



Sulcus Vocalis, Mucosal Bridges and Vocal Fold Scar

Sulcus vocalis and mucosal bridges are distinct benign vocal fold pathologies which may be present at birth and may also arise secondary to intrinsic or extrinsic trauma. These occur in specific layers of the vocal fold. Vocal fold scar is a more general term for scarring which can arise in any layer of the vocal fold. The end result of these pathologies is derangement of the vibratory function of the vocal fold leading to glottic insufficiency and significant dysphonia. Diagnosis is based primarily on stroboscopic appearance in combination with audio-perceptual characteristics of a breathy but strained voice. Treatment for these pathologies is difficult but combines several different biologic and structural approaches.

Anatomy/Physiology

- To better understand sulcus, scar and mucosal bridges, it is imperative to understand the delicate microarchitecture of the vocal fold vibratory surface. The epithelium is most superficial and made of stratified squamous epithelium. The subepithelial, or Reinke's, space is comprised of the lamina propria (LP) which is divided in three parts: the superficial LP, intermediate LP and deep LP. The SLP in particular is critical for vibration and is comprised of several extracellular matrix molecules (ECM), most important of which is hyaluronic acid. The intermediate and deep LP comprise the vocal ligament and contain differing levels of elastin and collagen proteins.
 - Gray SD, Alipour F, Titze IR, Hammond TH. Biomechanical and histologic observations of vocal fold fibrous proteins. *Ann Otol Rhinol Laryngol* 2000;109: 77-85. PMID: 10651418. This paper is one of the early seminal papers on the microarchitecture of the lamina propria.
- Sulcus vocalis is a focal invagination of the epithelium into the superficial lamina propria. Ford subdivided sulcus vocalis into 3 types:
 - *Type I sulcus* is a physiologic variant characterized by atrophy but with an intact superficial lamina propria.
 - *Type II sulcus* is otherwise known as sulcus vergeture in which there is some loss of lamina propria and epithelium may contact deeper layers of the lamina propria.



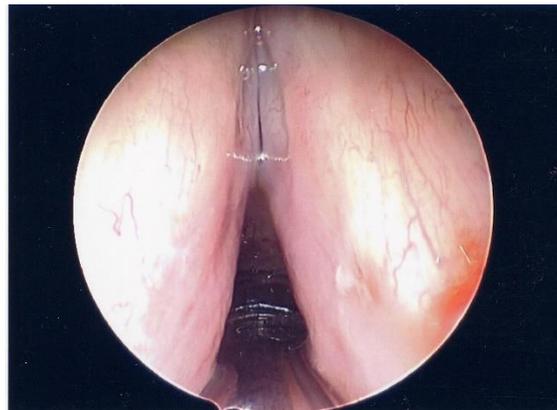
- *Type III sulcus* is the true sulcus vocalis or complete sulcus characterized by contact of epithelium to the vocal ligament (which is made up of intermediate and deep layers of the lamina propria) or to the thyroarytenoid muscle.
 - Ford CN, Inagi K, Bless D, Khidr A, Gilchrist KW. Sulcus vocalis: a rational analytical approach to diagnosis and management. *Ann Otol Rhinol Laryngol* 1996;105:189-200. PMID: 8615582
- Mucosal bridge-Bouchayer, et al. defined it as a strip of epithelium with a central axis of connective tissue most likely from the superficial lamina propria. Mucosal bridges tend to be associated with other benign lesions such as vocal fold cysts or sulci. Nerurkar et al defined three types of mucosal bridges: thin, thick and the incomplete mucosal bridge. The first two extend along the entire membranous vocal fold.
 - Bouchayer M, Cornut G, Loire R, Witzig E, Roch JB, Bastian RW. Epidermoid cysts, sulci, and mucosal bridges of the true vocal cord: a report of 157 cases. *Laryngoscope* 1985; 95:1087-1094. PMID: 4033333
 - Martins RH, Tavares ELM, Fabro AT, Martins MG and Dias NH. Mucosal bridge of the vocal fold: difficulties in the diagnosis and treatment. *J Voice* 2012;26(1):127-131. PMID:21353466
 - Nerurkar NK, Sapre A, Gosavi R. Mucosal bridges: a 9-year retrospective study of their incidence with a third variant proposed. *Eur Arch Otorhinolaryngol* 2018; epub ahead of print Nov 26. PMID:30474701
- Vocal fold scar is a general fibroplastic disorder of the vocal folds affecting the microarchitecture of the vocal fold at any level.
 - Friedrich G, Dikkers FG, Arens C, et al. Vocal fold scars: current concepts and future directions. Consensus report of the phonosurgery committee of the European Laryngological Society. *Eur Arch Otorhinolaryngol* 2013;270:2491-2507. PMID:23605306
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Pathophysiology

- Sulcus vocalis and mucosal bridges have a possible congenital origin, arising from remnants of the 4th through 6th branchial arches.



