

Allied Health Media

SpeechPathology.com

If you are viewing this course as a recorded course after the live webinar, you can use the scroll bar at the bottom of the player window to pause and navigate the course.

Allied Health Media

SpeechPathology.com

This handout is for reference only. It may not include content identical to the powerpoint.

Any links included in the handout are current at the time of the live webinar, but are subject to change and may not be current at a later date..

Allied Health Media

SpeechPathology.com

Tracheoesophageal Voice Restoration: Problems & Solutions

Presenter: Julie K. Bishop-Leone, M.A., CCC-SLP

Moderated by:
Amy Natho, M.S., CCC-SLP, CEU Administrator, SpeechPathology.com

Allied Health Media

SpeechPathology.com

SpeechPathology.com Live Webinar

**Need assistance or technical
support during event?**

Please contact
SpeechPathology.com at
800-242-5183

Allied Health Media

SpeechPathology.com

Earning CEUs

- **Log in to your account and go to Pending Courses under the CEU Courses tab.**
- **Must pass 10-question multiple-choice exam with a score of 80% or higher**
- **Two opportunities to pass the exam**

Allied Health Media

SpeechPathology.com

Peer Review Process

Interested in Volunteering to be a Peer Reviewer?

APPLY TODAY!

3+ years SLP Professional Experience Required

Contact Amy Natho at anatho@speechpathology.com

Tracheoesophageal Voice Restoration: Problems & Solutions

Julie K. Bishop-Leone, M.A., CCC-SLP
Director of Clinical Education
Atos Medical, Inc.

Disclosures

Julie Bishop-Leone has financial relationship or relationship affiliations to disclose:

She is employed as the Director of Clinical Education at Atos Medical, Inc. There are no other nonfinancial relationships to disclose.

Learning Objectives

- Identify the various etiologies for leakage through and around a tracheoesophageal (TE) voice prosthesis and describe the various practical means for solving these problems.
- Describe how gastroesophageal reflux affects the health of the TE puncture and the life of the TE voice prosthesis.
- Describe the assessment protocol for assessing a patient with immediate and delayed post-fitting aphonia.

TE Voice Restoration: Problems & Solutions

9

Troubleshooting: Facts & Figures

Data based on St Louis University Experience

- 2/3 of the patients only require replacement of the prosthesis, mostly for mild leakage (median device life 3-4 months)
- 1/3 of the patients experience adverse events, which require special attention, but mostly are easily solvable
- Adverse events are seen in only 1 out of 9 (10.7%) replacements

Focus on the underlying **CAUSE**, NOT the SYMPTOM!

TE Voice Restoration: Problems & Solutions

10

Problems & Solutions: Leakage through the Prosthesis

- Causes
 - Blockage of valve by mucus/crust/food
 - Improper prosthesis fit
 - Biofilm formation on valve
 - Increased intraesophageal pressure during swallow or inhalation
 - Superior tract migration

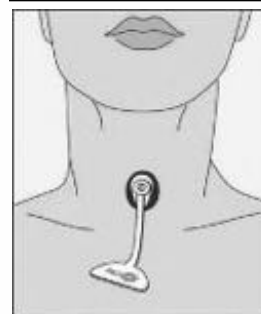
Video courtesy of Saint Louis University Cancer Center – Dennis Fuller

TE Voice Restoration: Problems & Solutions

11

Leakage Through the Prosthesis: Valve blockage by mucus/crust/food

- Solutions
 - Clean the prosthesis with brush and/or flush
 - If still leaking, replace prosthesis
 - Temporarily use plug
 - Consider temporary diet modifications



TE Voice Restoration: Problems & Solutions

12

Leakage Through the Prosthesis:

Too short

- Solutions

- Resize and refit
- Educate pt about signs of improper fit
 - voice deterioration and/or increased effort with speaking

