Special Issue: Systemic disease and otolaryngology-related disease

Journal of INTERNATIONAL MEDICAL RESEARCH

Journal of International Medical Research
2017, Vol. 45(5) 1486–1494
© The Author(s) 2017
Reprints and permissions:
sagepub.co.uk/journalsPermissions.nav
DOI: 10.1177/0300060517705985
journals.sagepub.com/home/imr
SAGE

Traumatic laryngotracheal stenosis treated by hyoid–sternohyoid osseomuscular flap combined with xenogenic acellular dermal matrix: A case report and literature review

Hang Yang[1,2,*], Zhe Chen[1,*], Shui-Hong Zhou[1], Qin-Yin Wang[1], Li-Xia Weng[3], Fang Wang[3], Ting-Ting Wu[1], Min-Li Zhou[1] and Yang-Yang Bao[1]

Abstract

Objective: The treatment of laryngotracheal stenosis is a major therapeutic challenge. Various treatments include observation, medical management, and surgical management. The most effective surgical management is resection and reconstruction. To the authors' knowledge, no reports have described the use of xenogenic acellular dermal matrix (ADM) for laryngotracheal stenosis.

Methods: A 27-year-old man presented with hemoptysis of the neck due to a traffic accident. Emergency orotracheal intubation was performed. Tracheostomy was then performed under local anesthesia. Computed tomography revealed fractures of the right thyroid cartilage and posterior arc of the cricoid cartilage and stenosis of the subglottis and first and second tracheal rings. We used a composite hyoid–sternohyoid osseomuscular flap with xenogenic ADM and a straight silicone tube as a lumen stent to reconstruct the laryngotracheal stenosis.

[1]Department of Otorhinolaryngology, First Affiliated Hospital, College of Medicine, Zhejiang University, Hangzhou, Zhejiang, China
[2]Department of Otorhinolaryngology, People's Hospital of Jiangshan City, Zhejiang Province, China
[3]Department of Operation Room, First Affiliated Hospital, College of Medicine, Zhejiang University, Hangzhou, Zhejiang, China

*These authors contributed equally to this work and are co-first authors.

Corresponding author:
Shui-Hong Zhou, Department of Otorhinolaryngology, First Affiliated Hospital, College of Medicine, Zhejiang University, Hangzhou, Zhejiang 310003, China.
Email: zhouyunzhoush@163.com

Results: Surgical recovery was uneventful. The tracheotomy opening was changed to a metal tube 5 days postoperatively. Four months postoperatively, the silicone tube was endoscopically removed under local anesthesia. The patient was decannulated 20 days later. The patient satisfied with his voice, respiration, and deglutition at the 16-month postoperative follow-up.
Conclusion: The use of ADM for laryngotracheal stenosis may reduce the growth of granulation tissues and promote the repair process.

Keywords
Laryngotracheal stenosis, surgery, xenogenic acellular dermal matrix, composite hyoid–sternohyoid osseomuscular flap

Date received: 27 November 2016; accepted: 29 March 2017

Introduction

Laryngotracheal stenosis mainly occurs after intubation,[1] tracheostomy,[2] or trauma.[3,4] The treatment of laryngotracheal stenosis is a major therapeutic challenge. Various treatments include observation, medical management, and surgical management.[1] The most effective surgical management is resection and reconstruction.[2] Laryngeal stents are used to maintain the laryngotracheal lumen following surgical resection or reconstruction.[1] A T-tube is commonly used both as a stent and for tracheostomy.[5-7] A straight silicone tube is also used for endoscopic treatment of laryngotracheal stenosis because it can be easily removed.

A composite hyoid–sternohyoid osseomuscular flap is commonly used to support the injured laryngotracheal framework, especially when the anterior cricotracheal architecture has been destroyed by trauma or chondritis.[8-10] Xenogenic acellular dermal matrix (ADM) was recently used to repair a tracheal defect caused by resection of a tracheal tumor.[11] To the authors' knowledge, however, no reports have described the use of ADM to treat laryngotracheal stenosis.

