European Review for Medical and Pharmacological Sciences 2023; 27 (5 Suppl): 95-100

Caudal septal extension grafts: conchal cartilage or PDS foil-empowered nasal cartilage

Y. KURT[1], O. OĞUZ[2,3], N. BAYAR MULUK[4], C. CINGI[5]

[1]Department of Otorhinolaryngology, Antalya Finike State Hospital, Finike, Antalya, Turkey
[2]Department of Audiology, Istanbul Nişantaşı University, Health Services Vocational School, Istanbul, Turkey
[3]Dr. Oğuzhan Oğuz Wellnose Clinic, Istanbul, Turkey
[4]Department of Otorhinolaryngology, Faculty of Medicine, Kırıkkale University, Kırıkkale, Turkey
[5]Department of Otorhinolaryngology, Faculty of Medicine, Eskisehir Osmangazi University, Eskisehir, Turkey

Abstract. – We reviewed the potential benefits of conchal cartilage or Polydioxanone (PDS) foil-empowered nasal cartilage as caudal septal extension grafts (CSEGs). Research methods included searching online databases such as Google, Google Scholar, PubMed, and Proquest Central at Kırıkkale University. Use terms like "caudal septal extension grafts," "septal extension grafts," "conchal cartilage," and "PDS foil-empowered nasal cartilage" to find related articles. Due to the anchoring of the lower alar cartilage to the nasal septum, the results of a CSEG rhinoplasty are relatively stable over the long term. They can be adjusted independently by the rhinoplasty surgeon. Over time, the skin and soft tissue envelope contract and a downward force for these grafts develops. It allows for independent regulation of projection and rotation, unlike conventional columellar strut procedures and lateral crural steal techniques. Inadequate cartilage may need conchal or costal cartilage, depending on the application and the need for projection and counter rotation. Costal cartilage transplant outperformed conchal cartilage graft in a rabbit model regarding tip projection and angle relapse rate. Three-patient case series show that PDS foil-enhanced nasal cartilage led to septal cartilage loss. However, other research draws a different result, finding that PDS foil-enhanced nasal cartilage prevented growth inhibition in the developing nasal septum following septoplasty, and reduced late problems in animals. The caudal septal extension grafts should prioritize septum cartilage if it is readily available, of adequate size, and with sufficient strength. If this is not possible, PDS foil-enhanced nasal cartilage fragments or conchal cartilage could be used as a backup. PDS foil will maintain the integrity and stability of the implanted cartilage. Due to its strength, stability, and convenient location, conchal cartilage will serve as the second donor site.

Key Words:
Caudal septal extension grafts (CSEGs), Conchal cartilage, Polydioxanone (PDS) foil-empowered nasal cartilage.

Introduction

Toriumi[1] pioneered the caudal septal extension graft (CSEG) for cosmetic rhinoplasty because it provides a safe and reliable way to independently adjust the nasal tip's projection, rotation, and length. Cartilage strut enlargement grafts (CSEGs) are inserted at the bottom of the nose. Adjusting the angle of the anterior or posterior septum can help to improve the position of the nasal tip or the contour of the columella. The grafts are attached to the caudal border of the septum, setting them apart from the more common free-floating columellar strut grafts. Using the septal attachment as a defining feature, the first description of a caudal septal extension graft was called a columellar strut and described as a surgical procedure for closing clefts in the nose[2,3].

Septal extension grafts are more adaptable than columellar strut grafts, which are only good for unifying the nasal tip and keeping it in place without allowing for precise control over nasal tip rotation[4-6].

Half to two-thirds of the overall nasal projection should be in front of the upper lip, with the ideal nasal tip projection equaling two-thirds of the ideal nasal length. The ideal nasolabial angle is 95-100° for women and 90-95° for men[7]. It is placed onto the anterior septal angle as a "fixed-floating" graft with extension beyond the anterior septal angle into the internal space, with "the most caudal and inferior portion of the graft" pla-

Corresponding Author: Nuray Bayar Muluk, MD; e-mail: nbayarmuluk@yahoo.com; nurayb@hotmail.com

ced on "the cephalic border of the medial crus at the columellar lobular angle". The graft is shaped like a keel to mimic the middle crura[7].

In cases with insufficient columellar cartilage, an onlay graft of concha cartilage or soft tissue was employed to bridge the gap. All septal extension grafts were performed with a unilateral batten graft to add a small amount of cartilage to the other side, allowing for centralized support and the efficient use of cartilage rather than on both sides anatomically[8].

