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The Relation Between the Lower Lateral Cartilages and the Function of the External Nasal Valve

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Abstract

Introduction The position of the lower lateral cartilages (LLC) is closely related to the function of the external nasal valve (ENV). When there is a cephalic malposition of these cartilages, the nasal alae have inadequate support, which leads to ENV insufficiency during deep inspiration.

Methods Retrospective study with 60 patients evaluated: the positioning of the LLC and the occurrence of ENV insufficiency; the effectiveness of structuring the medial and lateral walls of the ENV; and the frequency of the grafts used for structuring it.

Results Of the 60 operated cases, 37 patients (62%) had ENV insufficiency, in 23 cases there was cephalic malposition of the LLC, and in the latter group 17 patients (74%) presented this insufficiency. A structured ENV was effective in the treatment of this insufficiency ($p = 0.001$). A lateral crural strut graft was performed in 24 cases (40%) of 60 patients operated. The alar contour graft was performed from 2013 to 2015 in 4 patients (22%) of 18 cases operated, and between 2016 and 2018 it was performed in 29 patients (69%) out of 42 cases. The columellar strut was routinely used from 2013 to mid-2016 in 33 cases (100%), and after that period until the present day the tongue-in-groove technique was performed in 11 cases (41%) and in the remaining 16 cases (59%) the caudal septal extension graft was performed.

Conclusion Cephalic malposition of the LLC is an important red flag of ENV insufficiency. This insufficiency should be treated by structuring the walls of the ENV.

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 Nose · Nasal cartilage · Nasal obstruction · Rhinoplasty

Introduction

The external nasal valve regulates the air flow through the nose, is located in the nose rim and is limited by three walls (Fig. 1):

- lateral: lateral crura of the lower lateral cartilage and fatty-fibrous tissue of the nasal alae;
- medial: membranous septum and medial crura of the lower lateral cartilage;
- inferior: the floor of the nose [1–8].

The position of the lower lateral cartilages plays an important role in the proper functioning of this valve, because these cartilages are the main structural element of the lateral wall [3–10]. Cephalic malposition of these cartilages results in unsuitable support to the nasal alae, which leads to insufficiency of the external nasal valve during deep inspiration, which can be partial or total, depending on the degree of changes [3–10].

Research performed at private clinic, Ponta Grossa, PR, Brazil.

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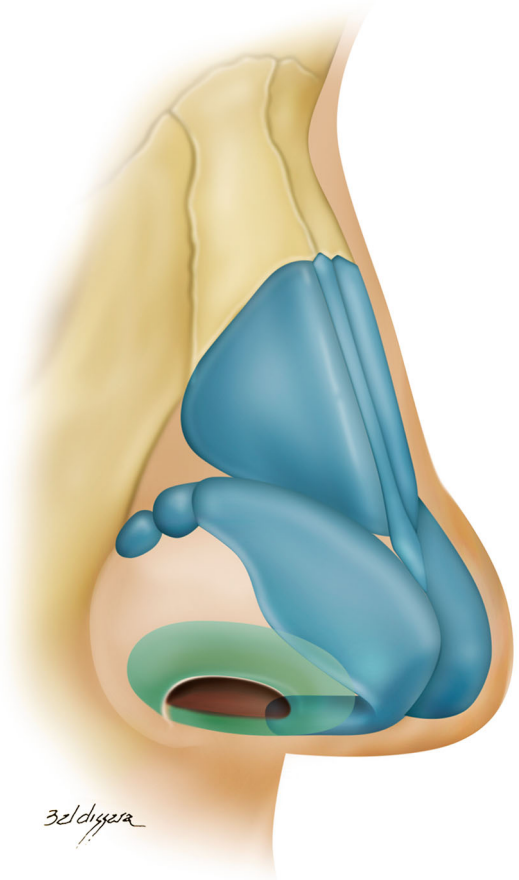

Fig. 1 External nasal valve (green) [9]. Reprinted with permission from *Brazilian Journal of Plastic Surgery*

In 1978, Sheen was the first surgeon to point out the relation between lower lateral cartilages and the external nasal valve function [11]. In 1997, Gunter published the lateral crural strut graft which allows repositioning and/or reinforcing these cartilages [5]. In 2002, Rohrich described the alar contour graft to reinforce the external nasal valve [12]. In 2004, Constantian classified the vector of the lower lateral cartilage (a straight line drawn between the domus and the insertion site of this cartilage in the pyriform aperture) and defined suitable positioning. Finally, in 2015, Toriumi defined as unsuitable the vector when in the transoperative, the angle formed by the lateral crus of the lower lateral cartilage with the sagittal plane was smaller than 30° [10].

Suitable positioning of the lower lateral cartilages is closely related to proper functioning of the external nasal valves, as well as the ideal anatomical configuration of the nasal tip structures relates to ideal aesthetic features [13, 14].

