What more can be done to popularize phonosurgical ideas in everyday handling of vocal folds?

Popularyzacja idei fonochirurgicznych w codziennej pielęgnacji strun głosowych – co jeszcze można zrobić?

Małgorzata Wierzbicka ¹, Elisabeth V. Sjogren ², Frederik G. Dikkers ³

¹ Department of Otolaryngology - Head and Neck Surgery, Poznan University of Medical Sciences, Poznan, Poland
² Dept of Otolaryngology - Head & Neck Surgery, Leiden University Medical Centre, Leiden, Netherlands
³ Department of Otolaryngology - Head & Neck Surgery, University of Groningen, University Medical Center Groningen, Groningen, Netherlands

ABSTRACT: This paper is focused on vocal fold surgery with phonosurgical intent. The aim of this review is to broaden phonosurgical knowledge, spread the ideas of the European Laryngological Society (ELS) on phonosurgery and translate the layered structure and physiology of the vocal fold described in Hirano’s classic body-cover model into the graphic illustration of the “fluttering sleeve” created by Dikkers. In numerous countries, where phonosurgery is a relatively novel field of knowledge or still in its infancy, simple patterns and plain associations will serve the best in popularizing sophisticated vocal fold anatomy and preservation surgery and converting it into everyday routine.

KEYWORDS: phonosurgery, phonosurgical, sleeve model, vocal fold, vocal cord, lamina propria

The sound of the human voice is produced via flow-induced vocal fold vibration. The vocal folds consist of several layers of tissue, each with differing material biomechanical properties. Acoustic physical phenomena occur as a result of complex coupling between aerodynamic structures. The physical acoustic signal (voice) occurs as a result of the complex aerodynamic interaction of airflow with these different vocal fold layers. Therefore, healthy tissue and an intact micro-architecture of the vocal folds are necessary for normal voice production.
Since the seminal work of M. Hirano, which defined the three-layered lamina propria of the human vocal fold, recent studies have described the composition of fibers and interstitial molecules within the lamina propria, leading to various biomechanical properties, in more detail [1]. The deep layer of the lamina propria is the most densely organised band of collagen, with type I and III fibers penetrating the superficial muscle bundles of the vocal muscle [2]. The superficial layer of the lamina propria is a narrow band of collagen fibers immediately below the basement membrane of the epithelium and shows strong birefractive fibers. The intermediate layer is the less densely organised band with fibers characterised as collagen type III [2], [3]. The layered structure of the lamina propria is completely developed around 17 years of age. The development of the layered structure and the maturity of the fibers appear to reflect the complexity of phonatory function during adolescence [4]. There are age-related and gender-related differences between male and female infant, adult, and geriatric vocal folds [5]. A precise molecular schema for classifying different cell types of the normal human vocal fold epithelium that covers the lamina propria has been recently published [6]. Three distinct cell strata with unique marker profiles are present within the stratified squamous epithelium of the true vocal fold. Replicating cell populations are largely restricted to the parabasal strata within the epithelium. The complex, multi-layered structure of the vocal fold (epithelium – lamina propria – muscle) is very important for vibration. This was described in Hirano’s body-cover theory where the lamina propria acts as an intermediate layer. Any pathology disturbs this layered structure.

The term phonosurgery (PS) was first used by Von Leden [7] to any operation designed primarily for the improvement or restoration of voice. It is defined by the intended operative goal, which pertains to quality of life, improvement or maintenance of vocal function [8]. The Committee on Phonosurgery of the European Laryngological Society (ELS) examined the definition and technical description of phonosurgical procedures [9]. Based on this review, the committee proposed a working classification of vocal fold surgery (VFS) with phonosurgical intent. Both the pathology and the therapeutic aim define VFS: (1). vocal fold lesions that impair vibratory movements and require excision (e.g., vocal fold nodules), incision and suction (e.g., Reinke’s edema), dissection and/or augmentation (e.g., sulcus-vergeture), coagulation or vaporization (e.g., varicosity) and incision and stenting (e.g., glottal web); (2). vocal fold movement disorders that require position and/or tension correction by augmentation (e.g., vocal fold hypomobility), injection (e.g., botulinum toxin for spasmodic dysphonia) and excision (e.g., dysphonia plicae ventricularis). Phonosurgery can be conducted either by laser or cold steel, according to the individual surgeon’s experience and opinion, which will determine which of the tools offers the best precision during the procedure [10-13].

