Phonosurgery

- Phonosurgery is defined as 'any surgery designed primarily for the improvement or restoration of the voice'.
- Complete assessment of a patient with a voice disorder should now include video laryngoscopy, stroboscopy and other laboratory recordings including laryngeal electromyography and quantitative voice measurements.
- Before considering a patient for surgery, the underlying cause of the vocal abnormality must be ascertained; a multitude of factors such as smoking, alcohol, voice abuse (both speaking and singing), gastro-oesophageal reflux: and voice misuse should be assessed and a reasonable trial of therapy for these factors attempted.
- Phonosurgery includes a wide range of surgical techniques such as Microlaryngoscopic surgery, vocal fold injection, laryngeal framework surgery, nerve grafting and neuromuscular surgery.

MICROLARYNGEAL SURGERY

Anatomy

- The poor lymphatic drainage of the lamina propria predisposes it to collect tissue fluid (Reinke's oedema)

Instrumentation

- Benign disease is usually located in the mucosal layer or in the superficial part of the lamina propria.
- Surgery should, therefore, be superficial, staying out of the vocal ligament, with limited mucosal excision only.
- There is currently no role for stripping of the mucosa of the vocal fold for benign disease.

Exposure

- A flexed neck and extended atlanto-occipital joint is now the universally accepted best position for surgical access.
- External laryngeal counterpressure, which can be done either with an assistant's fingers or with a specifically designed strap, will also improve exposure of the vocal folds.

Microlaryngeal surgery

- Microlaryngoscopy has the following advantages over direct laryngoscopy:
  1. Binocular vision.
  2. Magnification.
  4. The ability to use bimanual instrumentation.
  5. The ability to use the carbon dioxide laser.
- Microlaryngoscopy concentrates mainly on the glottis area in cases where the diagnosis is already established and, unlike direct laryngoscopy, is not primarily concerned with other areas of the larynx which should have been assessed preoperatively.
Laser and alternative dissecting instrumentation

- In many ways, laser and cold instruments should be considered as synergistic tools rather than in direct opposition.
- Author prefers to limit *laser* to *vascular lesions* or those that bleed on removal, such as papillomatosis or granulomas, or to the *removal of cartilage and when excising large areas of tissue*.
- Some surgeons now advocate the use of power instrumentation, such as the *laryngeal microdebrider*, as it eliminates many of the risks of laser.
- Microdebrider has less postoperative pain and a quicker return to a usable speaking voice.
- Microdebrider – for papillomas, polyps, Reinke's oedema and also for removing tumours at both glottis and subglottic levels.

Anaesthesia

- GA is a norm
- Ventilation during phonosurgery can either be via an endotracheal tube, which may be laser proof, or via jet ventilation.

Voice rest

- 48 hours of absolute voice rest following a phonosurgical procedure is essential.

VOCAL NODULES : Ch 167

- < 3mm, bilateral, midmembranous, whiplash hypothesis of shearing forces, hourglass vocal folds
- Histopathological studies show *thickening of the basement membrane* together with areas of *Haemorrhage, Fibrin deposits and Hyalinization*.
- Their aetiology is associated with phonatory strain and a stroboscope can be useful in distinguishing between hard (usually require surgery) and soft (usually respond to speech therapy) nodules.
- The centre of the nodule is held with grasping forceps and pulled medially towards the opposite cord.
- Microscissors are then used to cut the mucosa close to its base, thus preserving normal mucosa, keeping a straight vibratory edge and preventing secondary notching. Remember voice therapy utmost important or high chance of recurrence.
- Anterior commisure mucosa should be preserved.
- Postoperative voice rest for 48 hours.

POLYPS

- >3mm, These are usually unilateral, localized areas of oedematous tissue although some may be angiomatous and contain areas of haemorrhage.
- M>F, Smokers, 30 to 50 yrs, Phonotrauma causes.
- Disruption of vascular basement membrane, capillary proliferation, thrombosis, minute haemorrhages and fibrin exudation.
- Some are haemorrhagic, some gelatinous and grey.
- Occasionally, a *sulcus, mucosal bridge or intracordal cyst* is found immediately opposite on the other vocal fold.
Polyps can shrink spontaneously or even be coughed up.

Voice therapy ➔ Excision under GA

The site of the lesion is again superficial to the vocal ligament and careful examination may show a contact response on the contralateral vocal fold.

