

**SERVIZIO SANITARIO REGIONALE
EMILIA-ROMAGNA**
Azienda Sanitaria Locale della Romagna

Videofluoroscopy course by ESSD

***Norm data in the metrics
(timing, space, velocity, flow variables)***

Daniele Farneti

Performing Interpretation

General considerations

***Norm data in the metrics
(timing, space, velocity, flow variables)***

Performing: *setting, contrast medium, volumes, n. trials....*

Interpretation

General considerations

***Norm data in the metrics
(timing, space, velocity, flow variables)***

Despite empirical evidence to support the use of standardized VFSS protocols, they are not widely applied in clinical practice for a variety of reasons.

(Gosane and Suitner, 2019)

What do VFSS look like at your facility?

Performing **Interpretation**

General considerations

***Norm data in the metrics
(timing, space, velocity, flow variables)***

They reflect our “borrowings” from other clinicians and investigators, as well as many of our own conventions, and over time have proven useful to us in assessing our patients.

(Leronard and Kendall, 2014)

.....try to “measure” it.

Performing Interpretation

.....try to “measure” it.

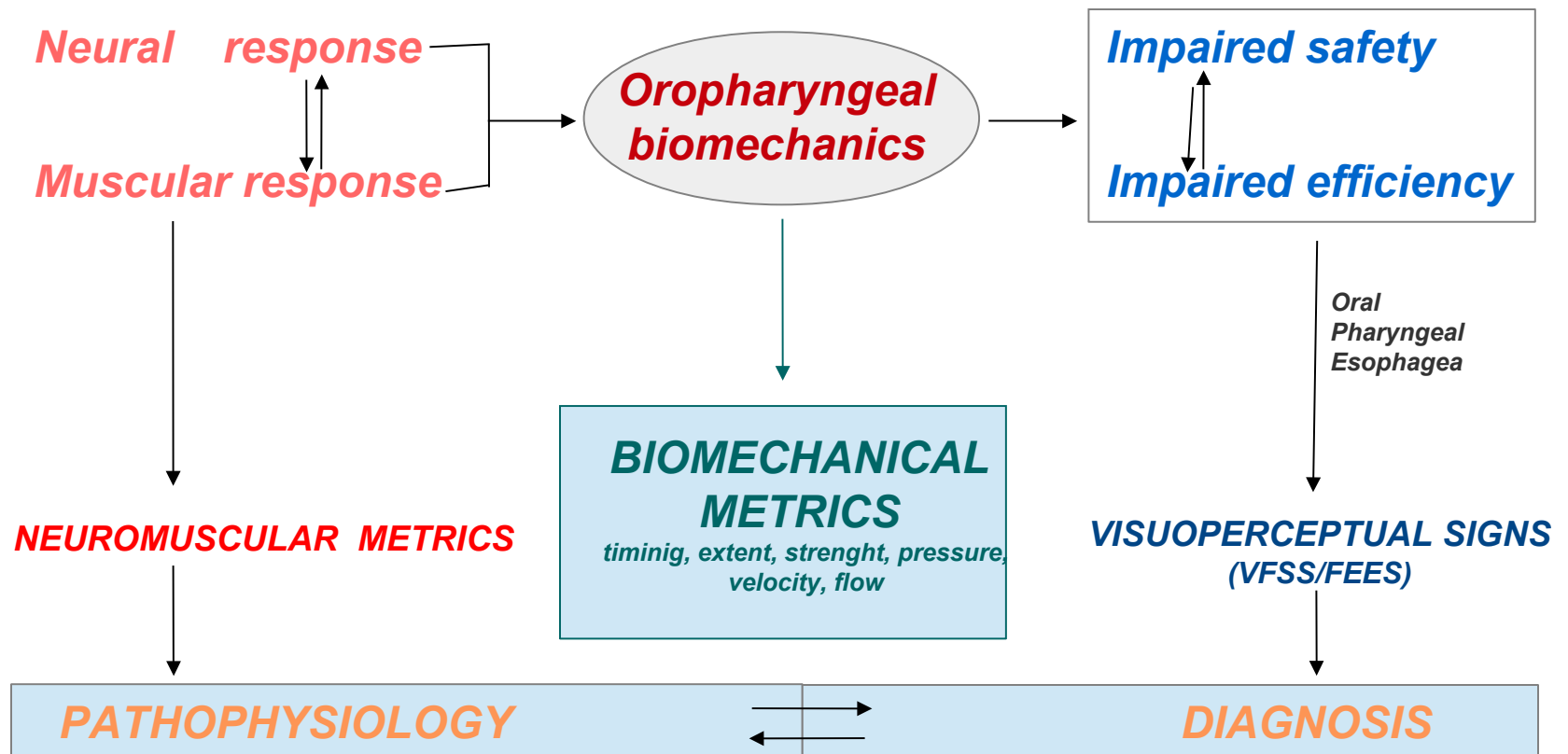
- *Provide a structured approach to observation*
- *Standardize reporting technique, improve communication*
- *To establish inter- and intra-rater reliability*
- *As a resource for audit and research*
- *To demonstrate change in repeated assessments and its use as an outcome measure for therapeutic purposes*
- *Inform:*

Safety of oral intake and compensatory

Strategy recommendations

Grounds for referral to other specialists

Physiological measurements of swallow function: metrics and signs



Performing

Interpretation: 3D —————> 2D

General considerations

***Norm data in the metrics
(timing, space, velocity, flow variables)***

VFSS

3D

Head-Neck Structures (Effectors):

- . anatomy**
- . movement**

2D

Visual-perceptual measures (adaptations):

- Anatomy and injuries**
- Presence and absence of predefined events**
- Movement patterns (kinematics and times)**

Basic psychometric properties

- Objectivity / correctness**
- The extent to which test reviews are free of bias in their assessments**
- Reliability (Intra / Inter / Test-retest)**
- The extent to which a measurement is reliable under similar conditions**
- Validity (content / construct / criterion)**
- The extent to which a test measures what the clinician / researcher intends to measure**

Detailed standards: COSMIN <https://www.cosmin.nl/>

Article

A Visuoperceptual Measure for Videofluoroscopic Swallow Studies (VMV): A Pilot Study of Validity and Reliability in Adults with Dysphagia

Katina Swan ¹, Renée Speyer ^{1,2,3}, Martina Scharitzer ⁴, Daniele Farneti ⁵, Ted Brown ⁶ and Reinie Cordier ^{1,7,*}

Dysphagia
<https://doi.org/10.1007/s00455-020-10174-3>

ORIGINAL ARTICLE

2022

Visuoperceptual Analysis of the Videofluoroscopic Study of Swallowing: An International Delphi Study

Katina Swan ¹  · Reinie Cordier ^{1,2}  · Ted Brown ³  · Renée Speyer ^{1,4,5} 


Dysphagia
<https://doi.org/10.1007/s00455-018-9918-3>

REVIEW ARTICLE



2020

Psychometric Properties of Visuoperceptual Measures of Videofluoroscopic and Fibre-Endoscopic Evaluations of Swallowing: A Systematic Review

Katina Swan ¹  · Reinie Cordier ¹ · Ted Brown ² · Renée Speyer ^{1,3,4}

2018

2.4. Manual

A manual was constructed based on Delphi study results. This manual includes: detailed instructions on contrast preparation, administration, patient positioning, items with descriptions, response scales, instructions for rating items, and anchor images [16].

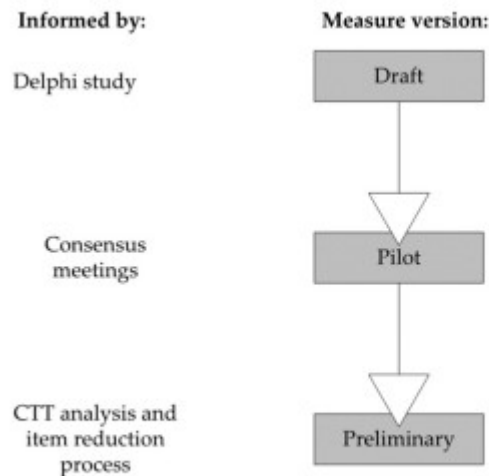


Figure 1. Overview of measure development and versions of the VMV.

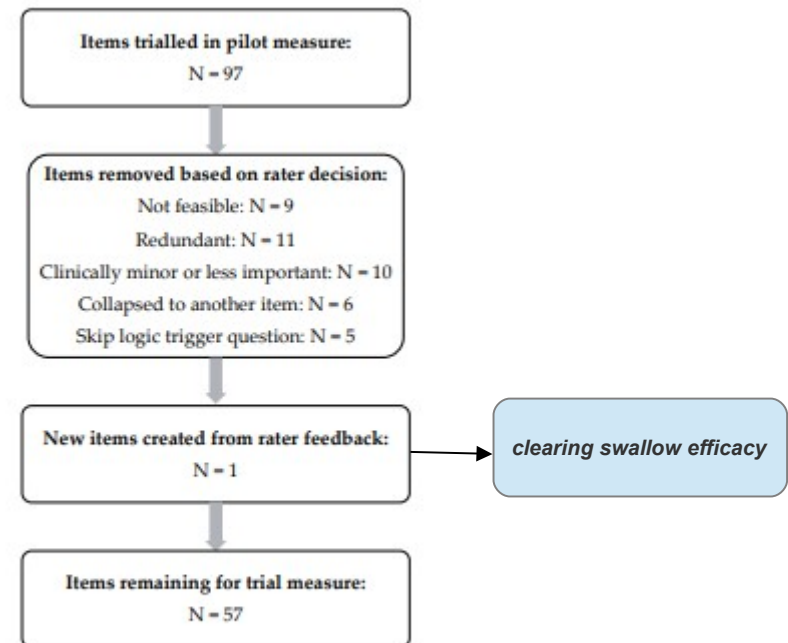


Figure 3. Item reduction from rater feedback.