Methods

Research methods included searching online databases such as Google, Google Scholar, PubMed, and Proquest Central at Kırıkkale University. Terms like "caudal septal extension grafts," "septal extension grafts," "conchal cartilage," and "PDS foil-empowered nasal cartilage" were used to find related articles.

Septal Extension Grafts (SEGs)

Byrd et al[4], in 1997, pioneered the use of a septal extension graft to manage nasal lengthening and tip projection, rotation, and form by permanently affixing a graft to the caudal or dorsal septum between both of the lower lateral cartilages. The septal extension graft is preferable to the columellar strut for supporting the tip projection in patients with weak mid-vault or lower lateral cartilage[4,9].

Tip projection did not diminish in cases with an anchoring intercrural columellar strut to the caudal septum, suggesting that the septal extension graft is appropriate for high-risk patients with deficient mid-vault or lower lateral cartilage. A septal extension graft is created when the septum is sutured in place at a septal angle and then extended into the intradural space. The graft's distal end is secured using three contact points at the lower lateral cartilage, and the tip's position is adjusted accordingly. In addition, three methods – the paired spreader type, the paired batten type, and the direct extension type – are given for securing the proximal section to the septum following the shape and direction. The spreader graft of the paired spreader type is placed caudally of the dorsal septum and laterally of the upper lateral cartilage. Widening of the internal valve may occur due to this adjustment, which can also strengthen a mid-vault that is too weak. Dorsal trimming or suturing the posterior region of the septal angle may decrease the lateralization of the upper lateral cartilage[4,10]. However, an excessive graft can collapse the internal valve, and the mid-vault area can be expanded after double-layered grafting. If this is not possible, a minor batten graft on the contralateral side can be performed as an alternative. Across the dorsal and caudal septum, paired battens are fastened in a diagonal pattern. Unlike the spreader tip projection from the supporting vectors, this method does not enlarge the mid vault[11].

Septal extension grafts have undergone a series of refinements and advancements[8]. Although effective for tip projection, the intercrural strut was not as flexible when adjusting the nasal tip's rotation or the columella-labial angle. Tebbetts[12] attached the caudal septum to the columella control strut to improve projection and rotation. Depending on the nasal tip position, Byrd et al[4] proposed three distinct septal extension grafts: paired spreader grafts, paired batten grafts, and direct extension grafts. While overlapping grafts can minimize deviation and add support, they also make the nose's tip rigid and the septum thick and membranous.

The prevalence of a thin caudal septum makes it challenging to apply techniques such as those introduced by Seyhan et al[13] to overcome these deficiencies with septal extension grafts of a modified batten type and by Sen and Iscen[14] to slide the nasal septum to the front, allowing fixation without an overlapping surface in East Asians.

Caudal Septal Extension Grafts (CSEGs)

Toriumi et al[15] used a caudal extension graft that was longer inferiorly to increase tip rotation and blunt the nasolabial angle and longer superiorly to press the nasal tip down for counter-rotation of the nasal tip. However, these techniques require substantial cartilage because the graft reaches the front nasal spine and fixes the dynamic nasal tip to a static structure.

Historically, "caudal septal extension" refers to a specific surgical technique employed in subtotal septectomy and rebuilding. Specifically, the dorsal length of the reconstructed L-strut was increased to rest below the level of the original caudal septal edge. The medial crura were subsequently sutured to the new caudal edge using a tongue-in-groove technique[16], which affected the position and stability of the nasal tip and the form of the columella. The benefits of caudal septal extension for individuals with retracted columella were later described. The medial crura were also attached to

the extension graft for increased stability of the tip and columella, as described in earlier descriptions of caudal septal extension grafting[1].

Kim and Kim[17] performed rib cartilage septal extension grafts for short nose repairs in cases where utilizing the septum was not viable due to previous rhinoplasty or trauma. When considering the use of rib cartilage, it is essential to consider the possibility of donor site morbidity and the danger of cartilage warping. Septal cartilage must be used effectively to minimize harvesting cartilage from other areas. Depending on the desired outcome of the surgery (upturned tip correction, tip lengthening, simultaneous tip lengthening, nasal tip projection, or retracted columella correction), we used a variety of septal extension grafts.

