Laryngeal Framework Surgery
Introduction:

- Payr in 1915: Laryngeal framework surgery, anteriorly based cartilage flap from thyroid cartilage ala
- Isshiki, 1974: Silastic block medialization laryngoplasty
- Alternative materials: pre-molded silastic, Hydroxylapatite implants, Gore-Tex and Titanium
Nomenclature:

- **Laryngeal framework surgery (LFS)**
  - whole group of phonosurgical procedure

- **Laryngoplasty (LPL)**
  - functional aspect of the LFS, more suited for daily practice

- **Thyroplasty (TPL)**
  - subgroup of LPL, involves alteration or modification of the thyroid cartilage

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<td>Medialization thyroplasty (Thyroplasty type IIa [14, 16])</td>
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<td>Arytenoid adduction</td>
<td>Rotation (pull) techniques [18] (Lateral cricoarytenoid pull technique [24])</td>
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<td>Fixation techniques [37, 38, 42] (Adduction arytenopexy [53])</td>
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<td>Expansion laryngoplasty</td>
<td>Lateralization thyroplasty Lateral approach (Thyroplasty type IIa [14, 16]) Medial approach (Thyroplasty type IIb, expansion of the anterior commissure, midline lateralization thyroplasty [14, 15, 16, 23])</td>
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<td>Vocal fold abduction Suture technique [14] Resection technique [2] (Thyroarytenoid myectomy [52])</td>
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<td>Relaxation laryngoplasty</td>
<td>Shortening thyroplasty Lateral approach (Thyroplasty type III [14]) Medial approach (Anterior commissure retraction [48, 49, 50])</td>
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<td>Tensioning laryngoplasty</td>
<td>Cricothyroid approximation (Thyroplasty type IV a [16], cricothyroid subluxation [54]) Elongation thyroplasty Lateral approach (Thyroplasty type IVb [14, 19, 22]) Medial approach (Springboard advancement [29], anterior commissure advancement, anterior commissure laryngoplasty [48, 49, 50])</td>
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Laryngeal framework surgery:

- Type I: medialization
- Type II: lateralization
- Type III: relaxation
- Type IV: tension
- More effective means for medialization: arytenoid adduction

*Fig. 1.* Four types of laryngeal framework surgery. Type I medialization, type II lateralization, type III relaxation and type IV tensing (cricothyroid approximation) of the vocal folds.
Thyroplasty type I indications and Contraindications

- **Indications**
  - Symptomatic (dysphonia, aspiration) glottic insufficiency, especially if there is little change of return of normal neurologic function
  - Unilateral vocal fold paralysis
  - Unilateral or bilateral vocal fold paresis
  - Vocal fold atrophy, including age-related atrophy

- **Contraindications**
  - Malignant disease overlying the laryngotracheal complex
  - Poor abduction of the contralateral vocal fold
  - Previous history of radiation therapy to the larynx (relative contraindication)
Goals of the medialization laryngoplasty

- Improve voice quality
- Protect airway by achieving complete glottic closure
  - Patients with vocal fold paralysis: 1/3 with laryngeal penetration and aspiration
  - *nor always a sure remedy*
- At least one vocal fold should have intact inspiratory vocal fold abduction
Procedure selection:

- By surgeon’s own preference
- No evidence based comparative trial to prove
- Framework surgery
  - J. Koufman: glottic gap >2~3mm during phonation
- Injection Augmentation
  - prognosis for recovery uncertain
  - no safe injection materials for consistent correction
  - could not achieve immediate voice result
Patient selection:

- Not necessarily the best approach in every case
- Moderate to severe glottic insufficiency ( >2~3mm glottic gap on phonation)
- C/O: breathy dysphonia, dysphagia case
- Anxious/uncooperative patients, pediatric patients: not ideally
Timing of medialization laryngoplasty

- Defer 6~12 months: for spontaneous recovery
  - surgery not compromise the chance of recovery
  - dynamic nature of the vocal fold paralysis
  - severely denervated vocal folds tend to atrophy

- **Early (<6 mons post-injury) laryngoplasty**
  - EMG showed severe neuronal degeneration
  - history demonstrated nerve transection
  - if recovery, implant could be removed

- **Delayed (9~12 mons post-injury) laryngoplasty**
  - LEMG data are equivocal or favorable
Surgical technical note:

- Identify the level of vocal fold in relation to the thyroid lamina
- No single method of vocal fold localization is guaranteed
- Place the thyroplasty window at the most inferior location possible
- Inferior cartilaginous strut below the window:
  - at least 3mm tall to prevent fracture
- Gender-related differences in the thyroid cartilage configuration
Surgical technical note:

- Male vocal fold are longer
- Thyroid alae form a more acute angle
- More posterior cartilage window
- Male: 7mm back from the midline
- Female: 5mm back from the midline
- Anterior soft tissue inside the thyroid cartilage: prone to perforation
Surgical technical note:

- Check on the result of medialization intraoperatively
- Preserve inner perichondrium or not ??
  - Isshiki: prevent medial migration and extrusion
    minimize the possibility of endolaryngeal bleeding
  - deeper implant to achieve effective results
Complications:

- **Airway obstruction**
  - Post operative intubation or tracheostomy
  - Thyroplasty alone v.s. Thyroplasty with arytenoid adduction
    ➔ 0.6% V.S. 2.2%

- **Implant extrusion**
  - Predominantly into the airway rather than transcutaneous; rare, 0.8%
  - Ventricular mucosa: easily tear in the anterior aspect of the window
Complications:

- **Implant extrusion**
  - avoid undermining of the paraglottic space anterior to the window
  - Valsalva maneuver then looking for air bubbles in the field
  - suture the implant to the cartilage
Suboptimal results/ Surgical errors

- Most common cause:
  - rate 5.4~14%
  - most common: unsatisfactory voice result
  - not an airway problem or implant extrusion

- Unsatisfactory voice cause:
  - persistent posterior glottic gap
  - undermedialization
  - superior implant malposition
  - anterior implant malposition
Suboptimal results/ Surgical errors

- Persistent posterior glottic gap
  - account for up to 50%
  - arytenoid lie outside of its normal trajectory, so called prolapsed arytenoid (below the plane of glottic closure)

- Implant malposition, too far superior
  - most common overall cause for revision

- Undercorrection
  - intraoperative vocal fold edema to accumulate
  - preoperative intravenous steroid administration
Montgomery thyroplasty system

- Lateral, medial and inner plate
- Hypotenuse of the triangle: correspond to the long axis of the vocal fold; 116° Angle to the base
- Horizontal skin incision: 2cm from the midline on the contralateral side → midway between the thyroid notch and thyroid cartilage inferior margin → just anterior border of the SCM muscle

Fig. 9.2.1. Thyroplasty implant. Outer portion of implant consists of three tiers. A Lateral plate remains outside thyroid cartilage on its surface and prevents lateral displacement. B Middle plate stabilizes implant and is the same dimension as thyroid lamina window. C Medial plate secures inside thyroid lamina and prevents outward displacement. Outer portion of implant is of constant size for all male and all female implants. D Triangular intralaryngeal portion of implant designed to medialize vocal fold. The height of this portion varies depending on size of implant (females 6, 7, 8, 9, 10 mm, and males 8, 9, 10, 11, 12 mm). Tip of the implant projects posteriorly to reach vocal process of arytenoid, providing posterior medialization. (From [21])
Montgomery thyroplasty system

- The window calipers, 7mm wide in women and 9mm wide in men, are used to locate the key point of the window.
- Superior and inferior border of the window: must be parallel to the inferior border of the thyroid lamina.
- Female 5x10mm; male 7x12mm

![Diagram of window measurement. The appropriate-size window caliper is used to measure from inferior border of thyroid cartilage, anterior and posterior to inferior thyroid tubercle, to superior border of thyroplasty window. A line is extended anteriorly through these points. The key point is then measured with the same caliper from anterior midline of thyroid cartilage, marking the anterior-superior angle of thyroplasty window. (From [2])](image-url)
Montgomery thyroplasty system

- Longitudinal incision is made in the inner perichondrium in the mid-portion of the window
- Five size implant system for male and female
- In 176 consecutive case study (Montgomery WW, 1997): no major complications
- Result (Muse AM, 2000): 43 cases, 80% improved, satisfaction with vocal quality 86%

Fig. 9.2.4. Window outline. a The anterior-superior point of the window outline instrument is placed on the key point. The posterior-superior point of the instrument is placed along the line indicating superior border of window. b Cautery is applied, making four marks that locate the four corners of thyroplasty window. The four corners are connected with a surgical marking pen. (From [2])
VoCoM vocal medialization system

- **Advantages**
  - streamline the actual surgical procedure
  - hydroxylapatite material
  - osteogenesis in the fenestra

- **Disadvantages**
  - firm nature of the implant
  - modification by a diamond drill

→ not used in individuals in whom removal is anticipated
VoCoM vocal medialization system

- **Procedure**
  - Under local anesthesia
  - 50~100mg lidocaine iv or topical anesthetic into the subglottic airway
  - Level of the true vocal fold:
  
  Halfway between the fundus of the thyroid notch and anterior inferior edge of the thyroid cartilage
VoCoM vocal medialization system

- Female: 5-8mm lateral to the midline; Male 8-10mm lateral to the midline
- Place the implant external to the inner perichondrium
- Rotate the implants into four orientation to determine the optimal position
- Most common position for implant: *Inferior posterior quadrant in the vertical orientation*
VoCoM vocal medialization system

- Before placement, perform valsalva maneuver → if air bubble (+), procedure terminated
- Johns Hopkins University analysis (Cummings CW, 1993): 35 cases, subjective improvement 89%
- Simple, efficient, just for candidates needed permanent Implantation

