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Article

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Simultaneous correction of secondary unilateral cleft lip nasal deformity using autologous iliac cartilage during alveolar cleft repair

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ABSTRACT

Objective: To evaluate the postoperative outcomes of the correction of secondary nasal deformity associated with unilateral cleft lip with autologous iliac cartilage graft, we try to find a new source of cartilage graft for nasal deformity.

Methods: The operation to graft autologous iliac cancellous bone to treat alveolar cleft and cartilage to repair nasal deformity was performed simultaneously in 17 patients with unilateral cleft lip and palate with complex nasal deformities from 2020 to 2021. Patient satisfaction, two-dimensional linear quantitative and three-dimensional radiographic results

after the surgery were used to evaluate the effect of the surgery.

Results: Satisfactory effectiveness was achieved in all 17 patients after the operation. Seventeen patients were followed up for 6 to 24 months and presented symmetrical nostrils, higher nasal tip and natural nasal shape. Only two patients exhibited red nasal tips and abscess formation, which were cured by mupirocin ointment. Moreover, there was no endochondral ossification in the 17 patients after the operation.

Conclusions: Correcting the secondary nasal deformity associated with unilateral cleft lip with autologous iliac cartilage graft is feasible. It provides a new source of cartilage to avoid adding a new operative approach for cartilage obtaining and reduces the financial burden on patients' families. As for the positive results of this treatment, it is worth being widely used in clinical practice.

Key Words: autologous iliac cartilage, secondary nasal deformity, unilateral cleft lip, simultaneous correction

INTRODUCTION

Even after surgery, the cleft lip and palate complicated with the alveolar cleft may be complicated with secondary nasal deformity [(1)]. The Team Approach (TEAM) in the cleft lip and palate is the most effective method to cure severe cleft lip and palate but needs enough to withstand several surgeries, injuries, and expenses. [(2)] According to statistics, most parts of the patient with cleft lip and palate cured in our hospital come from rural areas of southwest China (Yunnan, Sichuan, Chongqing and Guizhou), where the economic, transportation, and healthcare conditions are disadvantageous. TEAM in the cleft lip and palate heavily bears on the patients and their families. Hence, we tried to find a method to repair multiple deformities in a single-stage surgery to minimize the number of surgical interventions and costs.

In our hospital, alveolar grafting with autologous iliac bone, a classic surgical method, is usually used to repair the alveolar cleft. By accident, we found in one clinical practice of iliac bone harvesting that the iliac cartilage in young adolescents is abundant and more accessible to sculpture. Hence, we proposed whether the correction of nasal deformity with autologous iliac cartilage is feasible. However, autologous cartilage iliac is rarely mentioned as an autograft material. Because the iliac cartilage gradually ossifies with age.

Some autologous cartilages, such as costal, conchal, and nasal septal cartilage, are used as autograft material[(3-8)]. Past conchal cartilage transplantation may damage auricle-supporting structures and lead to secondary donor area deformities. Furthermore, conchal and septal cartilage cannot provide enough volumes and be hard to maintain a long-lasting shape. Though costal cartilage can provide larger volumes and maintain a long-lasting shape, it may occur

along with postoperative complications such as pneumothorax and infection. Besides, same as the conchal cartilage and septal cartilage graft, costal cartilage graft needs to increase incisions, surgical injuries, and costs. Therefore, we proposed the opinion that iliac cartilage can be used as a source of graft in secondary rhinoplasty owing to its significant volumes and its strength and ability to sculpt maintain a long-lasting shape.

Since February 2020, adolescent patients with complex secondary nasal deformity have been treated with this method in our institute. This method has been applied to provide patients with complete, simultaneous correction of nasal deformities and alveolar cleft. Positive clinical outcomes have been achieved and are reported as follows.

METHODS

Patient selection and study design

Forty-eight patients with complex secondary nasal deformity and alveolar cleft were treated at our hospital from June 2020 to June 2021. Only 17 patients met the inclusion and exclusion criteria (Fig 1): 6 females and 11 males whose ages ranged from 6.75 to 12.75 years with a mean age of 9.931 years (Table 1). The study was approved ethically by the Ethics Committee of our hospital (No.2019-36). All patients' parents were informed of the aim of the study, and they signed a formal consent before participating.