A graft preserves as much of the membranous septum as possible for upturned tip correction or tip lengthening. This graft provides a flexible tip, using less septal cartilage than the traditional septal extension graft[17].

Benefits of CSEGs

CSEGs are increasingly being employed instead of the more conventional columellar strut graft methods in open-structure rhinoplasty. CSEGs offer various benefits over the conventional method. The degree of projection that can be obtained with conventional columellar struts is constrained by the fact that they are free-floating. Columellar struts either call for a long graft that rests on or is sutured to the nasal spine or rely on shield- and cap-type grafts to achieve the desired degree of projection. By binding the tip complex to an extended septum section, CSEGs enable the surgeon to take advantage of the native domes in tip definition. With CSEGs, you can make separate changes to "your nose's length, projection, supratip break, tip rotation, columella form, infra-tip lobule position, and nasolabial angle"[2,4,18].

The Disadvantages of CSEGs

The CSEG technique has less successfully reduced nasal tip stiffness and increased compliance than more conventional floating columellar strut approaches. This must be discussed with the patient prior to any surgical procedures. All of the characteristics mentioned above of the nose tip in lateral view are subject to change, and surgery requires intraoperative examination and reanalysis to achieve an appropriate conclusion. Therefore, there is a technical learning curve involved in applying this method. To evaluate the efficacy of this method, it may be necessary to repeatedly attach and reconnect the medial crura and reposition the CSEG. If the CSEG is not meticulously planned, the columella may be blunted, and the "double break" curvature may be lost, necessitating intraoperative scrutiny. Conchal or costal cartilage may be required if the normal articular cartilage is insufficient for the intended purpose, including projection and counter rotation[2].

Methods for CSEGs

The nasal septum (the best option), the conchal bowl, or the costal margin can all be used to harvest the cartilage. Conchal cartilage transplants may be bent or lack proper mechanical stability (Figures 1, 2A, 2B, and 3). Therefore, their use should be approached with caution. Usually, the graft will be roughly sized and formed before implantation but fine-tuned once it is in place. After separating the nasal domes, dividing the intervening soft tissue, and elevating the mucoperichondrial flaps on either side down to the posterior septal angle, the septal cartilage is exposed during open rhinoplasty and a graft is typically partially overlapped with the caudal margin of the nasal septum and sutured into place with multiple mattress sutures. The graft is usually maintained in place using hypodermic needles of 25 or 27 gauge by overlapping it with the native caudal septum. The senior author

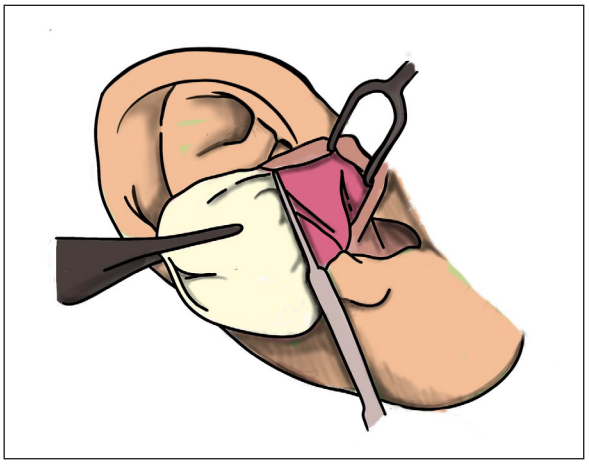

Figure 1. Conchal cartilage harvesting.

utilizes either absorbable or permanent sutures, depending on the predicted load, although the choice of suture remains disputed. Three sutures are always utilized to keep the transplant in place. When the natural caudal septum is displaced from the midline, the CSEG is very helpful since the graft can be positioned to correct the deviation. If this overlap causes a caudal deviation at the tip or columella, either the cephalic portion of the graft is shortened, or the graft is placed end-to-end with the caudal septum, with thin splinting grafts or "extended spreader grafts placed to reinforce the extension graft on its lateral aspects"[2].

Sutures for the SEG Method

It is easy to regulate the tip's projection, shape, and rotation with the septal extension graft. Crucial repairs to the SEG method were reported by Rochrich et al[7].

Suture for SEG Body and Inferior for Stability

The nasal tip is reshaped from the bottom up, revealing transdermal and interdomain suturing and it creates "the medial crural footplate, low medial crural, and high medial crural" approximation[7].