Fig. 9.3.5. An implant in situ just prior to closure
Titanium Medialization implant

- Friedrich and Kurz first introduced in 1999
- Three sizes are commercially available
  - 6x15mm, 6x13mm, 4.5x11mm
- Not to enter the paraglottic space during dissection of perichondrium
- Anterior flange inserted first
- Advantage: reduce OP time ↓, simple to handle

Fig. 9.4.2 a–d. Principle of external vocal fold medialization using the TVFMI
Medialization laryngoplasty with Gore-Tex

- Semiporous implant, limited vascular ingrowth without significant inflammatory response
- FDA-approved thyroplasty device: 0.6mm in thickness, ribbon shape, with a pore for tissue ingrowth

<table>
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<tr>
<th>Reference</th>
<th>Number</th>
<th>Descriptive results</th>
<th>Maximum phonation time</th>
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<tbody>
<tr>
<td>[5]</td>
<td>16</td>
<td>Ten patients with pre- and post-op voice data: mean improvement in voice &quot;grade&quot; from 2.3 to 1.1 and &quot;breathiness&quot; from 2.0 to 0.4</td>
<td>Not reported</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gore-Tex alone: grade 2.2 to 1.5; breathiness 1.9 to 0.9</td>
<td>Mean changes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Plus AA grade 2.1 to 0.8; breathiness 1.9 to 0.3</td>
<td>Gore-Tex Alone: 8.3 to 9.9 s Plus AA: 6.9 to 16.7 s</td>
</tr>
<tr>
<td>[7]</td>
<td>13</td>
<td>Ten patients with pre- and post-op data: mean improvement in voice &quot;grade&quot; from 2.8 to 0.8; jitter form 14.5 to 0.88</td>
<td>Not reported</td>
</tr>
<tr>
<td>[8]*</td>
<td>26</td>
<td>69% with post-op &quot;good voice,&quot; 27% with satisfactory voice</td>
<td>Mean changes 8.1 to 13.1 s</td>
</tr>
<tr>
<td>[9]</td>
<td>142</td>
<td>Overall very positive results; details not reported</td>
<td>Not reported</td>
</tr>
<tr>
<td>[10]</td>
<td>24</td>
<td>Mean improvement post-op in: jitter (2.9); shimmer (8.6); and noise-harmonic ratio (0.2)</td>
<td>Mean postoperative results: 7 s</td>
</tr>
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*Utilized a small fenestration technique. All patients in this report had Gore-Tex alone without arytenoid adduction

GRBAS scale of Hirano [16]
Medialization laryngoplasty with Gore-Tex

- Skin incision over the midportion of thyroid cartilage
- The ipsilateral thyroid cartilage is exposed inferiorly to the cricothyroid membrane, posteriorly to lateral edge
- Slips of the cricothyroid muscle inserting on the lateral border of the muscular process of thyroid cartilage
- One percent lidocaine is injected into the cricothyroid membrane immediately below the lower border of the thyroid cartilage
- Window creation
  - inferior border: 3~5mm above cricothyroid membrane
  - anterior border: at least 10mm posterior to midline
Medialization laryngoplasty with Gore-Tex

- Elevate perichondrium from the thyroid cartilage window
- From the inferior approach, Gore-Tex strip is placed
- Wedge the Gore-Tex strip between the contents of the paraglottic space (perichondrium and LCA/TA muscles group) and the overlying thyroid cartilage
Medialization laryngoplasty with Gore-Tex

- Easily combined with arytenoid adduction
- Advantage:
  - dose not need to refashion an implant
  - simplicity
- Disadvantage:
  - inability to manipulate the Gore-Tex within the paraglottic space

Fig. 9.5.1. Gore-Tex-implanted human larynx, 5 months post-implantation. Human larynx coronal section mid-vocal-cord level. Arrow indicates Gore-Tex implant
Medialization laryngoplasty with Gore-Tex

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<th>Management suggestion</th>
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| Intra-operative airway swelling: edema or hematoma | Pre-operative steroids  
Intubation with small endotracheal tube, controls bleeding, check coagulation status; post-op steroids; controlled extubation after resolution  
Assess implant; insure that implant size or location is not the cause of airway obstruction |
| Post-operative airway swelling           | Same as above: tracheotomy only if conservative airway management fails                                                                                   |
| Complaints of shortness of breath or exertional dyspnea | Glottic evaluation for over-correction and/or contralateral weakness  
Bilateral weakness will require addition work-up with airway management based on clinical findings. Over-correction can diminish with time if airway is otherwise safe. Revision procedure will be required if improvement not seen during the first few months |
| Persistent breathy voice                 | Assess glottis for under-correction  
Revision procedures may required:  
- Augmentation Gore-Tex laryngoplasty  
- Injection laryngoplasty  
- Arytenoid adduction |
| Gore-Tex extrusion                       | Intraoperative, endolaryngeal Gore-Tex removal with secondary procedure after healing, or Transcutaneous removal with strap muscle augmentation |