Inclusion criteria were as follows: (1) patients with alveolar cleft presented complex nasal deformity who underwent an initial operation for a unilateral cleft lip and palate between approximately three months after birth and one year of age, and (2) the institutional review

board-approved parent- or guardian-signed informed consent. Exclusion criteria were (1) previous treatment with filling materials, such as other autologous cartilage or a prosthesis；(2) the presence of other craniofacial anomalies; or a family history of scar diathesis and (3) cases with incomplete clinical data and missing follow-up.

Surgical Procedure

Iliac cartilage graft harvest and carving

The ilium on the leg that was not accustomed to using was routinely selected as the donor area. A 5-cm long incision was located on the medial side of the anterior superior iliac crest parallel to the iliac crest. Skin and subcutaneous tissue were cut layer by layer; muscles and fascia attached to the iliac crest were carefully separated; the cartilage surface was exposed; the cartilage was incised with a rectangle-shaped notch. A size of 2.5cm*1.0cm*0.5cm cartilage was harvested. The fascia attached to the cartilage surface was trimmed, and the thin cartilage next to the iliac cancellous bone was removed. The cartilage transplanted to the tip of the nose should be carved to be flat, thus presenting a fine nasal tip (Fig.2).

Rhinoplasty and iliac cartilage implantation

The outline of the surgical procedure is illustrated in Fig.3. The incision line was made along the muco-cutaneous junction from the nasal columella to the nasal vault and extended laterally. Bilateral incisions were connected at the columellar base by a broken line. Incise the skin along the incision line and put the flap upwardly. The connective tissue was removed from the space between the bilateral alar cartilage, then the middle crus and medial surface of the medial crus and upper surface of the lateral crus were entirely exposed. The carefully carved

iliac cartilage was transplanted between the medial crus of the bilateral alar cartilage, and its upper, middle and lower parts were separately sutured and fixed on the lobular segment of the middle crus, the columellar segment and footplate segment of the medial crus with 4-0 absorbable sutures. Malpostioned alar cartilages on both sides were restored and sutured to the contralateral. The patient's nostrils were supported postoperatively by wearing a silicone nasal model for more than eight months.

Outcomes evaluation

Two-dimensional linear quantification: nasal symmetry

Basal view photographs were taken by an experienced photographer pre-operatively and post-operatively to assess symmetry and improvement of nasal aesthetics. 4 measurements were as follows: nostril height, nostril width, nostril gap area, columellar axis deviation angle[7]. Anthropometric analysis of photographs was compared post-operatively by Digimizer 4.2.0 (an image analysis software developed by MedCalc Software) (Fig.4). In order to eliminate the influence of photograph parameters and minimize the comparison errors caused by the year-long facial growth, the symmetric ratios (SRs) (affected side divided by non-affected side)[9, 10] were used to evaluate the outcomes. The closer the value of SR is to 1, the more well-symmetrical the area is (Table 2, Fig.5). All data were measured and analyzed by two surgeons who were unaware of the clinical evaluation records. All images were examined twice and taken the average of the measured results.

Three-dimensional radiographic evaluation: endochondral ossification

In order to assess whether the iliac cartilage ossify, computerized tomography with the 3D

reconstruction of the facial skeleton was performed approximately six months to two years after surgery (Fig.6).

Satisfaction evaluation

Four pictures of every patient were taken from the frontal view, lateral view, and basal view (Fig.7 and Fig.8). After the surgery, two plastic surgeons, two nurses, two patients and two patients' parents were elected randomly to evaluate the postoperative outcome. The evaluation indexes concluded the nasal alar symmetry, nostril symmetry, nasal base symmetry, nostril shape, shape and position of the nasal tip and height of the nasal columella. The satisfaction evaluation criteria were as follows: (1) very satisfied: all eight evaluators were satisfied with the postoperative outcome; (2) satisfied: 6 to 7 evaluators were satisfied with the postoperative outcome; (3) dissatisfied: less than or equal to 5 evaluators were satisfied with the postoperative outcome. The sum of the patients who were very satisfied and satisfied with the postoperative outcomes determined the overall satisfaction (Table 3).

Statistical Analysis

All data management was performed using Microsoft Excel 2010, and statistical analysis and chart preparation were performed with GraphPad Prism Ver. 9.3 for Windows (GraphPad Software, LLC). Paired t-test was used to compare data between groups. The results were expressed as mean ± standard deviation (SD); a value of $p<0.05$ denoted a statistical significance.