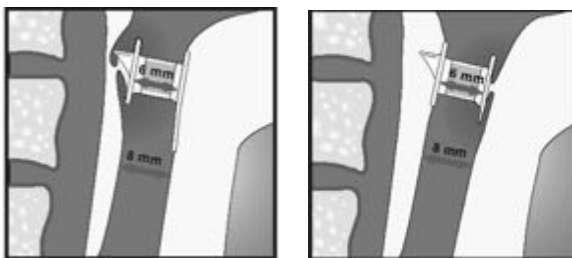


Illustration courtesy of: Elizabeth C. Ward and Corina J. van As-Brooks, Head and Neck Cancer, Treatment, Rehabilitation, and Outcomes

TE Voice Restoration: Problems & Solutions

13

Leakage Through The Prosthesis:

Biofilm formation



Biofilms on voice prostheses consist of a large variety of oral of micro organisms, including streptococci, staphylococci, and yeasts

Mahieu et al., 1986

TE Voice Restoration: Problems & Solutions

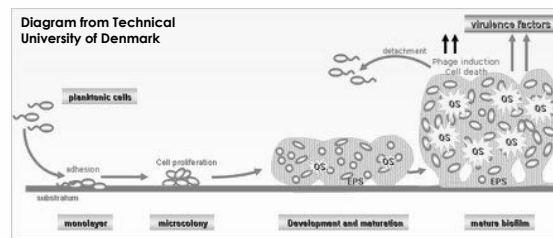
14

Leakage Through The Prosthesis: Biofilm Formation

Manning et al., 2003; Douglas et al., 2003

• What is Biofilm?

- Free-floating opportunistic bacteria and/or fungi
- Likes inert & rough surfaces, necrotic tissue or ischemic normal tissue
- Extracellular polysaccharide matrix (EPS) acts as protection from drugs and it is then difficult to tx



TE Voice Restoration: Problems & Solutions

15

Leakage Through The Prosthesis: Biofilm Formation

Williams et al., 2011

• Who is at risk for biofilm formation?

- Immunosuppressed pts
- Diabetics
- Pts on antibiotics and/or oral/inhaled steroids
- Malnourished pts
- Chemo/XRT pts
- Pts with poor oral hygiene and/or dental caries
- Denture users
- Pts with xerostomia (XRT, Sjogren's)

TE Voice Restoration: Problems & Solutions

16

Suggestions & Anecdotal Treatments Used in the Field that May Prevent/Help Biofilm Formation

Williams et al., 2011

- **PREVENTION IS THE KEY!**
- **Good Oral Hygiene**
 - Brush after each meal
 - mechanical toothbrush may disrupt biofilms
 - Colgate's Total ® Toothpaste (contains Triclosan)
 - Salt & soda rinses for pts undergoing XRT
 - Clean and remove dentures each night
 - Mouthwashes as needed
 - 0.2% Chlorhexidine Gluconate – GUM ® Brand doesn't have alcohol
 - Essential Oils Mouthwash

TE Voice Restoration: Problems & Solutions

17

Suggestions & Anecdotal Treatments Used in the Field that May Prevent/Help Biofilm Formation

Free et al., 2003

- **Daily Cleaning of the VP**
 - Brush and Flush at least twice a day and after meals (see IFU)
 - Avoid vigorous brushing of VP



TE Voice Restoration: Problems & Solutions

18

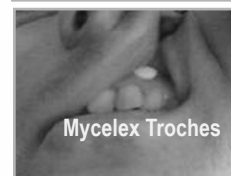
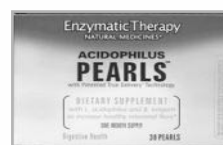
Suggestions & Anecdotal Treatments Used in the Field that May Prevent/Help Biofilm Formation

- **Diet**

- Avoid sugars and yeast-containing foods (i.e. beer, carbs)
- Drink buttermilk (Busscher et al., 1998)
- Probiotic liquids and supplements containing *L. lactis* 53 and *S. thermophilus* B (Free et al., 2001)
- Yakult yogurt drink (Schwandt et al., 2005)
- Honey (Alandejani et al., 2009)
- Try caffeinated drinks containing sugar – Coca Cola Classic (Free et al., 2000)

