Aesth Plast Surg (2024) 48:1926–1934
https://doi.org/10.1007/s00266-023-03619-1

M-Shaped Auricular Cartilage Grafts for Correcting Short Nose Deformity in Asians: A Retrospective Study

Chong Zhang[1] · Guanhuier Wang[1] · Yonghuan Zhen[1] · Yang An[1]

Received: 13 June 2023 / Accepted: 10 August 2023 / Published online: 5 September 2023

Abstract

Background The demand for rhinoplasty in Asia is growing annually, and short nose deformity has been one of the main reasons for the surgery due to its high incidence. There is an urgent need for rhinoplasty suitable for Asians because of their different facial features from Westerners. The M-shaped auricular cartilage rhinoplasty has been developed as a new method for correcting short nose deformity for Asians. This study aimed to evaluate the aesthetic and functional results of M-shaped auricular cartilage rhinoplasty compared to clinically commonly used rhinoplasty methods.

Methods A total of 45 patients were enrolled and divided into three groups of 15 patients: The first group underwent M-shaped auricular cartilage rhinoplasty, the second group underwent auricular-septal cartilage rhinoplasty, and the third group underwent overlapped auricular cartilage rhinoplasty. All of these patients underwent comprehensive rhinoplasty and had silicone or expanded polytetrafluoroethylene implants in the dorsum of their noses.

Results The patient score improvements on the three patient-reported outcome measures were higher in the M-shaped auricular cartilage rhinoplasty group (1.65/1.79/0.11) compared with the overlapped auricular cartilage rhinoplasty group (1.40/1.51/0.05), and the score improvements in the auricular-septal cartilage rhinoplasty group (2.04/1.98/0.28) were the highest.

Conclusions This is a retrospective clinical study demonstrating the clinical efficacy of M-shaped auricular cartilage rhinoplasty. Compared with the overlapped auricular cartilage rhinoplasty, the effect of this novel M-shaped method is better. However, when compared to the auricular-septal cartilage rhinoplasty with septal extension and reinforcement using nasal septal cartilage, its effect is slightly worse.

Level of Evidence IV This journal requires that authors assign a level of evidence to each article. For a full description of these Evidence-Based Medicine ratings, please refer to the Table of Contents or the online Instructions to Authors www.springer.com/00266.

Keywords Rhinoplasty · Short nose · Nasal cartilage · Finite element analysis

Introduction

Rhinoplasty has become increasingly popular in recent years, and the short nose deformity is one of the main reasons why Asians choose rhinoplasty due to its high incidence [1]. The primary short nose is a congenital or developmental deformity while secondary short nose deformity results from previous rhinoplasty or trauma [2]. Thick skin envelope, low radix and dorsum, bulbous tip, weak lower lateral cartilages, and short columella and septal cartilage are characteristic of most Asian noses [3, 4]. Thus, the difficulty in controlling the position and shape of the nose tip and the small available volume of septal cartilage as a source of graft are major challenges for plastic surgeons. Thus, based on such a weak osseocartilaginous skeleton, it is difficult to maintain postoperative balance and control the position and shape of the nasal tip

✉ Yang An
anyangdoctor@163.com

[1] Department of Plastic Surgery, Peking University Third Hospital, 49 North Garden Road, Haidian District, Beijing 100191, China

[5]. In addition, the small and thin septal cartilage, which limits its volume as a graft source, and the often retrusive caudal septum also present challenges to the plastic surgeon [5].

Nasal septal cartilage, auricular cartilage and costal cartilage are autologous materials commonly used in clinical rhinoplasty, sometimes one alone and sometimes in combination, depending on the patient's situation and wishes. In addition, autologous cartilage can be used for the tip in combination with synthetic implants in the dorsum (silicone, expanded polytetrafluoroethylene (ePTFE), etc.) [6–8]. Auricular-based rhinoplasty often acquires the patient's auricular cartilage, which is later cut into small pieces to create a nose tip graft. To achieve more optimal clinical results, autologous septal cartilage can be used along with the auricular cartilage. Auricular-septal cartilage rhinoplasty often uses auricular cartilage as the tip graft while cutting off the lower posterior aspect of the septal cartilage for reinforcement and lengthening of the residual L-shaped septal cartilage scaffold (L-strut) as a septal extension graft (SEG).

However, the previously mentioned rhinoplasty methods still have a couple of problems to solve. It is difficult to use an onlay or shield graft to shape the tip-defining points to the patient's satisfaction and recreate the tactile sensation and elasticity of the nose tip. Besides, using septal cartilage for reinforcement is more traumatic, while patients with a small volume of septal cartilage may not be able to provide enough septal cartilage while ensuring the stability of the L-strut. At the same time, the procedure of the SEG implantation also increases the difficulty of the operation. To solve the above-mentioned problems, we have proposed the corrective use of M-shaped auricular cartilage for short nose deformity, which can lengthen the nose while increasing the tip prominence and imitating the natural shape of the nose tip [4]. The M-shaped cartilage with a double-arched structure is mechanically stable and elastic, and its curved front end provides better results than the tip grafts and SEG, and avoids showing an abrupt shape under the tight skin of the nose (Fig. 1). Being sutured middle on the septal cartilage laterally on the lower lateral cartilage, the M-shaped cartilage has a similar shape to the bilateral lower lateral cartilage and could play a good supporting role at the nose tip. Besides, the auricular cartilage is chosen to make the M-shaped cartilage for its natural radian, accessibility and its good mechanical properties as elastic cartilage histologically.

