A small groove with major impact

Phonosurgical concepts for sulcus vocalis and sulcus vergeture

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The diagnosis and treatment of vocal fold sulci are among the most demanding challenges in laryngology. Often patients are diagnosed only after years of suffering of susbtantial symptoms. Whereas treatment previously focused primarily on medialization procedures using augmentation to improve glottic closure, microsurgical and regenerative approaches are increasingly moving to the forefront.

Many otolaryngologists are familiar with the following clinical scenario: a patient reports years of persistent dysphonia, a strained or pressed voice quality, rapid vocal fatigue, and difficulty projecting the voice in larger rooms. Singers complain of a loss of vocal stamina and upper range, whereas professional voice users report progressively increasing effort during speaking. On initial inspection, laryngoscopy may reveal little that is remarkable; only videostroboscopy discloses the actual cause – a sulcus.

Few other disorders produce such a marked discrepancy between the morphological findings and the patient's subjective burden of symptoms. If endoscopy is not performed at very high resolution, a sulcus is frequently overlooked. The vocal folds may appear „white and smooth - there must be another explanation." This is only one of the reasons why sulci remain a particularly demanding challenge in modern voice diagnostics.

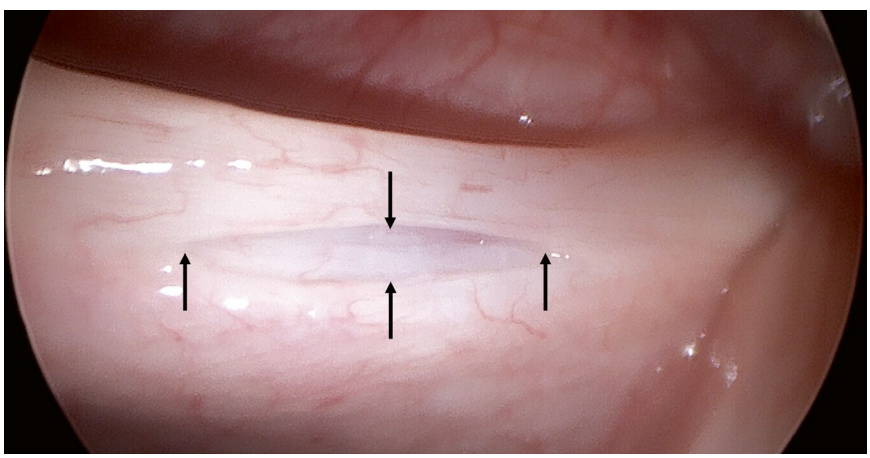
The vibratory basis of the voice disorder lies in the specific anatomy of the vocal fold. Whereas many laryngeal disorders primarily affect glottic closure, a sulcus directly involves the layers of the lamina propria that are responsible for vocal fold vibration and the mobility of the free edge. Tissue softness, pliability, and viscoelasticity determine the biomechanical properties of the vocal fold and, ultimately, the quality of phonation.

What is a sulcus?

A sulcus is a longitudinal invagination or groove along the free margin of the vocal fold **(Fig. 1)**. Histologically, the epithelium is adherent to the deeper layers of the lamina propria or even to the vocal ligament. This results in a substantial alteration of the vibratory characteristics of the vocal fold.

The normally loose, elastic, and mobile lamina propria - the so-called Reinke's space - becomes rigid at the site of the tissue invagination and loses its mobility. Movement of the free edge and propagation of the mucosal wave are reduced or may be completely absent. Thus, the lesion may remain a „hidden lesion." In addition, incomplete glottic closure is frequently present [1].

The precise etiology and pathogenesis of sulcus have not yet been conclusively established. Proposed mechanisms include genetic factors, inflammatory processes, microtrauma (phonotrauma), and scar-related tissue remodeling. Sulcus probably does not represent a single disease entity but rather a group of different pathophysiological processes with a similar clinical appearance. A sulcus may coexist with other structural abnormalities, including a laryngeal web, ectatic vessels with an irregular course, epidermoid cysts, mucosal bridges, or scar formation.



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Fig. 1: Pronounced sulcus vergeture (Ford type 2)

Frequently overlooked

The diagnosis can be particularly difficult in superficial sulci. At rest, the vocal fold may appear almost normal. The characteristic abnormalities become apparent only during vibration:

- Longitudinal groove along the free vocal fold margin

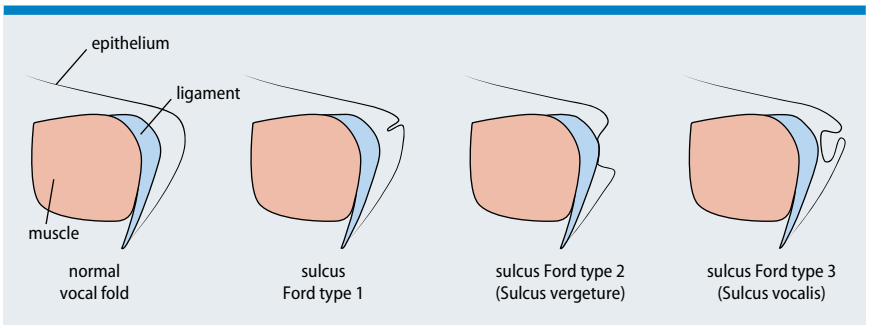
- Reduced mobility of the free edge / impaired mucosal wave
- Reduced vibratory amplitude
- Oval glottic gap
- Asymmetric vibratory patterns

Videostroboscopy therefore remains the diagnostic gold standard. Professional singers in particular may already have substantial functional impairment despite comparatively subtle morphological abnormalities on initial inspection. Palpation is also diagnostically valuable because it can reveal the presence and extent of the sulcus. With appropriate experience, such palpation can even be performed in the examination chair under topical spray anesthesia by advancing a catheter through the working channel of a transnasal flexible endoscope.

Not all sulci are the same

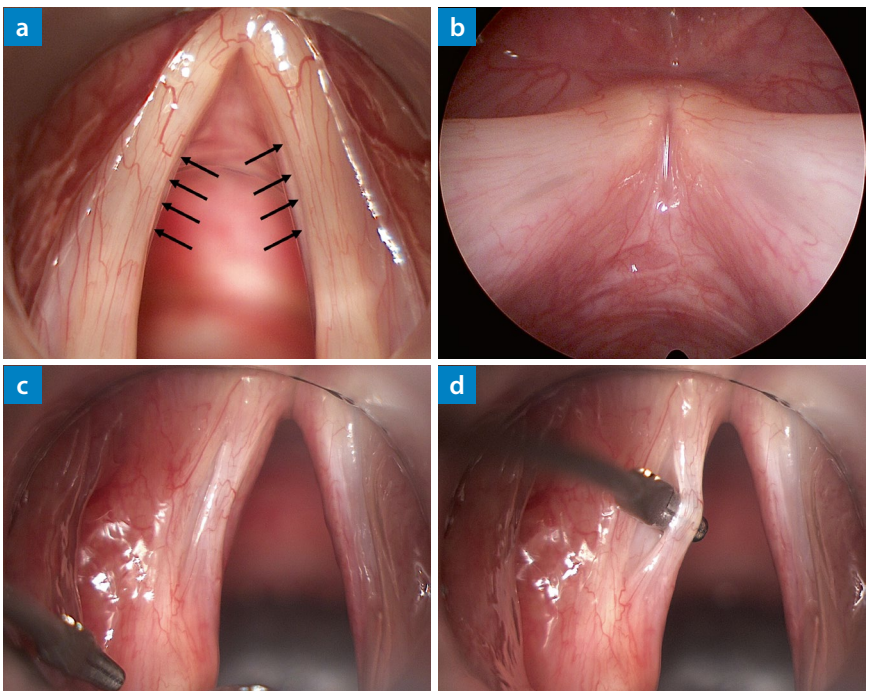
In clinical practice, the classification proposed by Ford has become widely established **(Fig. 2)** [2]:

- Type 1: A superficial groove only, usually associated with little functional impairment.
- Type 2 (sulcus vergeture): The sulcus extends deeper, with loss of all layers of the lamina propria. This already results in a marked impairment of vibratory function and is consistently associated with dysphonia **(Fig. 3)**.
- Type 3 (sulcus vocalis): More or less pronounced depressions are present within the lamina propria, with pouch-like extensions (so-called „open cysts"), corresponding fixation, and dysphonia of variable severity **(Fig. 4)**.



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Fig. 2: Ford classification of vocal fold sulcus [2]



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Fig. 3: Two examples of sulcus vergeture (Ford type 2); **a**) bilateral sulcus formation with longitudinal extension in the contact zone of the vocal folds (arrows); **b)** the same finding viewed from posteriorly; **c**) another patient with bilateral sulcus formation; **d**) additional mucosal bridge on the left

For treatment planning, however, the degree of functional impairment is more important than the exact morphological classification. Two patients with apparently similar morphological findings may experience entirely different symptom profiles.

Why treatment is difficult

The treatment of sulcus differs fundamentally from the management of recurrent laryngeal nerve paresis or presbyphonia. In these disorders, restoration of adequate glottic closure is often sufficient. In sulcus, the problem is located deeper within the vibratory tissue. Even when complete closure of the glottic gap can be achieved, dysfunction of the lamina propria and vocal fold stiffness persist. Although voice quality often improves after medialization, it rarely reaches the quality of a healthy vocal fold. For many years, treatment therefore consisted of a range of compromise solutions.

