Original Article - Analytical Study

Costal cartilage nasal augmentation rhinoplasty: Study on warping

Access this article online
Website: www.amsjournal.com
DOI: 10.4103/2231-0746.110070
Quick Response Code:

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ABSTRACT

Background: To retrospectively study the costochondral graft (CCG) based nasal dorsum augmentation failures due to warping. **Materials and Methods:** All patients fulfilling inclusion and exclusion criteria between January 2008 and December 2011 were included in the study. The details of the dorsal nasal length (DNL) immediate postoperative and 1 week postoperative period as well as the degree of divergence from midline by warping noted down in mm along with age, gender, and nature of graft. **Statistics:** Data analyzed using Statistical Package for the Social Sciences version 17. Descriptive statistics, Chi-square test and one-way analysis of variance are presented. *P* value ≤0.05 was considered significant. **Result:** One hundred and fifty seven cases fulfilled the criteria. Of these, 44 (28%) were males and rest were females. The mean age of the patients was 24.41 ± 4.9 years with a range of 17-37 years. In 102 cases (65%) had soft CCG while 55 (35%) were identified to be gritty type of CCG. Of the 157 cases, warping was identified in 41 cases (26.1%) and required revision of the surgery. Age group was significantly associated with presence of warping (*P* = 0.000). **Discussion:** With increase in age, the number of patients with gritty CCG was higher. Older patients had lesser incidence of warping while younger patients had more incidence of warping. The incidence was not significantly related to gender or the DNL. The grafts that were relatively straight had less incidence of warping.

Keywords: Costochondral grafts, nasal dorsal augmentation, rhinoplasty, warping

INTRODUCTION

Rhinoplasties for cosmetic and functional reasons are increasing over the last decade. Congenital, iatrogenic, and traumatic etiologies also cause a deficient or deformed nasal dorsum requiring correction with dorsal augmentation. With increasing number of surgeries, refinement of technique is evolving. Surgeons understood the need for improving the structure and tip contour of nose in such rhinoplasties. Moreover, there is a frequent and complex need for structural augmentation to improve contour of nasal structures. A deficient osteocartilaginous dorsum is the most common challenge for which augmentation with graft material is required. Achieving a symmetric, smooth, stable, and desired nasal dorsum that fulfills the criteria of adequate form, function, and patient expectation remains a principle challenge during primary or secondary rhinoplasties.[1] Though alloplastic implants provided a good alternative, a good number of patients developed complications including thinning of the skin over the implant, extrusion, infection, displacement, translucency of the implant, and chronic pain. Although such treatment initially caused increase in dorsal nasal height and projection, sustaining this over a time period was not feasible.[2] Autologous grafts such as split calvarial bone graft, iliac bone, costal bone, and costal cartilage have been used effectively with varying effects in nasal dorsal augmentation (NDA).[2,3] It is reported that with proper carving and meticulous construction, augmentation rhinoplasty using costochondral material can produce excellent results.[1-3]

Warping refers to the distortion of the costochondral graft (CCG) which result in latent deformity of the nasal dorsum and/or tip. Dynamics of warping has been studied.[4-6] The effect of age on calcification extent/status of costochondral cartilage has been

documented.[7] Recently, it is been reported that there were no statistical significant changes in CCG material properties with aging and increased calcification.[8] However, the effect of age of the patient and warping has not been studied in detail. The aim of the present retrospective pilot study is to observe the effect of age on CCG based NDA owing to warping.

MATERIALS AND METHODS

Surgical procedure

CCG harvesting was done after standard procedure. The straightest of the 5th, 6th, or the 7th rib was chosen by palpation and used in the study. The skin incision was placed on the region over the right rib for about 3 cm in length. After incising skin, blunt dissection was performed to carefully divide the overlying breast tissue. Bleeders were cauterized with cautery. Fascia over the muscle was incised, and the muscle fibers were separated with a hemostat. The remaining soft tissue was cleared off the rib for visualization. Depending upon the hardness felt, the graft area was classified as soft or gritty in nature. Incisions were made into the perichondrium along the periphery of the rib and an elevator was used to remove this 5-to 10-mm strip of perichondrium. The cartilaginous part of the rib was dissected away from the perichondrium circumferentially, taking care to avoid injuring the perichondrium. An incision was made halfway through the rib just medial to the osteochondral junction. A medial incision was made based on the required length of cartilage. The segment of costal cartilage was removed and set aside. After checking for any injury, closure was performed in layers. The CCG was carved sequentially over long time period so as to allow the natural warping tendencies of each piece to be demonstrated. The dorsal graft must have minimal warping, and is best carved from the central core of the rib in a centric fashion.[2]