Evaluation of the external nasal valve function is carried out during the dynamic physical examination, by asking the patient to deeply inspire through the nose and expire through the mouth, and this shows the movement of the nasal alae and the lateral wall collapse degree, which might be absent, partial or total [7, 8].

The functional importance of nasal valves, mainly the external one, has been addressed in several studies in the last 25 years [15]. Constantian is well known in this area for having evaluated pre- and postoperative rhinomanometry in 1994 and concluded that proper breathing is not only related to the absence of septal deviation, but also to the proper functioning of the nasal valves [4].

This research aims to evaluate the positioning of the lower lateral cartilages and the occurrence of external nasal valve insufficiency and to investigate the frequency of graft use to structure the medial and lateral walls of the external nasal valve.

Materials and Methods

This is a retrospective study that was developed with 60 patients who were operated on in private hospitals between March 2013 and October 2017. Out of these patients, 46 were women (77%) and 14 were men (23%). Their ages ranged between 16 and 73 years. Routine pre- and postoperative photographic records and video recordings were carried out to evaluate external valve functioning.

All patients underwent a thorough preoperative dynamic physical examination evaluating the internal and external nasal valves, and computerized tomography of the paranasal sinuses was used to evaluate: septal deviation; maxillary and ethmoidal crest spurs; bulbous type concha bullosa; hypertrophy of inferior turbinate; and maxillary sinuses.

The external nasal valve was evaluated with regard to nasal alae movement and the lateral wall collapse degree during deep inspiration, as well as the lower lateral cartilage vector.

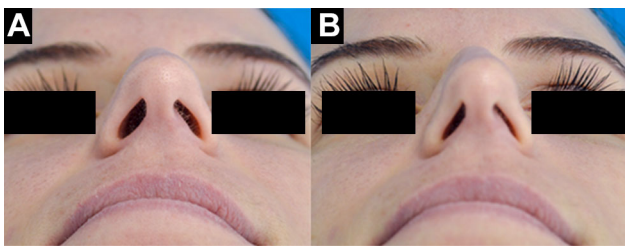

Fig. 2 Evaluation of nasal alae collapse during deep inspiration. **a** Mentonasal statics, **b** mentonasal dynamics (deep inspiration). Detail: external nasal valve partial insufficiency on the right and total on the left

Lateral wall collapse (Fig. 2) was classified according to the degree of insufficiency of the externa nasal valve:

- total: nasal alae touching the columella.
- partial: reduction of the horizontal axis of the nostril, without the nasal alae touching the columella;
- absent: absence of change in the horizontal axis of the nostril.

Regarding the vector of the lower lateral cartilages, the preoperative classification by Constantian was used as well as the trans-operative by Toriumi.

According to Constantian in a frontal picture, a line was drawn between the domus and the site of insertion of this cartilage into the pyriform aperture. Its projection was then evaluated in relation to the pupil.

When this line was medially directed toward the pupil, the vector was considered inappropriate and, in cases in which this line was laterally directed to or matched the pupil, the vector was considered appropriate (Fig. 3).

After the procedures to change the lower lateral cartilage complex, we evaluated the angle between the lateral crura of these cartilages and the sagittal plane, and according to Toriumi, the angle was considered inappropriate when smaller than 30° and ideal when closer to 45°.

All the patients were operated on under general anesthesia and local infiltration with a vasoconstrictor at a concentration of 1:200,000.

The surgical technique of choice was open structure rhinoplasty with a stair-step columellar incision (positioned at the columellar segment of the medial crura) and two marginal incisions (positioned at the site where the lower lateral cartilages should be positioned after the vector was made appropriate).

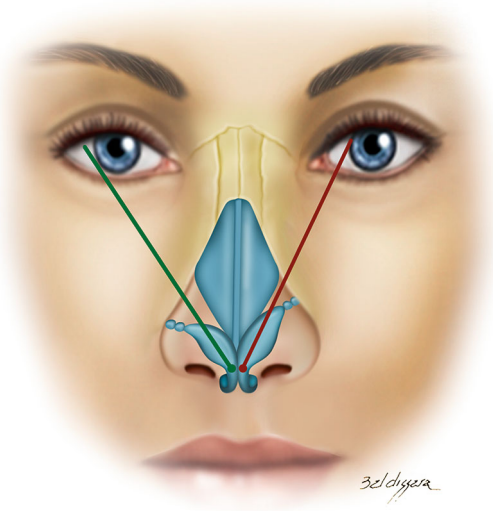

Fig. 3 Vector of the lower lateral cartilages [9]. *Note*: Green = appropriate. Red = inappropriate. Reprinted with permission from *Brazilian Journal of Plastic Surgery*

The dissection was performed as follows: lower lateral cartilages in the sub-SMAS plane to keep intact the nasal tip SMAS; upper lateral cartilages in the subperichondrial plane; and nasal bones in the subperiosteal plane.