Vocal fold medialization

For many years, augmentation procedures were the mainstay of treatment, whereas thyroplasty was used less frequently. Injection materials included hyaluronic acid, autologous fat, and calcium hydroxylapatite. The aim was to increase vocal fold volume and thereby improve glottic closure. In particular, breathiness and vocal power can often be improved substantially with this approach.

The limitations of these procedures soon became apparent. Although injection increases vocal fold volume and facilitates glottic closure, it does not alter the rigidity of the vocal fold surface.

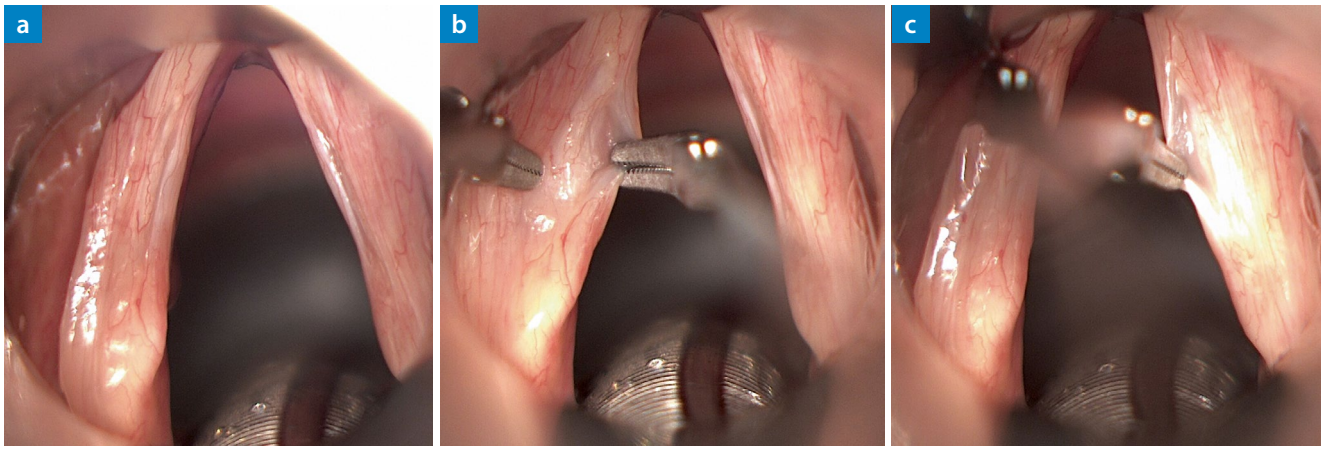


Fig. 4: Example of sulcus vocalis (Ford type 3): **a**) microscopic view of both vocal folds; **b**) opening/spreading of the sulcus on the left; **c**) opening/spreading of the sulcus on the right

The fundamental pathological feature of the sulcus therefore remains unchanged.

Nevertheless, injection laryngoplasty is still usually the first therapeutic step because it is relatively straightforward to perform. Temporary augmentation may be offered as a therapeutic trial („trial injection"). Some patients benefit sufficiently from this intervention to justify subsequent permanent medialization.

Hyaluronic acid

In recent years, hyaluronic acid has become established as a standard material for temporary medialization. Its advantages are evident: favorable viscoelastic properties, good biocompatibility, suitability for office-based application, and a low complication rate. Particularly in Ford type 2 sulcus, even small volume corrections may result in a marked improvement in voice quality. Patients frequently report improved vocal endurance and reduced phonatory effort. However, because hyaluronic acid is resorbed, the effect is primarily functional rather than regenerative.

Autologous fat

In parallel, autologous fat augmentation has experienced a notable resurgence. Whereas the volumizing effect was formerly the principal consideration, increasing attention is now being directed toward the biological properties of adipose tissue. Adipose tissue contains numerous regenerative cell populations as well as growth factors. Autologous fat may therefore be more than a simple filler material. Several recent studies have demonstrated long-term improvements in the Voice Handicap Index, maximum phonation time, and glottic closure. In more pronounced forms of sulcus, autologous fat is now frequently combined with surgically reconstructive procedures.

Testosterone

Local injection of testosterone into the vocal folds (off-label use) induces structural changes in vocal fold tissue and alters vocal timbre. It is assumed that androgenic effects lead to an increase in muscle mass and tissue volume within the lamina propria, together with trophic changes of the mucosa, resulting in changes in the biomechanical properties of the vocal folds.

These effects may be exploited in the treatment of sulcus. Repeated testosterone injections at intervals of several weeks may improve glottic closure, facilitate vocal fold vibration, and reduce breathiness. A case report also described improvements in maximum phonation time, subjective voice quality, and stroboscopic findings [3]. However, because the available evidence is currently limited to case reports, the efficacy of this approach remains insufficiently established. Its role in the treatment of sulcus must therefore still be regarded as experimental.

