

EXPERIMENTAL STUDY

Experimental autogenous cartilaginous grafts for laryngotracheoplasty: a comparison of two techniques and two different types of grafts

Larengotrakeoplasti için otojen kartilaj greftlerinin kullanımı:
İki tekniğin ve iki tür greftin karşılaştırıldığı deneysel çalışma

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Objectives: This experimental work was performed to compare the results of laryngotracheoplasty with the use of autogenous cartilaginous grafts harvested either from the auricula or costal cartilage using two techniques, anterior or posterior graft placement.

Study Design: This study was carried out in 20 healthy dogs of both sexes and varying ages, weighing about 12-15 kg. The animals were divided into two groups (A and B), equal in number. We used costal cartilage grafts in group A, and auricular cartilage grafts in group B. The anterior and posterior laryngeal walls were vertically divided and the cartilage grafts were sutured in place.

Results: Microscopic examination of laryngeal specimens showed a higher rate of graft displacement in group B (40% vs 20%) and in those placed posteriorly (50% vs 10%) ($p < 0.05$). Auricular cartilages showed more resorption and degeneration than costal cartilages. Severe to complete resorption was detected in 30% in group B, which was twice as much in anteriorly placed grafts, whereas no resorption occurred in group A.

Conclusion: The use of auricular grafts and posterior placement was significantly associated with more graft displacement.

Key Words: Laryngeal diseases/surgery; tracheal stenosis/surgery.

Amaç: Bu deneysel çalışmada, anterior veya posterior greft yerleştirme teknikleriyle, otojen olarak aurikula ve kostal kıkırdaktan elde edilen greftler kullanılarak uygulanan larengotrakeoplasti sonuçları karşılaştırıldı.

Çalışma Planı: Çalışmada ağırlıkları 12-15 kg arasında değişen, her iki cinsiyetten seçilen 20 sağlıklı köpek kullanıldı. Hayvanlar eşit sayıda oluşturulan A ve B gruplarına ayrıldı. Grup A'da kostal kartilaj grefti, grup B'de auriküler kartilaj grefti kullanıldı. İki grupta da larenksin anterior ve posterior duvarları vertikal olarak ayrıldı ve kartilaj greftler buraya dikildi.

Bulgular: Larenks örneklerinin mikroskopik incelemesinde, grup B'de (%40, grup A %20) ve posteriora yerleştirilen greftlerde (%50, anterior %10) daha yüksek oranda yer değiştirme gözlemlendi ($p < 0.05$). Auriküler kartilajlar kostal kartilaja göre daha fazla rezorpsiyon ve dejenerasyon gösterdi. Grup B'de %30 oranında ve anteriora yerleştirilen greftlerde iki kat fazla olmak üzere ciddi ve tam rezorpsiyon görüldü. Grup A'da ise rezorpsiyon gelişmedi.

Sonuç: Auriküler kartilaj greftlerinin kullanımı ve bunların posteriora yerleştirilmesi greftte belirgin olarak daha fazla yer değiştirmeyle sonuçlanmaktadır.

Anahtar Sözcükler: Larenks hastalıkları/cerrahi; trakeal darlık/cerrahi.

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Stenosis of the larynx, either congenital or acquired, is one of the most important causes of upper airway obstruction in the pediatric population.^[1]

The incidence of acquired subglottic stenosis is still rising resulting from the increased survival rate of pre-term infants ventilated for various bronchopulmonary diseases.^[2] Also with the introduction of a carbon dioxide laser as a surgical tool for the treatment of juvenile laryngeal papillomas and subglottic hemangiomas, injudicious prolonged use of laser has shown to result in scarred contracted laryngeal opening.^[3]

Management of laryngeal stenosis is a major challenge. Therapeutic procedures range from repeated dilatation, prolonged laryngeal stenting with or without the use of steroids, the use of carbon dioxide laser to create an airway with or without tracheostomy, to early tracheostomy and open surgical operation on the child's larynx. An important breakthrough in surgical repair is the introduction of cartilage graft for tracheolaryngoplasty.

The aim of this work was to evaluate the use of autogenous cartilaginous grafts for tracheolaryngoplasty in an animal model, with special emphasis on postoperative complications and the effect on the airway. We also set out to compare the outcome of two types of autogenous cartilaginous grafts: auricular and costal grafts. We also compared the outcomes of two techniques in cartilage placement; anterior and posterior graft placement with respect to the vertically divided anterior laryngeal wall and the vertically divided posterior lamina of the cricoid cartilage respectively.

MATERIAL AND METHODS

This study was carried out on 20 healthy dogs of both sexes and of different ages weighing about 12-15 kg. Animals were divided into two groups A & B, comprising 10 animals each. We used costal cartilage grafts in group A and auricular cartilage grafts in group B.