During the exposure of the nasal tip, the following ligaments were routinely cut: dermocartilaginous; interdomal; intercrural; membranous septum; and when transposing the lower lateral cartilages, the pyriform ligament and the scroll.

In all cases, the perichondro-periosteal flap was used for a better closure of the nasal dorsum and to avoid irregularities in this region.

Surgical sutures were routinely used as follows: cartilage grafts were fixed with PDS 5.0 using an atraumatic needle (Ethicon, Inc.®, Somerville, N.J.); marginal incisions were sutured with catgut 5.0 (Ethicon®); and skin columella with mononylon 6.0 (Ethicon®).

After surgery, a micropore tape was used on the dorsum and lateral wall of the nose and a thermo-moldable dressing was placed for 7 days and then changed to remain for the next 7 days.

A gauze moistened with neomycin sulfate (5 mg/g) with bacitracin (250 UI/g) was used as an anterior nasal tampon until the patient was discharged the following day. After removing the nasal tampon, oxymetazoline chlorydrate (0.5 mg/ml) was sprayed three times in a row in each nostril and the patient was kept in a lying position for 30 min to prevent bleeding.

The preferred donor area for the cartilage grafts was the nasal septum, and in cases requiring more cartilage, conchal and costal cartilages were used.

The surgical procedures selected for each case depended on the pre- and trans-operative examinations and the availability of cartilage to perform the grafts. Whenever needed functional treatments were employed such as internal nasal valve, deviation of the nasal septum (cartilaginous and bone), maxillary crest and ethmoid spurs, middle bullous concha, inferior turbinate hypertrophy and maxillary sinuses.

The choice of grafts for the treatment or prevention of nasal external valve insufficiency varied according to the availability of autologous material to prepare them (mainly in secondary rhinoplasty), anatomical characteristics of the patient, vector of lower lateral cartilages, and severity of external nasal valve insufficiency.

We used the following grafts:

- lateral crural strut graft: the entire length of the lateral crura of the lower lateral cartilage was strengthened with a graft measuring 4–6 × 15–25 mm (Fig. 4).

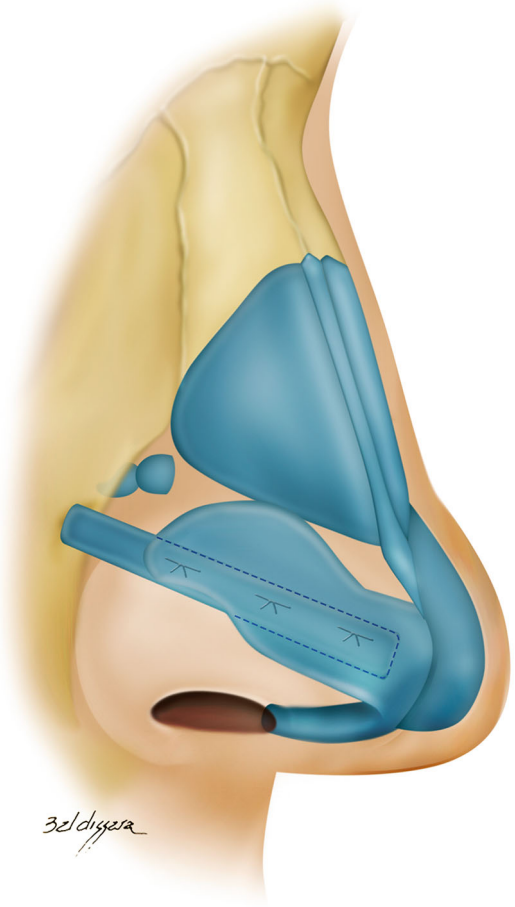

Fig. 4 Lateral crural strut graft [9]. Reprinted with permission from *Brazilian Journal of Plastic Surgery*

In some cases, these cartilages were disinserted and repositioned in the correct position. In cases in which the lateral crura was disinserted, its lateral reinsertion was fixed to the fatty-fibrous tissue of the nasal alae, below the pyriform aperture positioned as the alar groove (Fig. 5), so it was impalpable, thus preventing the risk of fracture over the years.

It seems relevant to observe the angle between the lateral crura of these cartilages after repositioning (Fig. 6).

- alar contour graft: the nasal alae were strengthened caudally around the side line with a graft measuring 3–4 × 15–20 mm positioned caudally to the marginal incision (Fig. 7).

The pocket for the insertion of this graft was initially dissected with Fox scissors and then a 2-mm osteotome was introduced in the nasal alae contour. The osteotome extended from the soft triangle to the most lateral portion of the nasal alae (Fig. 8).