Suggestions & Anecdotal Treatments Used in the Field that May Prevent/Help Biofilm Formation

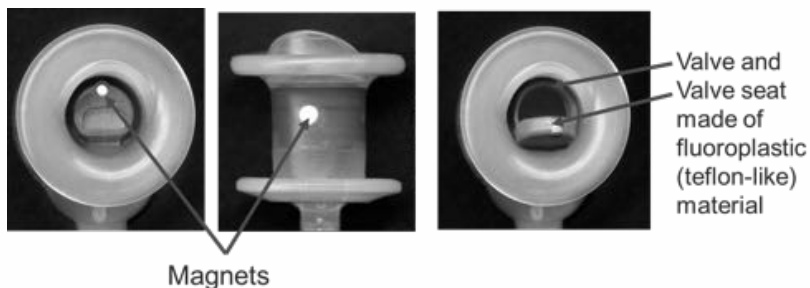
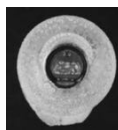
- **If taking antibiotics, may want to pair with prophylactic antifungal or probiotics**
- **Antifungals**
 - Prophylactic use?
 - Chlorhexidine Gluconate
 - Nystatin?
 - Mycelex Troches (clotrimazole)
 - Amphotericin B Lozenges (Mahieu et al, 1986)
 - Slow-releasing tablets containing miconazole nitrate (Van Weissenbruch et al., 1997)
- **Anti-GERD medications**



Treating Biofilm with a Prosthesis

Hilgers et al., 2003; Soolsma et al., 2008; Graville et al., 2011; Timmermans et al., 2015

- Excessive biofilm solution
 - ActiValve, light strength



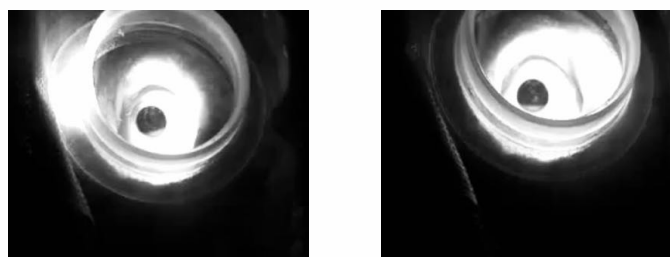
TE Voice Restoration: Problems & Solutions

21

Leakage Through the Prosthesis: Increased Intraesophageal Pressure during Swallow or Inhalation

• Indicators

- Ruled out biofilm
- Early device life failure of less than 1 month
- Inadvertent opening of the valve during the swallow
- Ingestion of air and/or gastric filling



TE Voice Restoration: Problems & Solutions

22

Leakage Through the Prosthesis: Increased Intraesophageal Pressure during Swallow or Inhalation

• Solutions

- Teach pt to lower swallowing pressure
- Evaluate and treat for stricture
- Plug can prevent in certain situations (i.e., if gastric filling only occurs under specific situations)



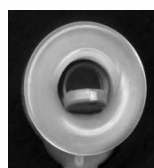
TE Voice Restoration: Problems & Solutions

23

Leakage Through the Prosthesis: Increased Intraesophageal Pressure during Swallow or Inhalation

• Solutions continued

- NiD
- Increased resistance prosthesis
- Duckbill
- ActiValve



TE Voice Restoration: Problems & Solutions

24

Leakage Through the Puncture Tract: Missing Prosthesis

• Causes

- May have inhaled into lung (coughing – not always!)
- Pt could have coughed out and swallowed
- May have dislodged prosthesis while cleaning or placing a laryngectomy tube
- Flaccid TE tract
- Removed during medical procedure



