Tongue movement and speech following partial lateral tongue resection (glossectomy): Findings from 2D and 3D ultrasound imaging

Tim Bressmann, Orchid Rastadmehr, Heather Flowers

Department of Speech-Language Pathology, University of Toronto

Jonathan C. Irish

Princess Margaret Hospital, University Health Network, Toronto

With the help and support of:

- Voice and Resonance Lab:
  - Elizabeth Ackloo, Yarixa Barillas, Brent Carmichael, Chiang-Le Heng, Bill Johnson, Roxanna Smallwood, Ihab Suwwan
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Cancer of the tongue

Approaches to the reconstruction of lingual resection defects

- Primary wound healing:
  - The defect is left open to heal
- Local closure:
  - Surrounding tissue is closed over the defect
- Local flap/ pedicle flap closure:
  - A tissue flap is lifted close to the defect but retains its original blood supply
- Free flap closure:
  - Tissue is lifted somewhere else on the body and transplanted into the defect site. Requires reconnection to tiny local blood vessels (anastomosis)

Approaches to defect reconstruction

Local reconstruction

Free flap (radial forearm)

Gracilis free flap

What we know:

- A loss of lingual tissue necessarily leads to a reduced movement range (Nicoletti et al. 2003, Pauloski et al., 1998).
- This reduced movement range is believed to cause the speech distortions (Korpijaakko-Huuhka et al., 1998).
- Speech therapy interventions for glossectomy speakers often focus on lingual strengthening exercises (Appleton & Marchin, 1995; Leonard, 1994).

Question

- Which factors determine speech acceptability (and intelligibility) after a glossectomy operation?

- Defect localization?
- Defect size?
- Defect reconstruction?
- Non-speech tongue motility?

Study 1:
Static 3D ultrasound analysis of 12 speakers before and after lateral lingual resections and reconstructions

Participants

- 12 patients: 8 males, 4 females
  - Mean age 45.67 years (SD 10.39)
  - Age range: 31-58 years
- Tumour locations:
  - 'right' lateral tongue
- Reconstructive techniques:
  - defect closure with free flaps in 5 patients
  - local defect closure in 7 patients

- 12 controls (6 females, 6 males)
  - Mean age 26.0 years (SD 11.6; range 20-31)

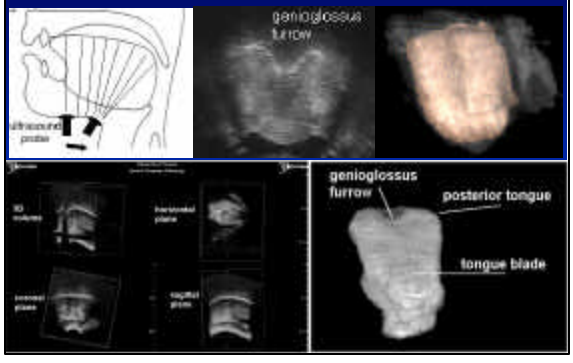
Materials and methods

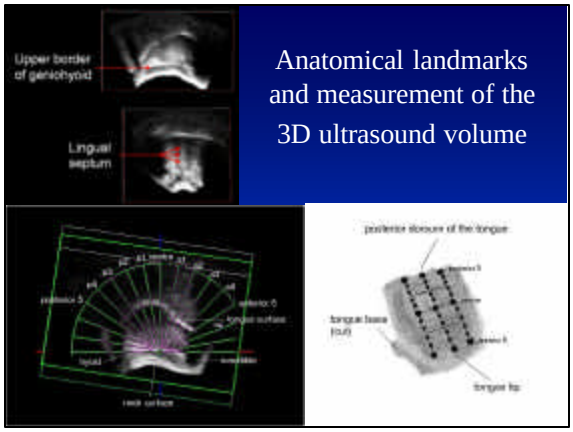
- Sustained speech sounds (x3):
  - Vowels: /a/, /i/, /u/
  - Consonants: /s/, /ʃ/, /l/, /r/, /n/, /ŋ/

- Ultrasound equipment:
  - GE Logiq á 100 MP ultrasound machine with a E72 endocavity transducer (6.5 MHz)
  - 3D Echotec FreeScan workstation with an Ascension Technology PC-Bird electromagnetic movement sensor

- Assessment of speech acceptability (preliminary):
  - Three listeners evaluated 20 TOCS+ sentences using a 4-point rating scale

3D ultrasound



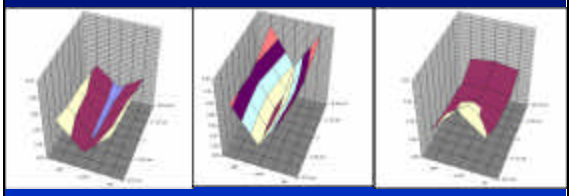


Anatomical landmarks and measurement of the 3D ultrasound volume

Analyses

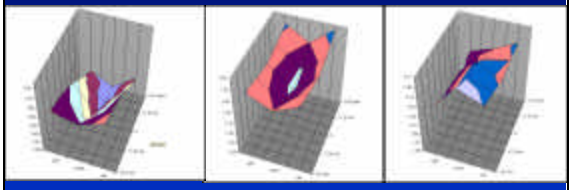
- Qualitative appraisal of tongue surface plots
- Identification of functional segments using Principal Component Analyses
- Concavity
- Asymmetry
- Anteriority – not reported here