We herein report the successful application of a composite hyoid–sternohyoid osseomuscular flap with xenogenic ADM and a straight silicone tube as a lumen stent to reconstruct laryngotracheal stenosis caused by accidental trauma.

Case report

A 27-year-old man presented with sudden breathing difficulty and short unconsciousness due to a traffic accident and was transferred to the emergency room of the People's Hospital of Jiangshan City (Zhejiang Province, China) on 2 February 2015. Emergency orotracheal intubation was performed. His consciousness recovered several minutes after intubation. Emergency computed tomography (CT) showed fractures of the right thyroid cartilage, edema and narrowing of the laryngeal cavity, and subcutaneous emphysema in the neck. On 3 February 2015, he was referred to the Department of Otorhinolaryngology. On 4 February 2015, tracheostomy was performed under local anesthesia. On 24 February 2015, he was referred to the Department of Otorhinolaryngology (First Affiliated Hospital, College of Medicine, Zhejiang University, China). Physical examination showed that the right thyroid cartilage was collapsed; the left thyroid cartilage was unaffected and the tracheostomy was unobstructed. Laryngoscopy showed granulation tissue in the laryngeal cavity. CT revealed fractures of the right thyroid cartilage and posterior arc of the cricoid cartilage and stenosis of the subglottis and first and second tracheal rings (Figure 1).

The patient underwent surgical repair under general anesthesia on 4 March 2015. The operation started with a primary tracheostomy incision. A U-shaped platysma muscle flap was elevated and careful dissection of the strap muscles was performed, thus exposing the thyroid, cricoid cartilages, and first through third tracheal rings. The anterior arch of the cricoid cartilage was fractured and crumpled. A midline incision into the laryngeal cavity, lumen of the cricoid cartilage, and first and second tracheal rings exposed the affected area. The inferior aspect of the right thyroid cartilage and posterior arch of the cricoid cartilage were fractured. Granulation tissue was removed from the laryngeal cavity, lumen of the cricoid cartilage, and first through third tracheal rings (above the tracheostoma). The fracture of the inferior aspect of the right thyroid cartilage was reduced. The fractured anterior cricoid cartilage was excised, and the posterior cricoid cartilage was split in the center. The remaining bilateral anterior cricoid cartilages were sutured toward the strap muscle laterally (Figure 2(a)). A straight silicone tube (single-use chest drainage tube, outside diameter = 1 cm; Suzhou Jingle Polymer Medical Apparatus Co., Ltd., Suzhou City, China) was inserted into the reconstructed lumen between the subglottis and tracheotomy opening for use as a lumen stent (Figure 2(b)). The two ends of the silicone tube were fixed to the neck skin by a through-and-through braided absorbable suture (Polysorb, CL-915; Covidien, Mansfield, MA). A 2.0- × 2.5-cm piece of ADM (Yantai Zhenghai Biotechnology, Ltd., Yantai City, China) was used to cover the silicone tube (Figure 2(c), (d)). The lateral margins of the ADM were sutured to the tracheal and cricoid mucosa. The hyoid bone was then exposed and cut along the midline. A left composite hyoid bone–sternohyoid muscle flap was prepared. The vascular supply from the superior thyroid artery mediolateral to the composite hyoid–sternohyoid osseomuscular flap and the fascia of the sternohyoid muscle were carefully preserved (Figure 3(a)). The composite hyoid–sternohyoid osseomuscular flap was interposed into the cut edges of the anterior cricoid cartilage and tracheal rings and fixed by polydioxanone suture (Figure 3(b)). The wound was closed in layers.