One new item, ‘clearing swallow efficacy’, was created with data derived from items rating the volume residue that remained after clearing swallow/s.

Pilot: Results – Inter/intra-rater reliability

Table: Interrater reliability Average and per Texture Weighted Kappa

	<i>Rater One vs Two</i>	<i>Rater One vs Three</i>	<i>Rater Two vs Three</i>	<i>Average</i>
Thick	0.932	0.886	0.882	0.900
Thin	0.930	0.866	0.860	0.885
Pudding	0.939	0.874	0.868	0.894
Solids	0.934	0.892	0.852	0.893
Anterior- Posterior	0.868	0.910	0.842	0.873
Total (Average)	0.921	0.886	0.861	0.889

Intra-rater average: 0.944 *no effect of differences in textures noted*

Pilot: Results – internal consistency

<i>Factors and categories of items within the factor</i>	<i>Cronbach's Alpha</i>
<i>Factor 1: Lingual control and motion, velum motion, oral and oropharynx residue</i>	0.810
<i>Factor 2: Number of swallows, clearing swallows and pharyngeal contraction</i>	0.861
<i>Factor 3: Hyoid and larynx movement</i>	0.876
<i>Factor 4: UES</i>	0.836
<i>Factor 5: Premature spillage and swallow initiation</i>	0.698
<i>Factor 6: Aspiration and underside epiglottis residue</i>	0.934
<i>Factor 7: Epiglottis movement, aspiration, penetration permanence and response and LVC</i>	0.873
<i>Factor 8: Penetration</i>	0.853
<i>Factor 9: Pharyngeal wall movement, pharyngeal residue and clearing swallows</i>	0.714
<i>Total Measure</i>	0.902

Pilot: Results – Hypothesis Testing

Hypothesis One: Factor scores will be significantly positively correlated with FOIS and VAS scores in 70% of factors.

- *Supported*

Hypothesis Two: There will be no significant difference on item scores between genders.

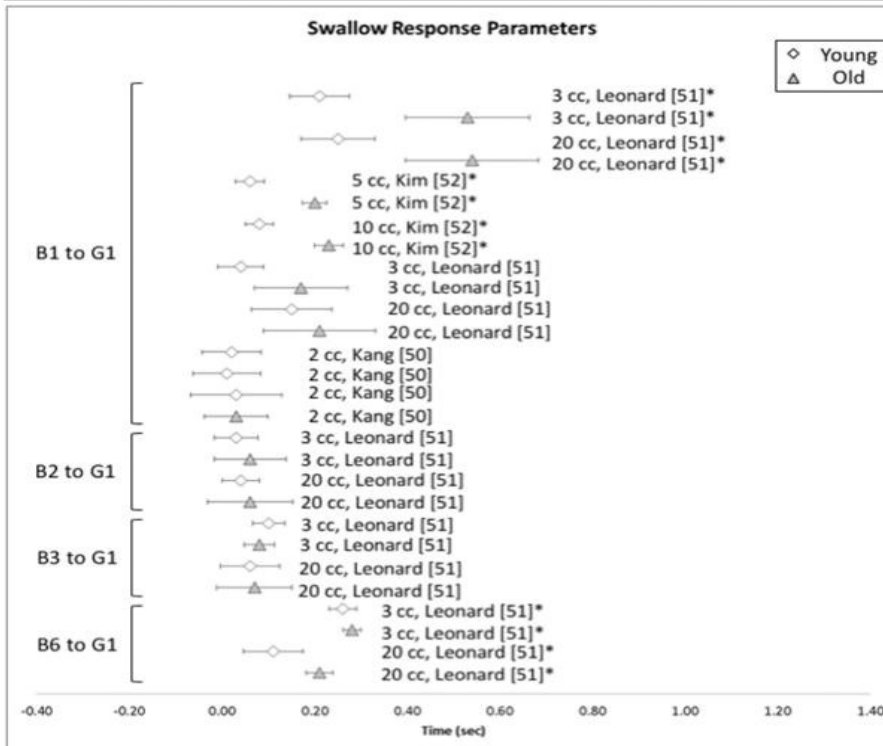
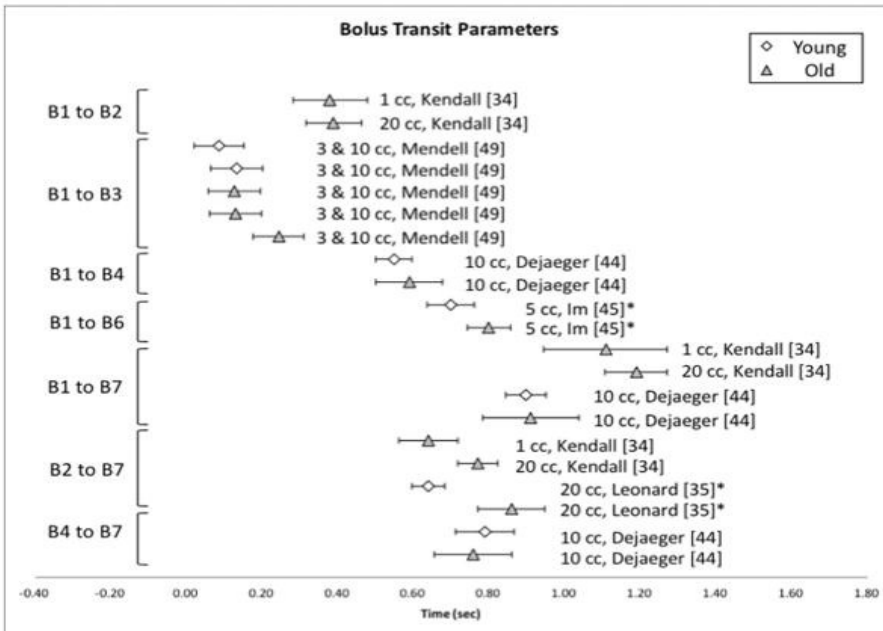
- *Supported*

Timing of Swallowing

Many measures (and definitions of measures) used in the literature

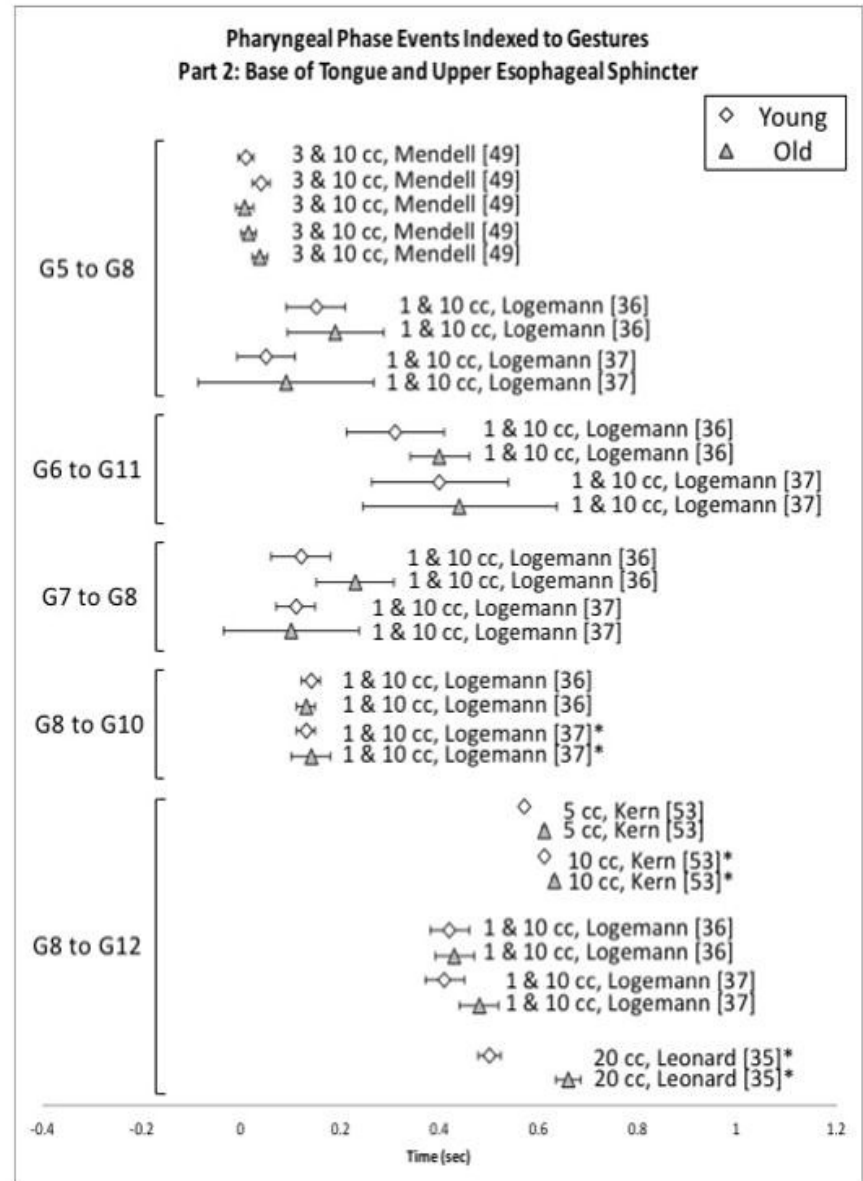
Namasivayam, MacDonald et al, 2018

Molfenter & Steele, 2012 found 119 different temporal measures in use



A review of swallow timing in the elderly

(Namasivayam-MacDonald AM et al. 2018)



Timing of Swallowing

Overview of selected VFSS Measurements



(not exhaustive)