Gentle, steady traction is applied by grasping forceps towards the opposite cord and the base of the polyp cut with microscissors.

Preservation of mucosa is essential, too little resulting in reformation of the polyp, too much resection giving a notched, scarred cord with tethering of the layers of the vocal fold.

**REINKE’S OEDEMA**

This is a bilateral diffuse condition where there is a collection of polypoidal tissue in the superficial layer of the lamina propria in the membranous portion of vocal cord from anterior commissure to vocal process.

Vocal folds are chronically and irreversibly swollen

Aka Other terms for the condition include:

- Polypoid vocal cord, polypoid degeneration or polypoid hypertrophy; cordal polyposis or polypoid corditis.
- Chronic oedema of vocal folds;
- **Pseudomyxoma** or pseudomyxomatous laryngitis;
- Smoker's larynx.
- Exclusively in moderate to heavy smokers. Voice strain and GERD can play role
- Some cases concomittent hypothyroidism seen.

**HISTOPATHOLOGICALLY:**

- Epithelium shows nonspecific changes and **basement membrane is thickened**
- In Reinke’s space there are lakes of oedema, extravasated erythrocytes, and thickening of walls of subepithelial vessels
- This poor lymphatic drainage, however, is also advantageous by giving a good prognosis for small glottic tumours.
- Patients most commonly seek a medical opinion between the ages of **40 and 60 years** of age.

**SYMPTOMS**

The most common symptoms are:

- Deepening of the pitch of the voice with women often being mistaken for a man, particularly on the telephone.
- Gruffness of the voice.
- Effortful speaking.
- An inability to raise the pitch of the voice;
- Choking episodes;
- Other symptoms associated with extraoesophageal reflux.

Bilateral in 62-85 percent of cases.
Typically the vocal folds are grey or yellowish in colour with prominent superficial vessels.

In severe cases the vocal folds look like bags of fluid that flop up and down through the glottis with respiration.

The severity of the swelling is best judged on deep inspiration and is frequently underestimated if an assessment is only made on phonation as the oedematous tissue bunches up on the superior surface and into the ventricle.

A severity grading system has been proposed by Savic.

The decision to treat a patient with Reinke's oedema depends on their symptoms, the severity of the oedema and the presence of leukoplakia. In most cases conservative measures, such as reassurance, an explanation of their condition and vocal hygiene advice including smoking cessation, should be tried initially. Hypothyroidism, upper airway infections and allergies and extraoesophageal reflux should be treated.

**Surgical treatment should be considered when:**

- leukoplakia is present and a histological diagnosis is required;
- gross Reinke's oedema is present causing choking episodes or airway compromise;
- pitch elevation of the voice is the main requirement of treatment.

Patients must be aware that after surgery:

- friends and relatives may not recognize them by their voice;
- the singing voice may be permanently altered;
- speaking may be more effortful for up to one year (or occasionally permanently);
- the voice seldom returns to 'normal', but is generally of better quality.
- the Reinke's oedema is likely to return within two years if the patient continues to smoke.

The principles of surgery for Reinke's oedema include:

- reducing the bulk of the mucosa (mass per unit length) of the vocal fold;
- obtaining a straight mucosal edge, i.e. avoiding leaving small deposits of the myxoematous material behind;
- avoiding damage to and exposure of the underlying ligament, thereby reducing the chances of scarring and web formation.

**HIRANO's APPROACH**

A cordotomy incision is made on the lateral aspect of the superior surface of the vocal fold with an arrow-headed knife or laser.

Mucosa is then elevated with a blunt dissector and myxomatous contents either aspirated or removed with cupped forceps.
Care must be taken to avoid damaging the vocal ligament or traumatizing the overlying mucosa with excessive suction.

Following removal of the contents, the mucosal flap is replaced and any excess epithelium trimmed with micro scissors.

The mucosal flap can be laid on the surface and left to heal by surface tension, sutureing or tissue glue (autologous or, commercial) used to hold this in place.

INTRACORDAL CYSTS

These may be mucosal retention or epidermoid cysts, and stroboscopy has greatly increased the ease of diagnosis.

VOCAL FOLD VARICES

These are often considered a potential source of haemorrhage but in most cases, if lying in a longitudinal orientation, can be left and treated conservatively unless recurrent haemorrhage occurs. The presence of vessels lying at 90° or at a different orientation may indicate underlying disease and require further investigation.