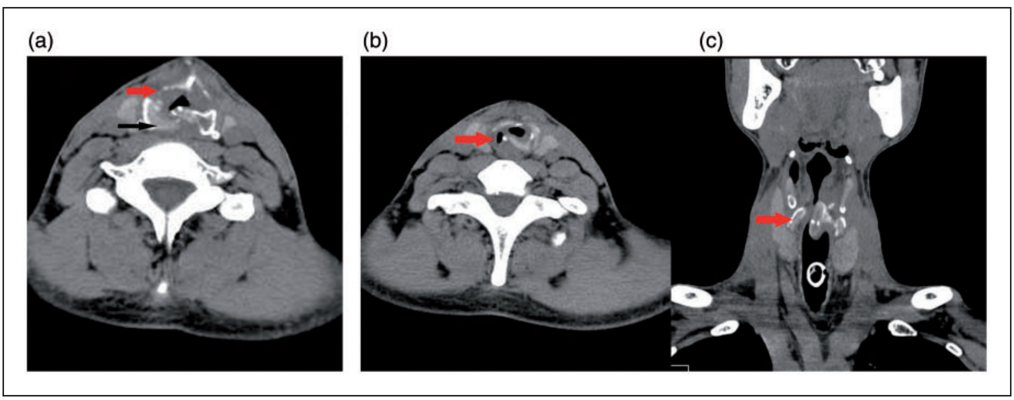

Figure 1. Computed tomography examination. Fractures were present in (a) the right thyroid cartilage (red arrow) and posterior arc of the cricoid cartilage (black arrow). (b, c) Stenosis was present in the subglottis and first and second tracheal rings.

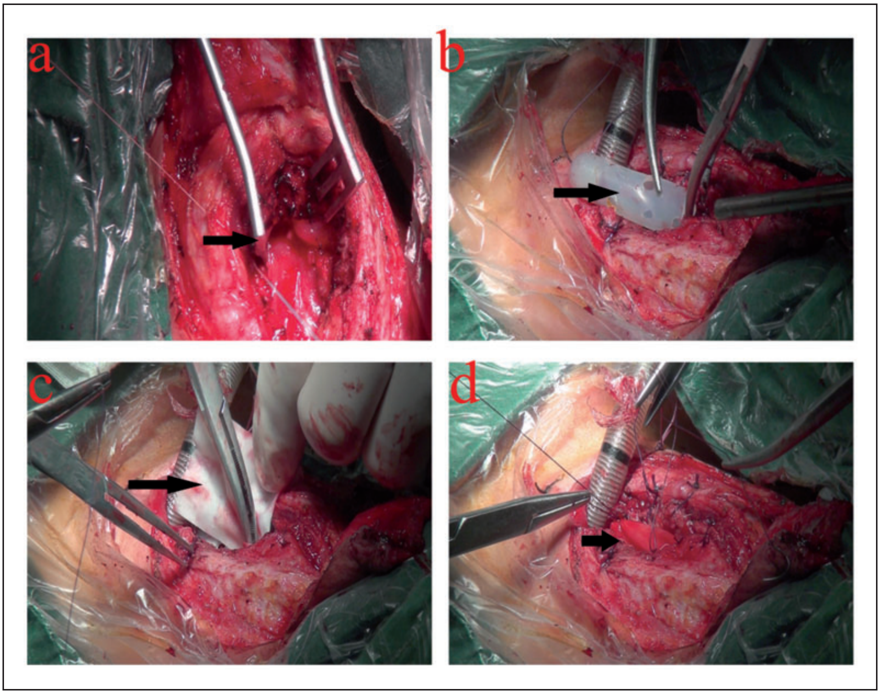

Figure 2. Surgical procedures. (a) The remaining bilateral anterior cricoid cartilages were sutured toward the strap muscle laterally. (b) A straight silicone tube was inserted into the reconstructed lumen between the subglottis and tracheotomy opening for use as a lumen stent. (c, d) A 2.0- $\times$ 2.5-cm piece of acellular dermal matrix was used to cover the silicone tube.