Results

Of the 60 cases operated on, 37 patients (62%) presented external nasal valve insufficiency and 23 patients (38%) showed cephalic malpositioning of the lower lateral cartilages.

The malposition of the lower lateral cartilages (LLC) in the preoperative period had a higher association with the occurrence of external nasal valve (ENV) insufficiency (74%) in relation to the adequate position (54%). No statistically significant differences were found (Table 1 and Fig. 9).

A structured external nasal valve with grafts was effective in the treatment of this insufficiency with statistical significance ($p = 0.001$). The results obtained are shown in Table 2 and Fig. 10.

The lateral crural strut graft and/or the alar contour graft were mostly used to structure the external nasal valve lateral wall.

The lateral crural strut graft was used in 24 cases (40%) out of 60 patients operated on. In only one case, it had to be removed due to provoking obstructive insufficiency of the

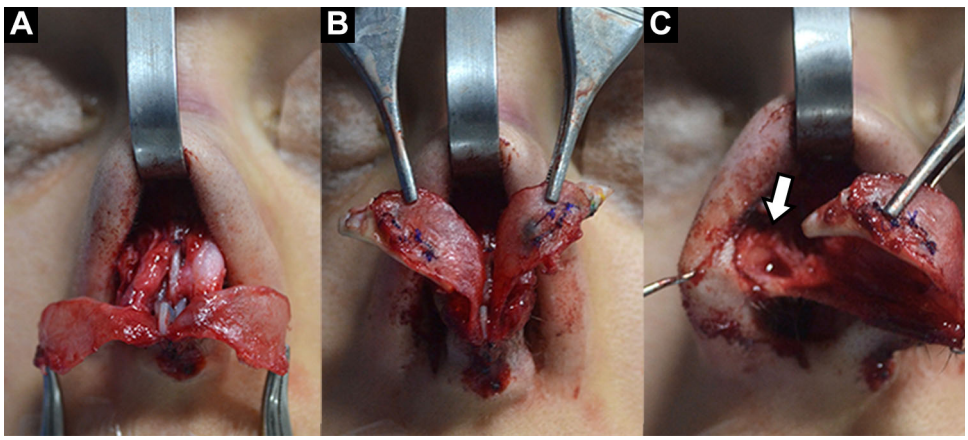

Fig. 5 Repositioning of the lower lateral cartilages. **a** Disinsertion of cartilages. **b** Sutured lateral crural strut graft. **c** Place where the graft is to be fixed

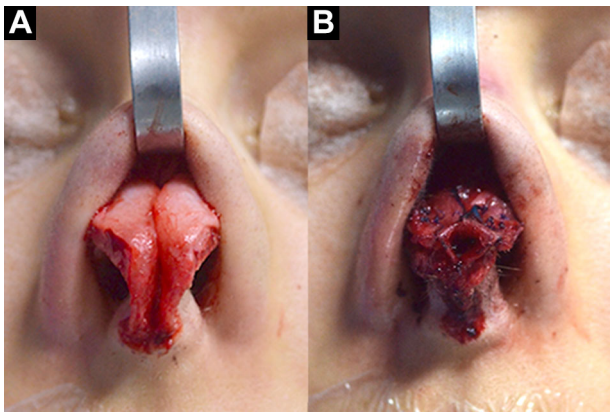

Fig. 6 Angle formed between the lateral crura of the lower lateral cartilages. **a** Nasal tip dissection. **b** Repositioning of the lower lateral cartilages

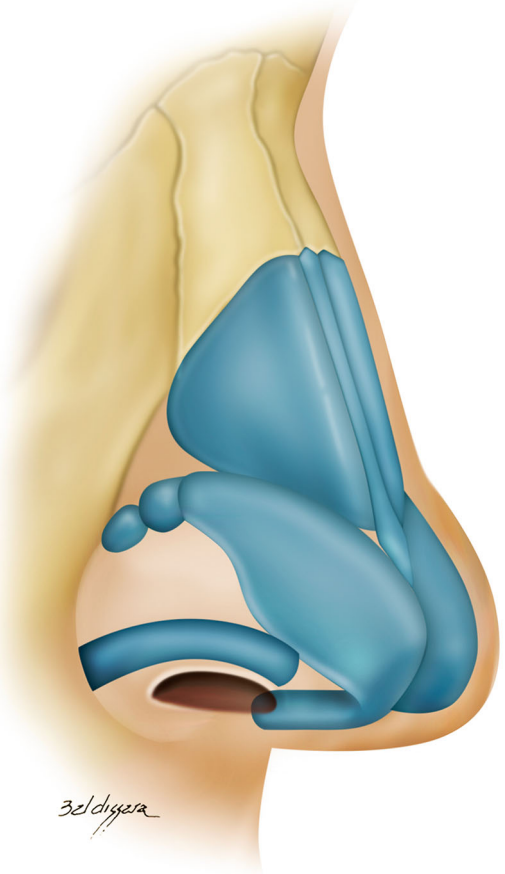

Fig. 7 Alar contour graft [9] Reprinted with permission from *Brazilian Journal of Plastic Surgery*

bilateral external valve because the patient presented narrow alar base.