3D surface reconstruction of /s/



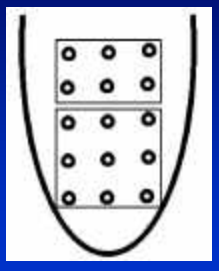
Normal speakers | patient pre-operative | patient post-operative

3D surface reconstruction of /ʃ/



Normal speakers | patient pre-operative | patient post-operative

Functional topography of the tongue surface in normal speakers and in the patients before the surgery: Principal component analysis



Component 1: 'Protrusion/ retraction'

Protrusion: inferior genioglossus

Retraction: hyoglossus

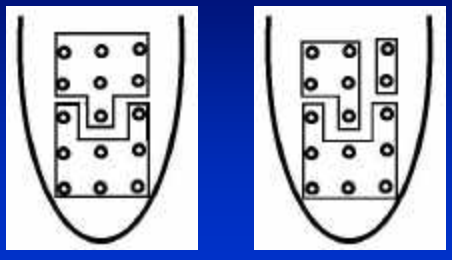
Component 2: 'Dorsal position/ height control'

Height control/ anterior pull: Superior genioglossus

Retraction: Styloglossus

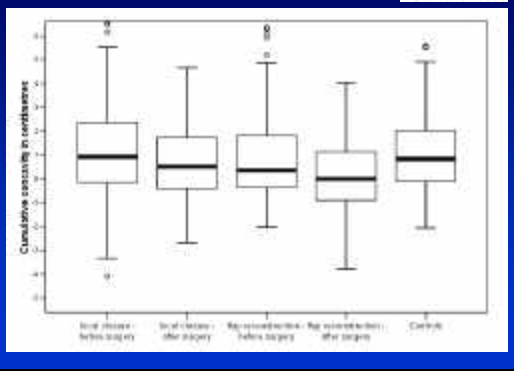
(Component 3: 'Tongue blade control')

Functional topography of the tongue surface in the patients after the glossectomy: Principal component analysis

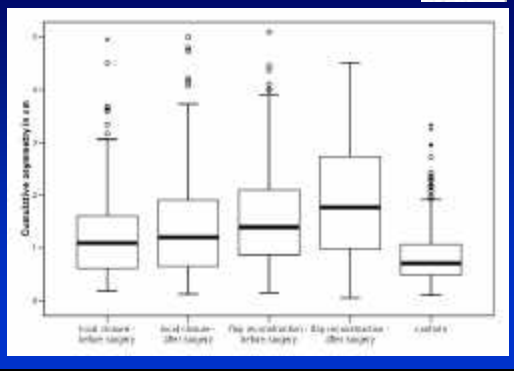


local reconstruction | flap reconstruction

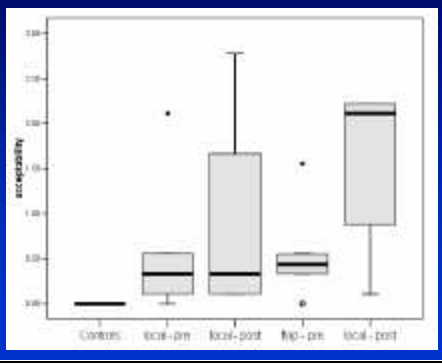
Concavity



Asymmetry



Speech acceptability ratings



Correlations

- Correlation between the amount of change and the postoperative speech acceptability
- Concavity: r=.688* (p<0.02)
- Asymmetry: n.s.
- Anteriority: n.s.

Discussion (I)

- The 3D ultrasound imaging technology allowed to visualize and quantify the normal and partially resected tongues
- The principal component analysis identified two main functional components in the tongue dorsum (protrusion/ retraction and dorsal position/ height control)
  - In the patients with flap reconstructions, a new principal component emerged, involving the affected side

Discussion (II)

- The concavity measure demonstrated a postoperative decrease in midsagittal grooving
  - More pronounced in the patients with flap reconstructions than in the patients with local closures
- The asymmetry measure demonstrated increased asymmetry between the two sides of the tongue
  - More pronounced in the patients with flap reconstructions than in the patients with local closures

Discussion (III)

- The speech acceptability ratings demonstrated that the patients with flap reconstructions had worse results than the patients with local reconstructions
- The amount of change from the pre- to the postoperative concavity values correlated moderately with the postoperative speech acceptability ratings

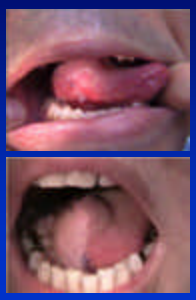
Study 2:
The impact of lateral tongue resections on midsagittal tongue movement in speech