RESULTS

Postoperatively, only two patients (11.8%) presented with red nasal tips and abscess formation and were cured by mupirocin ointment and complete aseptic drainage. One patient (5.9%) had numbness on the medial side of the donor site, getting better without any special treatment. The appearance of the nose of all 17 patients was significantly improved and kept stable during 6-month to 2-years follow-up. The detailed data are shown in Table 2. The iliac cartilage donor site had no deformity and iliac crest bone fracture. There was no restriction on both lower limb movements, such as claudication.

The SRs of nostril height, nasal width, nostril gap area and columellar axis deviation angle of the 17 patients were compared by two-dimensional linear quantification before and after the surgery (Table 2, Fig.5). The ratio of nostril height, width and gap area between the affected side and non-affected side showed significant improvement after than before surgery ($P < 0.05$), the columellar axis deviation was significantly being towards the midline after than before the surgery ($P < 0.05$). The computerized tomography with 3D reconstruction comparison showed no endochondral ossification in the 17 patients after the operation (Fig.6). The patient satisfaction evaluation presented more than 94% satisfaction for all evaluation indexes after the surgery (Table 3).

DISCUSSION

Even after an excellent primary rhinoplasty, some distortions can often persist. Secondary cleft lip nasal deformity mainly results in residual deformity, iatrogenic deformities and growth-

related[1]. Patients with alveolar cleft usually present complex nasal deformity owing to the lack of maxilla continuity. Therefore, the alveolar cleft repair is necessary to supply support to the nostril base of the affected side in secondary rhinoplasty of the cleft lip patients with the alveolar cleft. All 17 patients in the present study had an alveolar cleft repair and simultaneous correction of secondary nasal deformity.

At present, cleft lip nasal deformity is usually repaired using transplantation, such as autologous [3-8]and allogeneic transplantation. [11,12] Compared with allogeneic transplantation, autologous transplantation was used more widely, such as costal cartilage, conchal cartilage or septal cartilage. Every autologous transplantation has its advantages and disadvantages. For example, costal cartilage is abundant and solid and easy to carve, while the surgery to harvest costal cartilage causes extreme trauma and potentially severe postoperative complications, such as pneumothorax and infection. Besides, conchal cartilage and septal cartilage have convenient access, and the surgical wound is hidden; but there is little cartilage in the nasal septum and auricular, and they are hard to carve, lacking high strength and good elasticity. Alveolar grafting with iliac bone is a classic and crucial surgical procedure to repair secondary cleft lip deformity. In the surgery of alveolar grafting, the authors found that the iliac cartilage in young adolescents is thicker, stronger and more accessible to sculpture. D.Tao De-tao et al.[13] had an experimental study on iliac crest cartilage and costal cartilage graft in alae nasi soft tissue and on maxilla surface. The results showed that the iliac crest cartilage and costal cartilage grafted on the maxilla surface had become mature osseous tissues. However, the cartilages grafted on the alae nasi soft tissue had no histological change. It demonstrated that the cartilages graft has no relationship with the donor area but is closely related to the recipient. This experiment provides

a reliable basis for using iliac cartilage as a graft material. Moreover, because of the histological similarity between the iliac cartilage and the costal cartilage, we guess the iliac cartilage might be a suitable implant to correct the nasal deformity.

In this study, secondary nasal deformity of the unilateral cleft lip was repaired simultaneously with correction of alveolar cleft using autologous iliac cartilage as transplantation. Compared with the accesses of other transplantation, when the iliac bone is harvested to graft onto the alveolar deformity lesion, the iliac cartilage can also be extracted from the same incision. Therefore, because we harvest cartilage from the donor site with the iliac crest, it reduces incisions, injuries, operation time, and costs, thereby reducing the risk of deformity and the occurrence of complications of harvesting cartilage from another donor site and the financial burden on patients' families. Usually, there is much cartilage in the ilium of immature adolescents, and its high strength and good elasticity make it easier to carve[(14)]. Therefore, the technique is available and particularly suitable for pediatric patients. The absence of other surgical involvements such as conchal cartilage or costal cartilage is an advantage of our method. During the operation, the harvested rectangle-shaped iliac cartilage segment was trimmed, carved, and transplanted to reconstruct the height of the columellar and restore the shape of the nasal tip. 6 to 2 years' follow-up indicated significant improvement of the nasal appearance of the 17 patients. Furthermore, patient satisfaction evaluation presented more than 94% satisfaction for all evaluation indexes after the surgery. The height of the nostril on the affected side was significantly higher after than before surgery ($P < 0.05$), and the width, gap area and the columellar axis deviation angle were significantly shorter after than before surgery ($P < 0.05$).