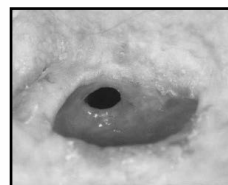
TE Voice Restoration: Problems & Solutions

25

Leakage Through the Puncture Tract: Missing Prosthesis

• Solutions

- Chest X-ray or flexible scope to r/o aspiration (educate your radiologist!)
- Re-educate, resize & refit
- May require a XtraSeal™ or BS Large Esophageal Flange(LEF)
- Educate medical staff
- If aspirated, NiD for safety medallion
- Change to prosthesis with thicker retention collar or NiD with safety ring & tape or glue the strap



TE Voice Restoration: Problems & Solutions

26

Periprosthetic (Around) Leakage

- **Causes**

- Prosthesis too long/pistoning in the tract
- Superior tract migration
- Enlarged TEP due to GERD/GPR and/or tissue issues
- Stricture

Video courtesy of Saint Louis University Cancer Center – Dennis Fuller

TE Voice Restoration: Problems & Solutions

27

Periprosthetic Leakage: Prosthesis too Long/ Pistoning in Tract

- **Solutions**

- Resize and refit
- Educate pt about signs of an improper fit

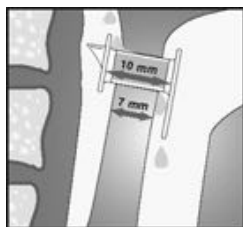


Illustration courtesy of: Elizabeth C. Ward and Corina J. van As-Brooks,
Head and Neck Cancer, Treatment, Rehabilitation, and Outcomes

Video courtesy of Saint Louis University Cancer Center – Dennis Fuller

TE Voice Restoration: Problems & Solutions

28

Periprosthetic Leakage: Superior Tract Migration

- **Solutions**

- Resize and refit
- XtraFlange, XtraSeal or BS LEF
- NiD or duckbill
- Glue/tape the strap to reposition TE tract horizontally
- Surgical closure and repuncture with primary placement



TE Voice Restoration: Problems & Solutions

29

Periprosthetic Leakage: Tissue Issues

- **Causes**

- | | |
|-----------------------------------|--------------------------|
| - Prolonged pistoning | - TEP surgical technique |
| - Previous cancer TX (XRT/chemo) | - Stricture |
| - Recurrent or metastatic disease | - Diabetes |
| - Poor thyroid function | - GERD/GPR |
| - Poor nutrition | - Atrophy of party wall |

TE Voice Restoration: Problems & Solutions

30

GERD and Periprosthetic Leakage

Lorenz et al., 2011

- Occurs in approx. 25-45% of pts with VP
- **n = 60 randomly selected pts (mean age of 64.7)**
 - 44/52 XRT
 - 29/60 (48%) reported TEP problems (i.e. recurrent leakage around, enlarged TEP, & atrophy of trachea)
 - All pts received 24hr pH probe using a 2-channel sensor spaced 10cm apart with proximal sensor study placed at the level of the TEP (done at beginning of study and after 6 mos)
- **Results:**
 - Enlarged TEP pts had significantly more reflux events (162.2 ± 144.3) than those without enlarged TEP (71.9 ± 86.8) at $p=0.001$
 - From 2001-2005, pts were not tx'd with PPIs and 24-29 pts required invasive surgeries (i.e. pedicled flaps)
 - Since 2006, aggressive PPI treatments resulted in reduction in # of pts with leakage around & # of highly invasive procedures

TE Voice Restoration: Problems & Solutions

31

Leakage Through the Prosthesis Secondary to STRICTURE

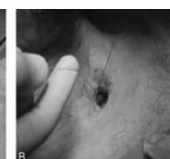
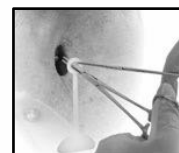