Steps for nasal tip reshaping:

1. Horizontal mattress suture used for body fixation.
2. An exceptional euture for stabilization.
3. Suture used for inferior stabilization.
4. Horizontal mattress suture for body support.

Domal Suturing for SEG

Closing the dead space after a septal extension graft begins with horizontal mattress sutures in the medial crura footplate and continues inferior to superior and caudal to cephalic[7].

Steps for closing the dead space:

1. Deformities and asymmetry of the footplates can be corrected with medial crural approximation.
2. The graft is stabilized, footplate asymmetries are corrected, columellar width is regulated, and the medial crura are strengthened by "low" medial crural approximation.
3. The tip width and symmetry can be established with the help of "high" medial crural approximation, which further stabilizes the medial crura to the graft.

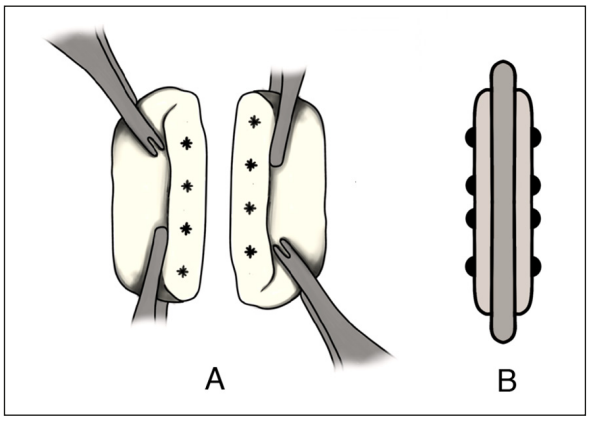

Figure 2. Two enforcement and straightening rectangular pieces of cartilage were cut from the harvested conchal cartilage. Then they sutured on both sides of the septal extension graft to secure the straightness of the graft. **A**, Side views; **B**, Frontal view. The fabricated CSEG with a double-layered caudal segment and a single-layered cephalic segment. CSEG, caudal septum extension graft..

4. Asymmetries, lateral crural convexities/concavities, and a widening tip can all be improved with transdermal suturing.
5. Eversion is further emphasized, the angle of divergence is reduced, the tip-defining points are narrowed, vertical asymmetries are corrected, and the graft is hidden thanks to internal approximation.

CSEGs with Cartilage Grafts

The septal extension graft typically employs septal cartilage due to its high supporting force, although it is generally insufficient. Although the risk of deformation is higher than with the over-

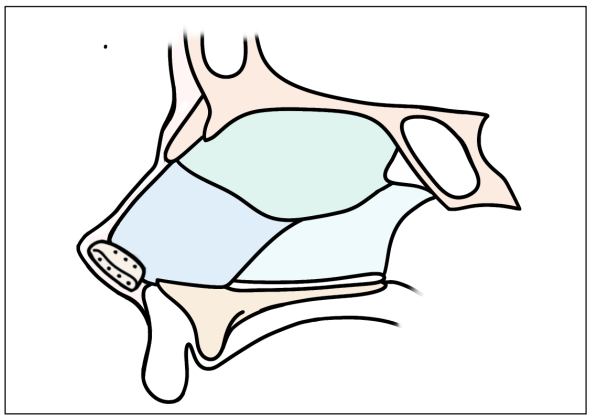

Figure 3. Sutured septal extension graft.

lapping type, a direct extension graft (butt type) can be employed in certain situations; the surgeon should take every precaution to secure the graft. To fortify the graft, as with the batten type, or to generate extra tip projection, as with an onlay graft, ear cartilage can be placed instead of septal cartilage. Although autogenous costal cartilage may be used, its extreme thickness and strength and the scarring that may result from its harvesting make its usage cautious. Irradiated homologous costal cartilage (IHCC) is one option that could reduce the need for cartilage removal[9,10].

Instead of employing autogenous cartilage, Suh et al[19,20] advocated for the use of IHCC to treat a constricted nose due to its minimal risk of resorption and infection. Despite the risk of implant exposure, Han et al[21,22] advocated employing a porous high-density polyethylene sheet (Medpor sheet, Porex Surgical Inc., Newnan, GA, USA) to create a septal extension graft.

According to Kim et al[8], selecting the most appropriate septal extension graft for a given patient population based on their desired surgical outcome allows adequate nasal tip lengthening and projection.