Measurement	What does it measure?
MBSImp™ (Martin-Harris et al., 2008)	17 physiological components ratings
Penetration Aspiration Scale (Rosenbek et al., 1996)	Airway invasion level and patients' response (penetration/aspiration)
Kinematic measures (many investigators)	Movement patterns of structures
Temporal/timing measures (many investigators)	Onset, offset, duration, reaction time of events
Dynamic Imaging Grade of Swallowing Toxicity (DIGEST) (Hutcheson et al., 2017)	Penetration, aspiration, residue
Computational Analysis of Swallowing Mechanics (CASM) (Thompson et al., 2014)	Shape and movement patterns of structures
ASPEKT (Steele et al., 2019)	Comprehensive measure

(Malandraki G. 2021)

Timing of Swallowing

frm/sec

Technical prerequisite

Swallow Motor Response
(integrity of the motor response)

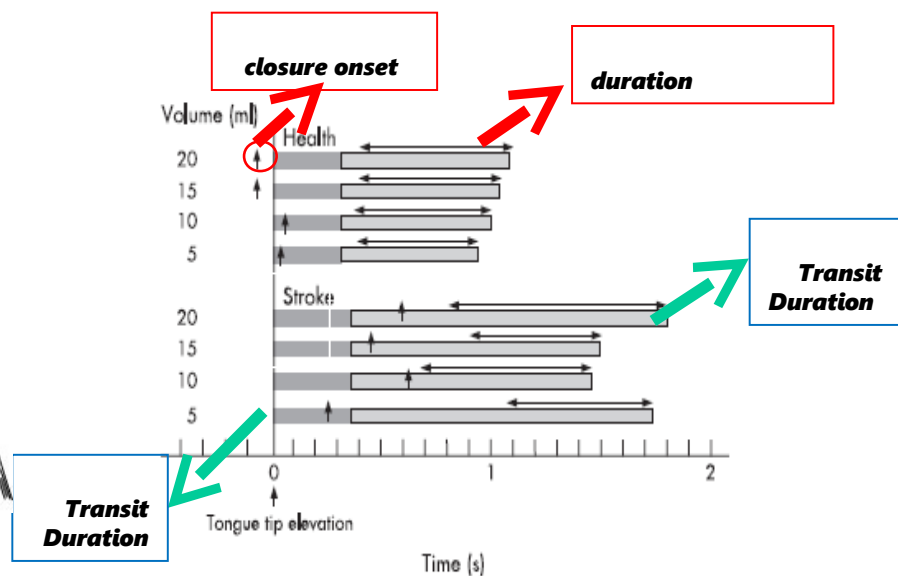
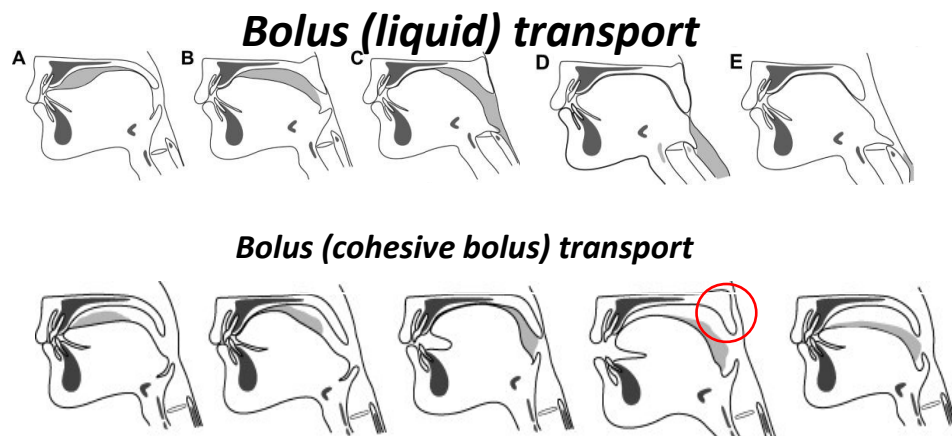
landmarks (key points) **definition**

displacement: distance

measurement: durations

Lateral view

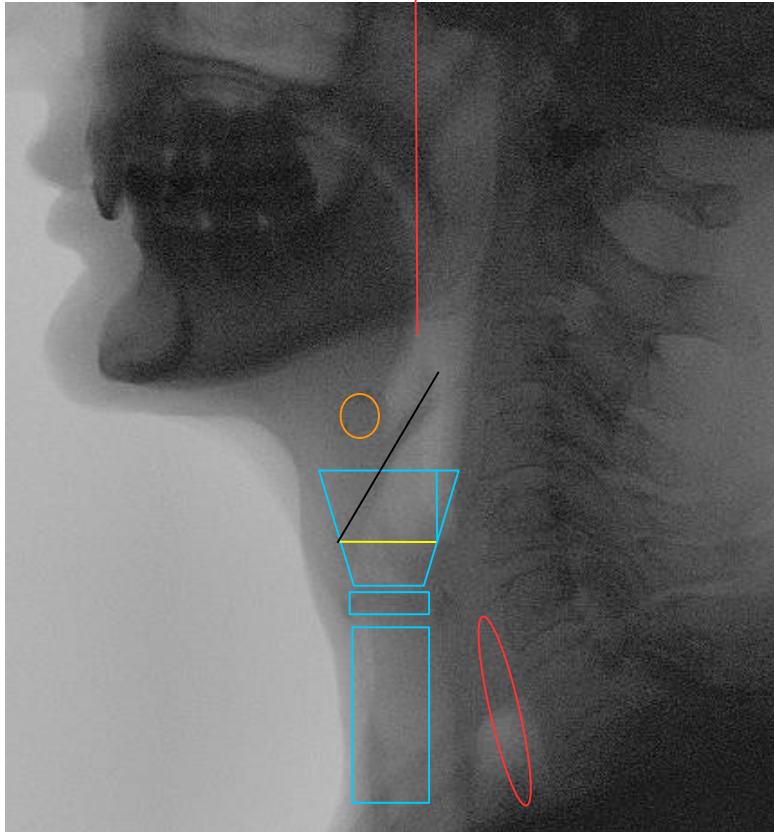
Analysing Physiological measures



Topographic Anatomy

Oral

Pharyngeal



Landmarks definition

Pharyngeal phase

Nasopharynx

Oropharynx: vallecula

Hypopharynx: pyriform sinus

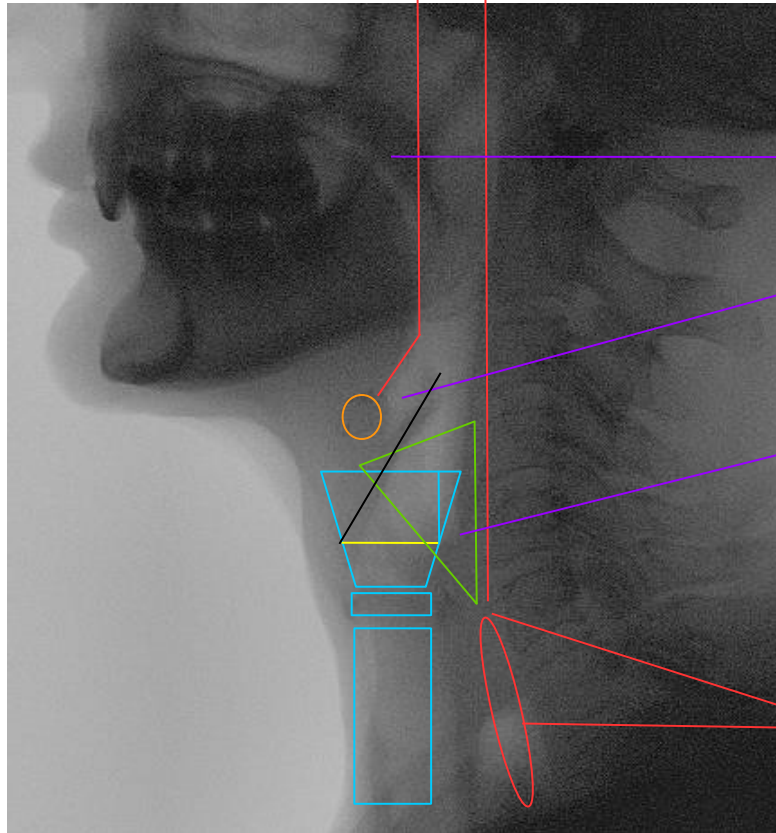
Esophageal phase

UES area

Topographic Anatomy

Oral

Pharyngeal



Landmarks definition

Pharyngeal phase

Nasopharynx

Oropharynx: vallecula

Hypopharynx: pyriform sinus

Esophageal phase

UES area

Timing of Swallowing

- . *lateral projection*

- . *movements of the hyoid and bolus (head and tail)*

DST (duration of stage transition) or **STD** (stage transition duration) head of the bolus at the point of contact between the base of the tongue and the ramus of the mandible and the highest and anterior point reached by the hyoid

0,03-0,06 seconds for a bolus of 3 ml (Rosembek et al. 96)

-OTD (oral transit duration)

bolus head in the pharynx

-PTD (pharyngeal transit duration)

bolus in the pharynx

bolus tail into the esophagus

-OPTD (oropharyngeal transit duration)

posterior movement ed

entry of the tail of the bolus into the esophagus

- OPSE (oropharyngeal swallow efficiency)

Timing of Swallowing

OPSE (oropharyngeal swallow efficiency)

*relationship between speed of movement and bolus clearing
expresses the efficiency of the swallowing act*

- . 98-100% of a 1 cc liquid bolus on the first swallow*
- . volume and viscosity of the bolus*
- . subjective parameter (% of inhaled or stagnant bolus)*

OPSE = 100 – (% residue + % aspiration) / oropharyngeal transit time

OPSE = % bolus transported to the esophagus / OTD + PTD

Dynamic Swallow Studies: Measurement Techniques

Rebecca Leonard

B1	Onset of bolus transit through the pharynx. In our studies, this time represents the "zero" point to which all later events during the swallow are compared. It is defined as the first movement of the bolus past the posterior nasal spine that leads to a swallow. If the bolus is large, its head may extend beyond the posterior nasal spine at "Hold." If a portion of bolus material falls in or towards the valleculae early, this is regarded as valving failure or inadequate instruction/attention and is considered a part of oropharyngeal transit, that is, B1 would start with the early bolus loss. OPT would likely be prolonged in this case, and the explanation for it (inability to contain the bolus orally, inattention, etc.) would be included in the narrative.
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Em	Epiglottis returns to its upright position; supraglottic airway opens.