While, iliac cartilage used as autograft material was rarely mentioned because the iliac cartilage gradually ossifies with age[14, 15]. Some scholars think that secondary reconstruction of nasal deformities based on alveolar graft and orthodontic treatment is the best stage for correcting nasal deformities[16]. However, iliac cartilage mostly ossifies at this stage which is hard to find. While in our institute, orthodontic treatment and reconstruction of dental arch morphology are usually performed before alveolar repair. Then, simultaneous correction of secondary nasal deformity of the unilateral cleft lip using autologous iliac cartilage during alveolar cleft repair was performed, minimizing the postoperative nasal morphology changes to the greatest extent, thus reducing the probability of reoperation of nasal deformity[1, 17]. Thus, we accidentally found a cartilage iliac in clinical practice that did not ossify and used it as an autograft material. In this study, we used three methods to evaluate the effect of the operation. In addition to the satisfaction survey and two-dimensional linear quantitative evaluation, a three-Dimensional radiographic evaluation was introduced to evaluate whether the endochondral ossification exists[18, 19]. The study demonstrated that iliac cartilage did not show apparent absorption and ossification in the follow-up period.

However, some limitations existed in this clinical study. The most prolonged follow-up period is only two years, and longer positive results did not be followed. We will continue to follow up to get more positive results. Besides, the mechanism of iliac cartilage ossification did not verify. Therefore, we removed the fascia on the surface of the iliac cartilage in order to avoid ossifying. The mechanism of iliac cartilage ossification remains to be studied. Moreover, we will try to perform the related animal testing next step.

CONCLUSION

The positive results have certified that when repairing the alveolar cleft, iliac cartilage can be used as a new graft source to repair the nasal deformity simultaneously. It provides a new source of cartilage to avoid adding a new operative approach for cartilage obtaining and reduces the financial burden on patients' families. As for the positive results of this treatment, it can be widely applied in clinical practice.

Data availability The datasets generated during and analysed during the current study are available from the corresponding author on reasonable request.

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Author contributions

Yijun Li wrote the manuscript. Lishu Liao and Wanshan Li performed the operations. Yijun Li, Shengyu Tang, Xiaorong Wang, Li Xiang, Li Liang and Yuxiang Zhong collected the data. Yijun Li and Xiaorong Wang analysed the data. Wanshan Li reviewed and edited the manuscript.

Competing interests

The authors declare that no competing interests

Fig.1 Flow chart of patient selection.

Fig.2 Harvested a size of 2.5cm*1.0cm*0.5cm cartilage. Trimmed the fascia attached to the cartilage surface, and removed the thin cartilage next to the iliac cancellous bone.

Fig.3 (A) Schematic diagram of surgical incision. (B) Restored malpositioned alar cartilage on both sides. (C) Inserted the carved iliac cartilage between the medial crus of the bilateral alar cartilage and fixed it with 4-0 absorbable sutures. (D) Postoperative situation.

Fig.4 Anthropometric measurements performed on the basal view of digital photographs: nostril width (green line), nostril height (orange line), nostril gap area (yellow closed curve), columellar axis (blue line), interpupillary line and its perpendicular line (black line).

Fig.5 (A) Seventeen patients' SR of nostril height measurements before and after the operation. (B) Seventeen patients' SR of nostril width measurements before and after the operation. (C) Seventeen patients' SR of nostril gap area measurements before and after the operation. (D) Seventeen patients' columellar axis deviation angle measurements before and after the

operation.

Fig.6 (A) pre-operative situation (B) 1year after surgery: there was no endochondral ossification.

Fig.7 Patient 1:1 frontal view, 2 lateral views, and 1 basal view photos were taken before and after the operation. 2 plastic surgeons, 2 nurses, 2 patients and 2 patients' parents determined the postoperative satisfaction by comparing the effects before and after the operation.