Using a rabbit model for rhinoplasty, Zhang et al[23] compared costal and conchal autologous cartilages in SEG. Group A received a bilateral batten costal cartilage graft, and Group B received a bilateral batten conchal cartilage graft during the SEG procedure on 20 rabbits. The form of the nasal tip and the graft were monitored over time with a series of pictures. Extension graft histologic characteristics and indices, such as tip projection and tip angle, are observed. Tip projection and angle relapse rate were better for the costal cartilage graft than the conchal cartilage graft ($p = .05$ for both comparisons). Compared to a graft made from conchal cartilage, the costal cartilage graft was more stable. They reported that in Group A, calcification was more prevalent, and that fibrous capsules formed surrounding the extension graft, suggesting that this model may be used to teach these techniques to rhinoplasty surgeons. More focus should be on the costal cartilage extension graft because it is more stable.

PDS Foil-Empowered Nasal Cartilage as a CSEG

In rhinoplasties, polydioxanone (PDS) foil is commonly used as a replacement for septal cartilage because of its reputation as being fully resorbable and biodegradable. Various surgeons regard PDS foil as the perfect implantable biomaterial, as evidenced by the various research conducted on the subject, and it received FDA approval in the United States in 2010[24]. After surgical correction of the developing septal cartilage in young rabbits, Boenisch et al[25] found that the resorbable PDS foil eliminated secondary deviation. Using this foil after a septoplasty may avoid development inhibition in a child's nasal septum and reduce the risk of late problems such as septal deviations[25]. However, the study by Wang et al[24] on 3 patients showed that PDS plate usage could cause septal cartilage loss and, ultimately, saddle nose deformity linked to persistent postoperative swelling and inflammation.

A case series involving three humans revealed that PDS foil-enhanced nasal cartilage led to septal cartilage loss[24]. At the same time, animal studies[25] suggested that it prevented growth inhibition in the developing nasal septum following septoplasty and reduced late problems. Therefore, further research into this subject is warranted.

Conclusions

Because the CSEG fixes the lower alar cartilage to the nasal septum, the rhinoplasty surgeon has complete freedom to adjust the projection and rotation of the nasal tip[26-28]. Over time, the skin and soft tissue envelope contract, creating a downward force these grafts resist. Projection and rotation are separately tunable[2], unlike traditional columellar strut procedures or lateral crural steal techniques.

Septum cartilage should be prioritized for the caudal septal extension grafts, if available, of appropriate size and acceptable strength. If this is not feasible, conchal cartilage or pieces of nasal cartilage reinforced with PDS foil could be used as a substitute. PDS foil will keep the implanted cartilage strong and in place. The second donor site will be conchal cartilage because of its durability, consistency, and proximity to the first.

Funding

No funding was obtained from any companies or organizations for this paper.

Authors' Contributions

The authors declare that they do not have any conflict of interest with this paper.

Ethics Approval
Not applicable.

Informed Consent
Not applicable.

ORCID ID
Yucel Kurt: 0000-0001-5111-0240
Oğuzhan Oğuz: 0009 0002 7019 1386
Nuray Bayar Muluk: 0000-0003-3602-9289
Cemal Cingi: 0000-0003-3934-5092

Availability of Data and Materials
All data used for this review are presented in this paper.

