly focused on the shape and contour symmetry of both sides of the nostril; severity of the defect before repair was also considered. Surgical outcomes were graded according to the

FIGURE 4. A 23 years old male with left side cleft lip nasal deformity before surgery (above left). The restoration of orbicularis oris muscle, formation of upper lip, embedment of diced cartilage in nostril base and fastening cartilage graft on the left alar have been completed (above right). The symmetry of bilateral nostrils was good immediately after operation (below).

degrees of symmetry in width, height, and angle of the long axis between the normal and cleft side nostril. The results were scored on a 5-point Likert scale: 5 (excellent), 4 (good), 3 (fair), 2 (poor), and 1 (very poor).[8] Three plastic surgeons, who were not involved in the surgeries, evaluated reconstructive effects by comparing the preoperative and postoperative photos. The postoperative photos used for our analysis were obtained 12 months after surgery. All patients were followed up for 14 to 26 months.

Patients were surveyed during their postoperative visits. The questionnaire included: (1) Are there improvements in your nostril contour compared with before surgery? (2) Do your family members or friends notice improvements in the shape of your nostril compared with before surgery? (3) Do you feel that your present nostril contour has increased your self-confidence compared with before surgery? (4) Would you like to change the present contour of your nostril with another surgery? (5) Did you receive satisfactory treatment services during the surgery? As shown in Table 1, the answers ranged from strongly disagree (0), disagree (1), neutral (2), agree (3), strongly agree (4). The scores were calculated to obtain the total satisfactory score (TSS). Patients' satisfaction was graded as very satisfied (TSS ≥ 15), satisfied (10 < TSS ≤ 15), dissatisfied (5 < TSS ≤ 10), very dissatisfied (TSS ≤ 5).

FIGURE 5. A 26-year-old woman with right side cleft lip nasal deformity before surgery (above). The asymmetry of bilateral nostrils, scar and pitting of upper lip were all corrected and stable aesthetic results were obtained at 12 months follow-up after surgery (below).

Statistical Analysis

Based on angle of axis of the nostril on the noncleft side, all patients were divided into horizontal ($\theta < 43°$), moderate ($43° \leq \theta \leq 49°$), and vertical ($\theta > 49°$) types. Statistical analysis of the data was separately calculated using SPSS (IBM Corp., Version 22.0. Armonk, NY) for each parameter. The overall scoring similarity between the two evaluators was compared using the Pearson correlation coefficient. The difference between the measurements by the 2 observers was compared using the Wilcoxon signed rank test. The preoperative and postoperative ratios of the width and height of the cleft side compared with those of the normal side were compared using the Wilcoxon signed-rank test. The preoperative and postoperative ratios of the angle of the nostril axis were also compared using the Wilcoxon signed-rank test.

RESULTS

All corrective surgeries were performed successfully without complications, and all implanted cartilages survived completely (Figs. 4–6). No contracture scar formation was observed during the follow-up period. Slight bleeding from the upper lip incision was seen in two patients within 24 hours after surgery, which was relieved after pressure bandaging and without hematoma formation.

The results of the evaluators' analysis are summarized in Table 2. The Pearson correlation coefficients between the two evaluators on the three parameters were higher than 0.83, which indicates acceptable interevaluator reliability. Furthermore, no significant differences were found between the two observers on all three parameters measured.

The results of the nostril parameters measured before and after surgery are shown in Table 3. Data of the 3 parameters are presented as the ratio of the cleft side to the normal side. The nostril width was lower postoperatively (137.5 ± 19.3 vs 106.7 ± 13.2, $P < 0.05$). However, the nostril height and angle of the long axis were higher postoperatively (86.5 ± 9.1 vs 97.6 ± 8.2, $P < 0.05$). Flat and collapsed nostrils on the cleft side showed significant improvement after correction. As shown in Table 4, majority of the cleft-side nostrils were of the horizontal type (86.6%) before surgery and without vertical type. After correction, the proportion of moderate type increased from 13.4% to 80.4%, while the proportion of horizontal type decreased from 86.6% to 17.5%.

In Table 5, the symmetry score of the width, height, and angle of the long axis showed that the rate of high scores (AS > 3) in the postoperative groups was 84.5%, 93.8%, and 87.6%, respectively, which was higher than that before the surgery (0%). The patients' satisfaction results demonstrated that more than 95% of patients were satisfied with the overall outcome of the surgery; 4 patients were not satisfied with the outcome (Table 6).