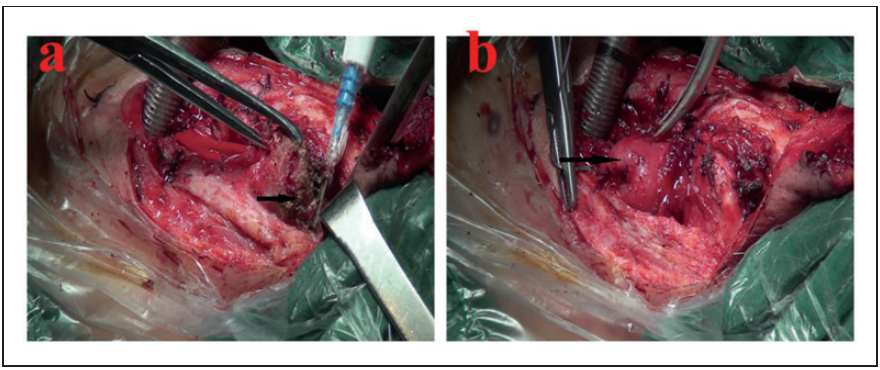

Figure 3. Construction of the composite hyoid–sternohyoid osseomuscular flap. (a) The hyoid bone was cut along the midline. The left composite hyoid bone–sternohyoid muscular flap was prepared. (b) The composite hyoid–sternohyoid osseomuscular flap was interposed.

Results

The patient's postoperative course was uneventful. The disposable tracheal tube was changed to a metallic tube after 5 days because the disposable tracheal tube was easily occluded by dried mucus and sputum. The inner portion of the metallic tube was cleaned and disinfected regularly. Laryngoscopic examination showed that the laryngeal lumen was unrestricted. CT examination 1 month after surgery showed that the lumens of the larynx and trachea were patent and that the silicone tube was correctly aligned (Figure 4(a), (b)). Four months after surgery, the silicone tube migrated into the right bronchus because the nylon sutures were absorbed (Figure 4(c)) (this occurred because space was present between the metallic tube and silicone tube as shown in Figure 2(b)). The silicone tube was endoscopically removed under local anesthesia (Figure 4(d)). Twenty days later, the patient was decannulated. CT showed that the airway was patent (Figure 4(e), (f)). Three months after decannulation, laryngoscopy showed that the laryngeal cavity was no longer stenosed and that the motivation of the left vocal cord was fixed. The patient was satisfied with his voice, respiration, and deglutition at the 16-month follow-up.

This study was approved by the local ethics committee (institutional review board no. 2016491) of the First Affiliated Hospital, College of Medicine, Zhejiang University

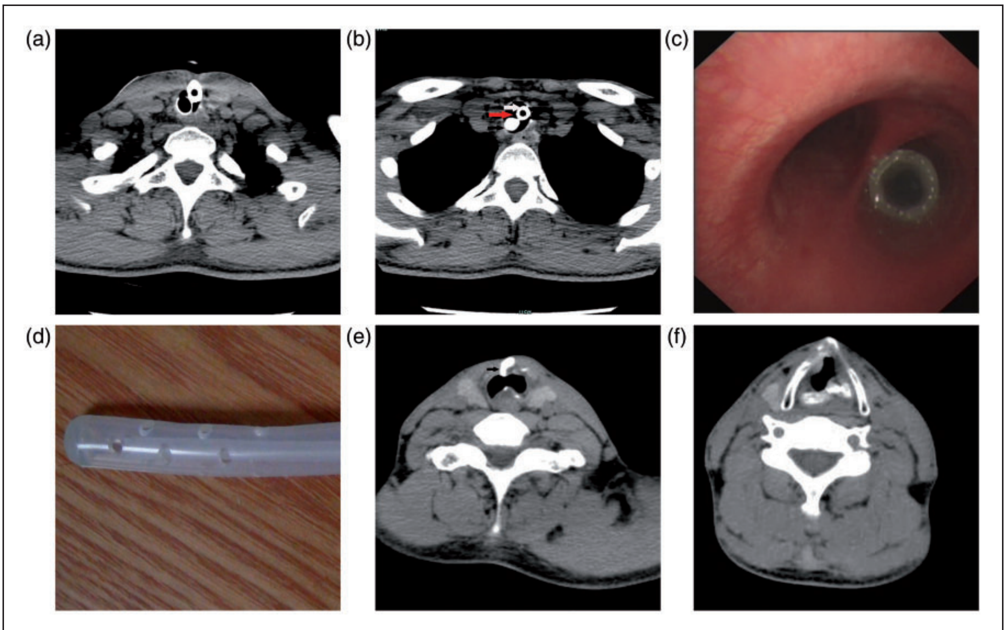

Figure 4. Follow-up. (a, b) Computed tomography examination 1 month after surgery showed that the lumens of the larynx and trachea were patent and that the silicone tube was correctly aligned. (c) Four months after surgery, the silicone tube had migrated into the right bronchus because the nylon sutures were absorbed. (d) The silicone tube was endoscopically removed under local anesthesia. (e, f) Computed tomography showed that the airway was patent 20 days after decannulation (arrow: composite hyoid).