Hypotheses

- Decrease in velocity of midsagittal tongue movement after glossectomy
- Decrease in range of midsagittal tongue motion after glossectomy
- Decrease in the vowel space after glossectomy
- Decrease in speech intelligibility

Participants

- 10 patients with partial lateral tongue resection (5:T1, 3:T2, 2:T3)
  - 34 - 64 years of age (M: 45 SD: 8.4)
  - Five received local closure reconstruction and five received free flaps
- 6 adults with normal speech (comparison group)
  - 25 - 55 years of age (M: 38 SD: 10.1)

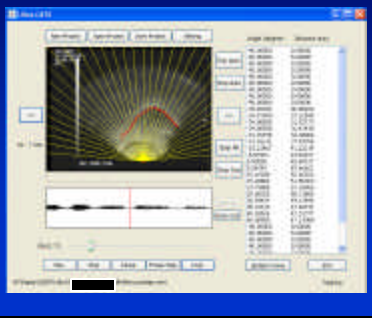


Tasks

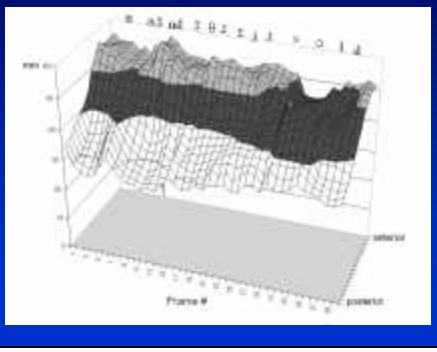
- Midsagittal Tongue Movement:
  - The first 4 sentences from the Grandfather passage (Van Riper,1962)
- Vowel Space
  - VCV syllable repetition : /aka/, /iki/, /uku/, /ata/, /iti/, and /utu/
  - → Not discussed here
- Speech intelligibility
  - Word and sentence modules of the TOCS+ program (Hodge & Daniels, 2004)

Comfortable Head Anchor for Sonographic Examinations (CHASE)

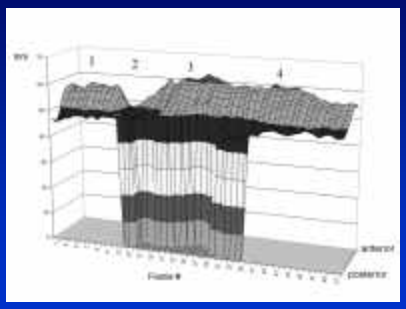
Ultrasonographic Contour Analyzer for Tongue Surfaces (Ultra-CATS)



Sample data: '… ninety-three years old'

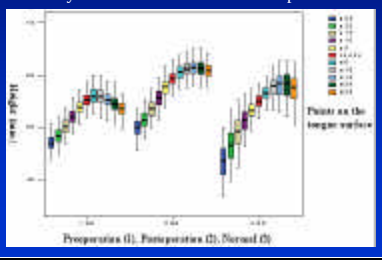


Sample data: Water swallow

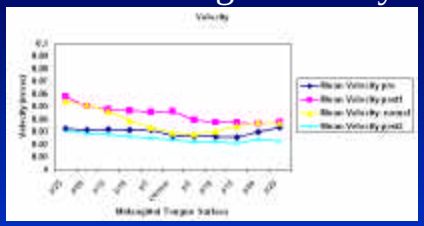


Results: Tongue elevation

- In all the patients, the average distance from the transducer to the midsagittal tongue surface increased postoperatively.
- The average distance was greater in patients after glossectomy than in adults with normal speech.



Results: Tongue velocity



- 0.029 m/sec (SD: 0.0027) before glossectomy
- 0.044 m/sec (SD: 0.0065) two months after the operation.
- 0.025 m/sec (SD:0.0029) 6 -12 months after the operation.
- Controls 0.038 m/sec (SD: 0.0084).

Results: Word intelligibility and acceptability

- Speech intelligibility:
  - 86% before
  - 87% after
- Acceptability
  - 72% before
  - 62% after
- Association between word intelligibility & velocity
  - r=-0.778** (p<0.02)

Results: Sentence intelligibility and acceptability

- Speech intelligibility:
  - 92% before
  - 94% after
- Acceptability
  - 69% before
  - 63% after
- Association between sentence intelligibility & velocity
  - r=-0.794** ($p<0.02$)

Discussion

- After the glossectomy surgery, tongue cancer patients increased the velocity of their midsagittal tongue movements in order to compensate for the loss of lateral tongue tissue.
  - This finding may contradict the clinical practice of range-of-movement exercises (Applteon & Marchin, 1995; Leonard, 1994).
- The increase in velocity was correlated with a decrease in speech intelligibility
- Six months after glossectomy, the patients' lingual velocity was similar to the preoperative performance levels.

Questions?

Contact:
tim.bressmann@utoronto.ca

Voice and Resonance Lab webpage:
http://www.slp.utoronto.ca/English/Voice-and-Resonance-Laboratory.html