DISCUSSION

In this study, the costal cartilage was used to correct the collapsed nostril in unilateral secondary cleft lip nasal deformity. Remarkable surgical outcomes with improved nostril symmetry were achieved by comparing and analyzing the related parameters of both the cleft and normal sides before and after surgical correction. The effectiveness and reliability of reconstructing the weak alar cartilage by grafting the costal cartilage for correcting the nostril asymmetry were also proven during the long-term follow-up.

FIGURE 6. A 20-year-old man with left side cleft lip nasal deformity before surgery (above). Effective improvement of bilateral nostril symmetry was achieved at one-year follow-up time (below).

Although simultaneous correction of the nasal deformity with lip repair has become a trend, it is only possible in the recent years due to advancement in rhinoplasty techniques.[9,10] However, most plastic surgeons are more likely to agree to perform a definitive rhinoplasty, which aims to improve the aesthetic and functional outcomes.[11] Considering the imbalance in economic and social development in Asia, a 2-stage surgical correction still accounts for the vast majority of patients undergoing repair for the cleft lip nasal deformity, due to the limited resources. Majority of the cases in our study presented with more severe secondary deformities and scar formation at the time of surgical consultation. Moreover, solid and stable supportive material is extremely essential in Asian patients who have a thick nasal skin, round nostrils, and weak cleft-side tip structures. Owing to its easy availability and the ability to provide strong structural support, costal cartilage was used to construct the alar cartilage scaffolds and fill the base of the nose. The width ratio of the cleft side to the normal side decreased significantly compared with that before the surgery, along with an increase in the angle of the long axis, which demonstrated that our technique can successfully change the horizontal-shaped nostrils into the more aesthetic circular shape.

Costal cartilage has always played a crucial role as supportive material for rhinoplasty in cases with severe cartilage deficiency and

TABLE 2. Variability Between the Evaluators

		Difference Between Evaluators	
Parameters	**Pearson Correlation**	**Mean Difference (95% CI)**	***P***
Nostril width	0.886	0.17 (−1.52 to 1.86)	0.862*
Nostril height	0.837	−0.31 (−2.17 to 1.55)	0.624*
Nostril axis angle	0.901	−0.77 (−2.86 to 1.42)	0.473*

* $P > 0.05$, values between the evaluators shown no significant difference.

TABLE 3. Nostril Parameters Ratio of the Cleft Side Over the Normal Side Between Preoperative and Postoperative Groups (n = 97)

	Preoperative Group	**Postoperative Group**	***P***
Nostril width	137.5 ± 19.3	106.7 ± 13.2	0.006*
Nostril height	86.5 ± 9.1	97.6 ± 8.2	0.017*
Nostril axis angle	80.3 ± 4.6	93.4 ± 7.7	0.023*

* $P < 0.05$, ratios between preoperative and postoperative group were significant difference.

TABLE 4. Proportion Changes of Cleft-Side Nostrils Types Between Preoperative and Postoperative (n = 97)

	Preoperative		Postoperative	
Type	n	Percentage (%)	n	Percentage (%)
Horizontal	84	86.6	17	17.5
Moderate	13	13.4	78	80.4
Vertical	0	0	2	2.1

deformity.[12] Merely using the costal cartilage to strengthen LLC might inevitably lead to collapse of the nostril in complex cases.[13] We modified the previous methods and divided the harvested cartilage into a supporting part and a filling part. To comply with the biomechanical principle, we simulated the U-shaped alar cartilage into a physiological shape and carved the supporting part into a similar form including medial crus, lateral crus, and genu. The short arm of the grafts need to be sculpted thick and solid to avoid deviation of the columella and nostril collapse caused by the pulling force from the lower lateral sides. It is recommended that the lateral part be sculpted to form a certain degree of curl to mimic the natural round radian of the alar ring. At the same time, due to its connection with the other 2 structures, the reconstructed lateral crus would be less prone to displacement and deformation. If one considers the nostril as an oval structure composed of the base, alae, and columella, raising the nasal base can be beneficial in improving the nostril symmetry on both sides. Compared with implanting the entire cartilage graft as a whole,[11] diced costal cartilages not only have a high survival rate but also are not easily reabsorbed, which can effectively lift the base of nostril. For patients with cleft side alar cartilage dysplasia, diced costal cartilage can be inserted as grafts on both sides to strengthen the overall rigidity of the tip, columella, and ala of the nose. This additional surgery is definitely instrumental in modifying the shape of the nose closer to an equilateral triangle when observed from the submental-vertical view in Asian patients, especially for those with severe nostril flattening and poor alar cartilage development, which was more common in this study. Without solid structural support, the reconstructed nostril collapses easily and satisfactory long-term aesthetic results are harder to achieve.