The nasal region was intra-nasally approached. It began with an inverted V shaped incision between the upper and lower cartilage. The dissection was carried up onto the middle nasal vault, staying in a plane immediately adjacent to the cartilage. A periosteal elevator was used to create a small subperiosteal pocket over the bony dorsum in the midline. The size/position of this pocket determines the future place of the CCG and hence be made with great care. The superior aspect of this pocket should lie at about the midpupillary line and correspond to the proposed nasal starting point. This place was created with a notch (inverted C) so that the CCG sits over this notch. Nasal dorsal height is based on the tip projection. The CCG is often a canoe-shaped graft. Depending on the degree of augmentation required, the thickness of graft could be increased by staking making sure of beveling edges. The graft was then placed into the narrow dorsal pocket created and stabilized using sutures. Before suturing, careful inspection and palpation of graft is performed to ensure the graft is in midline, symmetric, and without irregularities [Figures 1 and 2].[2] Preoperative dorsal nasal length (DNL) measurement was taken as mentioned earlier.[9] After this Plaster of Paris cast was applied to ensure no warping. This was removed in a week and examination including measurement done. If there was warping, surgery was immediately advised considering patient's apprehension and expectation. Measurement of DNL was done again. If there had been warping, the extent of the warp (deviation in mm) was measured from the midline and noted for future reference.

Study

This is a retrospective study done in the institute, by a single surgeon, using conveniently sampled records of rhinoplasty cases satisfying the following inclusion and exclusion criteria in the time period between January 2008 and December 2011. The inclusion criteria included all types of rhinoplasties done for NDA using CCG including secondary rhinoplasties with follow up. The exclusion criteria included the following:

1. Any defect or abnormalities of orbit and eye structures
2. Surgeries involving structural realignment of orbit/nasal bone
3. Complex facial fractures involving orbital bones
4. Cases lacking measurements and relevant photographic records
5. Cases with no follow up records of 3 months or less
6. Absence of details of nature of graft (soft-cartilaginous/gritty, with calcifications)

Cases satisfying these criteria were included for the study. The DNL immediate postoperative and 1 week postoperative as well as the degree of divergence from midline by warping was noted down in mm along with age, gender, and nature of graft. Age group was classified as below 20 years, 21-25 years, 26-30 years, and those above 31 years. Data entry and analysis were done using Statistical Package for the Social Sciences (SPSS, Version 17.0., IBM, IL, USA). Descriptive statistics were presented between the soft and gritty type of CCG. Cross tabulation between presence and absence of warping to nature of CCG were presented. One-way analysis of variance (ANOVA) was employed to find the association of type of graft, warping to age and gender. P value of ≤0.05 was taken as significant.

RESULTS

One hundred and fifty seven cases fulfilled the inclusion and exclusion criteria. Of these, 44 (28%) were males and rest were females. The mean age of the patients was 24.41 ± 4.9 years with a range of 17-37 years. All of them were operated and measured by the same surgeon at the center using same procedure during the study period. It was found that 102 cases (65%) had soft CCG while 55 (35%) were identified to be the gritty type of CCG. Of the 157 cases considered, warping was identified in 41 cases (26.1%) and required revision surgery.

Of the soft CCG, 35.3% (36 cases) showed clinical evidence of warp while 64.7% (66 cases) did not warp. In the gritty type of CCG, 9.1% (5 cases) showed warping while 50 cases (90.9%) did not produce warping. The difference was statistically significant (P = 0.000). One-way ANOVA is given in Table 1. Warping in side-to-side was highly significant (P = 0.001) while DNL was not significant. Age and nature of graft was also highly significant (P = 0.000). Gender was never significant.

Age group was significantly associated with the presence of warp. The incidence of warp significantly decreased with increasing age. The difference was statistically significant (P = 0.000) [Table 2]. However, one-way ANOVA failed to produce a linear association with the degree of warp [Table 3].