Procedure

After a premedication using intravenous chlorpromazine (neurazine) in a dose of 1 mg/kg, we used thiopental sodium for general anesthesia. The donor site and the operative site were shaved and cleaned with betadine solution. Harvesting the costal cartilage grafts was performed by incising the skin par-

allel to the tenth or eleventh rib dissecting the intercostals muscles from the upper and lower borders of the anterior end of the rib. Approximately 3-4 cm long pieces were harvested, keeping the perichondrium intact on both sides. The donor site was closed in layers. The costal cartilage grafts were divided into two, each about 1.5-2 cm long. They were sculptured making a step on either side along the whole length of the graft to help in fitting and fixing the graft in place. The average width of the graft was 0.55-0.6 cm.

Auricular cartilage grafts were harvested through a vertical skin incision made at the root of the auricle dissecting through the submucosa to reveal the cartilage. Approximately 2 by 3 cm grafts were obtained keeping the perichondrium intact on both sides of the grafts. Grafts were divided into two and fashioned to an elliptical shape of an average size of 0.6-0.7 cm wide at the centre and about 2.5 cm in length. All grafts were kept in saline until use.

A vertical neck incision was made in the midline of the animal's neck extending from the level of the hyoid bone to 2-3 cm below the cricoid cartilage. Skin and strap muscles were retracted from the midline. A vertical midline incision was made in the anterior larynx beginning from the third tracheal ring and extending to, but not, completely through the upper one-third of the thyroid cartilage (Fig. 1). One percent lidocaine in 1/100,000 epinephrine was injected into the posterior larynx for hemostasis. The divided thyroid and cricoid cartilages were retracted and a posterior midline division of the cricoid cartilage lamina was performed (Fig. 2). The grafts were fixed in place with 4/0 proline sutures. The wound was closed in layers.

Animals were kept under observation and were sacrificed after 12 weeks.

RESULTS

No serious complications were encountered during surgery neither at the donor nor at the recipient sites. Microscopic examination of laryngeal sections stained with hematoxylin and eosin revealed graft displacement that was higher in group B (40%) than in group A (20%). Graft displacement was also higher in posteriorly placed grafts (50%) than in anteriorly placed ones (10%). The differences were statistically significant ($p < 0.05$) (Table 1).

Auricular cartilage showed more cartilage resorption and degeneration than costal cartilages. Severe to complete resorption was detected in 30% of cartilages in group B that was twice as much in anteriorly placed grafts than in posteriorly placed ones, compared to 0% in group A (Table 2).

There was a direct relation between the degree of cartilage degeneration and postoperative graft displacement. Cartilages showing severe to complete degeneration had an incidence of 67% graft displacement compared to 31% in cartilages showing mild to moderate graft degeneration. Infection was also an important factor associated with graft displacement. In two animals (4 cartilages) with postoperative neck infection, there was a 100% incidence of graft displacement as opposed to 29% incidence of displacement in noninfected cartilage grafts. The difference was statistically significant.

New cartilage formation was evident in most of the grafts of both groups. It was more evident in group A compared to group B; however this difference was not significant.

DISCUSSION

The aim of laryngotracheoplasty is to provide a lining mucosa and augment the cartilaginous supporting framework while maintaining glottic competence.^[4] Many autogenous grafts were described. Ideally, the graft material should be malleable to permit carving and shaping, but firm enough to stent the cricoid and tracheal wall open and prevent collapse of the lumen. The autogenous material

should be similar to the tissue in the implantation area. It should hold sutures well and be easy to harvest. The graft harvest should be associated with minimal donor site morbidity. It is for this reason, that costal and auricular cartilages are the most common augmentation materials used in laryngotracheoplasty procedures.^[5,6] This was the reason for selecting to evaluate these two cartilages in the present study. The observed complications were minimal and resolved spontaneously. Neck infection was the most serious complication encountered due to its effect on the graft take. This occurred in only two animals; one of them developed a tracheocutaneous fistula. We have used postoperative antibiotics but not graft stents. This might have reduced our rate of postoperative infection as compared to the higher rate of infection in Cotton's series^[7] in which they similarly placed both anterior and posterior cartilaginous grafts but did not use postoperative antibiotics and used endolaryngeal stents that were kept for two weeks.

Graft displacement was marked in this study, more in the posteriorly than in the anteriorly placed grafts and also more in auricular grafts than in costal cartilage grafts. Posteriorly placed grafts are technically more difficult to suture in position than anteriorly placed grafts. The rate of graft displacement would have undoubtedly decreased by the use of stents for graft support. Other factors affecting the rate of graft displacement, we believe, are related to the graft type; auricular cartilage grafts were not hard enough to support the divided halves of the laryngeal cartilages especially posteriorly, which

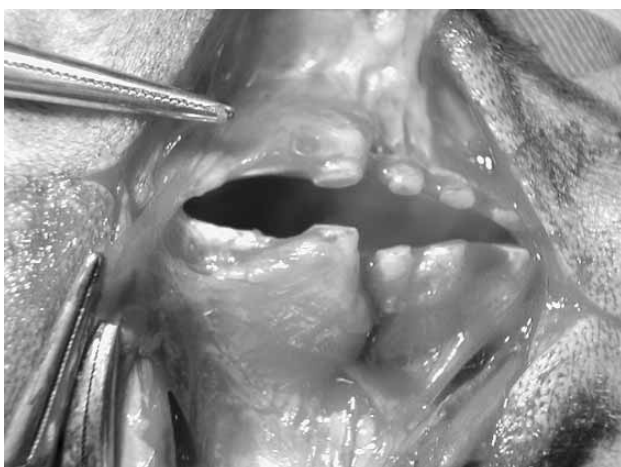


Fig. 1. Midline division of the cricoid cartilage, cricothyroid membrane and first 3 tracheal rings.