ANTERIOR WEBS

If these are small and thin, they can be divided either with a laser or with cold steel. A microweb is frequently associated with vocal cord nodules and can be removed at the same time.

GRANULOMAS

These are located on the vocal process of the arytenoid cartilage and are usually unilateral, sessile, bilobed lesions.

Combination of surgery to confirm histological diagnosis together with postoperative gastro-oesophageal reflux treatment, injection of steroids into the base, oral prostaglandins, speech therapy, osteopathy for neck manipulation and even botulinum toxin injection into the lateral cricoarytenoid muscle to decrease the force of adduction have been tried.

There is also an opinion that a granuloma is a self-limiting process that will burn itself out when the arytenoid cartilage scleroses.

The author's preference is a local mucosal rotational flap at the time of laser excision to cover the exposed cartilage.

PAPILLOMAS

These are due to the human papilloma virus (subtypes 6 and 11) and frequently recur.

CO2 laser excision is the treatment of choice with minimal trauma to surrounding tissue.

Single papillomas are grasped gently as they may be friable and the laser is used to excise the base. Surgical techniques for multiple papilloma include using injection of saline (+/-epinephrine) submucosally (hydrodissection) and excising the mucosa en-bloc.

Other Rx for papilloma include retinoids, α interferon, ribavarin, Cidofovir, COX2 inhibitors, Photodynamic therapy.

VOCAL SULCUS
This is a groove along the mucosa and can be classified into three types; the first is a physiological or pseudosulcus often associated with reflux, the second is a sulcus vergeture, which goes down to the superficial layer of the lamina propria, and the third is a sulcus vocalis going down to the deeper layers of the ligament.

They frequently present with persistent dysphonia following puberty.

Numerous phonosurgical approaches have been suggested from excising the sulcus to injecting collagen or fat to boost the underlying layers.

Pontes advocates a technique involving parallel mucosal incisions of varying lengths running in a cephalad to caudal direction to break up the linear scar of the vocal fold.

**VOCAL FOLD INJECTION**

Brunings was the first to describe when he injected paraffin

**Materials**

TEFLON so only ( TEtra FLuoro )

This is a polymer of tetrafluoroethylene (TFE) and is sold as a paste consisting of 50 percent glycerine.

The glycerine component is absorbed in the first few weeks and its volume is partially replaced initially by an acute inflammatory reaction and later by a localized chronic inflammatory response. which encapsulates the remaining Teflon. This is, in effect, a localized granuloma

**PROBLEMS ASSO..**

- Initial volume injected and final SOL is unpredictable.
- If Teflon is incorrectly placed superficially and erosion of the overlying mucosa occurs, this can lead to a granuloma on the surface of the vocal fold, and a 36 percent incidence of granuloma production has been reported.
- Teflon particle sizes in the paste are sold as 50-100 microns, too large for immediate lymphatic spread since macrophage lymphatic cut-off is 40 microns. BUT distal spread has been reported with Teflon particle size seen as 4 to 40 micron.
- Long-term studies regarding Teflon have found migration locally into the superficial layers of the vocal fold leading to absent mucosal wave on stroboscopy and, therefore, poor long-term voice results.

- given in patients with short life expectancy and unilateral VC palsy.
- Inserted deep in Thyroarytenoid muscle.
- Removal of Teflon with a CO₂ laser gives high thermal damage and the vocal fold is scarred to such an extent that poor voice is almost guaranteed.

**FAT**

- Numerous advantages:
- This autogenous material, it is easily harvested (liposuction), readily available and does not give a foreign body reaction.
Fat Harvesting ➔ Liposuction (which can lead to up to 30 percent cell destruction and an increased hypersensitivity reaction) whilst others harvest through a larger incision followed by irrigation with saline and soaking in insulin.

30-50 percent absorbed within the first month and long-term studies also suggest a decrease in volume with time. As a result of its absorption, many suggest overcorrection at the time of injection.

Like Teflon requires insertion deep into the vocal fold.

Voice results better.

**GLYCERINE**

- This can be used as a temporary material as it is absorbed within the first two to six weeks.
- It is completely reversible and frequently combined with laryngeal electromyography (EMG) in cases of a temporary paralysis.
- Once again, its site should be deep within the muscle of the vocal fold.