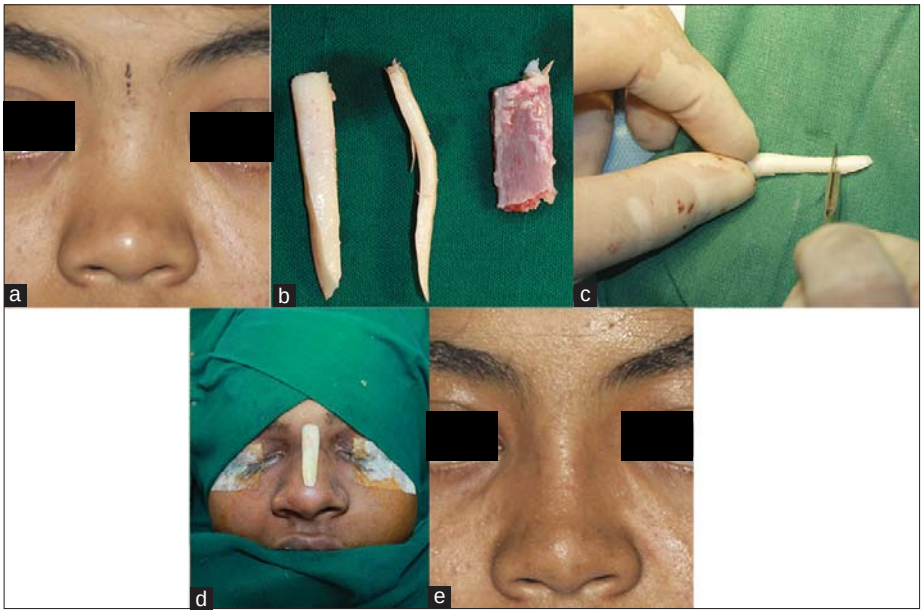

Figure 1: (a) Preoperative appearance of depressed nasal dorsum**,** (b) Harvested costal cartilage graft, (c) Shaping the concentric cartilage graft and scoring, (d) The shaped cartilage graft before placement, (e) Postoperative appearance after dorsal augmentation with costal graft

Figure 2: (a) Preoperative view of depressed nasal dorsum, (b) Dorsal augmentation using Costal cartilage - sculpted cartilage before placement in the nasal dorsum, (c) Intraoperative view of augmented dorsum without deviation, (d) Warping of costal cartilage after dorsal augmentation – 1 year after surgery, (e) Warped cartilage scored, (f) Warped cartilage strengthened using additional graft and re-inserted in the dorsum for augmentation, (g) Correction of deviation

DISCUSSION

NDA using CCG is extremely useful in conditions such as saddle nose deformities, congenital nasal deformity, severe tip weakness or under projection, and secondary rhinoplasties. CCG also functions to create strong grafts to augment or support the nasal dorsum, tip, or septum. Though irradiated homograft costal cartilage is also a viable option, resorption occurs over a period of time, when they are used especially for structural grafting. The possible disadvantages of CCG include donor site morbidity, increased operative time, and a risk of graft warping. In reality, the risk of donor site morbidity such as pneumothorax is extremely low if meticulous surgery is carried out. The main disadvantage of CCG is warping.

Gibson and Davis[4] used concentric segments of CCG to minimize interlocking stresses and in a series of 46 cases they did not observe any warping. It has been demonstrated that dynamic composition of protein-polysaccharides within cartilage produces internal tensile stresses that cause the cartilage to change shape with time.[5] It has been documented that the central portions of CCG warped less than peripheral portions.[10,6] It has been proved that warping of CCG can be effectively reduced by systematic, concentric carving of cartilage from the center of rib segments. The inherent forces of warping appear to act more in the dorsal-ventral dimension of CCG, but not clinically manifesting owing to compensation by thick skin. But the side-to-side warping is more clinically evident due to less soft tissue resistance in this dimension. Similarly the end time of warping of CCG is still debated.[10]

Table 1: One-way analysis of variance, nature of graft with age, warp, and altered dorsal nasal length

One-way ANOVA	Nature of CCG			Gender		
	Soft	Gritty	*P* value	Male	Female	*P* value
Altered DNL (in mm)	1.52±0.79	0.88±0.30	0.083	1.39±0.79	1.47±0.78	0.765
Warping (side-to-side in mm)	3.32±0.95	1.66±0.70	0.001	3.14±1.06	3.11±1.09	0.945
Age (in years)	22.58±3	27.8±5.88	0.000	24.72±5.59	24.28±4.62	0.612

ANOVA = Analysis of variance, CCG = Costochondral graft, DNL = Dorsal nasal length

Table 3: One-way analysis of variance to study the influence of age group in warping

Age group	*N*	Mean	SD	95% CI for mean		Minimum	Maximum	*P* value
				Lower	Upper			
20 years and below	23	3.22	0.97	2.80	3.64	1.60	4.80	0.269
21-25 years	9	3.46	1.04	2.66	4.26	1.60	4.80	
26-30 years	4	2.60	1.58	0.08	5.12	1.20	4.50	
31 years and above	5	2.46	0.99	1.24	3.69	0.90	3.40	