TE Voice Restoration: Problems & Solutions

32

Periprosthetic Leakage Solutions

- Medical workup to uncover the underlying etiology
- Resize TE tract length
- Evaluate swallowing function as indicated
- Prosthetic modifications: XtraFlange, XtraSeal, LEF, custom washer
- Temporary removal of prosthesis to allow puncture to shrink
- Cauterization (i.e., silver nitrate)
- Purse string suture
- Injection of filling materials (i.e. collagen, Cymetra, Restylane)
- Re-evaluate TEP surgical technique
- Surgical closure and repuncture
- Diet modification
- Anti-GERD medication



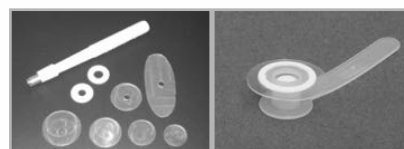
TE Voice Restoration: Problems & Solutions

33

Algorithm for Treating Periprosthetic Leakage

Lorenz et al., 2011

- **Minor Leakage with 8-11mm puncture diameter**
 - Replace with shorter prosthesis
 - Use of a silicone washer (Provox® XtraFlange™)
 - Custom-fit VP with large esophageal flange
 - Aggressive proton pump inhibitor (PPI) therapy
- **Substantially Enlarged TEP with >11mm diameter**
 - Use injectable augmentation material (i.e. GMCSF, collagen, Cymetra, Radiesse)
 - If injectable fails, remove VP for 7-14 days, insert cuffed trach tube and NPO
 - Aggressive PPI therapy
 - If all of above fail, then close TEP surgically
 - Purse string suture?



TE Voice Restoration: Problems & Solutions

34

Periprosthetic (Around) Leakage: Considerations

- **Puncture Evaluation:**
 - Prosthesis too long?
 - Shape of puncture?
 - Position of puncture?
 - Location of leakage?
 - TEP atrophy?
- **Functional Evaluation:**
 - Dysphagia?
 - Stricture?
- **Medical Evaluation:**
 - Recurrent or metastatic disease?
 - Diabetes?
 - Hypothyroidism?
 - Malnutrition?
 - Evidence of **GERD/GPR**?



TE Voice Restoration: Problems & Solutions

35

Problems & Solutions: Immediate Post-fitting Aphonia

- **Causes**
 - Overfitting or underfitting
 - Prosthesis valve is closed
 - Hood of the prosthesis is abutting the posterior esophageal wall
 - Forceful stomal occlusion

TE Voice Restoration: Problems & Solutions

36

Immediate Post-fitting Aphonia: Overfitting and Underfitting

- VP embedded in tracheal or esophageal mucosa
- VP may also be extruded
- **Solutions**
 - Remove prosthesis, stent tract, and resize tract
 - Insert measuring device flush against tracheal wall before retracting to read the size;
 - Check open tract voicing (voicing should be consistent)
 - Insert correct length voice prosthesis and/or rest site if indicated (48 hr) with red rubber catheter

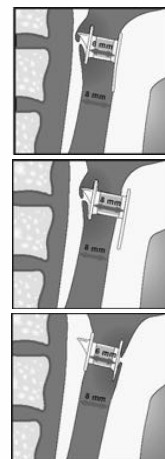


Illustration courtesy of: Elizabeth C. Ward and Corina J. van As-Brooks, Head and Neck Cancer, Treatment, Rehabilitation, and Outcomes

TE Voice Restoration: Problems & Solutions

37

Immediate Post-fitting Aphonia: Prosthesis Valve Closed

- **Solutions**
 - Insert brush into prosthesis
 - Remove the prosthesis and inspect valve, if indicated



TE Voice Restoration: Problems & Solutions

38

Immediate Post-fitting Aphonia: Prosthesis Hood Abutting Posterior Esophageal Wall or Forceful Occlusion

Solutions:

- Place prosthesis with smaller or no hood
- Practice "gentle" occlusion
- Put on Provox® FlexiVoice™ or HME with Titanium Cap to reduce pressure on prosthesis during voicing.