(Hangzhou City, China), and informed consent for publication was obtained from the patient.

Discussion

ADM is a biological material that has been mainly used to repair small defects in otorhinolaryngology-head and neck surgery, such as nasal septal mucosal defects,[12] anterior skull base defects,[13] tympanoplasty,[14] and reconstruction of defects from head and neck tumors.[11,15-17] Li et al.[11] recently reported that xenogenic ADM was successfully used to repair defects after resection of half of the tracheal circumference in two patients with tracheal adenoid cystic carcinoma. They suggested that the use of ADM can avoid damage to the donor site without severe anastomotic stricture or fistula formation. In the present case, we used ADM combined with a composite hyoid–sternohyoid osseomuscular flap and straight silicone tube. The patient was successfully decannulated and achieved satisfactory phonation, respiration, and deglutition. In our case, the ADM was used to cover the straight silicone tube and sutured to the tracheal and cricoid mucosa. ADM, as a smooth membrane, may separate the tube from the composite hyoid bone–sternohyoid muscular flap and laryngotracheal mucosa. This management may reduce the growth of granulation tissue. The advantages of ADM include its resistance to infection and good biocompatibility and mechanical properties. Thus, ADM may lead to tissue regeneration and a reduction in granulation formation.[11]

Although we applied ADM combined with a classic composite hyoid bone–sternohyoid muscular flap and straight silicone tube in only one patient with traumatic laryngotracheal stenosis, the therapeutic outcome was satisfactory and this technique was simple, safe, and feasible.

As early as 1981, Freeland[18] successfully applied a composite hyoid–sternohyoid graft to the repair of subglottic stenosis combined with a silastic mold for internal support. However, the composite hyoid–sternohyoid graft technique has not been widely accepted by surgeons for treatment of laryngotracheal stenosis.[8] Surgical treatment of laryngotracheal stenosis includes a number of techniques depending on the site and extent of the airway pathology.[19,20] The most commonly used surgical technique is laryngotracheal airway reconstruction. Others include tracheal resection, cricotracheal resection, slide tracheoplasty, and endoscopic management (laser ablation and balloon dilatation).[19-21]

These techniques have both advantages and disadvantages. Open surgical resection always involves the placement of a stent, either temporarily or permanently.[22] Tracheostomy is the simplest stent placement technique; however, it is not the most effective and always leads to chronic coughing and production of secretions.[22] The T-tube is widely used as a temporary stent. Its main advantage is its ability to protect the patency of the lumen and its stability.[5,6] It can also be used both as a stent and for tracheostomy. Some experts have introduced grafts during reconstruction of laryngotracheal stenosis to reduce the required stenting duration.[20] Cartilage is the most commonly used graft material and includes the costal cartilage, thyroid ala, auricular cartilage, and septal cartilage.[20,21] Among these cartilages, the costal cartilage is the most widely used because it may minimize the risk of graft prolapse into the airway and increase the intraluminal diameter of the airway.[22] However, costal grafts require two skin incisions, the decannulation rate is variable, and this technique may be unfamiliar to head and neck surgeons. Other disadvantages include the risk of infection and extrusion.[20] Zhi et al.[23] reported that the decannulation rate was 74.1% using laryngotracheal airway reconstruction with a rib cartilage graft interposition technique.

The average decannulation time was 6 months. Decannulation failed in 15 patients because of wound infection followed by rib necrosis or granulation tissue formation and restenosis. Terra et al.[24] reported that the decannulation rate was 80% using this technique. The mean decannulation time was 23.4 months (range, 4–55 months). Decannulation failed in four patients because of tracheomalacia or restenosis.