SD = Standard deviation, CI = Confidence interval

In our present study, it is evident that higher calcified CCG gives lesser warping especially those of side-to-side nature. Age and gender appears to have lesser influence on the warping while the nature of CCG appears to play a vital role with high statistical correlation. The DNL reduction appears to be lesser and statistically not significant. This could probably be a result of thick skin in the study population that camouflages the DNL changes with warping. The role of mature calcified CCG cartilage on warping has not been deeply investigated. The presence of calcification in CCG is reported to lead to an effective stiffening of graft which increases the stress in the adjacent bone, often when an external force or stress is applied. The length of contiguous calcification infiltrating from the costochondral junction (CCJ) changes with the effective length of the rib and thereby could alter the structural response. The observed changes in cross-sectional area of CCG while maintaining the mineralized volume fraction when approaching the CCJ from a medial direction should be incorporated in models of the CCG graft.[8]

Mineralized cartilage, such as gritty CCG, is reported to have high calcium content than the adjacent bone especially along the "growth cartilages". There are reports of an abrupt change of calcium particle orientation at the interface between the bone and cartilage. The calcium-rich particles were aligned perpendicular to the interface in cartilage, they were oriented parallel to it in bone, reflecting the divergent morphology of the underlying organic matrices. The close proximation and bonding of calcified cartilage to bone underlines that interface of these two elastic tissues is influenced by mechanical retention.[11] This difference probably contributes to prevention of warping in gritty CCG and contributes

Table 2: Comparison of age group and presence of warp in study population

Age group	Warp		*P* value
	Yes *N* (%)	No *N* (%)	
20 years and below	23 (56.1)	18 (15.5)	0.000
21-25 years	9 (22)	48 (41.4)	
26-30 years	4 (12.5)	28 (87.5)	
31 years and above	5 (12.2)	22 (19)	

to the result of this study. Furthermore, it was recently reported that increasing the relative volume of calcification in CCG from 0% to 24% increased the stiffness of the costal cartilage segments by a factor of 2.3-3.8.[12] These results suggest that calcification may have a substantial effect on the stiffness of the costal cartilage especially when used in high-stress region such as dorsal nasal augmentation.

It is documented that cartilaginous tissues have three major phases: A solid matrix, interstitial water, and mobile ions (mainly sodium and chloride) within the tissue. The composition and structure of these phases differ with the type of cartilage and with depth. Collagen, water, and proteoglycan content as well as the orientation of collagen fiber vary with in these three phases. This in turn influences the material properties of the tissue.[13]

After any grafting or surgery, swelling of cartilage may arise from the high concentration of highly negatively charged glycosaminoglycans associated with the proteoglycan molecules of the extracellular solid matrix. The glycosaminoglycans contain a large number of negatively-charged groups which attract more cations into the tissue, creating an imbalance of the ion concentration between the inside and outside of the tissue. This imbalance leads to rise of osmotic pressure and an associated propensity to swell leading to dimension changes.[14] Besides these, the influences of inflammatory mediators have to be also accounted for.

In the author's opinion, the result observed in Table 2 has more significance. When the patient is younger, the incidence of warping is increased. This probably owes to the plasticity of the cartilage. When the patient is relatively older, the incidence of warp is lesser. The cartilages in older patients have more calcium content and this provides the necessary rigidity. In addition, the amount of ground substance (glycosaminoglycans) in older patients is altered. Similarly when a relatively straight graft is obtained, the patient had no warp. The manipulation of graft probably induces more residual stress that relieves itself by the warping. The alteration of ionic content also probably contributes to the change.

CONCLUSIONS

The results of this study imply that centric CCG when taken from osteocartilaginous area appear to produce less warping especially those that cause a side-to-side warping. This warping does not appear to be related to gender or age. However, the presence of gritty type of CCG is directly related to age. The study also indicates that younger patients have more incidences

of warping and older patients face less incidence of warping. It is also observed that straighter the graft, lesser the manipulation and lesser the warp. Large scale confirmatory studies are essential to identify the clinical usefulness of this observation.

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Cite this article as: Balaji SM. Costal cartilage nasal augmentation rhinoplasty: Study on warping. Ann Maxillofac Surg 2013;3:20-4.

Source of Support: Nil, **Conflict of Interest**: None declared.