- They may also be a result of ruptured epidermoid cysts which have healed: if both sides of the cyst rupture (above and below the free edge of the VF), a mucosal bridge is left.
- Sulcus may also arise from phonotrauma and inflammatory processes.
- Vocal fold scar may arise from phonotrauma, previous surgical procedures or other trauma, intubation, radiation or inflammatory processes. There is an increase in collagen type IV deposition typically in all LP layers and loss of hyaluronic acid in the SLP.
 - Friedrich G, Dikkers FG, Arens C, et al. Vocal fold scars: current concepts and future directions. Consensus report of the phonosurgery committee of the European laryngological society. *Eur Arch Otorhinolaryngol* 2013; 270:2491-2507. PMID:23605306



Sulcus vergeture

Assessment

- Assessment of vocal folds for sulcus, bridge or scar is multidimensional:
 - Auditory-perceptual evaluation- voice is typically breathy, asthenic, strained and effortful due to supraglottic phonation in severe cases; these are hallmarks of glottic insufficiency. In congenital cases, voice will be severely dysphonic since childhood. Phonation time is short.
 - Stroboscopy or high-speed photography is essential to define the vibratory characteristics of the vocal folds with disorders of the lamina propria. Remacle divided glottic scars into 4 types based on vibratory characteristics:
 - Type I-mild moderate glottic insufficiency and reduced vibration of vocal fold involving mucosal and submucosal levels of vocal fold



- Type II- anterior moderate glottic insufficiency involving anterior commissure, with adynamic vocal fold and involvement of thyroarytenoid muscle
 - Type III-considerable glottic insufficiency in which scar is adherent to inner perichondrium and cartilage and may extend to supraglottic region with “twisted” arytenoids
 - Type IV-considerable glottic insufficiency with web formation at anterior commissure and bilateral reduced vibrations of vocal folds.
- Microlaryngoscopy and microendoscopy-may be very important if the scar or sulcus is not readily visible on stroboscopy. Palpation of the vocal fold and examination of the epithelium directly may be required for diagnosis. Subepithelial infusion can also help define an area of scar or distinguish between types of sulci.
 - Arens C, Remacle M. Scarred larynx. In: Remacle M, Eckel H (eds) *Surgery of the Larynx and Trachea*. 1st edn. Springer Verlag, Berlin, p. 171-176.
 - Burns J, Friedman AD, Lutch MJ, Zeitels SM. Subepithelial vocal fold infusion: a useful diagnostic and therapeutic technique. *Ann Otol Rhinol Laryngol* 2012;121(4):224-230. PMID: 22606925

Treatment

- Approaches to treatment may be divided up into structural and biologic approaches. Both approaches have the potential of improving the vibratory function of the vocal folds.
 - Structural methods:
 - ❖ Injection augmentation-to treat the glottic insufficiency
 - ❖ Superficial injection into Reinke’s space to help elevate the scar
 - ❖ Gray’s minithyrotomy with implantation of fat or fascia -an open approach where small thyroplasty windows are created and a pocket is dissected in the SLP to elevate scar/sulci and place graft material

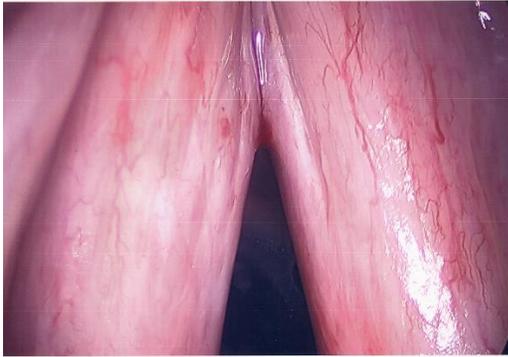


- ❖ Microflap release of the epithelium with implantation of fascia or injection of steroids
- ❖ Pontes' slicing technique – z-plasty of the vocal fold

These methods have good results in terms of improving mucosal wave and vibratory amplitude. These methods may have some impact on improvement of vocal function in terms of patient self-reported indices but results on phonatory quality are less consistent. Gray's minithyrotomy can improve VHI 10 scores in about 50% of patients with the most severe scar and sulcus deformities.

Autologous temporalis fascia has also more consistent improvement in voice quality in terms of GRBAS and VHI10 scores over at least a 1 year period.