M-shaped cartilage rhinoplasty, as previously described, is now widely used in Asians. Preoperative and postoperative three-dimensional anthropometric analysis comparison has been made to prove the effect of the operation [9]. In the previous study, we have used finite element analysis to discuss the details of the surgical procedure, including fixing methods, suturing positions and sizes of the M-shaped cartilage [10]. In this study, we compared the M-shaped auricular cartilage rhinoplasty with two clinically commonly used surgical methods (auricular-septal cartilage rhinoplasty and overlapped auricular cartilage rhinoplasty). The clinical effect and patients' satisfaction were evaluated by patient-reported outcome measures (PROMs), and the score improvements of the items in PROMs were compared among groups.

Methods

Study Design

A total of 45 patients were enrolled and divided into three groups of 15 patients: The first group underwent M-shaped auricular cartilage rhinoplasty, the second group underwent auricular-septal cartilage rhinoplasty, and the third group underwent overlapped auricular cartilage rhinoplasty. All of these patients underwent comprehensive rhinoplasty and had silicone or expanded polytetrafluoroethylene (PTFE) implants in the dorsum of their noses except for the nose tip surgery.

All the included study patients had the following characteristics: underwent primary open rhinoplasty, had been followed for at least 6 months, underwent both standard pre-/postoperative photography, had a good understanding of Mandarin Chinese, could cooperate with phone follow-up and had signed a consent form for inclusion in the study. Informed consent related to the photography was required of every study patient, which included permission for publication. We excluded patients for the following characteristics: candidate for secondary rhinoplasty, invalid pre-/postoperative photographic images and inability to answer the questions in the rhinoplasty outcome evaluation (ROE), the FACE-Q rhinoplasty module (FACE-Q RM) and the nasal obstruction symptom evaluation (NOSE). The following data were obtained for each patient: age, gender, date of surgery, duration of follow-up, type of surgical procedure and types of grafts used. All patients were operated on by the same doctor between June 2015 and February 2022.

Rhinoplasty Operation Techniques

At the beginning of the operation, autogenous auricular cartilage was harvested. The amount of harvested cartilage was determined according to the actual requirement of cartilage. The cartilage was collected from the conchal cavity via an incision in the anterior auricular skin. The obtained cartilages measured approximately 35 × 6 mm and were set aside in 0.9% sodium chloride solution. After

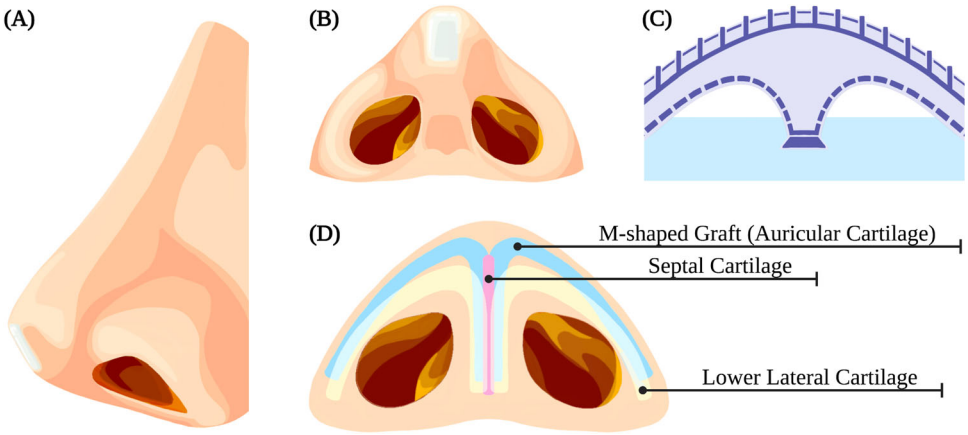

Fig. 1 **A**, **B** Explosion of the onlay graft's abrupt shape, which is commonly used as the nose tip graft clinically. **C** The double-arched structure of the M-shaped cartilage is similar to the double-curvature arch bridge and is mechanically stable. **D** Upward view of the nose with M-shaped auricular cartilage rhinoplasty. The septal cartilage (pink), lower lateral cartilage (yellow) and M-shaped auricular cartilage (blue) are shown in different colours

the preparation of autogenous auricular cartilage, an inverted V-shaped incision was made in the middle of the nasal column, extending to the medial nasal flange on both sides, and the nasal column and nasal flange were incised along the incision line, the flap was lifted, and the lower lateral cartilage and septal cartilage were separated and exposed.

