Costal cartilage nasal augmentation rhinoplasty: Study on warping

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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.[3] Recently, it has 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 nasal length (DNL) measurement was taken as mentioned earlier.[9] After this Plaster of Paris cast was applied to ensure the graft is in midline, symmetric, and required revision surgery. 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 nasal length (DNL) measurement was taken as mentioned earlier.[9] After this Plaster of Paris cast was applied to ensure the graft is in midline, symmetric, and required revision surgery.

**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].
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]
In our present study, it is evident that higher calcified CCG gives lesser warping especially those of side-to-side nature. Age and gender appear 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 the DNL 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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