*Transfert of the bolus from the mouth
Time 0*

Transfert of the bolus trough the pharinx

Transfert of the bolus trough the PES

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Timing measures presented for Both Bolus Transit and Swallow Gesture events During swallow. Exact order may vary depending on characteristics of bolus and on individual impairment to normal swallow

Dynamic Swallow Studies: Measurement Techniques

Rebecca Leonard

**PHARYNGEAL
TRANSIT TIME:
BP2 - BP1**

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trough the pharinx*

*Transfert of the bolus
trough the PES*

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Dynamic Swallow Studies: Measurement Techniques

Rebecca Leonard

OP transit time
BV1 - B1

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Dynamic Swallow Studies: Measurement Techniques

Rebecca Leonard

HP transit time
BP2 - BV2

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Dynamic Swallow Studies: Measurement Techniques

Rebecca Leonard

Duration of Aerway closure

AEc - AEs

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Aerway Closure

AEstart: 1st frame

AEclose: completion

Swallowing Gestures Times

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Dynamic Swallow Studies: Measurement Techniques

Rebecca Leonard

Maximum hyoid displacement
H3 - H2

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Em	Epiglottis returns to its upright position; supraglottic airway opens.

Hyoid displacement:

H1: first sup-ant displ.

H2: max sup-ant displ.

H3: first retreat

Swallowing Gesture Times

Timing measures presented for Both Bolus Transit and Swallow Gesture events During swallow. Exact order may vary depending on characteristics of bolus and on individual impairment to normal swallow

Dynamic Swallow Studies: Measurement Techniques

Rebecca Leonard

PES opening duration
Pcl - Pop

B1	Onset of bolus transit through the pharynx. In our studies, this time represents the "zero" point to which all later events during the swallow are compared. It is defined as the first movement of the bolus past the posterior nasal spine that leads to a swallow. If the bolus is large, its head may extend beyond the posterior nasal spine at "Hold." If a portion of bolus material falls in or towards the valleculae early, this is regarded as valving failure or inadequate instruction/attention and is considered a part of oropharyngeal transit, that is, B1 would start with the early bolus loss. OPT would likely be prolonged in this case, and the explanation for it (inability to contain the bolus orally, inattention, etc.) would be included in the narrative.
AEs	Start of arytenoid-epiglottis approximation to close the supraglottic airway.
H1	First onset of hyoid displacement that leads to a swallow. The hyoid sometimes moves around prior to the swallow. Try to be certain you identify H1 as the <i>first movement that leads to the swallow</i> . The nature of this movement is typically quite distinctive, so rapid and abrupt that it is blurred/hard to recognize in the fluoro study. In some patients, the hyoid is elevated at "Hold," possibly in response to expected difficulty. This can be noted in the narrative and may explain hyoid displacement that appears reduced during the swallow.
BV1	Bolus head arrival at the base of the valleculae.
BV2	Exit of bolus head from the valleculae (apparent with small bolus sizes; with larger sizes, BV1 and BV2 are typically the same because the bolus does not stay in the valleculae or is flowing laterally.)
AEc	Arytenoid-epiglottis approximation indicating supraglottic airway closure is maximally achieved.
H2	Hyoid arrival at maximum displacement (typically, anterior and superior). In some cases, the hyoid may pause at this point; if not, it may take checking several spots to know which represents the maximum displacement from Hold.
Pop	First opening of the lumen at the PES during swallow (defined as the narrowest point between C4 and C6).
BP1	Head of bolus enters PES. If it doesn't, this is noted in the narrative.
PES max	PES achieves maximum opening during the swallow.
H3	Hyoid begins to retract from maximum displacement.
HLmax	Hyoid and larynx achieve maximum approximation during the swallow.
PA max	Pharyngeal chamber is maximally obliterated/constricted during the swallow.
BP2	Tail of bolus clears PES. If it doesn't, this is noted in the narrative.
Pcl	PES closes. If it doesn't, no time is recorded for this event. In normal swallowers, Pcl and BP2 are typically the same.
Em	Epiglottis returns to its upright position; supraglottic airway opens.

PES dynamic

op: opening.

max: max opennig

cl: closes

Swallowing

Gestures

Times

Timing measures presented for Both Bolus Transit and Swallow Gesture events During swallow. Exact order may vary depending on characteristics of bolus and on individual impairment to normal swallow

Dynamic Swallow Studies: Measurement Techniques

Rebecca Leonard

B1	Onset of bolus transit through the pharynx. In our studies, this time represents the "zero" point to which all later events during the swallow are compared. It is defined as the first movement of the bolus past the posterior nasal spine that leads to a swallow. If the bolus is large, its head may extend beyond the posterior nasal spine at "Hold." If a portion of bolus material falls in or towards the valleculae early, this is regarded as valving failure or inadequate instruction/attention and is considered a part of oropharyngeal transit, that is, B1 would start with the early bolus loss. OPT would likely be prolonged in this case, and the explanation for it (inability to contain the bolus orally, inattention, etc.) would be included in the narrative.
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HLmax	Hyoid and larynx achieve maximum approximation during the swallow.
PA max	Pharyngeal chamber is maximally obliterated/constricted during the swallow.
BP2	Tail of bolus clears PES. If it doesn't, this is noted in the narrative.
Pcl	PES closes. If it doesn't, no time is recorded for this event. In normal swallowers, Pcl and BP2 are typically the same.
Em	Epiglottis returns to its upright position; supraglottic airway opens.

Apiglottic displacement

Timing measures presented for Both Bolus Transit and Swallow Gesture events During swallow. Exact order may vary depending on characteristics of bolus and on individual impairment to normal swallow

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Dynamic Swallow Studies: Measurement Techniques

Rebecca Leonard

B1	Onset of bolus transit through the pharynx. In our studies, this time represents the "zero" point to which all later events during the swallow are compared. It is defined as the first movement of the bolus past the posterior nasal spine that leads to a swallow. If the bolus is large, its head may extend beyond the posterior nasal spine at "Hold." If a portion of bolus material falls in or towards the valleculae early, this is regarded as valving failure or inadequate instruction/attention and is considered a part of oropharyngeal transit, that is, B1 would start with the early bolus loss. OPT would likely be prolonged in this case, and the explanation for it (inability to contain the bolus orally, inattention, etc.) would be included in the narrative.
AEs	Start of arytenoid-epiglottis approximation to close the supraglottic airway.
H1	First onset of hyoid displacement that leads to a swallow. The hyoid sometimes moves around prior to the swallow. Try to be certain you identify H1 as the <i>first movement that leads to the swallow</i> . The nature of this movement is typically quite distinctive, so rapid and abrupt that it is blurred/hard to recognize in the fluoro study. In some patients, the hyoid is elevated at "Hold," possibly in response to expected difficulty. This can be noted in the narrative and may explain hyoid displacement that appears reduced during the swallow.
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BV2	Exit of bolus head from the valleculae (apparent with small bolus sizes; with larger sizes, BV1 and BV2 are typically the same because the bolus does not stay in the valleculae or is flowing laterally.)
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PES max	PES achieves maximum opening during the swallow.
H3	Hyoid begins to retract from maximum displacement.
HLmax	Hyoid and larynx achieve maximum approximation during the swallow.
PA max	Pharyngeal chamber is maximally obliterated/constricted during the swallow.
BP2	Tail of bolus clears PES. If it doesn't, this is noted in the narrative.
Pcl	PES closes. If it doesn't, no time is recorded for this event. In normal swallowers, Pcl and BP2 are typically the same.
Em	Epiglottis returns to its upright position; supraglottic airway opens.

SPATIAL MEASURES

**Maximum Hyoid
Displacement**

**Maximum PES
opening**

**Maximum laryngeal-
hyoid approximation**

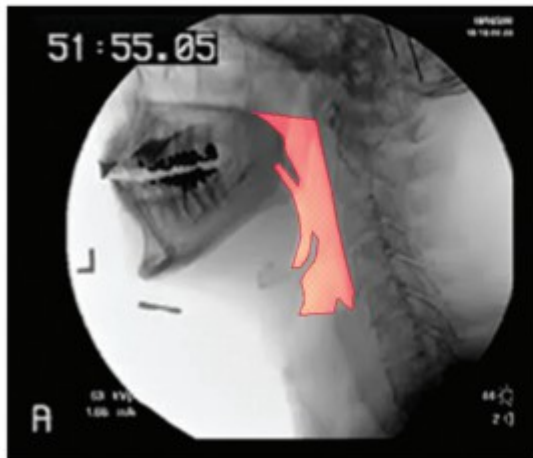
**Pharyngeal
Constriction Ratio
(PCR)**

**Timing measures presented for Both Bolus Transit and Swallow Gesture events During swallow.
Exact order may vary depending on characteristics of bolus and on individual impairment to
normal swallow**

Images Required for Displacement Measures

1cc Hold:	Identifies a pre-swallow frame "referent" to which movement of structures during the swallow can be compared. In our scheme, " Hold " is defined as the position of structures with a 1-cc bolus held in the oral cavity. A frame from the imaging study representing Hold is identified and saved. This will serve as the Hold referent for the 1-cc swallow, and for all subsequent swallows, i.e., 3-cc, 20-cc.
Hold: Hyoid	Hyoid position relative to the 3rd and 4th vertebrae is marked in the Hold frame and saved. This position of the hyoid will be compared to its maximally elevated position during the swallow.
Hmax	Hyoid position maximally elevated (at time H2) relative to the 3rd and 4th cervical vertebrae is identified and saved. The difference between the hyoid in this position and in the Hold:Hyoid position defines maximum hyoid displacement during the swallow.
PESmax	The greatest expansion during swallow of the site designated PES (narrowest opening in lateral view of upper esophagus at maximum distension between, typically, C4 and C6).
HLhold	The distance between the hyoid and larynx at Hold is measured.
HLmax	The distance between the hyoid and larynx at the point of their maximum approximation during the swallow is measured. The difference in this distance and the distance between the 2 structures at Hold defines maximum approximation of the hyoid and larynx during the swallow (HL)
PAhold	The boundaries of the pharynx before swallow are outlined in the Hold frame and this area is calculated for later comparison to the pharynx maximally constricted.
PAmay	The boundaries of the pharynx when it is maximally constricted are outlined, and this area is calculated and noted. The ratio of PAmay to PAhold is referred to as the Pharyngeal Constriction Ratio (PCR).