Fig.8 Patient 2:1 frontal view, 2 lateral views, and 1 basal view photos were taken before and after the operation. 2 plastic surgeons, 2 nurses, 2 patients and 2 patients' parents determined the postoperative satisfaction by comparing the effects before and after the operation.

Tables

Table 1. General patient information

Items	Patients(n=17)
Gender	
Male, n (%)	11(64.71)
Female, n (%)	6(35.29)
Age(years)	
Min	6.75
Max	12.75
Average age (mean ± SD)	9.93±1.95
Site	
Left	11
Right	6
Follow-up	
6 month to 1 year	10
1 year to 2 year	7
Complications	
Infections: recipient site	2
Infections: donor site	0
Numbness: recipient site	0
Numbness: donor site	1

Table 2 Comparisons of the SRs and columellar axis deviation angle before and after the operation

Item	Pre-operation	Post-operation	t-test	P-value
The SR of nostril height	1.521±0.3062	1.110±0.1371	5.887	<0.0001
The SR of nasal width	0.7980±0.2405	0.9368±0.1261	3.047	=0.0077
The SR of nostril gap area	1.153±0.2971	0.9801±0.1290	2.900	=0.0104
columellar axis deviation angle (°)	14.52±8.598	3.166±2.388	5.521	<0.0001

Table 3 Satisfaction evaluation

Item	Very satisfied(N)	Satisfied(N)	Dissatisfied (N)	Overall satisfactory (N(%))
Nostril shape	16	1	0	17(100.00%)
Shape and position of nasal tip	13	3	1	16(94.12%)
nasal alar symmetry	14	2	1	16(94.12%)
Nostril symmetry	14	2	1	16(94.12%)
Nasal base symmetry	14	2	1	16(94.12%)
Height of nasal columella	13	3	1	16(94.12%)