In addition to the effects described above, a regenerative potential of local testosterone injections has also been proposed. Androgen-mediated mechanisms might promote tissue healing and the structural integrity of the vocal folds. However, robust clinical evidence supporting this hypothesis is currently lacking.

Reconstruction of the lamina propria

In recent years, a fundamental paradigm shift has occurred in the treatment of vocal fold sulcus. Rather than performing medialization alone, modern approaches aim to restore the normal structure of the vocal fold and reduce tissue stiffness. To achieve this, adhesions between the epithelium and the deeper layers are first released microsurgically. The objective is to achieve a sustained improvement in the biomechanical properties of the vocal fold.

A recent systematic review published in 2024 analyzed 43 studies on sulcus and vocal fold scarring. The best outcomes were observed with combined procedures incorporating reconstruction and augmentation, particularly with respect to patient-reported voice quality and aerodynamic parameters [4].

Laser-Assisted Sulcus Release

In recent years, the group led by Dr. Nupur Nerurkar in Mumbai, India, has attracted particular attention. The team developed the concept of Laser-Assisted

Sulcus Release (LASR). In this technique, adhesions are released in a controlled manner using laser energy to restore mobility of the superficial tissue layers. In particular, longitudinal stiffened tissue bands are fractionated with the laser, conceptually resembling the technique described by Pontes and Behlau in 1993 [5, 6].

Nerurkar and Nagree demonstrated significant improvements in the Voice Handicap Index, maximum phonation time, and perceptual voice quality within only a few months in a clinical series [6]. Their work illustrates an important trend in contemporary sulcus surgery: the primary objective is no longer simply to increase tissue volume, but to restore vibratory function.

From reconstruction to regeneration

Advances in regenerative approaches are particularly promising. Conventional phonosurgery attempts to compensate for the consequences of a sulcus. Regenerative medicine, by contrast, aims to biologically repair the damaged lamina propria. This may represent the future direction of sulcus treatment.

Platelet-Rich Plasma

In recent years, injections of platelet-rich plasma (PRP) into the vocal folds have attracted considerable attention **(Fig. 5)**. PRP is prepared from the patient's own blood and contains high concentrations of several growth factors, including platelet-derived growth factor (PDGF), vascular endothelial growth factor (VEGF), transforming growth factor beta (TGF-beta), and epidermal growth factor (EGF). These factors play central roles in tissue repair and wound healing. Unlike conventional injectable materials, PRP is not intended to increase vocal fold volume. Instead, its objective is biological modification of the lamina propria.

The most extensive clinical experience to date has been reported by Woo and Murry in New York [8, 9]. In their studies, patients with vocal fold scarring, sulcus vocalis, and atrophy underwent repeated PRP treatments. The results demonstrated significant improvements in the Voice Handicap Index, stroboscopic findings, and subjective voice quality.



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Fig. 5: Percutaneous office-based injection of platelet-rich plasma (PRP) into the vocal folds

Notably, patients with mild to moderate structural changes appeared to benefit most, whereas severely scarred vocal folds responded less favorably.

Other groups have since confirmed the safety and feasibility of serial PRP injections as well as subsequent improvements in vocal function. The quality of the evidence is currently considered moderate. Nevertheless, PRP is among the most promising developments in regenerative laryngology at present.

Growth factors

Even before PRP gained attention, Japanese research groups had investigated regenerative treatment strategies intensively. In particular, the group led by Dr. Shigeru Hirano repeatedly examined injections of fibroblast growth factor (FGF) [10]. Several studies suggested that this approach can improve the elasticity of the lamina propria. These findings provided an important foundation for the current understanding of regenerative vocal fold therapies. Many contemporary PRP concepts build directly on these observations.

Where is sulcus surgery heading?

Over the past 20 years, treatment initially focused on medialization, most commonly by augmentation, followed by reconstructive techniques involving excision, laser fractionation, and microflap procedures [11]. We are currently witnessing a transition toward regenerative phonosurgery. Future developments are likely to focus on growth factor-based therapies, stem cell approaches, next-generation biomaterials, tissue engineering, and personalized regenerative concepts. Whether these strategies will ultimately permit true restoration of the lamina propria remains to be determined.

Key points for clinical practice

- Sulcus is one of the most complex disorders of the vocal folds.
- Improving glottic closure alone is frequently insufficient, particularly in more advanced structural abnormalities.
- Modern phonomicrosurgical treatment combines medialization, microsurgical reconstruction, and regenerative approaches.
- Platelet-rich plasma (PRP) injections have emerged as a promising approach and allow substantially more differentiated and individualized treatment than was possible only a few years ago.

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