TE Voice Restoration: Problems & Solutions

39

Immediate Post-fitting Aphonia: Assessment Protocol

- Ensure proper fit
- Put brush through the prosthesis
- Check for pressure during stomal occlusion
- Remove prosthesis and assess valve function and open tract voicing

TE Voice Restoration: Problems & Solutions

40

Delayed Post-fitting Dysphonia/Aphonia:

• **Causes**

- Prosthesis valve is closed
- Prosthesis not fully inserted
- TE tract stenosis/closure
- Granulation
- Infection
- False tract
- Separated party wall

TE Voice Restoration: Problems & Solutions

41

Delayed Post-fitting Aphonia: Prosthesis Not Fully Inserted

• **Solutions**

- Remove prosthesis
- Re-dilate & confirm tract direction
- Replace prosthesis
 - Dilate 1-2 sizes up or longer duration
 - Loading tube
 - Capsule



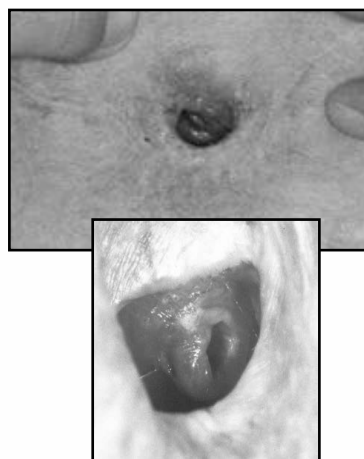
TE Voice Restoration: Problems & Solutions

42

Delayed Post-Fitting Dysphonia/Aphonia: TE Tract Stenosis/Closure

• Solutions

- Remove prosthesis
- Check voice
- Water/leak test
- Medical management as indicated
 - Antibiotics
 - Topical steroid cream
 - Cauterization
 - GERD meds
- Allow puncture tract to heal:
 - Catheter
 - Softer prosthesis
- Resize and refit



Pictures submitted by the Netherlands Cancer Institute

TE Voice Restoration: Problems & Solutions

43

Delayed Post-Fitting Aphonia: Separated Party Wall

• Indicators

- Gradually deteriorating voice
- Difficulty inserting the prosthesis
- Unable to advance catheter or dilator
- Misaligned tract
- 2 “pops” with the sizing device
- TE tract significantly increases

• Solutions

- Use catheter instead of dilator
- Avoid unnecessary replacement
- Antibiotics as needed
- Retrograde placement of prosthesis
- KEY: appropriate sizing (flush against TEP)

Causes Trauma, Infection, XRT

TE Voice Restoration: Problems & Solutions

44

Delayed Post-fitting Aphonia: Assessment Protocol

1. Ensure proper fit
2. Put brush through the prosthesis
3. Remove prosthesis
4. Dilate
5. Assess TE voice with an open tract
6. If fluent, then prosthetic or mechanical problem
 - Resize
 - Choose appropriate type of prosthesis
 - Refit
 - Immediate Post-Fitting Aphonia Protocol if indicated
7. If nonspeaker or nonfluent, then physiologic problem
 - Dilate tract
 - Assess what the physiologic problem could be
 - Check open tract again
 - Medical management as indicated

TE Voice Restoration: Problems & Solutions

45

Accidental Dislodgement

- Don't panic!
- Pt. should lean forward and cough to make sure that prosthesis is not lodged in airway
- Once Pt. is breathing easily, insert catheter in puncture
- Tie exposed end off so that gastric juices do not leak out
- Tape to neck
- If prosthesis wasn't located, go to hospital for chest xray to ensure that prosthesis is not in the lung

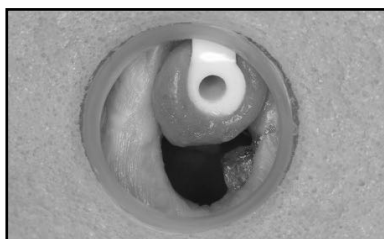
TE Voice Restoration: Problems & Solutions