Phonosurgery requires technical precision and careful tissue handling. The layered structure of the vocal fold should be infringed as little as possible. All these single-operator procedures require acquisition of necessary skills and perfect technique [14]. Simultaneously, thorough knowledge of vocal fold...
anatomy and perfect acquaintance with spatial histology of all major elements of the vocal fold layers is essential.

The vocal fold epithelial cells, the connective and muscle fibers, and even the blood vessels run longitudinally, which is parallel to the vocal fold free edge. This indicates a high adjustment to the phonation requirements and the vibration process. In each process of manipulations this anatomy must be taken into consideration. In numerous countries, where phonosurgery is a relatively novel field of knowledge or still in its infancy, simple patterns and plain associations will serve the best in popularizing sophisticated vocal fold anatomy and preservation surgery and converting it into everyday routine. Thus, to popularize Hirano’s model of vocal fold layer structure, Dikkers presented it using the illustrative simile of the “fluttering sleeve”. The common denominator of these two absolutely different figures (Fig. 1 and Fig. 2) is the philosophy of the layered model. The “fluttering sleeve model” of the vocal fold, created by Dikkers and most recently offered at the 3rd Congress of European ORL-HNS in his presentation “Decision-making in phonosurgical strategies” during the panel “Phonosurgery revisited: past, present and future trends”, presents a man dressed in a shirt and jacket that exposes his hand out the window of a moving car. The essence of this model is the space between the loosely fluttering jacket and close-fitting shirt sleeve (cover) on one side, and the man’s arm (body) on the other. The sleeves of the jacket and shirt represent the complex, multilayered structure of the vocal fold. The space between the clothes and the arm, essential to making the sleeves flutter, corresponds to the lamina propria and its essential role in vocal fold vibration. Everyone can recall this picture during an ongoing surgery and remind themselves as a warning: be delicate with the jacket! All manoeuvres should be restricted to the air space, corresponding to the lamina propria! Do not touch the skin unless it is absolutely necessary! However the most important thing is also to keep the lamina propria intact as much as possible. If the lamina propria is scarred by the vocal fold, it cannot vibrate. Dikkers uses the image of a wet jacket to symbolize scarring of the lamina propria. If the jacket is wet (resembling epithelial thickening) and there is no air then it will stick to the arm. If the arm is very fat (resembling an intramuscular tumor), there is too much body, thus there will be too little air, and reduced flutter. If the jacket is made of leather (also resembling epithelial thickening) instead of cloth, the fluttering properties will not be the same. All these disturbed fluttering properties lead to the clinical observation of dysphonia.

This paper is focused on vocal fold surgery with phonosurgical intent and aimed at broadening phonosurgical knowledge, spreading the ELS idea and explaining the multi-layer structure that plays a central role in governing vocal fold flow-induced vibratory response indispensible for each phonosurgeon. In order to present readers and practicing surgeons with greater understanding of vocal fold micro-anatomy, both the physiological Hirano model and the graphic scheme of the “fluttering sleeve” created by Dikkers were implemented to create an effective explanation of the matter.

