Three Dimensional Imaging and Printed Reconstruction for Difficult Airway Surgical Planning

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Introduction
The ability to reconstruct CT and MRI imaging has been available since the early 1990s, and moving from two to three dimensions improves understanding of anatomy. It is especially valuable in evaluating the pediatric airway: endoscopic evaluations with laryngoscopy and rigid or flexible bronchoscopy, particularly in pediatric patients with airway anomalies can sometimes be limited by areas of stenosis that prevent endoscopes from passing, severe areas of collapse in tracheobronchomalacia, or patient instability from a medical standpoint. It can augment understanding of anatomy that might be challenging on endoscopy, particularly in complicated congenital airway malformations.

3D printing has been around since the 1980s, and use has expanded from industry to many fields including medicine and surgery. 3D printing enables the creation of models based on an individual patient that facilitate understanding of unusual anatomy, as well as creation of patient specific surgical guides and implants. It has been embraced in many fields particularly plastic surgery, oral-maxillofacial surgery, craniofacial surgery, and thoracic surgery.

Case 2: The second case is a 3 month old female with right lung aplasia. She was at home but developed severe expiratory stridor; bronchoscopy showed a tracheal sleeve with tracheobronchial stenosis. During bronchoscopy she required emergent intubation, and even a 2.5 endotracheal tube could not be passed due to stenosis.

A CT chest was performed showing severe tracheal narrowing and a 3D printed model was created incorporating the cartilaginous airway and great vessels. A slide tracheoplasty on bypass was performed with CT surgery. The 3D model allowed a “dry run” of surgery pre-operatively, which facilitated the procedure. The patient was extubated 7 days later to room air after bronchoscopy showed significantly increased minimal diameter to 2.5 mm

Case 3: The last case highlights the potential to create virtual models of both soft and bony tissue which can compliment endoscopic findings in the airway. This is a 6 year old child with Crouzon syndrome who presented with sleep disordered breathing symptoms without adenoid or tonsillar hypertrophy on flexible fiberoptic laryngoscopy. Given his craniofacial history a 3D CT reconstruction was obtained allowing views with bone, soft tissue surfaces, and the two together. This helped to explain that nasopharyngeal airway was narrowed due to the position of the clivus and C1 vertebra as well as some mild soft tissue abnormalities of the pharynx. Sleep endoscopy prior to surgery showed that glossoptosis was likely a factor in airway collapse; the patient underwent adenoidectomy, partial intracapsular tonsillectomy, and lingual tonsil coblation with resolution of sleep disordered breathing symptoms

Discussion/Conclusions: Resolution and accuracy of models are dependent on the quality of the scan from which the STL file is created as well as the ability of the 3D printer. Not all practices will have access to a 3D printer, especially one of high capabilities. 48 hour turnaround is still a long time for unstable patients, there are several exciting applications of 3D printing in congenital airway care on the horizon, including 3d printing custom biografts using tissue engineering.

The clinical application of technologies enabling 3D imaging reconstruction and 3D printing is still developing in otolaryngology. 3D reconstruction of imaging serves as a useful adjunct to endoscopic examination in congenital airway malformations. 3D printing is becoming more easily accessible and can be useful in treatment decision-making, practicing surgeries, and preoperative planning customized to patients with congenital airway anomalies.

References:


Financial Disclosures / Conflicts of Interest
None.