In M-shaped auricular cartilage rhinoplasty (Group 1) (Fig. 2A), the auricular cartilage was cut into two pieces and sutured to both sides of the nasal cartilage, medially to the middle of the septal cartilage and laterally to the lateral corner of the lower lateral cartilage, forming an M-shaped structure for nose tip lengthening or augmentation. The surgical procedure details had been fully described in the previously published article [4]. In overlapped auricular cartilage rhinoplasty (Group 3) (Fig. 2C), the auricular cartilage was trimmed into 2–3 pieces and sutured overlappingly, then placed at the top of the nose tip and fixed to modify the shape of the tip. In auricular-septal cartilage rhinoplasty (Group 2) (Fig. 2B), in addition to the same nose tip shape modification method as Group 3, the septal cartilage was disconnected from the lamina plate of the ethmoid bone and the vomer bone, and a cartilage block of about 1.0 mm in thickness, 30 mm in length and 20 mm in width was removed from the lower posterior side, after which an L-strut of about 1.0 cm in width was finally retained. The removed septal cartilage was made into two strip septal strengthening grafts and one extension graft, and the two strengthening grafts were fixed to the dorsal and caudal segments of the L-strut, and the extension graft was fixed to the caudal side of the septal cartilage. Finally, the dorsum of the nose was elevated with silicone or polytetrafluoroethylene dorsal grafts in all three groups.

Evaluation of Surgical Outcome: NOSE, FACE-Q Rhinoplasty Module and ROE

Multiple PROMs have been put forward for assessing patient satisfaction after rhinoplasty. PROMs can be used in combination to evaluate both functional and aesthetic outcomes after rhinoplasty, which shows advantages over a single-function PROM [11]. Therefore, three self-administered PROMs were used in this study, including ROE, FACE-Q RM and NOSE. The ROE is a PROM for evaluating the quality of life before and after rhinoplasty, containing 6 questions regarding the nasal appearance, ability to breathe and social acceptability of the respondent's nasal appearance, scored from 0 to 4, and higher scores correlate with a more satisfied nose [12]. The FACE-Q RM is a multidimensional PROM evaluating

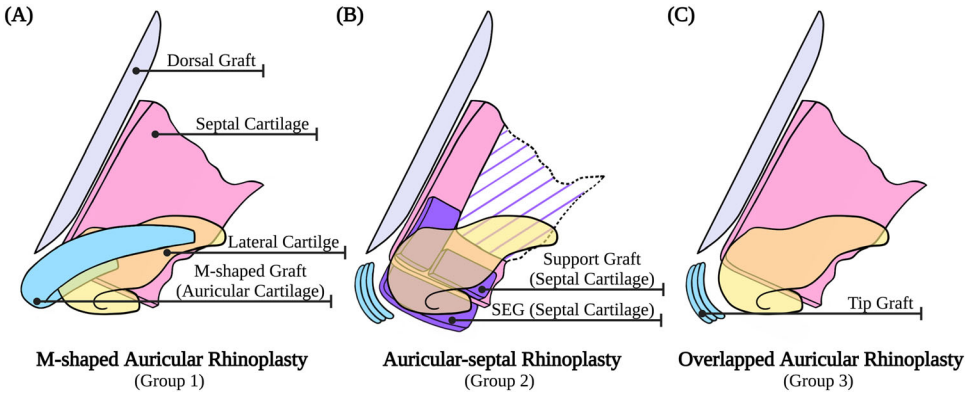

Fig. 2 Schematic diagrams of the three methods commonly used in rhinoplasty: **A** M-shaped auricular cartilage rhinoplasty; **B** Auricular-septal cartilage rhinoplasty; **C** Overlapped auricular cartilage rhinoplasty

nasal appearance and adverse events after rhinoplasty, containing a 10-item satisfaction with nose scale, a 5-item satisfaction with nostrils scale and a 4-item checklist for evaluating any postoperative adverse events [13]. Every item is scored from 1 to 4, and higher scores correlate with higher satisfaction [13]. The NOSE is a PROM evaluating the disease-specific quality of life, containing 5 questions about the nasal obstruction symptom, scored from 0 to 4, and higher scores correlate with severe nasal obstruction [14]. All the PROMs were translated and later completed through phone follow-up.

Statistics

R version 4.2.1 for macOS (R Foundation for Statistical Computing, Vienna, Austria) was used for data analysis and statistical plotting. The Shapiro–Wilk test was used to assess the normality of all continuous variables. If the score improvements conformed to the normal distribution, *F*-test would be used to test the homogeneity of variances of each two groups, followed by the *T*-test to assess between-group parameters. If not, the Wilcoxon–Mann–Whitney test would be performed. For all statistical analyses, *P* values less than or equal to 0.05 were considered statistically significant.

Power analysis was used to check whether the sample size is sufficient. The mean and standard deviation of each group and the intergroup effect size of each two groups were calculated. Given the sample size, mean and standard deviation (SD), the effect size *d* and power (1-β err prob) could be calculated. If the power was greater than 0.8, the sample size was proved to be appropriate.