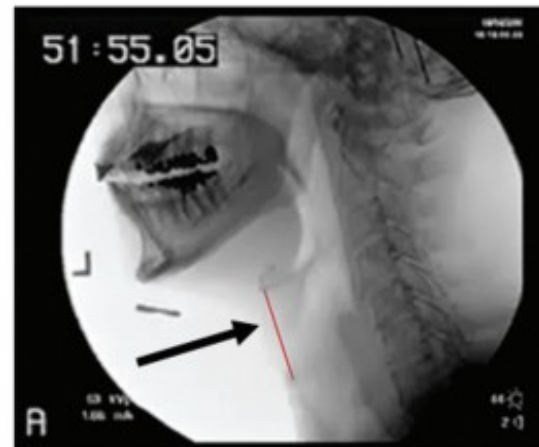
A. PHARYNGEAL AREA AT HOLD (cm²) -- USE RULER TOOL'S AREA+PERIMETER TO OUTLINE PHARYNX.



EXTEND A LINE FROM THE POSTERIOR NASAL SPINE TO PHARYNGEAL WALL AT TUBERCLE OF ATLAS, ALONG POSTERIOR PHARYNGEAL WALL, TO (AND JUST OVER) ARYTENOID (DON'T ENTER LARYNGEAL VESTIBULE), STRAIGHT ACROSS TO EPIGLOTTIS, SUPERIORLY ALONG BASE OF TONGUE AND SOFT PALATE UNTIL DRAWING CLOSES ON ITSELF AT STARTING POINT.

IF TONGUE IS NOT TOUCHING VELUM DURING MAXIMUM CONSTRICTION, USE SHORTEST DISTANCE BETWEEN TWO AND THEN COMPLETE AREA.

B. HYOID-LARYNX AT HOLD -- USE RULER TOOL'S DISTANCE MEASURING TO DEFINE DISTANCE.



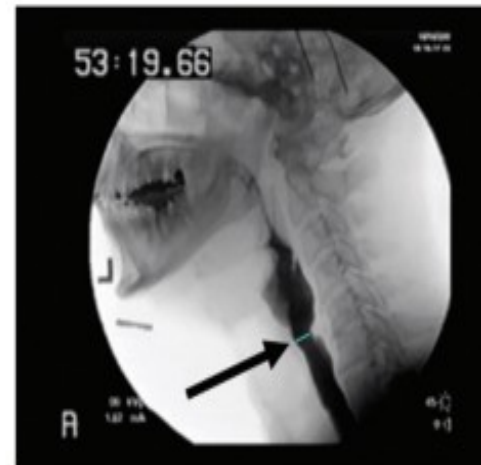
USE DISTANCE MEASURING TO MEASURE DISTANCE FROM INFERIOR POINT OF HYOID TO TOP OF TRACHEAL AIR COLUMN (IN CM). THIS VALUE WILL BE COMPARED TO VALUE MEASURED AT POINT WHEN TWO STRUCTURES ARE MAXIMALLY APPROXIMATED.

A. PHARYNX AT POINT OF MAXIMUM CONSTRICTION.



USE UDR AND AREA+PERIMETER TO MEASURE PHARYNGEAL AREA AT POINT OF MAXIMUM CONSTRICTION. INCLUDE ANY RESIDUAL AREA AND BOLUS RESIDUE. IF MORE THAN ONE AREA IS PRESENT, MEASURE BOTH AND ADD. THIS NUMBER WILL BE NUMERATOR IN PHARYNGEAL CONSTRICTION RATIO (PCR). DENOMINATOR IS AREA MEASURE CALCULATED ON "HOLD" FRAME ($PA_{max}/PA_{hold} = PCR$)

C. MAXIMUM PHARYNGOESOPHAGEAL SEGMENT OPENING (PES)



PHARYNGOESOPHAGEAL OPENING IS DEFINED AS NARROWEST POINT BETWEEN C4-C6 WHEN THIS AREA IS MAXIMALLY DISTENDED DURING SWALLOW (PES_{max}). THIS PATIENT HAS A SMALL CRICOPHARYNGEAL BAR, MAKING IDENTIFICATION EASIER. USE DISTANCE MEASURING TO DETERMINE (CAN ALSO DO THIS IN A/P VIEW). *Be careful to measure only the lumen of the opening...not the walls!*

Table 16-1. Normative Values for Timing, Duration and Displacement Measures for Subjects Under and Over Age 65 Years

NORMAL DISPLACEMENT mean with 2 SD													
< AGE 65 yrs						> AGE 65 yrs							
MEASURE (cm)	1 CC	3 CC	20 CC	MEASURE (cm)	1 CC	3 CC	20 CC						
Hmax (M)	2.00	1.42	2.12	1.38	2.4	1.36	Hmax (M)	1.98	1.41	2.08	1.62	2.48	2.04
Hmax (F)	1.39	1.0	1.62	1.12	1.81	1.46	Hmax (F)	1.63	1.06	1.79	1.54	2.07	.45
HL (M)	1.33	.92	1.30	1.08	1.25	.83	HL (M)	1.50	.68	1.71	1.43	1.58	1.35
HL (F)	1.10	1.48	1.08	1.17	1.07	1.10	HL (F)	1.27	.87	1.24	1.2	1.23	1.30
PESmax	.39	.38	.51	.30	.90	.55	PESmax	.37	.34	.50	.37	.80	.40
Pamax (M)	.13	.22	.24	.36	.28	.38	Pamax (M)	.24	.49	.35	.46	.90	1.06
Pamax (F)	.10	.18	.12	.23	.17	.33	Pamax (F)	.25	.46	.52	1.04	1.38	3.33
Pam/Pah (M)	.02	.04	.04	.05	.06	.12	Pam/Pah (M)	.02	.04	.03	.04	.13	.28
Pam/Pah (F)	.02	.03	.02	.04	.03	.06	Pam/Pah (F)	.02	.06	.07	.15	.14	.28
Hmax+HL (M)	3.33	1.86		3.72	1.82		Hmax+HL (M)				4.06	.98	
Hmax+HL (F)	2.49	1.7		2.88	.86		Hmax+HL (F)				3.30	.55	
PA HOLD (M)	7.9 (4.2)	(F) 6.5 (3.4)					PA HOLD (M)	11.4 (6.0)	(F) 8.09 (4.0)				

Morphometry of the Cartilaginous Larynx (mm)			
	(M)	(F)	
Cric	24.6±1.9	21.6±1.5	
Aryt	16.6±1.9	12.6±2.1	
Total	41.2 mm	34.2 mm	
	±15.1 mm	±13.6 mm	
Sprinzl GM, et al. Head & Neck, December (1999).			
Increased aspiration pneumonia risk post CVA			
	2-3 sec = 33%		
	3-5 sec = 48%		
	>5 sec = 90%		
Hyoid to mandible @ baseline (cm)			
	<65	>65	>65+bar
(M)	2.67 (.8)	2.68 (.62)	2.63 (.84)
(F)	1.86 (.53)	2.02 (.68)	2.08 (.53)
Hyoid to larynx @ baseline (cm)			
	<65	>65	
(M)	3.79 (.54)	4.20 (.74)	
(F)	2.95 (.59)	3.36 (.55)	

NORMAL DURATION <i>mean with 2 SD</i>												Maximum phx expansion, a-p (cm)		
< AGE 65 yrs						> AGE 65 yrs						<65	>65	
MEASURE (cm)	1 CC	3 CC	20 CC	MEASURE (cm)	1 CC	3 CC	20 CC	(M)			(F)			
H max	.22	.20	.21	.21	.20	.24	H max	.13	.12	.12	.14	.12	.20	
PES max	.34	.16	.41	.14	.50	.21	PES max	.47	.20	.62	.50	.64	.21	
AE closed	.53	.28	.60	.30	.72	.50	AE closed	.66	.28	.84	.62	.85	.93	
OP transit	.50	.33	.41	.34	.23	.26	OP transit	.50	.64	.49	.46	.42	.36	
HP transit	.41	.46	.43	.34	.64	.24	HP transit	.65	.37	.76	.62	.77	.26	
AEcl-Aest.	.27	.18	.27	.29	.25	.31	AEcl-Aest	.48	.65	.50	.66	.54	.69	
Em	1.07	.59	1.01	.24	1.0	.36	Em	1.30	.88	1.30	.95	1.30	.57	
Invariant Sequence Pairs														
AEs before Pop														
AEC no more than .1 sec after Pop, BP1														
HL after Pop														
PAMax after PESmax														
Pop before/same time as BP1														
Pcl after/same time as BP2														
UES Max Openings, a-p (cm)														
<65 >65 >65+bar														
(M) 1.69 (.18) 1.54 (.32) .65 (.17)														
(F) 1.35 (.25) 1.40 (.32) 1.21 (.21)														