References

1) Toriumi DM. Caudal septal extension graft for correction of the retracted columella. Oper Tech Otolaryngol Head Neck Surg 1995; 6: 311-318.
2) Chiu-Collins LL, Furze AD, Wong BJF. Caudal Septal Extension Grafts. In: Shiffman MA, Di Giuseppe A (eds.). Advanced Aesthetic Rhinoplasty. Chapter 42. Springer-Verlag Berlin Heidelberg, Germany 2013, pp. 667-678.
3) Dibbell DG. A cartilaginous columellar strut in cleft lip rhinoplasties. Br J Plast Surg 1976; 29: 247-250.
4) Byrd HS, Andochick S, Copit S, Walton KG. Septal extension grafts: a method of controlling tip projection shape. Plast Reconstr Surg 1997; 100: 999-1010.
5) Ha RY, Byrd HS. Septal extension grafts revisited: 6-year experience in controlling nasal tip projection and shape. Plast Reconstr Surg 2003; 112: 1929-1935.
6) Akkus AM, Eryilmaz E, Guneren E. Comparison of the effects of columellar strut and septal extension grafts for tip support in rhinoplasty. Aesthetic Plast Surg 2013; 37: 666-673.
7) Rohrich RJ, Savetsky IL, Avashia YJ. The Role of the Septal Extension Graft. Plast Reconstr Surg Glob Open 2020; 8: e2710.
8) Kim JH, Song JW, Park SW, Oh WS, Lee JH. Effective septal extension graft for Asian rhinoplasty. Arch Plast Surg 2014; 41: 3-11.
9) Kim MH, Choi JH, Kim MS, Kim SK, Lee KC. An introduction to the septal extension graft. Arch Plast Surg 2014; 41: 29-34.
10) Ha RY, Byrd HS. Septal extension grafts revisited: 6-year experience in controlling nasal tip projection and shape. Plast Reconstr Surg 2003; 112: 1929-1935.
11) Hubbard TJ. Exploiting the septum for maximal tip control. Ann Plast Surg 2000; 44: 173-180.
12) Tebbetts JB. Shaping and positioning the nasal tip without structural disruption: a new, systematic approach. Plast Reconstr Surg 1994; 94: 61-77.
13) Seyhan A, Ozden S, Ozaslan U, Sir E. Simplified use of septal extension graft to control nasal tip location. Aesthetic Plast Surg 2007; 31: 506-511.
14) Sen C, Iscen D. Caudal septal advancement for nasal tip projection and support in rhinoplasty. Aesthetic Plast Surg 2006; 30: 135-140.
15) Toriumi DM, Patel AB, DeRosa J. Correcting the short nose in revision rhinoplasty. Facial Plast Surg Clin North Am 2006; 14: 343-355.
16) Toriumi DM. Subtotal reconstruction of the nasal septum: a preliminary report. Laryngoscope 1994; 104: 906-913.
17) Kim SK, Kim HS. Secondary Asian rhinoplasty: lengthening the short nose. Aesthet Surg J 2013; 33: 353-362.
18) Toriumi DM. New concepts in nasal tip contouring. Arch Facial Plast Surg 2006; 8: 156-185.
19) Suh MK, Ahn ES, Kim HR, Dhong ES. A 2-year follow-up of irradiated homologous costal cartilage used as a septal extension graft for the correction of contracted nose in Asians. Ann Plast Surg 2013; 71: 45-49.
20) Suh MK. Contracted short nose correction using irradiated homologous costal cartilage. J Korean Soc Aesthetic Plast Surg 2010; 16: 117-124.
21) Han K, Jeong JW, Kim JH, Son D, Kim S, Park SW, Choi J, Choi TH. Complete septal extension graft using porous high-density polyethylene sheet or septal cartilage in unilateral cleft lip nasal deformities: photogrammetric analysis. J Korean Soc Plast Reconstr Surg 2010; 37: 400-408.
22) Han K, Jeong JW, Kim JH, Son D, Kim S, Park SW, Choi J, Choi TH. Complete septal extension grafts using porous high-density polyethylene sheets for the westernization of the Asian nose. Plast Reconstr Surg 2012; 130: 106e-115e.
23) Zhang Z, Yu Z, Wu J, Zhang J, Zhang Y, Song B. Septal Extension Grafts in Rabbit Models: A Comparative Study Between Costal and Conchal Cartilage Grafts. Aesthet Surg J 2023; 43: 609-617.
24) Wang LL, Frankel AS, Friedman O. Complications of Polydioxanone Foil Use in Nasal Surgery: A Case Series. Facial Plast Surg 2018; 34: 312-317.
25) Boenisch M, Tamás H, Nolst Trenité GJ. Influence of polydioxanone foil on growing septal cartilage after surgery in an animal model: new aspects of cartilage healing and regeneration (preliminary results). Arch Facial Plast Surg 2003; 5: 316-319.
26) Cingi CC, Bayar Muluk N, Cingi C. Preoperative computer imaging before augmentation rhinoplasty. Eur Rev Med Pharmacol Sci 2023; 27 (4 Suppl): 21-26.
27) Resuli AS, Dilber M, Bayar Muluk N, Cingi C. Septal extension graft use in the treatment of alar collapse. Eur Rev Med Pharmacol Sci 2023; 27 (2 Suppl): 8-13.
28) Azizli E, Bayar Muluk N, Dündar R, Cingi C. A new preservation technique for dehumping the dorsum. Eur Rev Med Pharmacol Sci 2023; 27 (2 Suppl): 57-62.