Finite Element Analysis

Finite element analysis (FEA) was used to evaluate the stability of the nasal cartilage by simulating nose tip palpation. The 3D models of nasal septal cartilage and lower lateral cartilage were reconstructed by Mimics 15.0 (Mimics, Materialise, Belgium) based on the high-resolution CT of a patient with short nose deformity. Besides, according to clinical surgical experience, the 3D model of the M-shaped auricular cartilage graft with a thickness of 1 mm and width of 4 mm was constructed, through Nomad Sculpt 1.71 (Nomad Sculpt, Hexanomad). The processed models were assembled by Magics 21.0 (Magics, Materialise, Belgium), and their mesh generation was performed using WELSIM 2.0 (WELSIM, WelSimulation LLC, Pittsburgh). The material properties of the cartilages were set according to the published data [15–17] in Ansys Workbench 19.0. (Ansys Workbench, ANSYS, Inc., USA). Since the load involved in this study and the deformation of the model is small, to improve the efficiency of simulation calculation, the linear elastic constitutive relation was used to characterize the material properties of the three kinds of cartilages. Besides, as the auricular cartilage is often used as the source of M-shaped cartilage grafts, the mechanical properties of auricular cartilage were selected as its properties.

To simulate clinical nose tip palpation, a compressive force of 0.01 N was applied to the 1 cm^2 surface of the nose tip. The max deformation of the whole cartilage model was observed and compared to evaluate the stability of the nasal cartilage structure.

Results

The Comparison of the Three Rhinoplasty Methods

A total of 45 patients were enrolled in this study, and they were all female. The mean age of the participants was 28.0 ± 9.8 years in the M-shaped group, 29.0 ± 5.7 years in the auricular-septal group and 28.0 ± 6.5 years in the overlapped auricular group. No significant age differences were observed between the groups ($p = 0.547$). Silicone prostheses were used as dorsal grafts for nine patients in the M-shaped group, ten patients in the auricular-septal group and seven patients in the overlapped auricular group. All the other patients used expanded polytetrafluoroethylene (ePTFE) prostheses as dorsal grafts.

The following table summarized the groups' preoperative and postoperative scores of ROE, FACE-Q RM and NOSE and their improvements (Table 1). The score improvements of the auricular-septal group in ROE and FACE-Q RM were statistically more significant than the other two groups (ROE: $p = 0.01366289$, $p = 3.33899E-05$; FACE-Q RM: $p = 0.00615092$, $p = 7.62964E-12$) (Fig. 3A, B). Besides, the score improvements of the M-shaped group in ROE and FACE-Q were more significant than the overlapped auricular group (ROE: $p = 0.04555676$; FACE-Q RM: $p = 8.6626E-11$) (Fig. 3A, B). However, the NOSE score improvements did not differ among the groups, except the auricular-septal group was significantly greater than the overlapped auricular group ($p = 0.118$, $p = 0.3776$, $p = 0.01973$) (Fig. 3C).

The Clinical Results of M-shaped Auricular Cartilage Rhinoplasty

Two patients with short nose deformity were taken as examples to show the clinical results of M-shaped auricular cartilage rhinoplasty (Fig. 4). In the two short nose correction cases, the M-shaped auricular cartilage grafts were combined with dorsal expanded polytetrafluoroethylene (ePTFE) and silicone implants respectively. The shape of

Table 1 Pre-/postoperative scores (mean ± SD) of patients accepted different surgical methods

Group	Surgical method	Scores								
		ROE			FACE-Q RM			NOSE		
		Pre	Post	Impro	Pre	Post	Impro	Pre	Post	Impro
1	M-shaped auricular cartilage rhinoplasty	2.133±0.318	3.787±0.233	1.653±0.381	1.987±0.181	3.780±0.157	1.793±0.139	0.107±0.014	0.000±0.000	0.107±0.014
2	Auricular-septal cartilage rhinoplasty	1.880±0.361	3.920±0.211	2.040±0.422	1.833±0.202	3.813±0.136	1.980±0.201	0.280±0.319	0.000±0.000	0.280±0.319
3	Overlapped auricular cartilage rhinoplasty	1.667±0.145	3.067±0.247	1.400±0.273	1.796±0.262	2.947±0.168	1.151±0.205	0.053±0.119	0.000±0.000	0.053±0.119

ROE, rhinoplasty outcome evaluation; FACE-Q RM, FACE-Q rhinoplasty module; NOSE, nasal obstruction symptom evaluation; Pre, preoperative; Post, postoperative; Impro, improvement