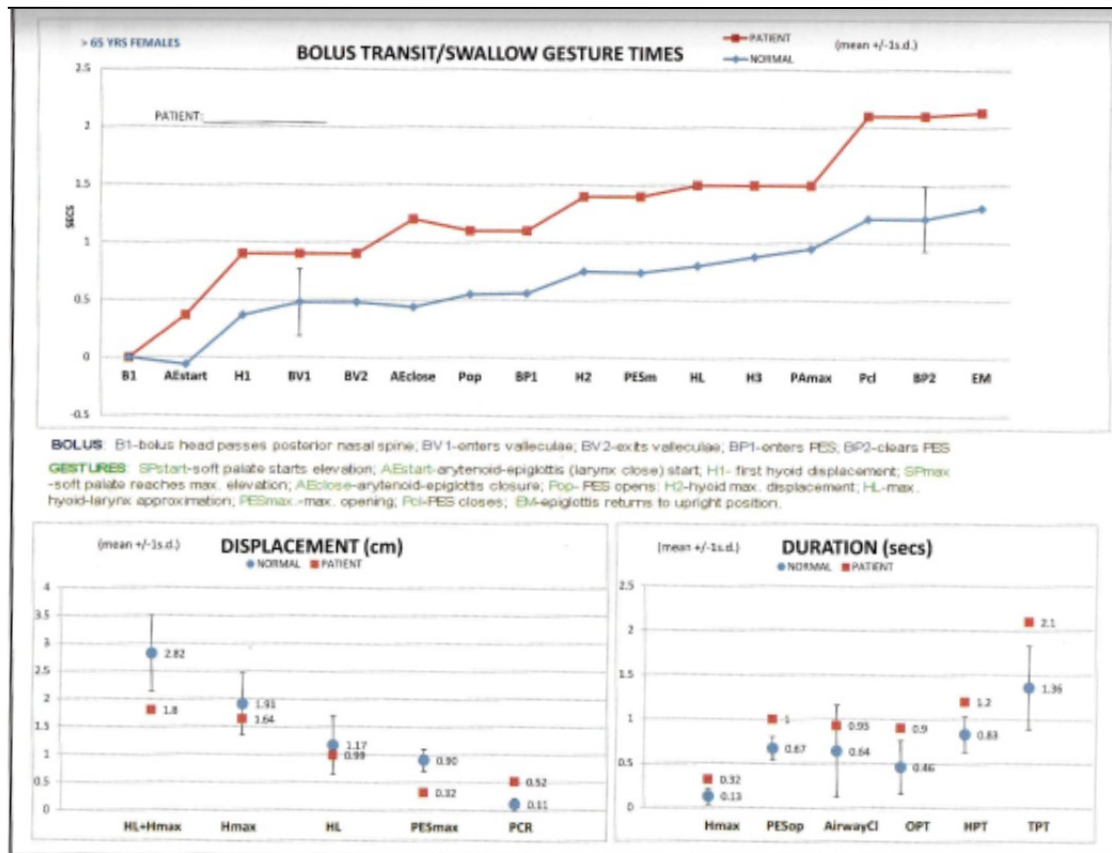
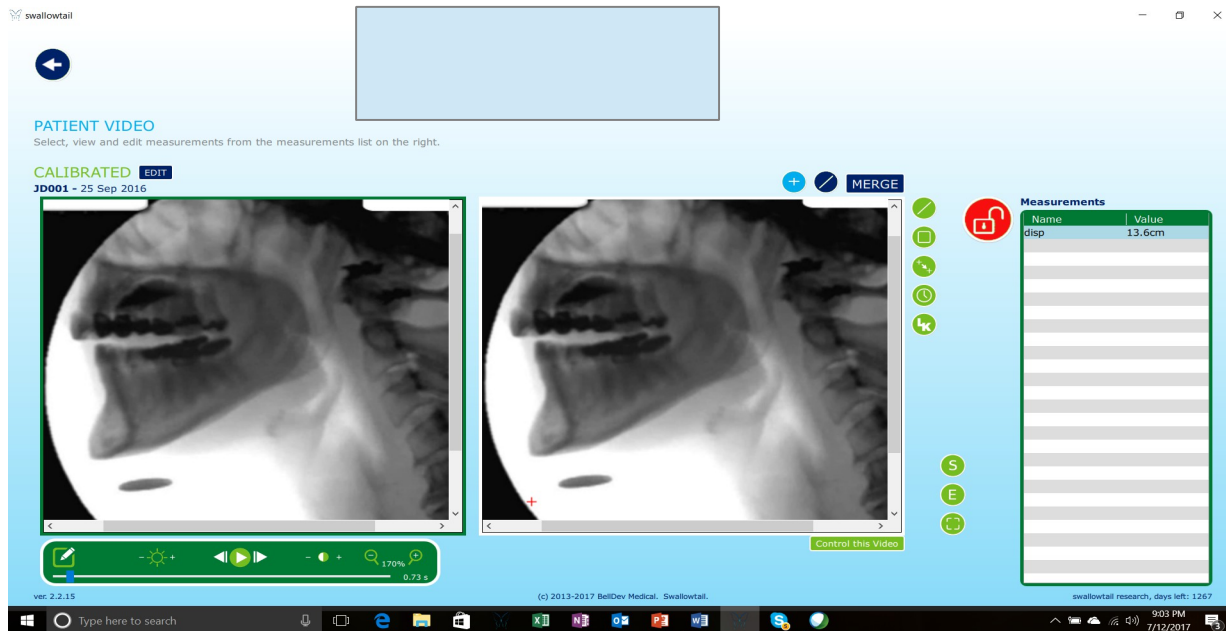


Figure 16-1. Plot (In Excel) displays objective data from fluoroscopic study.



Swallowtail is based on the quantitative measurement methodology developed by Dr. Rebecca Leonard and Dr. Katherine Kendall at the University of California, Davis. However, the program is not limited to their methods. Swallowtail tools can be used to make a wide variety of linear, area and temporal measures that may be of interest to, or developed by, clinicians and researchers.

<http://www.belldevmedical.com/swallowtail>



MBSimp (Modified Barium Swallow Impairment Profile)

The 17 components assessment including:

Oral Impairment Domain:

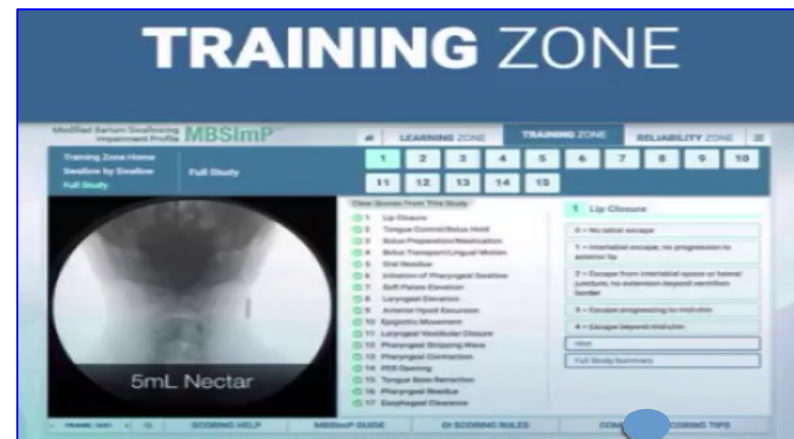
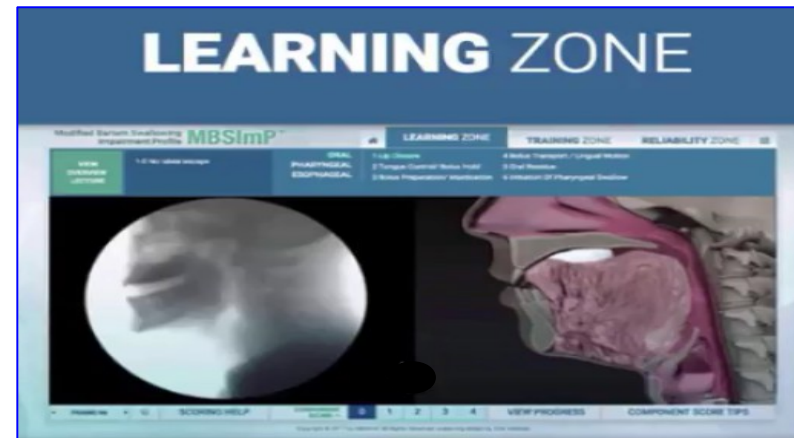
- 1. Lip Closure**
- 2. Tongue Control During Bolus Hold**
- 3. Bolus Preparation/Mastication**
- 4. Bolus Transport/Lingual Motion**
- 5. Oral Residue**
- 6. Initiation of the Pharyngeal Swallow**

Pharyngeal Impairment Domain:

- 7. Soft Palate Elevation**
- 8. Laryngeal Elevation**
- 9. Anterior Hyoid Excursion**
- 10. Epiglottic Movement**
- 11. Laryngeal Vestibular Closure**
- 12. Pharyngeal Stripping Wave**
- 13. Pharyngeal Contraction**
- 14. Pharyngoesophageal Segment Opening**
- 15. Tongue Base Retraction**
- 16. Pharyngeal Residue**

Esophageal Impairment Domain:

- 17. Esophageal Clearance (upright position)**



MBSimp

The 17 components assessment including:

Oral Impairment Domain:

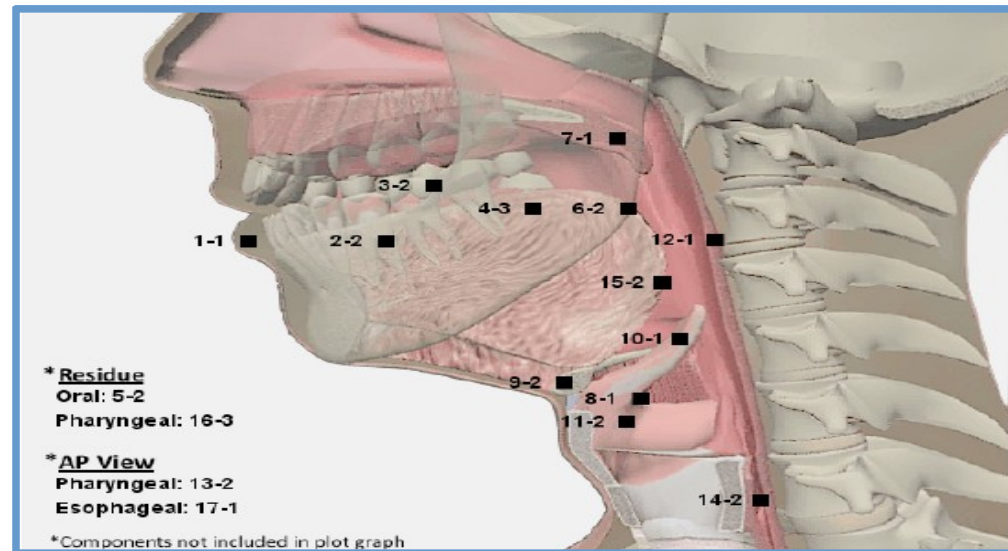
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- 15. Tongue Base Retraction**
- 16. Pharyngeal Residue**

Esophageal Impairment Domain:

- 17. Esophageal Clearance (upright position)**



COMPONENT Number and Descriptor		Scale	CURRENT Score and Descriptor		PREVIOUS Score and Descriptor at Time of Last Study	
1	Lip Closure	(0-4)	1	Resulted in interlabial escape, without progression to the anterior lip.	0	Resulted in no labial escape.
2	Tongue Control/Bolus Hold	(0-3)	2	Resulted in posterior escape of less than half of the bolus.	1	Allowed bolus escape to the lateral buccal cavity/floor of mouth.
3	Bolus Prep/Mastication	(0-3)	2	Demonstrated disorganized chewing/mashing with solid pieces of the bolus unchewed.	2	Demonstrated disorganized chewing/mashing with solid pieces of the bolus unchewed.
4	Bolus Transport/Lingual Motion	(0-4)	3	Was with repetitive/disorganized motion of the tongue.	3	Was with repetitive/disorganized motion of the tongue.
5	Oral Residue	(0-4)	2	Was a collection on oral structures.	4	Resulted from minimal to no clearance of the bolus.
6	Initiation of Pharyngeal Swallow	(0-4)	2	Occurred as the bolus head was at the posterior laryngeal surface of the epiglottis.	4	Was not visible at any level.
7	Soft Palate Elevation	(0-4)	1	Allowed a trace column of contrast or air between the soft palate and the pharyngeal wall.	3	Allowed bolus escape to the nasal cavity.
8	Laryngeal Elevation	(0-3)	1	Was decreased, with partial superior movement of the thyroid cartilage/partial approximation of the arytenoids to the epiglottic petiole.	2	Was incomplete, as indicated through minimal superior movement of thyroid cartilage with minimal approximation of the arytenoids to the epiglottic petiole.
9	Anterior Hyoid Excursion	(0-2)	2	Demonstrated no movement.	2	Demonstrated no movement.
10	Epiglottic Movement	(0-2)	1	Resulted in partial inversion.	2	Resulted in no inversion.
11	Laryngeal Vestibular Closure	(0-2)	2	Was absent, resulting in a wide column of air/contrast within the laryngeal vestibule at the height of the swallow.	2	Was absent, resulting in a wide column of air/contrast within the laryngeal vestibule at the height of the swallow.
12	Pharyngeal Stripping Wave	(0-2)	1	Was present, but diminished.	2	Was absent.
13	Pharyngeal Contraction	(0-3)	2	Resulted in unilateral bulging.	0	Was complete.
14	Pharyngoesophageal Segment Opening	(0-3)	2	Demonstrated minimal distension/minimal duration, with marked obstruction of bolus flow.	3	Yielded no distension, resulting in total obstruction of flow.
15	Tongue Base Retraction	(0-4)	2	Allowed a narrow column of contrast or air between the retracted tongue base and the posterior pharyngeal wall.	3	Allowed a wide column of contrast or air between the retracted tongue base and the posterior pharyngeal wall.
16	Pharyngeal Residue	(0-4)	3	Was the majority of contrast within or on pharyngeal structures.	3	Was the majority of contrast within or on pharyngeal structures.
17	Esophageal Clearance (upright)	(0-4)	1	Resulted in esophageal retention.	3	Resulted in esophageal retention with incidence of retrograde bolus flow through the pharyngoesophageal segment.

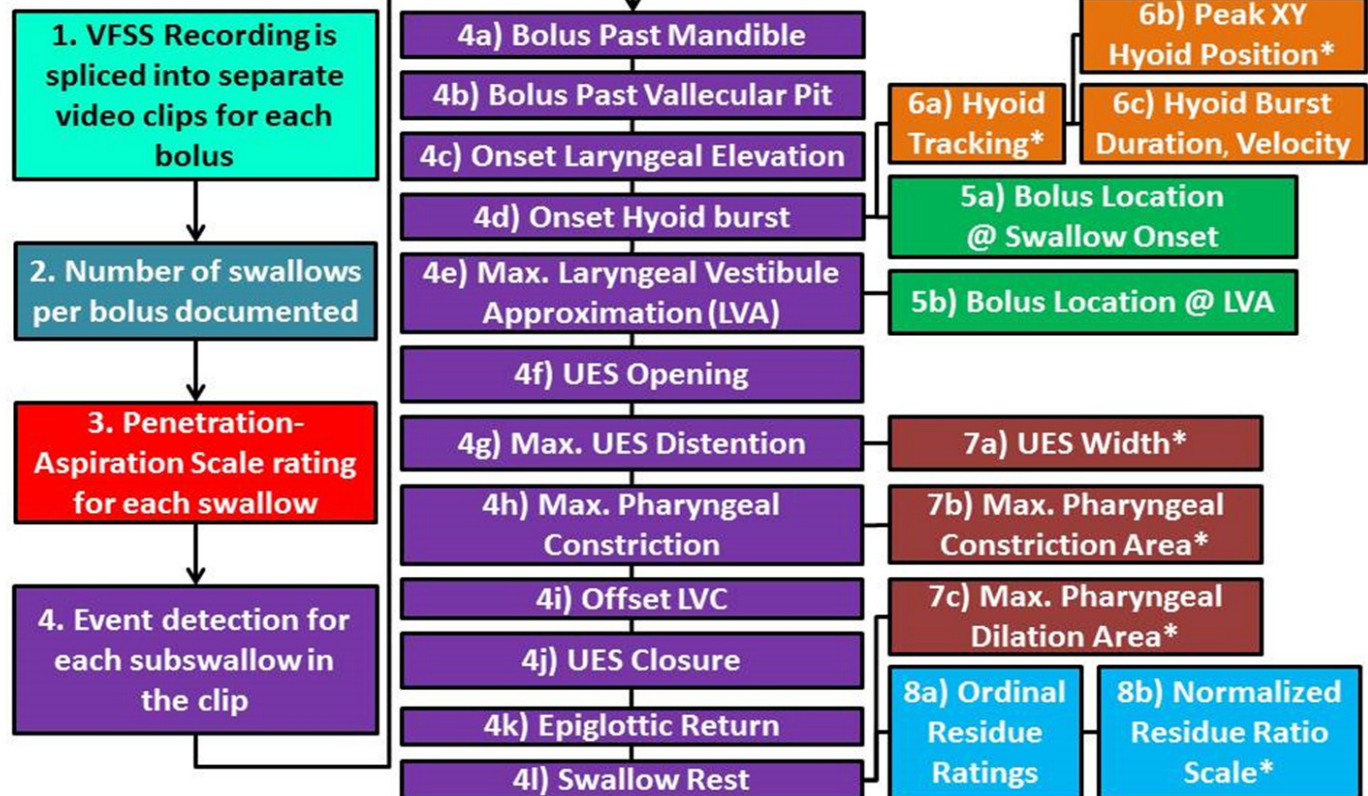
Oral Impairment Score: 11
 Pharyngeal Impairment Score: 17
 Esophageal Impairment Score: 1

VFS - Image preparation & Rating



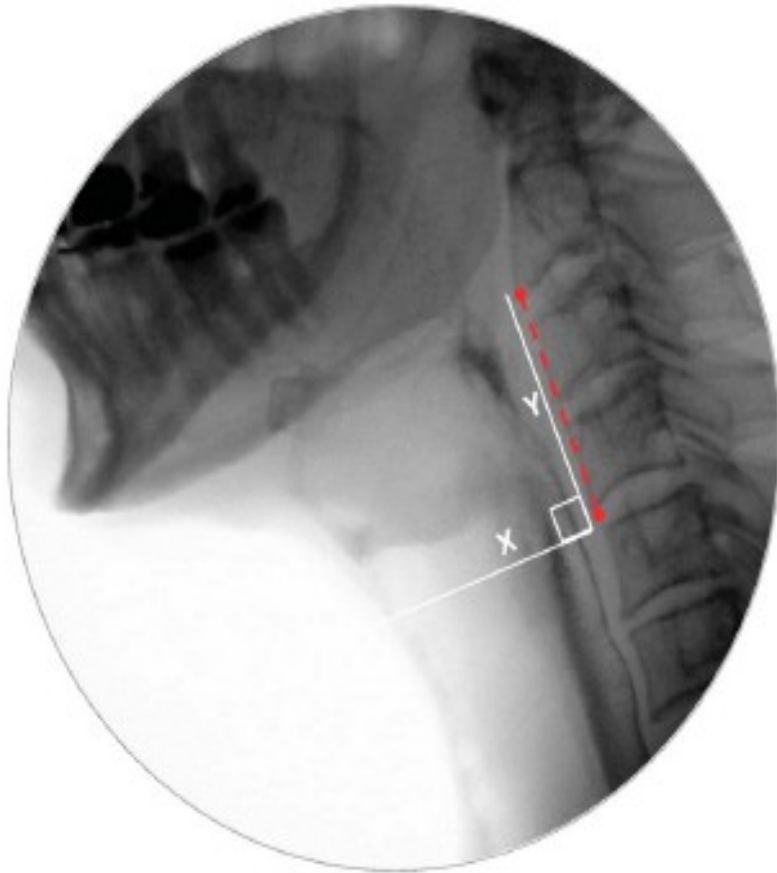
The ASPEKT Method

(Analysis of Swallowing Physiology: Events, Kinematics & Timing)