The use of a composite hyoid–sternohyoid graft in the repair of subglottic stenosis has also produced satisfactory results.[8-10] Freeland et al.[10] reported that the decannulation rate was 90% using a composite hyoid–sternohyoid graft, and the decannulation time was 4 months. Keghian et al.[9] reported that the decannulation rate was 100% using a composite hyoid–sternohyoid graft, and the decannulation was also 4 months. The advantages of this technique include the absence of a risk of graft rejection because the hyoid bone is an autologous material, the requirement for only one incision because the bone graft is near the stenosis and within the same operative field, and the minimal risk to damage to the recurrent laryngeal nerves.[8,9] Additionally, it is an easy, feasible, and effective technique for reconstruction of laryngotracheal stenosis. The decannulation time seems to be shorter than that associated with the costal graft technique.[8,9] However, the use of a composite hyoid–sternohyoid graft also has some limitations and disadvantages. This technique is not suitable for patients who have undergone total thyroidectomy or radiotherapy in the anterior cervical area.[8,9] The graft also requires a T-tube for internal support, increasing the risk of granulation formation and occlusion by dried mucus and sputum.[8,9] Keghian et al.[9] reported that the use of a composite hyoid–sternohyoid graft was only applied to stenosis involving either the cricoid cartilage alone or the cartilage and first tracheal rings. This technique requires preservation of the vascular pedicle to supply the hyoid bone graft. In 2014, Mizokami et al.[8] modified the classic composite hyoid–sternohyoid graft using the unilateral sternohyoid muscle as pedicle into bilateral thyrohyoid muscles as the pedicles to supply the blood. This novel composite hyoid–sternohyoid graft may be interposed with the longish hyoid bone graft in a transverse direction to widen the lumen.[8-10] In the present case, we successfully applied a composite hyoid–sternohyoid osseomuscular flap with xenogenic ADM and a straight silicone tube to manage traumatic laryngotracheal stenosis. The silicone tube was removed 4 months postoperatively, and decannulation was performed about 5 months postoperatively.

In conclusion, we treated a patient with traumatic laryngotracheal stenosis using a composite hyoid–sternohyoid osseomuscular flap with xenogenic ADM and a straight silicone tube. The patient was successfully decannulated and achieved satisfactory phonation, respiration, and deglutition. ADM used in laryngotracheal stenosis may reduce the growth of granulation tissue and effectively promote the repair process. This technique has some limitations: the outside diameter of the silicone tube might be small, leading to its migration into the trachea; additionally, the time until absorption of ADM is short, which might lead to granulation tissue formation. The fixation suture for the silicone tube should be nonabsorbable. The two ends of the silicone tube should be unobstructed to facilitate the patient's respiratory and phonation after surgery. The role of ADM in the management of laryngotracheal stenosis should be further evaluated in larger-scale studies.

Declaration of conflicting interest

The authors declare that there is no conflict of interest.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