46

Granulation Tissue

CAUSES

- Inflammation secondary to frequent removal of prosthesis
- Irritation/rubbing from prosthesis
- Chronic GERD (Pattani et al. 2009)



TREATMENT

- Remove granulation tissue
- Clean prosthesis in situ and remove only due to difficulties voicing or leakage
- Ensure correct fit of TEP
- Mometasone Furoate
- Silver Nitrate
- Anti-GERD meds

TE Voice Restoration: Problems & Solutions

47

Pharyngeal Constrictor Hypertonicity/Spasm

• **Indicators**

- Strained, tight, effortful voicing
- Inability to produce voice
- Tight & dysfluent voice with or w/o prosthesis
- Elevated intraesophageal pressure during objective insufflation testing
- No dysphagia or stricture
- Patent TE tract
- Voice improvement following pharyngeal plexus lidocaine block

TE Voice Restoration: Problems & Solutions

48

Pharyngeal Constrictor Hypertonicity/Spasm

• Solutions

- Therapeutic lidocaine block
- Botox
- Dilation
- Myotomy
- Manual manipulation

TE Voice Restoration: Problems & Solutions

49

Pharyngeal Constrictor Hypertonicity/Spasm Botox for PE Spasm Lewin et al., 2001

1. Inject 5% Lidocaine solution (CP segment) without Epinephrene
2. Diagnostic fluoro study (in lateral & AP view)
 - Mark high and low margins of stricture
 - Select mid-point
3. High dose injection of Botulinum Toxin (100 plus mouse unit dose)
4. EMG used to measure action potentials.



TE Voice Restoration: Problems & Solutions

50

Hypotonicity

- **Indicators**

- Voice often intermittent wet/gurgly
- Soft, weak and/or breathy voice

- **Solutions**

- Digital pressure
- Pressure band
- Head positioning
- Stomal occlusion vs. hands free speech
- If only during hands-free speech use FreeHands Stomal Support

TE Voice Restoration: Problems & Solutions

51

Gastric Bloating

- **Causes**

- Increased esophageal pressure causing air inhalation through voice prosthesis
- Aerophagia
- Resulting from hypertonicity/spasm which forces air inferiorly during voicing
- Stricture

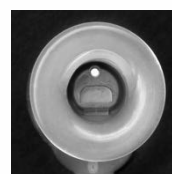
TE Voice Restoration: Problems & Solutions

52

Gastric Bloating

• Solutions

- Use duckbill, NiD, increased resistance prosthesis or ActiValve
- Use plug if indicated
- Teach patient to swallow with less pressure
- If severe, physician referral (GI should be consulted)



TE Voice Restoration: Problems & Solutions

53

Studies Referenced

- Alandejani, T, Marsan, J, Ferris, W, Slinger, R & Chan, F. Effectiveness of honey on *Staphylococcus aureus* and *Pseudomonas aeruginosa* biofilms. *Otolaryngology-Head and Neck Surgery* (2009) 141, 114-118
- Busscher, HJ, Bruinsma, G., van Weissenbruch, R., Leunisse, C., Van der Mei, HC, Dijk, F & Albers, FWJ. The effect of buttermilk consumption on biofilm formation on silicone rubber voice prostheses in an artificial throat. *Eur Arch Otorhinolaryngo* 1998; 255: 410-413.
- Douglas, IJ. Candida biofilms and their role in infection. *Trends Microbiol* 2003;11.: 30-36.
- Free, RH, Elving, G, Van der Mei, HC, Van Weissenbruch, R., Albers, FWJ, & Busscher, HJ. Caffeinated soft drinks reduce bacterial presence in the voice prosthetic biofilms. *Biofouling* 2000; 16: 69-76.
- Free, RH, Van der Mei, HC, Dijk, F., Van Weissenbruch, R., Busscher, JH, & Albers, FWJ. Biofilm formation on voice prostheses: *In vitro* influence of probiotics. *Ann Otol Rhinol Laryngol* 2001; 110: 946-951.
- Free, R.H., van der Mei, H.C., Elving, G.J., van Weissenbruch, F.W., Albers, J. & Busscher, H.J. Influence of the Provox Flush®, Blowing and Imitated Coughing on Voice Prosthetic Biofilms in Vitro. *Acta Otolaryngol* 2003;123(4):547-551.
- Graville DJ, Palmer AD, Andersen PE, Cohen JI. Determining the efficacy and cost-effectiveness of the ActiValve: results of a long-term prospective trial. *Laryngoscope* 2011;121(4):769-776.
- Hilgers FJ, Ackerstaff AH, Balm AJ, Van den Brekel MW, Bing T, I, Persson JO. A new problem-solving indwelling voice prosthesis, eliminating the need for frequent Candida- and "underpressure"-related replacements: Provox ActiValve. *Acta Otolaryngol* 2003;123(8):972-979.