In this specific case, the nasal alae support was carried out with the total reconstruction of the lower lateral cartilages with auricular cartilage, in which the concave side of the latter was positioned toward the nasal mucosa to allow better air inflow in the region of the external nasal valve.

The lower lateral cartilages were disinserted and caudally repositioned in 11 patients (46%) out of the 24 cases in which the lateral crural strut graft was used.

The alar contour graft was used from 2013 to 2015 in 4 patients (22%) out of the 18 cases operated on, and between 2016 and 2018, it was used in 29 patients (69%) out of 42 cases.

To structure the external nasal valve medial wall, a columellar strut graft was routinely used from 2013 to the middle of 2016 in 33 cases (100%), and after that period up to now, the tongue-in-groove technique was employed in 11 cases (41%) and in the remaining 16 cases (59%), the caudal septal extension graft was used.

The columellar strut graft has no longer been used due to the high number of patients that lost nasal tip projection in the long term (over 1 year postoperation).

Since the middle of 2016 until now, after performing the lowering of the dorsum, the cartilaginous septum is classified as appropriate or short. In cases in which it is considered appropriate, the tongue-in-groove technique is used, whereas in cases in which it is considered short the caudal septal extension graft is employed.

The caudal septal extension graft fixation is routinely carried out in two ways. When it is necessary to optimize the internal nasal valve or correct external nose deviations, or even improve the dorsum aesthetic lines, the extended bilateral spreader graft is preferred. It is performed in the anterior portion of the graft and a piece of cartilage measuring 10 × 5 mm is fixed unilaterally in the posterior portion of the caudal septal extension graft.

Only in exceptional cases, with extremely long cartilaginous septum, the cartilaginous septum is shortened up to a size considered appropriate. Membranous septum resection has not been used for 2 years.

Some cases showing insufficiency of the external nasal valve and the treatment carried out will be presented below.

Case 1 Inappropriate vector of the lower lateral cartilages with partial insufficiency of the bilateral external nasal valve.

Surgery: Bilateral lateral crural strut graft (changing the vector of the lower lateral cartilages) and alar contour graft (Fig. 11).

Case 2 Inappropriate vector of the lower lateral cartilages with partial insufficiency of the external nasal valve on the right and total on the left.

Surgery: Bilateral lateral crural strut graft (changing the vector of the lower lateral cartilages) and alar contour graft (Fig. 12 and Video 1).

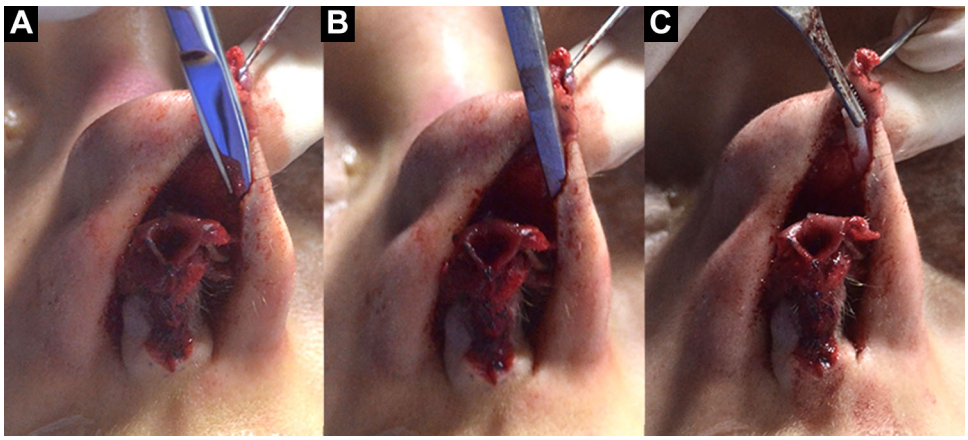

Fig. 8 Surgical technique used for the alar contour graft. **a** Start of dissection with the Fox scissors. **b** Creation of a pocket with the 2-mm osteotome. **c** Placing the graft

Table 1 Preoperative relation of the position of the LLC and the occurrence of external nasal valve insufficiency