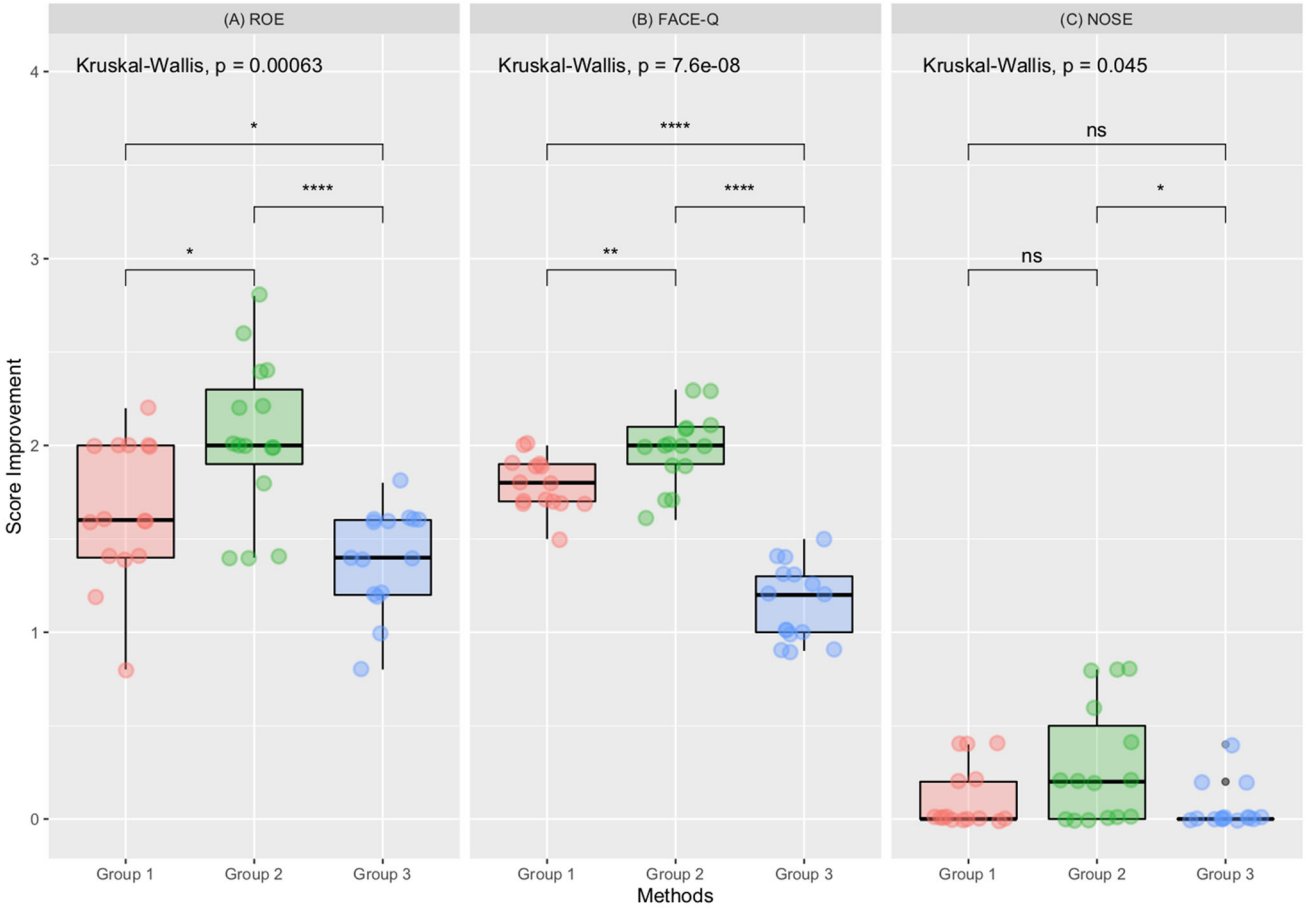

Fig. 3 Score improvements of patients accepted different surgical methods (Group 1: M-shaped auricular cartilage rhinoplasty; Group 2: Auricular-septal cartilage rhinoplasty; Group 3: Overlapped auricular cartilage rhinoplasty) (ns: $p > 0.05$, *: $p <= 0.05$, **: $p <= 0.01$, ***: $p <= 0.001$, ****: $p <= 0.0001$)