DISCUSSION

Voice disorders affect up to half a million people annually in Poland alone (ICD-10 diagnosis code - J37) and often result in significant financial, social, and other quality-of-life-related difficulties. Nevertheless, the decrease of life quality caused by this disability is probably underestimated in this country. Understanding of the physics of voice production has the potential to significantly benefit voice care, including clinical prevention, diagnosis, and treatment of voice disorders. Most of these tasks lie with the phoniatrians but thorough knowledge of vocal fold anatomy and phonosurgical rules is indispensable for all ENT surgeons touching the vocal fold. For more than a decade phonosurgery using the operating microscope has replaced simple resections of benign lesions on the vocal folds in order to optimise the preservation or restoration of the voice [7].

Benign lesions of the vocal folds are often classified according to the tissue layer of origin and their anatomical position [15],
Papillomas and benign metaplasias (such as hyperkeratosis) originate from the epithelium. Cysts are located in the lamina propria, and classified in mucous retention and epidermotaxis) originate from the epithelium. Cysts are located in the lamina propria using an operative microscope. The depth of the dissection was correlated with the elastin fibre concentration to determine whether the plane occurred at a predictable point between the superficial and middle layers. The dissection plane consistently occurred between 23–50% depth into the lamina propria and had an association with age: dissection planes occurred more superficially in older patients [21].

Despite the considerable progress in understanding of the underlying pathophysiology, the treatment of scarred vocal folds is still an unresolved chapter in laryngology and phonosurgery [22]. Scarring of the vocal folds leads to a deterioration of the highly complex micro-structure of the lamina propria with consecutively impaired vibratory pattern. Depending on the extent and infiltration of the lamina propria, the viscoelastic changes caused by scarring can result in irregular vibration and incomplete adduction of the lamina propria of the vocal folds, which results in glottic gap and glottic insufficiency. Mechanisms of vocal fold scar production have been examined in both macroscopic and microscopic detail. Trauma and injury involving any aspect of the lamina propria, particularly the deeper layers, may result in epithelial tethering and scar formation. At the molecular level, early inflammatory cytokines activate and recruit fibroblasts, which then drive the fibrotic cascade. Transforming growth factor-β enhances fibrosis and is balanced by tissue matrix metalloproteinases and hepatocyte growth factor activity. The role of hepatocyte growth factor preparation, which has a very strong anti-fibrotic effect on vocal fold scarring, has not been established yet [23].

The second goal of this paper was to “translate” the layer structure of the vocal fold from pathological Hirano model into the illustrative simile of the “fluttering sleeve” presented by Dikkers. The simplicity of this parallel is convenient in everyday handling. It enables transposition of histological vocal fold layer structure from the microscopic examination into a widely recognisable image. Hopefully, this model will be persuasive enough to prevent an average surgeon from hasty destruction of the sleeves as well as unnecessary touching of the arm’s skin.
While setting the microscope, always recall the layer anatomy of the vocal fold with its functional implications. Use high magnification.

Select either laser or cold steel according to own/the experience, decide which tool in your opinion will offer the very best precision during surgery.

Principal: minimal disruption of surrounding tissue.

The best way to handle the vocal fold scar is avoiding producing them.

Is the patient fully aware that:

Even proper healing, can result in scarring.

The likelihood of abnormal vibration of the vocal folds depends on the depth of the lesion, in spite of careful operating techniques.

The postoperative indications must be strictly followed (no voice abuse!)

The PS might not be the end of treatment: long and consequent voice training is often required.

To summarise, all surgeons touching the vocal folds ought to obey the “golden rules” (Table II.). Those pieces of advice, which must be followed prior to phonosurgery, guarantee the high quality of phonosurgical procedures and meeting the patient’s expectations.

Table II. The golden rules that must be followed before you proceed to phonosurgery

I The questions to be asked before PS:

How strongly does the patient feel impaired by his dysphonia?

Does the sufferer in fact feel that his deep and raspy voice is an integral part of his identity?

Does the patient actually want his audible personality trait to be changed at all?

Are there any conservative treatment options that have been used?

II Rules to be strictly obeyed:

Never start without good training, PS course etc.

REFERENCES