ENV insufficiency	Adequate LLC vector		Malposition of LLC vector	
	n	%	*n*	%
Total	3	8.1	4	17.4
Partial	17	45.9	13	56.5
Absent	17	45.9	6	26.1
Total	37	100.00	23	100.00

p value: 0.244; Chi-square test; $p < 0.05$

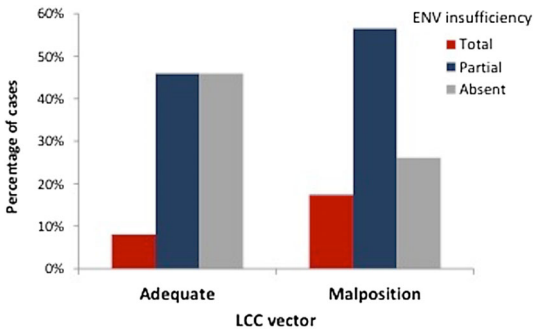

Fig. 9 Preoperative relation of the position of the LLC and the occurrence of external nasal valve insufficiency

Table 2 Postoperative relation between structured external nasal valve and ENV insufficiency

ENV insufficiency	Structured ENV		Unstructured ENV	
	n	%	*n*	%
Absent	32	94.1	0	0
Partial	2	5.9	3	100
Total	34	100	3	100

p value: 0.001; Fisher's exact test; $p < 0.05$

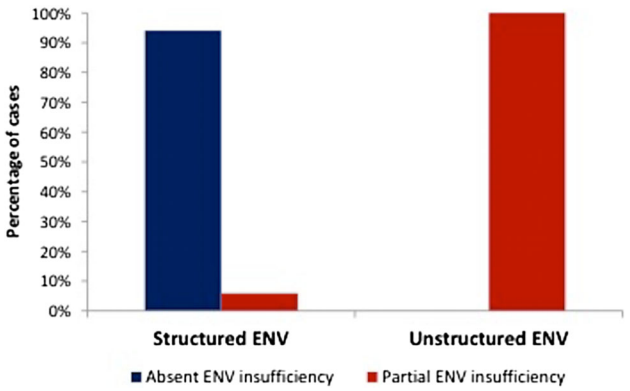

Fig. 10 Postoperative relation between structured external nasal valve and ENV insufficiency

Case 3 Inappropriate vector of the lower lateral cartilages with partial insufficiency of the bilateral external nasal valve.

Surgery: Bilateral lateral crural strut graft (changing the vector of the lower lateral cartilages) and alar contour graft (Fig. 13).

Discussion

The position of the lower lateral cartilages plays an important role in the proper functioning of the external nasal valve. When there is a cephalic malposition of these

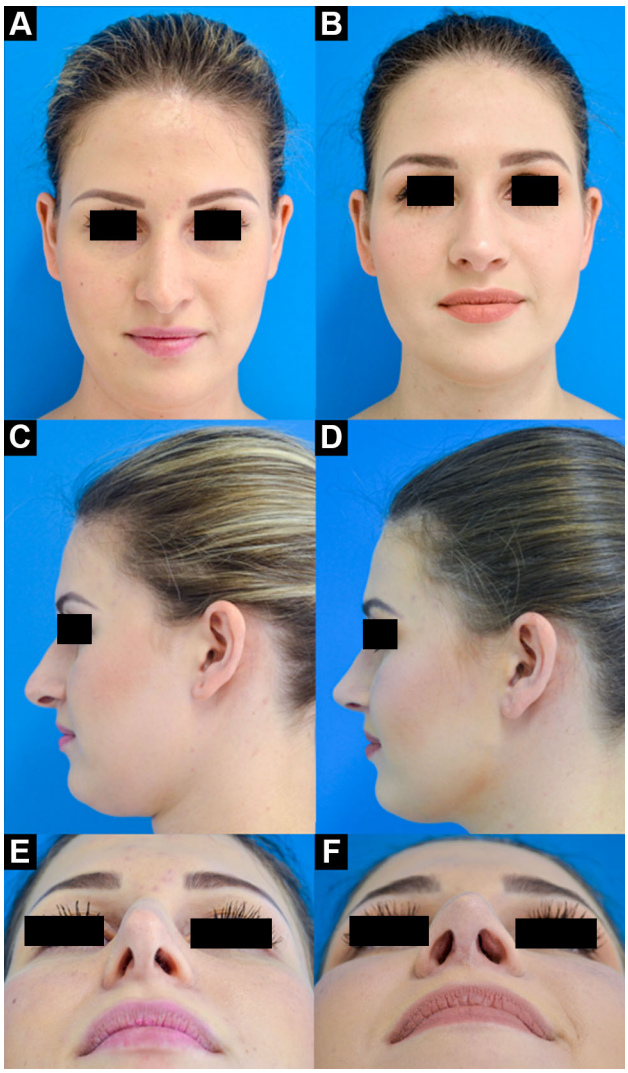

Fig. 11 Pre- and 1.6 year postoperative. **a**, **b** Frontal, **c**, **d** profile, **e**, **f** deep inspiration