TE Voice Restoration: Problems & Solutions

55

Studies Referenced

- Jacobs, K., Delaere, P. & Vander Poorten, VLM. (2008). Submucosal Purse String Suture as a Treatment of Leakage Around the Indwelling Voice Prosthesis. *Head and Neck* : 485-491.
- Lewin, J.S., Bishop-Leone, J.K., Forman, A.D., & Diaz, E.M. (2001). Further experience with botox injection for tracheoesophageal speech failure. *Head & Neck*, 23 (6): 456-460.
- Lorenz, Grieser, Ehrhart. & Maier.(2011). The management of periprosthetic leakage in the presence of supra-oesophageal reflux after prosthetic voice rehabilitation. *Eur Arch Otorhinolaryngol*, 268[5], 695-702.
- Mahieu, H. F., van Saene, H. K., Rosingh, H. J., and Schutte, H. K., Candida vegetations on silicone voice prostheses, *Arch.Otolaryngol.Head Neck Surg.*, 112[3], 321-325. 1986.
- Mahieu, H. F., van Saene, J. J., den, Besten J., and van Saene, H. K., Oropharynx decontamination preventing Candida vegetation on voice prostheses, *Arch.Otolaryngol.Head Neck Surg.*, 112[10], 1090-1092. 1986.
- Manning, S.C. Basics of biofilm in clinical otolaryngology. *Ear, Nose & Throat Journal*. 2003; 82(2): 18-20
- Schwandt, vanWeissenbruch, van der Mei, Busscher, & Albers (2005). Effect of Dairy Products on the Lifetime of Provox2 Voice Prosthesis in Vitro & in Vivo. *Head & Neck*; 27(6): 471-477.
- Soolsma J, Van den Brekel MW, Ackerstaff AH, Balm AJ, Tan B, Hilgers FJ. Long-term results of Provox ActiValve, solving the problem of frequent candida- and "underpressure"-related voice prosthesis replacements. *Laryngoscope* 2008;118(2):252-257.

Studies Referenced

- Timmermans AJ, Harmsen HJ, Bus-Spoor C, Buijsen KJ, van As-brooks C, de Goffau MC, Tonk RH, van den Brekel MW, Hilgers FJ, van der Laan BJ. Biofilm formation on the Provox ActiValve: Composition and ingrowth analyzed by illumina paired-end RNA sequencing, fluorescence in situ hybridization and confocal laser scanning microscopy. *Head and Neck* 2015; 12
- Van der Mei, Free, Elving, VanWeissenbruch, Albers, & Busscher (2000). Effect of probiotic bacteria on prevalence of yeasts in oropharyngeal biofilms on silicone rubber voice prostheses in vitro. *J. Med. Microbiol*, 49: 713-718.
- Williams, Kuriyama, Silva, Malic & Lewis. Candida Biofilms and oral candidosis: treatment and prevention. (2011) *Periodontology* 2000, 55:250-265.