- Carroll TL, Dezube A, Bauman LA, and Mallur PS. Using trial vocal fold injection to select vocal fold scar patients who may benefit from more durable augmentation. *Ann Otol Rhinol Laryngol* 2018; 127(2):105-112. PMID: 29231041
- Karle WE, Helman SN, Cooper A, Zhang Y and Pitman MJ. Temporalis fascia transplantation for sulcus vocalis and vocal fold scar: long-term outcomes. *Ann Otol Rhinol Laryngol* 2018;127(4):223-228. PMID: 29338292
- Mallur PS, Gartner-Schmidt JG, Rosen CA. Voice outcomes following the Gray minithyrotomy. *Ann Otol Rhinol Laryngol* 2012;121(7):490-496. PMID:22844870
- Paniello RC, Sulica L, Khosla SM, Smith ME. Clinical experience with Gray's minithyrotomy procedure. *Ann Otol Rhinol Laryngol* 2008;117(6):437-442. PMID:18646440
- Welham NV, Choi SH, Dailey SH, Ford CN, Jiang JJ, and Bless DM. Prospective multi-arm evaluation of surgical treatments for vocal fold scar and pathologic sulcus vocalis. *Laryngoscope* 2011; 121:1252-1260. PMID: 21557241



Sulcus Vocalis pre Gray's minithyrotomy



Sulcus vocalis post Gray's minithyrotomy-note the spreading out of the epithelium of the sulcus and fullness of the vocal fold free edge

- Biologic methods
 - ❖ Injection of steroids
 - ❖ Injection of hyaluronic acid (Hylan B gel) or other hydrogels
 - ❖ Cell therapy-mesenchymal stem cells, autologous fibroblasts, adipose derived stem cells
 - ❖ Growth Factor injections-hepatocyte growth factor, basic fibroblast growth factor
 - ❖ Fascia implantation-both structural and biologic because it may stimulate native fibroblasts
 - ❖ Pulse dye/photodynamic therapy
 - ❖ Cryotherapy
 - ❖ Pirfenidone and other antifibrotic agents

Autologous fibroblasts have been harvested from the buccal mucosa of patients, cultured in vitro and re-injected into the SLP of some patients with vocal fold scar with good success in improvement of acoustic, aerodynamic and stroboscopic measures. though repeated injections are frequently needed. Steroid injections have shown improvement as well in self-reported indices, perceptual characteristics as well as objective measurements of acoustic, aerodynamic and videostroboscopic parameters. Most of the other substances have been in used in preclinical trials with promising results in improvement of viscoelasticity of the



lamina propria. Hyaluronic acid injection is an attractive option given that the majority of the SLP is comprised of hyaluronic acid.

- Bartlett RS, Hoffman HT, Dailey SH , et al. Restructuring the vocal fold lamina propria with endoscopic microdissection. *Laryngoscope* 2013;123:2780-2786. PMID:23959803
- Chhetri DK and Berke GS. Injection of cultured autologous fibroblasts for human vocal folds scars. *Laryngoscope* 2011;121:785-792. PMID: 21287562
- Chhetri DK and Mendelsohn AH. Hyaluronic acid for the treatment of vocal fold scars. *Curr Opin Otolaryngol Head Neck Surg* 2010; 18:498-502. PMID:20856119
- Erndt-Marino JD, Jimenez-Vergara AC, Diaz-Rodriguez P, Kulwatno J, Diaz-Quiroz JF, Thibeault S, Hahn MS. *In vitro* evaluation of a basic fibroblast growth factor-containing hydrogel toward vocal fold lamina propria scar treatment. *J Biomed Mater Res Part B* 2015:00B:000-000. PMID: 28580765
- Gong T, Zhang C, Kang J, Lamb JJ, Jiang JJ. Cryotherapy has antifibrotic and regenerative effects on human vocal fold fibroblasts. *Laryngoscope* 2018:00:1-8. PMID: 30315572
- Kodama H, Kumai Y, Nishimoto K, Toya Y, Miyamaru S, Furushima S, Yumoto E. Potential treatment for vocal fold scar with pirfenidone. *Laryngoscope* 2017; 128:E171-177. PMID: 29171670
- Wingstrand VL, Larsen CG, Jensen DH, Bork K, Sebbesen L, Balle J, Fischer-Nielsen A, von Buchwald, C. Mesenchymal stem cell therapy for the treatment of vocal fold scarring: a systematic review of preclinical studies. *PLoS ONE*;2016;11(9):e0162349. PMID: 27631373