References

1. Kandakure VT, Mishra S and Lahane VJ. Management of post-traumatic Laryngotracheal stenosis: our experience. *Indian J Otolaryngol Head Neck Surg* 2015; 67: 255–260.
2. Grillo HC, Donahue DM, Mathisen DJ, et al. Post intubation tracheal stenosis. Treatment and results. *J Thorac Cardiovasc Surg* 1995; 109: 486–492.
3. Bent JP 3rd, Silver JR and Porubsky ES. Acute laryngeal trauma: a review of 77 patients. *Otolaryngol Head Neck Surg* 1993; 109(3 Pt 1): 441–449.
4. Cohn MA and Larson DL. Laryngeal injury arch. *Otolaryngology* 1976; 102: 166–170.
5. Dass A, M Nagarkar N, K Singhal S, et al. Tracheal T-tube stent for laryngotracheal stenosis: ten year experience. *Iran J Otorhinolaryngol* 2014; 26: 37–42.
6. Prasanna Kumar S, Ravikumar A, Senthil K, et al. Role of montgomery T-tube stent for laryngotracheal stenosis. *Auris Nasus Larynx* 2014; 41: 195–200.
7. Pereszlenyi A, Igaz M, Majer I, et al. Role of endotracheal stenting in tracheal reconstruction surgery-retrospective analysis. *Eur J Cardiothorac Surg* 2004; 25: 1059–1064.
8. Mizokami D, Araki K, Tomifuji M, et al. Composite hyoid bone graft interposition for the treatment of laryngotracheal stenosis. *ORL J Otorhinolaryngol Relat Spec* 2014; 76: 147–152.
9. Keghian J, Lawson G, Orban D, et al. Composite hyoid-sternohyoid interposition graft in the surgical treatment of laryngotracheal stenosis. *Eur Arch Otorhinolaryngol* 2000; 257: 542–547.
10. Freeland AP. The long-term results of hyoid-sternohyoid grafts in the correction of subglottic stenosis. *J Laryngol Otol* 1986; 100: 665–674.
11. Li P, Li S, Tang Q, et al. Reconstruction of human oncological tracheal defects with xenogenic acellular dermal matrix. *Auris Nasus Larynx* 2017; 44: 237–240. pii: S0385-8146(16)30119-5. doi:10.1016/j.anl.2016.04.008. Epub ahead of print.
12. Chhabra N and Houser SM. Endonasal repair of septal perforations using a rotational mucosal flap and acellular dermal interposition graft. *Int Forum Allergy Rhinol* 2012; 2: 392–396.
13. Clark DW, Citardi MJ and Fakhri S. Endoscopic management of skull base defects associated with persistent pneumocephalus following previous open repair: a preliminary report. *Otolaryngol Head Neck Surg* 2010; 142: 820–826.
14. Raj A, Sayal A, Rathore PK, et al. Sutureless tympanoplasty using acellular dermis. Am J Otolaryngol 2011; 32: 96–99.
15. Wang L, Li L and Lou W. Repair of a cervical skin defect using xenogeneic acellular dermal matrix in a patient with advanced laryngeal carcinoma. J Laryngol Otol 2015; 129: 715–717.
16. He J, Tian Y, Wu P, et al. Heterogeneous bovine acellular dermal matrix for mucosal repair in reconstructive surgery for laryngeal and hypopharyngeal carcinoma. *Oncol Res Treat* 2015; 38: 282–284.
17. Yin D, Tang Q, Wang S, et al. Xenogeneic acellular dermal matrix in combination with pectoralis major myocutaneous flap reconstructs hypopharynx and cervical esophagus. *Eur Arch Otorhinolaryngol* 2015; 272: 3457–3461.
18. Freeland AP. Composite hyoid-sternohyoid graft in the correction of established subglottic stenosis. *J R Soc Med* 1981; 74: 729–735.
19. Chen W, Gao P, Cui P, et al. Management of severe and complex hypopharyngeal and/or laryngotracheal stenoses by various open surgical procedures: a retrospective study of seventeen patients. *ORL J Otorhinolaryngol Relat Spec* 2016; 78: 111–118.
20. Bitar MA, Al Barazi R and Barakeh R. Airway reconstruction: review of an approach to the advanced-stage laryngotracheal stenosis. Braz J Otorhinolaryngol 2016 Apr 27. pii: S1808-8694(16)30051-9.

21. Jefferson ND, Cohen AP and Rutter MJ. Subglottic stenosis. *Semin Pediatr Surg* 2016; 25: 138–143.
22. Saghebi SR, Zangi M, Tajali T, et al. The role of T-tubes in the management of airway stenosis. *Eur J Cardiothorac Surg* 2013; 43: 934–939.
23. Zhi L, Wenli W, Pengfei G, et al. Laryngotracheal reconstruction with autogenous rib cartilage graft for complex-laryngotracheal stenosis and/or anterior neck defect. *Eur Arch Otorhinolaryngol* 2014; 271: 317–322.
24. Terra RM, Minamoto H, Carneiro F, et al. Laryngeal split and rib cartilage interpositional grafting: treatment option for glottic/subglottic stenosis in adults. *J Thorac Cardiovasc Surg* 2009; 137: 818–823.