For providing strong cartilage support, release and restoration of the muscle and bone cannot be ignored. The complete surgical approach includes removal and repair of the initial surgical scar, release of the fibrous adhesion tissue, rebuilding the orbicularis muscle layer by layer, rotation and advancement of the mucosal flap, and correction

TABLE 5. Symmetry Score Between Preoperative and Postoperative Groups (n = 97)

	Symmetry Score (SS)									
	1		1 < AS ≤ 2		2 < AS ≤ 3		3 < AS ≤ 4		4 < AS ≤ 5	
Parameter	n	%	n	%	n	%	n	%	n	%
Width										
Pre	57	58.8	32	33.0	8	8.2	0	0	0	0
Post	0	0	3	3.1	12	12.4	59	60.8	23	23.7
Height										
Pre	23	23.7	55	56.7	19	19.6	0	0	0	0
Post	0	0	1	1.0	5	5.2	55	56.7	36	37.1
Long axis angle										
Pre	37	38.1	47	48.5	13	13.4	0	0	0	0
Post	0	0	2	2.1	10	10.3	53	54.6	32	33

TABLE 6. Questionnaire Survey Results of Patients' Satisfaction

Satisfaction Degree	n	Percentage (%)
Very satisfied	26	26.8
Satisfied	67	69.1
Dissatisfied	4	4.1
Very dissatisfied	0	0
Total	97	100

of the septum and nasal bone deformity. Missing any of the above steps might result in suboptimal aesthetic outcome due to the complexity of the repair process. We based our technique on previously modified methods and meticulously executed every step of the procedure. Thus, we were able to achieve satisfaction in more than 95% of the patients in this study.

Measurement of the width, height, and angle of nostrils is known as the most effective and direct method to evaluate the improvement in nostril shape.[14,15] Whether the nostrils are eclipse-shaped or in other shapes, the long and short axes can be determined on the photographs. However, measurement errors are inevitable, which might not achieve the most realistic comparison results.[13] It is undoubtedly more accurate to determine the height and width of nostril according to its left, right, upper, and lower outermost points, and the reliability of data collected using this method seems to be relatively higher. Several ways are used to define the inclination of the angle of the nostrils. Compared with the method of measuring the angle between the long axis of both nostrils and horizontal line, the method that uses the angle between the long axis of the nostrils and horizontal line can more accurately and intuitively reflect the morphological changes of both nostrils before and after surgery.[16] To minimize the errors, the ratios of parameters, not the absolute values, were used in our analysis. Highly significant interobserver reliability was also proven through statistical analysis in our study.

Despite the growing trend that aesthetic standards accepted by the nonwhite society generally follow Caucasian standards in the recent years[17]; there are clear anatomical differences and evaluation criteria between the Asian and white patients. Therefore, it is essential to summarize the current methods and explore new surgical techniques to adapt to the characteristics of the Asian nasal structure, which includes thick nasal skin, round nostrils, and weak LLC support.[18–20] Although the postoperative evaluation in this report focused on comparison with the normal side, it should be noted that converting all nostrils to the vertical-type (more commonly seen in Caucasians) in our cases might be unrealistic. In addition, although we considered every measure to avoid potential errors in the analysis, subjective errors in measurement and evaluation might still exist in retrospective clinical studies. Inclusion of more cases and conducting multicenter, randomized controlled studies might be helpful to further verify the effectiveness of this modified method.

CONCLUSIONS

Owing to its easy availability and the ability to provide a strong structural support, the costal cartilage was chosen to repair the nostril asymmetry of the cleft lip. By altering its construction and optimizing its filling form, the modified use of costal cartilage showed excellent surgical outcomes in correcting the nostril asymmetry in Asian patients. Precise and comprehensive rhinoplasty technique is the cornerstone for achieving satisfactory long-term aesthetic outcomes, especially in severe cases, such as secondary cleft lip nasal deformity.

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