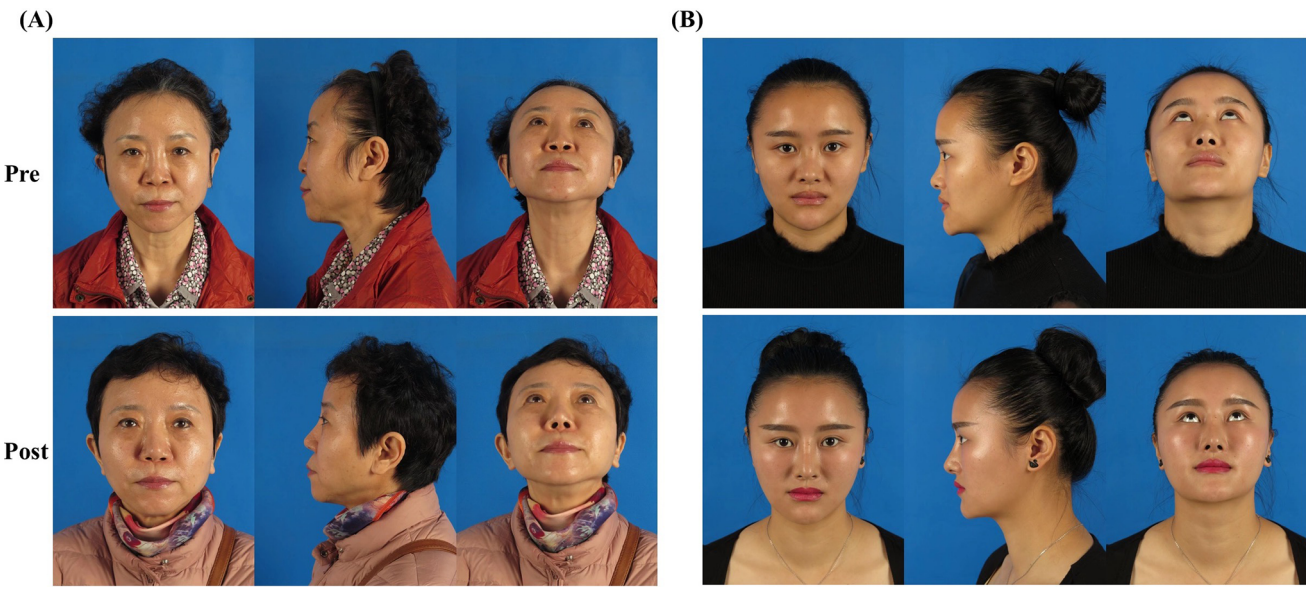

Fig. 4 Pre-/postoperative photographs of patients who underwent M-shaped auricular cartilage rhinoplasty. **A** Preoperative and 2 years postoperative photographs of a 58-year-old female. **B** Preoperative and 1 year and 2 months postoperative photographs of a 32-year-old female

the corrected nose was evaluated to be satisfactory by follow-up.

The Finite Element Analysis of the Cartilage Models

When 0.1 N force is applied vertically at the nose tip of the model to simulate palpation of the nose tip, the max deformation happened on the lower lateral cartilage, and the total trend of total deformation was similar between the two groups. Besides, the max deformation of the nasal cartilage model with M-shaped auricular cartilage (0.012726) was obviously smaller than the model without M-shaped auricular cartilage (0.24221), indicating that the stability of the model was strengthened after the implantation of M-shaped auricular cartilage (Fig. 5).

Discussion

Thick skin envelope, low radix and dorsum, bulbous tip, weak lower lateral cartilages, and short columella and septal cartilage are characteristic of most Asian noses, which leads high incidence of short nose deformity [3, 4]. Short nose correction surgery often consists of several modules, including dorsal augmentation and tip reshaping in addition to short nose lengthening, which often requires the use of multiple grafts such as septum lengthening grafts, tip grafts and dorsal grafts. There are various options for the surgery, and there are also choices of grafts, in which septal cartilage and auricular cartilage are the most widely used autologous materials [6, 8, 18, 19]. In M-shaped auricular cartilage rhinoplasty, the two slices of auricular cartilage are structurally biomimetic fixed above the lower lateral cartilages in an M-shape, which can bring aesthetically and functionally satisfactory postoperative results, as proved by the aforementioned PROMs and photographs.

As mentioned previously, though only using auricular cartilage as the autograft, the M-shaped auricular cartilage rhinoplasty was more satisfactory than overlapped auricular cartilage rhinoplasty. This is probably due to the fact that, in addition to the more aesthetic appearance of the nose tip after surgery, the M-shaped auricular cartilage played a certain role in reinforcing the nasal scaffold. To prove this hypothesis, we performed finite element analysis on the nasal cartilage model (including the lower lateral cartilage and septal cartilage) and the model loaded with M-shaped cartilage (Fig. 4). The results suggest that when 0.1 N force is applied vertically at the nose tip of the model to simulate palpation of the nose tip, the distribution trend of total deformation was similar between the groups, and the max deformation of the nasal cartilage model with M-shaped cartilage was obviously smaller than the model without M-shaped cartilage, indicating that the stability of the model was strengthened while the biomechanical feature of the nose tip was preserved. In overlapped auricular cartilage rhinoplasty, the overlapping graft was simply placed at the tip of the nose and externally fixed, which had no effect on improving the stability of the nose [20].