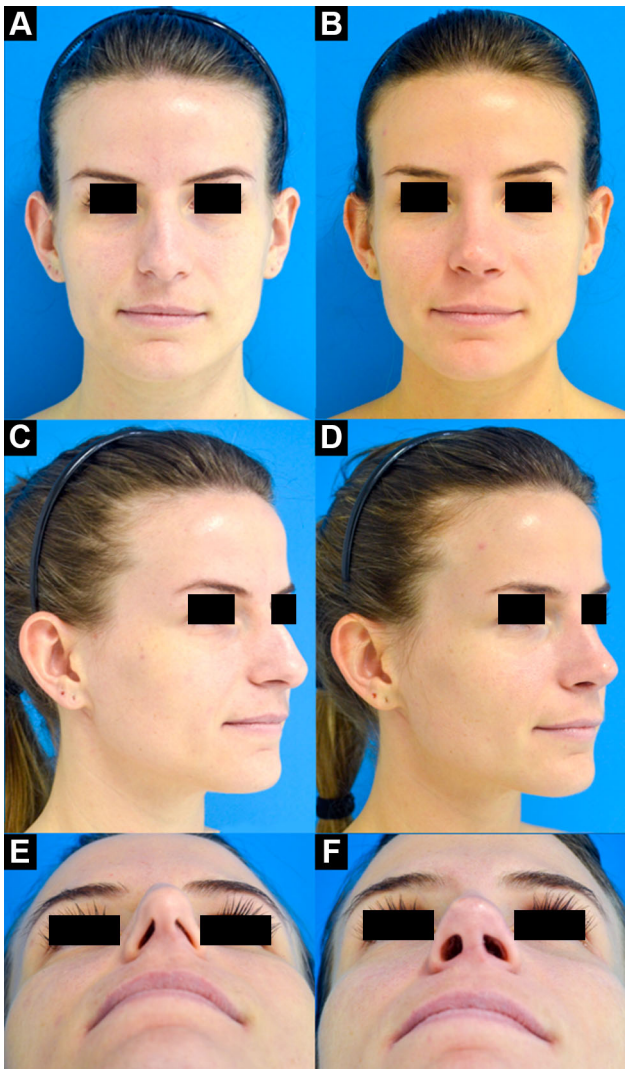

Fig. 12 Pre- and 1.5 year postoperative. **a**, **b** Frontal, **c**, **d** ¾, **e**, **f** deep inspiration

cartilages, the nasal alae region ends up with unsuitable support, which leads to insufficiency of the external nasal valve [3–10].

The disinsertion and repositioning of the lower lateral cartilages resulting in better positioning of these cartilages directly influenced the nasal tip aesthetics with a less pronounced alar groove, a softer transition from the nose lateral wall to the nasal alae and better anatomical arrangement of the Anderson tripod [10, 13, 14, 16, 17].

A very relevant detail during the repositioning of these cartilages is that in some cases, mainly those in which the cartilages are very cephalic, there might be an area without cartilage between the upper and lower lateral cartilages [18, 19]. In the long term, this might lead to the retraction of the nasal alae, nasal pinching and incomplete correction of the valve insufficiency. In such cases, the insertion of a batten graft in this region is extremely important [20].

In Caucasian patients with a narrow alar base, in which the lateral crural strut graft could cause some protuberance of the nose lining leading to obstructive external valve insufficiency, the alar contour graft was used [21].

In this study, all patients were evaluated using Constantian's preoperative classification [4], which enabled proper planning of the surgery, and Toriumi's trans-operative [10] that confirmed the effectiveness of the procedures adopted for the nasal tip.

Regarding the cephalic malposition of lower lateral cartilages, we agree with Constantian who showed this alteration in 46% of 100 consecutive rhinoplasty surgeries [7]. In this research, this malposition was found in 38% of the cases.

In relation to the lower lateral cartilage vector in the preoperative and the external nasal valve insufficiency, similarly to Constantian who diagnosed this condition in