**COLLAGEN**

- This protein is a natural constituent of the lamina propria of the vocal fold.
- **GAX-collagen (Zyplast)** is bovine collagen crosslinked by the addition of glutaraldehyde.
- Cross linking reduces rate of hypersensitivity (<1%) and also makes it more stable.
- Skin testing preoperatively is recommended before the collagen is injected superficially into the vocal ligament.
- Although excellent results are reported by Ford, others have found this technique difficult and noted irregularity in its mode of absorption and replacement.

**SILICONE**

- After an initial acute inflammatory reaction, the material develops a fibrous capsule.

**Selection of operative methods**

These maybe subdivided as follows:

- General anaesthesia: Direct laryngoscopic method;
- Local anaesthesia:
  - Direct laryngoscopic method;
  - Indirect laryngoscopic method;
  - Transcutaneous route through the cricothyroid membranes.
  - Transcutaneous route through the thyroid cartilage.

**GENERAL ANAESTHESIA**

- This is the commonest method in the UK. Drawbacks include visualization problems due to the anaesthetic tube, anatomical position of the neck, difficulty in gaining access to the larynx in patients
with cervical spine problems or other anatomical factors preventing direct laryngoscopy and, most significantly, lack of patient feedback via phonation during injection.

- This last factor plays an essential role in deciding the amount of material to inject at the time of surgery in patients undergoing procedures under local anaesthesia.

**LOCAL ANAESTHESIA**

- The indirect laryngoscopic technique with stroboscopic control (difficult to master)
- The head position is still abnormal and due to the length of the instruments it is difficult to assess the depth of penetration into the fold
- TRANSCUTANEOUS ➔ OPD setting, Head neutral.
- Penetration via lower half of thyroid cartilage but difficult if cartilage ossified or needle bore blocked with cartilage.
- Penetrating the cricothyroid membrane is becoming a more familiar technique now
- The injection needle can either pass directly into the cord without entering the laryngeal lumen or pass initially into the lumen and then penetrate the fold whilst being visualized via a nasoendoscope.

**LARYNGEAL FRAMEWORK SURGERY**

- Isshiki was the first to describe using an alloplastic material (Silastic) and also to stress the benefits of carrying out the procedure under a local anaesthetic using the patient's voice for feedback.
- Laryngeal framework surgery allows the size of the glottic aperture, plane of closure of the vocal folds and vocal fold length to be modified.

**TYPE I ISSHIKI (Medialization thyroplasty)**

- Selection of patients Medialization laryngoplasty can be performed in any patients with a unilateral vocal cord paralysis.
- **Wait 1 year in idiopathic U/l VC palsy before operating** although if there is severe aspiration or in exceptional cases where the vocal needs of the patients require early intervention, surgery may be carried out sooner as an alternative to repeated glycerine injections during laryngeal EMG monitoring.
- Medialization laryngoplasty can also be used in cases of unilateral or bilateral bowed vocal cords caused by ageing and may be useful to correct soft tissue defects in the vocal fold as a result of previous surgery.

**TECHNIQUES**

- Thyroplasty type 1
- Inward displacement with an implant placed through a window in the thyroid cartilage.
- In the original description, the cartilage window was preserved but many now remove this island of cartilage believing it can be displaced or absorbed leading to later complications.
- Ideally 30-40 minutes for a routine thyroplasty is adequate.
- Materials used are Silastic, hydroxlapatite and gortex.
- Implant out of the body of the vocal fold which allows the fold to vibrate and a mucosal wave to be seen.
- Fibrosis around implant makes it irreversible.
- Interestingly, one should preserve the outer perichondrium when using Gortex as this will need to be sewn back to close the defect (window) in the thyroid cartilage.
- Design of the implant also varies, some preferring to insert the implant in halves, others use partial incisions so that the implant will snap into place.
It is still not certain whether a posterior glottic chink can be closed with a Medialization thyroplasty alone.
When the paralysed cord is on a different vertical plane to the normal one, then a medialization laryngoplasty is insufficient for full closure.
Poor results following Medialization laryngoplasty are usually due to inaccurate preoperative assessment.