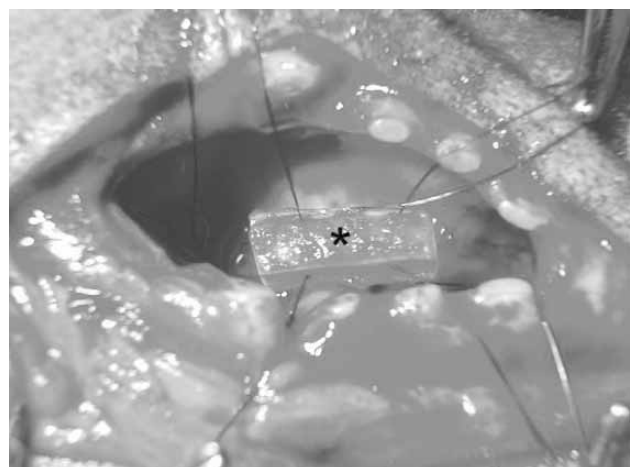


Fig. 2. Costal cartilage graft (*) sutured to the posterior cricoid lamina by 4 prolene sutures.

TABLE I
GRAFT DISPLACEMENT IN GROUPS A AND B; POSTERIOR VERSUS ANTERIOR PLACEMENT

| Displacement | Group A | | | Group B | | |
|--------------|----------|-----------|-------|----------|-----------|-------|
| | Anterior | Posterior | Total | Anterior | Posterior | Total |
| Present | 0 | 4 | 4 | 2 | 6 | 8 |
| Absent | 10 | 6 | 16 | 8 | 4 | 12 |
| Total | 10 | 10 | 20 | 10 | 10 | 20 |

TABLE II
GRAFT DEGENERATION IN GROUPS A AND B; POSTERIOR VERSUS ANTERIOR GRAFTS

| Cartilage degeneration | Group A | | Group B | | Total |
|------------------------|----------|-----------|----------|-----------|-------|
| | Anterior | Posterior | Anterior | Posterior | |
| Mild | 6 | 8 | 2 | 4 | 20 |
| Moderate | 4 | 2 | 4 | 4 | 14 |
| Severe | 0 | 0 | 2 | 2 | 4 |
| Complete | 0 | 0 | 2 | 0 | 2 |
| Total | 10 | 10 | 10 | 10 | 40 |

lead to either displacement or kinking of the grafts. On the other hand, costal cartilage grafts are harder compared to the auricular cartilage. We therefore attribute displacement in posteriorly placed costal cartilage grafts to the breakdown of sutures maintaining the grafts in place secondary to the high tension on the sutures in the absence of intraluminal stent support. Anteriorly placed grafts were not under too much tension compared to the posteriorly placed ones. This probably explains the less frequent displacement seen in the anteriorly placed grafts. Moreover, adhesions between the strap muscles and the anteriorly placed grafts may also give support to such grafts preventing their displacement.

We also observed severe complete cartilage degeneration confined to auricular cartilage grafts only. This graft resorption, also aided in the displacement of the grafts as also mentioned by Whited^[8] who found at least partial resorption centering on the holding sutures in the displaced grafts. Cotton^[7] advised that damage may occur from handling and for such, repeated attempts to place the sutures through the graft should be avoided to prevent necrosis and resorption associated with sutures

tracks. This might explain the degeneration observed in the softer auricular cartilage grafts and at the same time warrants delicate handling of this type of grafts.

In this study, all grafts were eventually lined with epithelium. Additionally, all grafts, except those which showed severe degeneration, demonstrated variable degrees of new cartilage formation that was observed at the junction of the grafts and the cut edges of the native cartilage. We consider this new cartilage formation as a positive sign in favor for the use of autogenous cartilaginous grafts in laryngotracheal reconstruction.

In conclusion, costal cartilage is a more reliable graft material for laryngotracheal reconstruction than auricular cartilage. It is rigid enough to maintain the airway patent and is not liable to kinking like auricular cartilage. Moreover, there is enough cartilage to harvest and has the potential to survive and regenerate. Prevention of infection and fine operative techniques to minimize trauma to the graft and its perichondrium increase the chance for graft survival. Performing anterior and posterior cricoid splitting for combined anterior and posterior graft placement, lead to the instability of the laryn-

geal framework. This may cause overriding of the cut edges of the cricoid cartilage especially posteriorly that may eventually lead to the displacement of the graft and the elimination of the desired expansion of the laryngeal lumen. Endolaryngeal stents are valuable but may increase the incidence of infection. We have not used stents in this study and have the impression that if only anterior cricoid grafting is planned, endolaryngeal stenting may not be necessary. This may aid in better and faster graft epithelialization and the avoidance of the formation of granulation tissue.

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