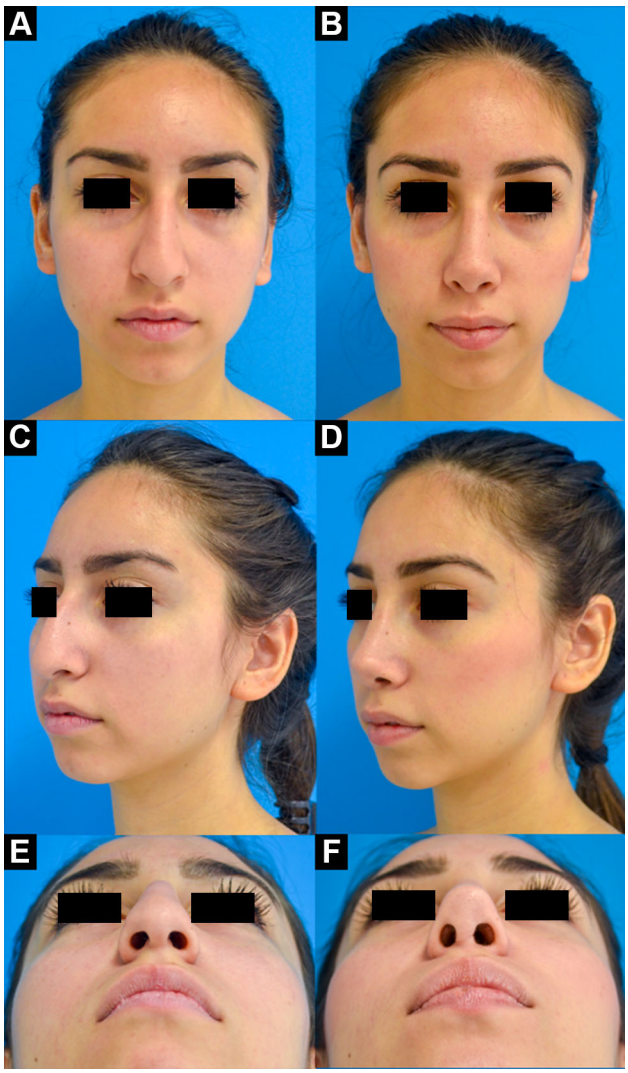

Fig. 13 Pre- and 1.5 year postoperative. **a**, **b** Frontal, **c**, **d** ¾, **e**, **f** deep inspiration

100% of the patients with an inappropriate vector of the lower lateral cartilages [8], this research found that 74% of the patients presented this condition along with the inappropriate vector.

Some situations should always be considered red flags for the presence of external nasal valve insufficiency, these are listed below: boxy tip; bulbous tip; nasal alae retraction; deep alar groove; and collapse of the nasal alae during deep inspiration [3–12, 22].

Another important factor directly related to the occurrence of external nasal valve insufficiency is the presence of weak lower lateral cartilages. This explains why in this study 54% of the patients with an adequate vector of these cartilages had external nasal valve insufficiency [3, 4, 6–8].

Correction of the external nasal valve insufficiency must be performed upon structuring the lateral and medial walls of this valve [9, 23, 24]. In 2017, Silva and Bittencourt concluded that structuring the nasal alae with the lateral crural strut graft and/or alar contour graft was shown efficient to correct external nasal valve insufficiency in 90% of the cases [9]. Agreeing with the authors in this study a structured external nasal valve with grafts was effective in the treatment of this insufficiency.

In this research, we used mainly the lateral crural strut graft and/or alar contour graft to structure the lateral wall. In the medial wall, since the middle of 2016, the author believes that this region must remain rigid in the late postoperative to help keep the external nasal valve and prevent loss of nasal projection [25, 26]. To achieve this objective, the tongue-in-groove technique or the caudal septal extension graft is used [27–35].

Evidently, in the preoperative all patients receive an explanation that they will never have the same mobility of the nasal tip as before the operation, but this situation is compensated by the functional optimization and maintenance of the result in the long term, mainly regarding the nasal projection maintenance [35].

As regards the alar contour graft, an increase was noticed in its use, because between 2013 and 2015 it was used in 22% of the cases and between 2016 and 2018 it was employed in 69% of the cases.

For this reason, we agree with Guyuron et al., who in 2015 described the use of the alar contour graft in 39% from a total of 1427 rhinoplasty surgeries carried out, and in a more recent investigation of 100 cases, 88% of the cases were reported to use this type of graft [36, 37].

Rohrich et al. also described the alar contour graft technique and reported a progressive use of this graft since 2002 up to 2016, when they reported routine use in 100% of the cases [12, 38, 39].

Regarding the surgical technique for this graft, it seems relevant to highlight that to prepare the pocket for this graft Rohrich et al. used Stevens scissors [12, 38], and we found it more practical and easy to start the dissection with Fox scissors and to prepare the pocket with a 2-mm osteotome [9].

This paper emphasizes the functional importance of the external nasal valve and recognizes the importance of Constantian's work, who in 1994 evaluated with pre- and postoperative rhinomanometry and concluded that proper breathing is not only related to the absence of septal deviation, but also to the proper functioning of the nasal valves, mainly the external one [4, 40].

Conclusion

The cephalic malposition of the lower lateral cartilages is an important red flag for external nasal valve insufficiency. When this insufficiency is identified, the treatment should

be carried out reinforcing the medial and lateral walls of the external nasal valve by using grafts.

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