Fig.1

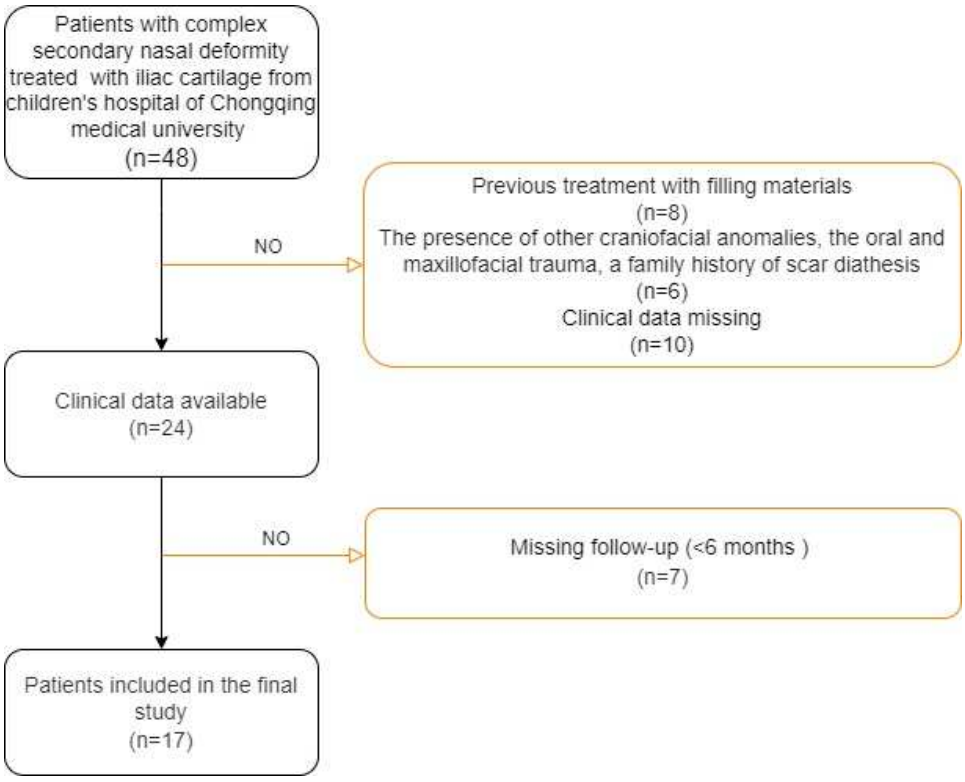

Fig.2

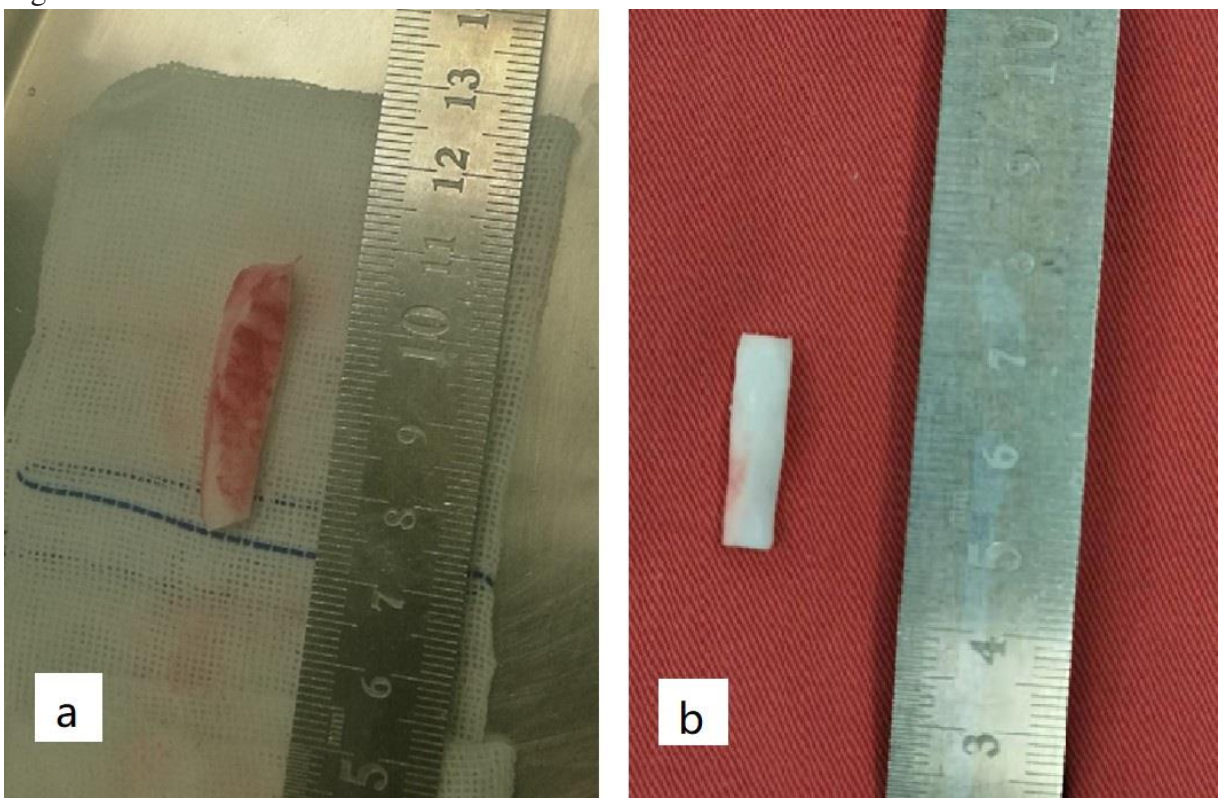

Fig.3

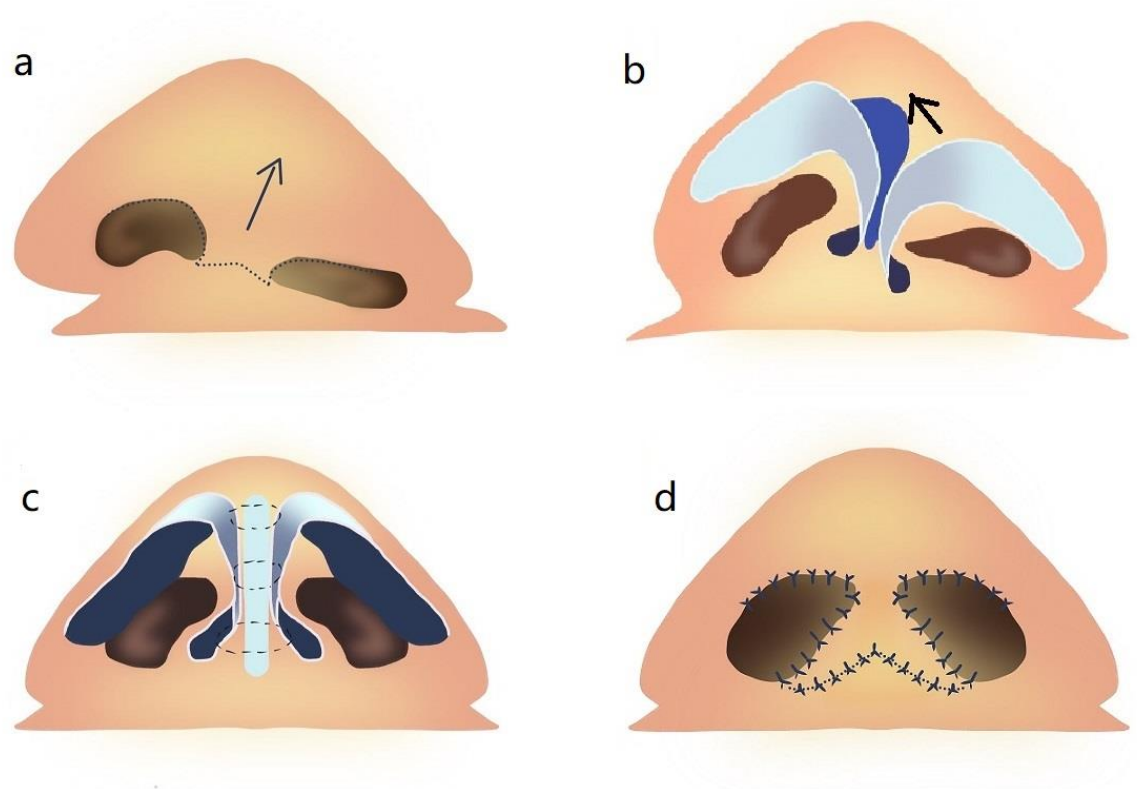

Fig.4


preoperation
postoperation

Fig.5

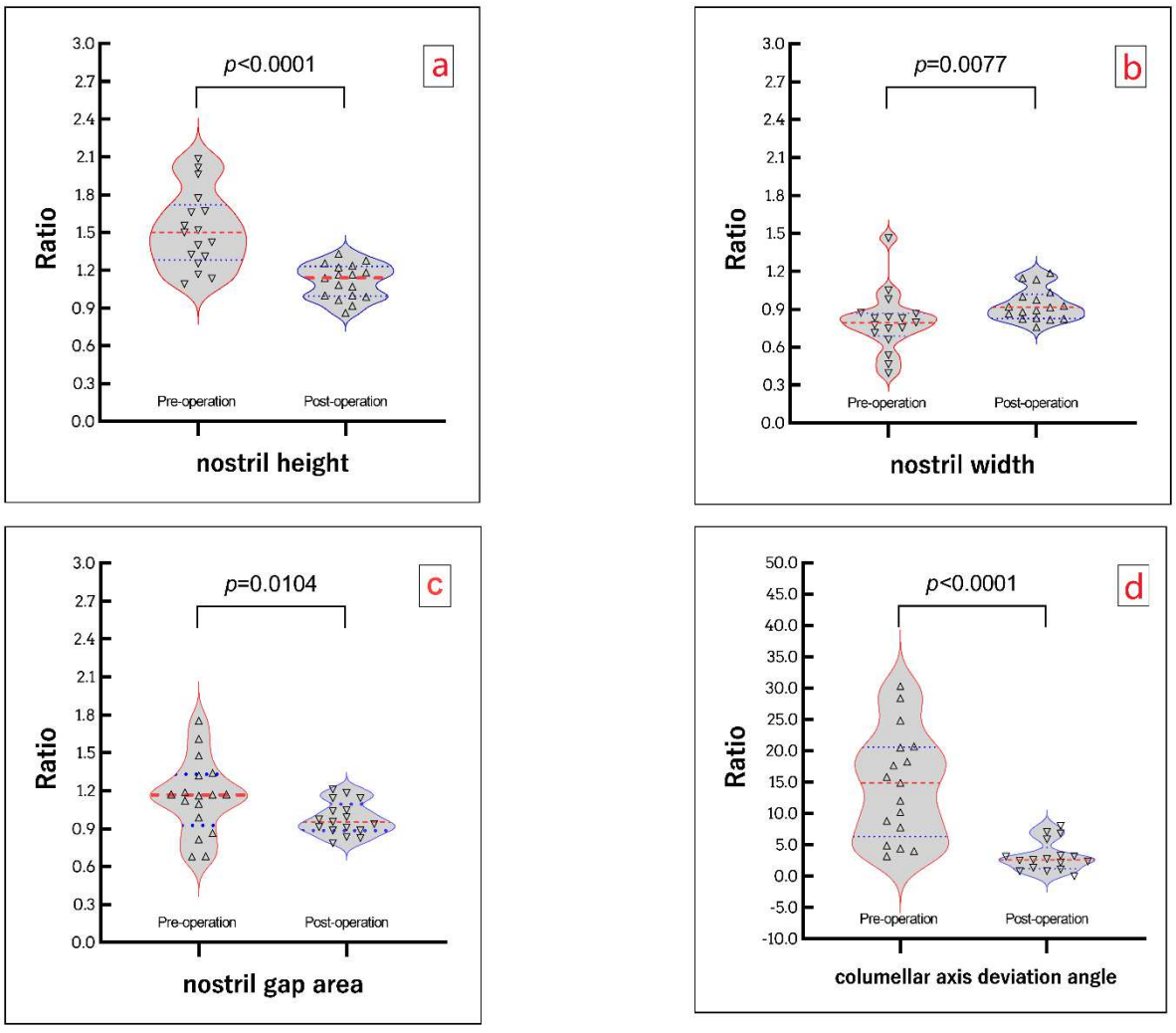
a
p<0.0001
Ratio
Pre-operation
Post-operation
nostril height
b
p=0.0077
Ratio
Pre-operation
Post-operation
nostril width
c
p=0.0104
Ratio
Pre-operation
Post-operation
nostril gap area
d
p<0.0001
Ratio
Pre-operation
Post-operation
columellar axis deviation angle