**Developments**

- Isshiki described an arytenoid adduction procedure for patients where there is a large posterior gap and the paralysed cord is at a different vertical level.
- A modification of this technique is the **arytenoid fixation** and **cricothyroid subluxation** as described by Zeitels.
- With an extended incision, the arytenoid cartilage is exposed, its attached muscles divided and the arytenoid cartilage is fixed in a midline position. Tension of the paralysed cord is obtained by a suture between the inferior horn of the thyroid cartilage and the cricoid cartilage anteriorly.
- This is usually combined with a medialization thyroplasty.
- Laryngeal EMG is useful in diagnosing an atrophic vocal cord.
- It is easy to perforate the laryngeal mucosa when lifting the inner perichondrium due to the thin sometimes nonexistent muscle bulk.

**REINNERVATION PROCEDURES** :

- Crumle has popularized the technique of ansa cervicalis to recurrent laryngeal nerve anastomosis.

**Neuromuscular physiology** :

- RLN is a mixed nerve containing afferent, sympathetic, parasympathetic and 500-1000 motor axons in an **adductor** to **abductor** ratio of 5:1.
- Muscle fibres can be divided into specific types based on the histochemical and contractile properties.

- There are three basic groups.
  1. Type 1: slow contractile period and aerobic metabolism.
  2. Type 2A: intermediate contractile period and both aerobic and anaerobic metabolism.
3. Type 2B: fast contractile period and anaerobic metabolism.

Thyroarytenoid ➔ Type 2B

Strap Muscles ➔ Type 1

This gross difference in the histochemical and contractile properties of these muscle groups and their nerve supply makes them poor recipients and donors for nerve transfer.

Muscle nerve pedicle reinnervation has also been described using a block of omohyoid with its branch from the ansa cervicalis.

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Time taken (minutes)</th>
<th>Results</th>
<th>Anaesthesia</th>
<th>Reversible</th>
<th>Demand on technical skill</th>
<th>Changes in vocal fold</th>
<th>Complications</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teflon injection</td>
<td>10–30</td>
<td>Immediate</td>
<td>Local/general</td>
<td>No</td>
<td>Moderate</td>
<td>Granuloma within body of fold</td>
<td>Under-injection</td>
<td>Cheapest</td>
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<tr>
<td>Fat injection</td>
<td>10–30</td>
<td>Immediate, but 30–50%</td>
<td>Local/general</td>
<td>Yes</td>
<td>Moderate</td>
<td>(nonrehabatory)</td>
<td>Over-injection, Airway compromise, Misplacement of Teflon, Migration, Granuloma formation</td>
<td>Free-easily harvested</td>
</tr>
<tr>
<td>Glycerine injection</td>
<td>10–30</td>
<td>Immediate</td>
<td>Local/general</td>
<td>Yes</td>
<td>Moderate</td>
<td>None</td>
<td>Over-injection, Airway compromise</td>
<td>Moderate</td>
</tr>
<tr>
<td>Collagen injection</td>
<td>10–30</td>
<td>Immediate</td>
<td>Local/general</td>
<td>?</td>
<td>High</td>
<td>None</td>
<td>Over-injection, Airway compromise, Under-injection, Airway compromise</td>
<td>Moderate</td>
</tr>
<tr>
<td>Silicone injection</td>
<td>10–30</td>
<td>Immediate</td>
<td>Local/general</td>
<td>?</td>
<td>High</td>
<td>None</td>
<td>Under-injection, Airway compromise, Over-injection, Airway compromise</td>
<td>Moderate</td>
</tr>
<tr>
<td>Laryngeal framework surgery</td>
<td>35–75</td>
<td>Immediate</td>
<td>Local/general</td>
<td>Yes</td>
<td>Moderate</td>
<td>None</td>
<td>Over-injection, Airway compromise, Wound infection, Haematoma, Airway compromise, Mucosal perforation, Dislodgement and/or extrusion</td>
<td>Operating theatre time</td>
</tr>
<tr>
<td>Reinnervation</td>
<td>60–120</td>
<td>2–3 months + Gelfoam/Glycerine injection</td>
<td>General</td>
<td>Yes</td>
<td>Most</td>
<td>Return of mucosal wave, but no vocal fold movement</td>
<td>Wound infection, Haematoma, Loss of abnormal synkinetic tone (placcid fold)</td>
<td>Operating theatre time</td>
</tr>
</tbody>
</table>