None of the patients developed complications or underwent reoperation during follow-up. The postoperative NOSE score of all patients was 0, indicating that the nasal obstruction of the 45 patients receiving three kinds of surgery was all well resolved after surgery. According to ROE and FACE-Q results, auricular-septal cartilage rhinoplasty improved patient satisfaction with their nose more than M-shaped auricular cartilage rhinoplasty, while at the same time, the effect of both is far better than overlapped auricular cartilage rhinoplasty. Although slightly less than overlapped auricular cartilage rhinoplasty, M-shaped auricular cartilage rhinoplasty avoids the risks associated with nasal septal L-strut. Fractures may occur intraoperatively during L-strut construction, caused by over-resection of the septum, excessive septal manipulation or misguided medial osteotomies, and secondary rhinoplasty patients may be at greater risk of L-strut fractures because of septal weakening from previously resected septal cartilage [21]. Besides, the long-term deformity may

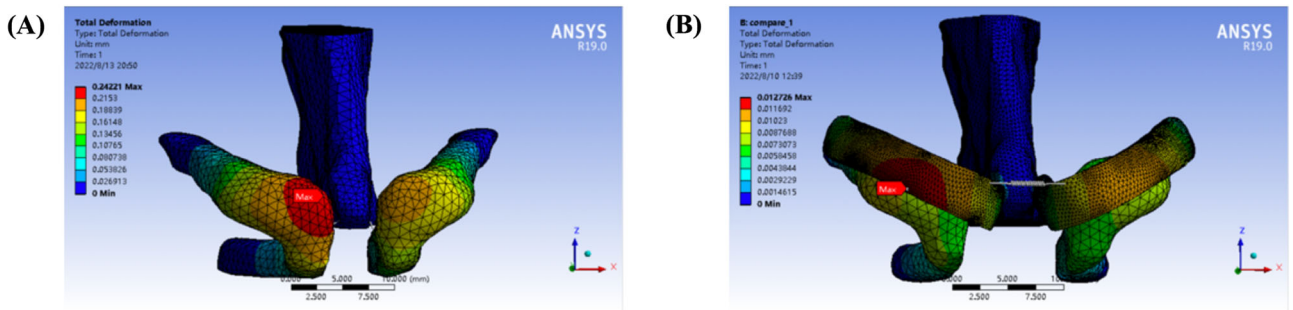

Fig. 5 The nose tip palpation was simulated by finite element analysis (FEA), and the maximum deformation was used to evaluate the stability of the model (including septal and lower lateral cartilage, with or without M-shaped auricular cartilage graft). **A** FEA of nasal cartilage model; **B** FEA of M-shaped auricular cartilage rhinoplasty model

occur postoperatively, creating functional and aesthetic problems such as a twisted nose, tip malposition, saddle deformity and internal valve insufficiency, resulting in secondary revision rhinoplasty [22, 23]. From this perspective, M-shaped auricular cartilage rhinoplasty may help improve the long-term prognosis and reduce the risk of long-term complications. However, a more definitive conclusion needs to be followed up.

Autogenous cartilage is generally considered the gold standard graft material for nasal surgery, and septal and conchal cartilage has traditionally been the primary types of cartilage used in rhinoplasty. In addition to septal cartilage and auricular cartilage, in some surgical procedures, autologous materials such as costal cartilage [24–26] and perpendicular plate of ethmoid (septal bone) [27, 28] are also used. Costal cartilage graft is a viable option in reconstructive rhinoplasty, especially in cases where septal cartilage is unavailable due to previous rhinoplasty or conspicuous trauma [2]. Therefore, one of the limitations of this study is that only auricular and septal cartilage-related surgical procedures were included, and patients using costal cartilage were not taken into account. Predictably, if modelling and finite element analysis were performed, the use of costal cartilage for reinforcement would result in a more stable nasal septum and a more desirable outcome, but this would only simulate and present the immediate postoperative status of the rhinoplasty. However, the costal cartilage graft is often seen as a second choice in rhinoplasty because of the potential for donor site morbidity and the risk of cartilage warping [7, 26].

This study also has other limitations. The patients included in this study have different basic conditions, which was shown by the preoperative PROM results. Therefore, the score improvements were chosen for comparison, which can reduce the impact of such differences on the accuracy of results to a certain extent. Besides, none of the patients had postoperative complications, which may be due to the small sample size. In the future, we will expand the sample size and conduct a multicentre study to evaluate the M-shaped auricular cartilage rhinoplasty more comprehensively.

Conclusions

This is a retrospective clinical study demonstrating the clinical efficacy of M-shaped auricular cartilage rhinoplasty. Compared with the overlapped auricular cartilage rhinoplasty, the effect of this novel method is better. However, when compared to the auricular-septal cartilage rhinoplasty with septal extension and reinforcement using nasal septal cartilage, its effect is slightly worse.

Acknowledgments This work was supported by the Key Clinical Projects of Peking University Third Hospital (No. BYSYZD2021020 and No. BYSYFY2021005)

Declarations

Conflict of interest The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the Declaration of Helsinki and its later amendments or comparable ethical standards. The experiments were approved by the Investigational Review Board.

Informed Consent All participants participated in the study knowingly and willingly.