Fig.6

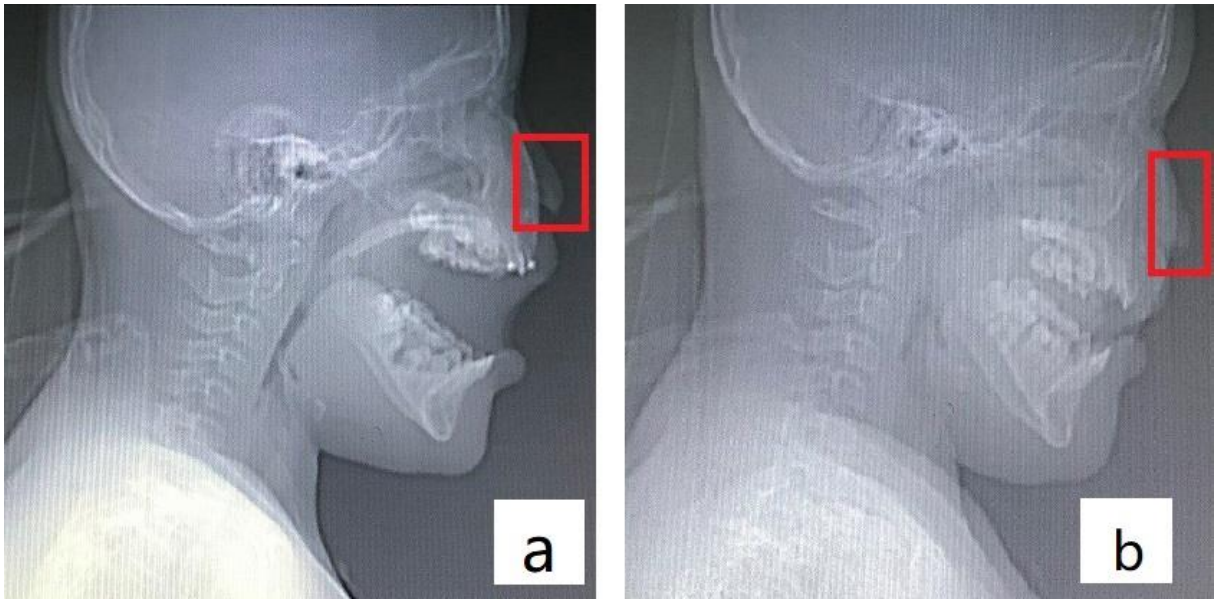

Fig.7

Fig.8