References

1. Pshenisnov KP, Pshenisnov KK (2021) Invited discussion on: M-shaped auricular cartilage as modified septal extension graft: a study by three-dimensional anthropometric analysis in Asian rhinoplasty. Aesthet Plast Surg 45(5):2295–2299
2. Kim SK, Kim HS (2013) Secondary Asian rhinoplasty: lengthening the short nose. Aesthet Surg J 33(3):353–362
3. Kim EK, Daniel RK (2012) Operative techniques in Asian rhinoplasty. Aesthet Surg J 32(8):1018–1030
4. An Y, Feng N, Chen L, Yang X, Yang X, Xia Y, Xue H, Li D (2019) A novel technique for short nose correction in Asians: M-shaped conchal cartilage combining with septal extension graft. J Craniofac Surg 30(5):1560–1562
5. Cobo R (2022) Non-caucasian rhinoplasty. Clin Plast Surg 49(1):149–160
6. Zhang Z, Yu Z, Song B (2022) Septal extension graft for correcting short nose in East Asians: review of autologous cartilage grafts and postoperative stability. Br J Oral Maxillofac Surg 60(9):1159–1165
7. Liang X, Wang K, Malay S, Chung KC, Ma J (2018) A systematic review and meta-analysis of comparison between autologous costal cartilage and alloplastic materials in rhinoplasty. J Plast Reconstr Aesthet Surg 71(8):1164–1173
8. Hwang NH, Dhong ES (2018) Septal extension graft in Asian rhinoplasty. Facial Plast Surg Clin North Am 26(3):331–341
9. Wang D, Hou K, Zeng N (2021) M-shaped auricular cartilage as modified septal extension graft: a study by three-dimensional anthropometric analysis in Asian rhinoplasty. Aesthet Plast Surg 45(5):2287–2294
10. Zhang C, Wang G, Zhen Y, Xiang H, An Y (2023) Correction of short nose using M-shaped cartilage in Asian patients: finite element analysis and recommendations for surgery. Aesthet Plast Surg. https://doi.org/10.1007/s00266-023-03435-7
11. Xiao H, Zhao Y, Liu L, Xiao M, Qiu W, Liu Y (2019) Functional/aesthetic measures of patient satisfaction after rhinoplasty: a review. Aesthet Surg J 39(10):1057–1062
12. Alsarraf R (2000) Outcomes research in facial plastic surgery: a review and new directions. Aesthet Plast Surg 24(3):192–197
13. Klassen AF, Cano SJ, East CA, Baker SB, Badia L, Schwitzer JA, Pusic AL (2016) Development and psychometric evaluation of the FACE-Q scales for patients undergoing rhinoplasty. JAMA Facial Plast Surg 18(1):27–35
14. Stewart MG, Smith TL, Weaver EM, Witsell DL, Yueh B, Hannley MT, Johnson JT (2004) Outcomes after nasal septoplasty: results from the Nasal Obstruction Septoplasty

Effectiveness (NOSE) study. Otolaryngol Head Neck Surg 130(3):283–290
15. Griffin MF, Premakumar Y, Seifalian AM, Szarko M, Butler PE (2016) Biomechanical characterisation of the human nasal cartilages; implications for tissue engineering. J Mater Sci Mater Med 27(1):11
16. Huang H, Luo X, Cheng X, Zhang Z, Ma G, Shi B, Li J (2018) Recapitulation of unilateral cleft lip nasal deformity on normal nasal structure: a finite element model analysis. J Craniofac Surg 29(8):2220–2225
17. Sun H, Zhou J, Wang Q, Jiang H, Yang Q (2021) Contribution of perichondrium to the mechanical properties of auricular cartilage. J Biomech 126:110638
18. Cingi C, Bayar Muluk N, Winkler A, Thomas JR (2018) Nasal tip grafts. J Craniofac Surg 29(7):1914–1921
19. Jang YJ, Alfanta EM (2014) Rhinoplasty in the Asian nose. Facial Plast Surg Clin North Am 22(3):357–377
20. Jang YJ, Kim SH (2018) Tip grafting for the Asian nose. Facial Plast Surg Clin North Am 26(3):343–356
21. Gunter JP, Cochran CS (2006) Management of intraoperative fractures of the nasal septal "L-strut": percutaneous Kirschner wire fixation. Plast Reconstr Surg 117(2):395–402
22. Kim DW, Gurney T (2006) Management of naso-septal L-strut deformities. Facial Plast Surg 22(1):9–27
23. Lee JS, Lee DC, Ha DH, Kim SW, Cho DW (2015) Redefining the septal L-strut in septal surgery. PLoS ONE 10(3):e0119996
24. Toriumi DM, Swartout B (2007) Asian rhinoplasty. Facial Plast Surg Clin North Am 15(3):293–307
25. Gunter JP, Rohrich RJ (1989) Lengthening the aesthetically short nose. Plast Reconstr Surg 83(5):793–800
26. Yoo SH, Jang YJ (2019) Rib cartilage in Asian rhinoplasty: new trends. Curr Opin Otolaryngol Head Neck Surg 27(4):261–266
27. An Y, Shu F, Xie L, Zhen Y, Li X, Li Y (2023) Use of nasal septal bone to straighten septal L-strut in correction of east Asian short nose: a retrospective study. J Cosmet Dermatol 22(6):1825–1834
28. Sazgar AA, Teimouri Y, Sazgar AK (2019) Use of bone-cartilaginous unit in revision rhinoplasty. Aesthet Surg J 39(8):841–847