* Pixel-based measures, normalized to the length of the C2-C4 spine

Automated (Pixel-based) measurements



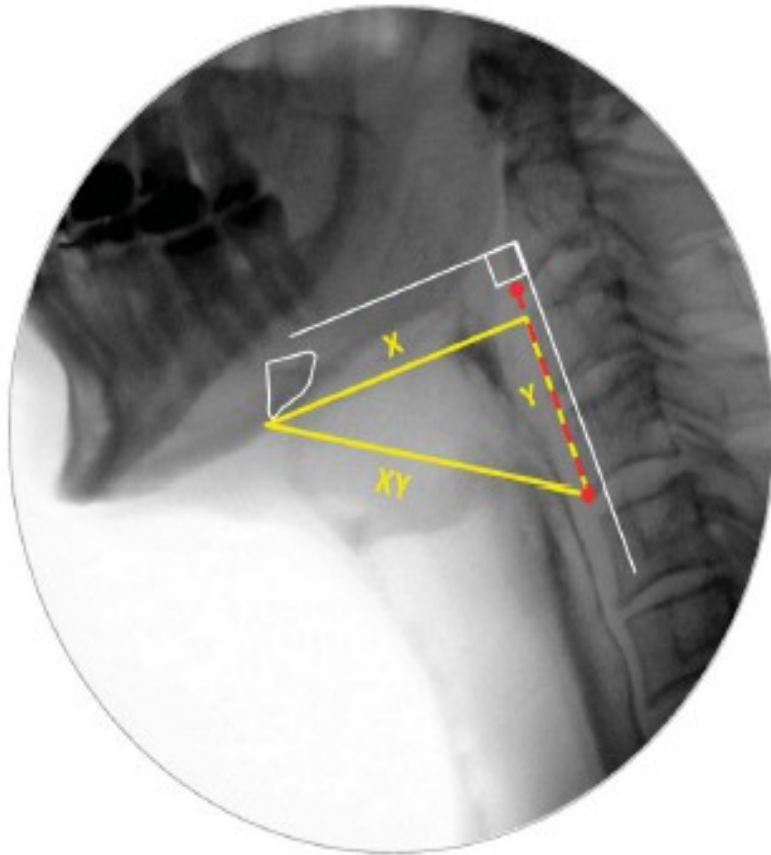
C2

anatomical reference scalar

C4

*y-axis defined by the C2–C4 cervical spine
x-axis derived at 90° to the y-axis.*

Automated (Pixel-based) measurements



Peak hyoid position

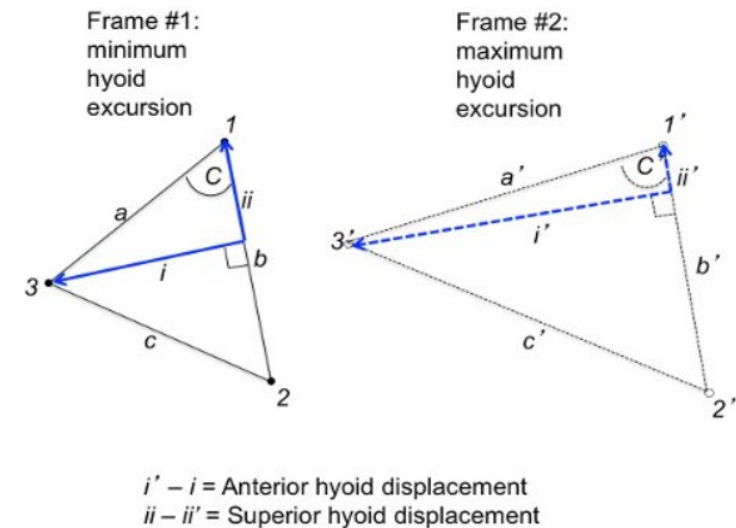
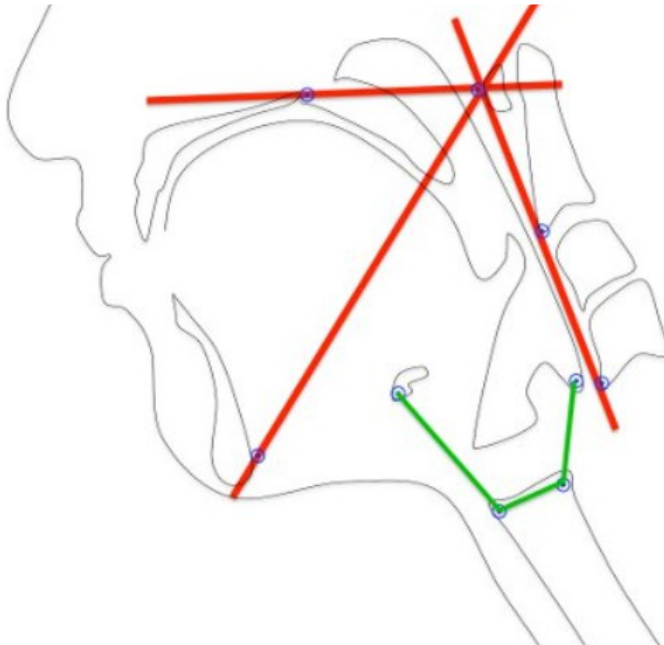
C2

anatomical reference scalar

C4

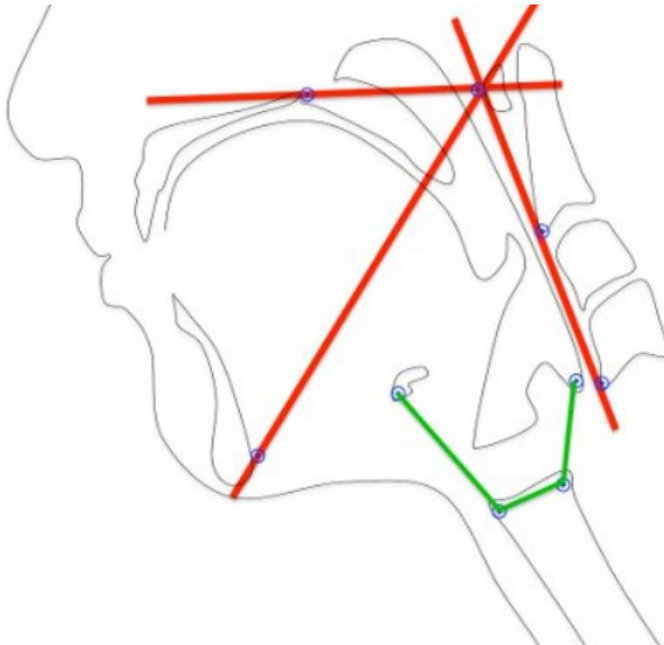
*y-axis defined by the C2–C4 cervical spine
x-axis defined C2 and hyoid bone
xy planes of movement anterior–inferior corner
of the C4 vertebra*

Computational Analysis of Swallowing Mechanisms (CASM)



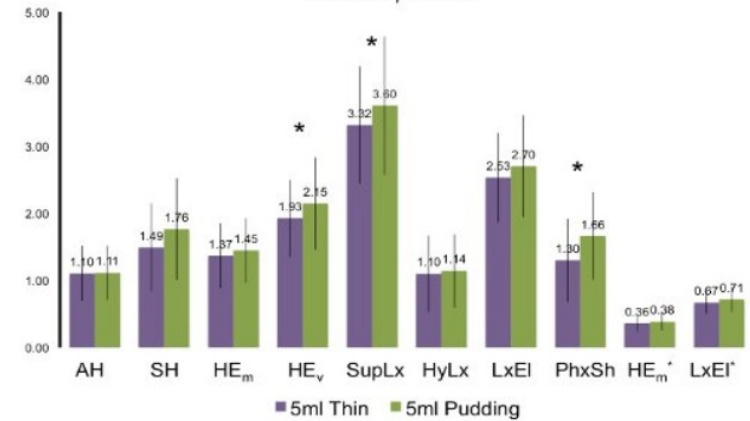
AH = anterior hyoid movement, SH = superior hyoid movement, HEm = hyoid excursion in reference to the mandible, HEv = hyoid excursion in reference to the vertebrae, SupLx = superior laryngeal movement, HyLx = hyolaryngeal approximation, LxEI = laryngeal elevation (towards the cranial base), PhxSh = pharyngeal shortening, HEm* = hyoid excursion in reference to the mandible with a C2 - 4 scalar, LxEI* = laryngeal elevation with a C2 - 4 scalar

(Thompson et al, 2014)



Kinematic Variables (cm)

*Indicates $p < 0.005$



AH = anterior hyoid movement, SH = superior hyoid movement, HEm = hyoid excursion in reference to the mandible, HEv = hyoid excursion in reference to the vertebrae, SupLx = superior laryngeal movement, HyLx = hyolaryngeal approximation, LxEl = laryngeal elevation (towards the cranial base), PhxSh = pharyngeal shortening, HEm* = hyoid excursion in reference to the mandible with a C2 - 4 scalar, LxEl* = laryngeal elevation with a C2 - 4 scalar

(Thompson et al, 2014)

Timing of Swallowing

frm/sec

Technical prerequisite

Swallow Motor Response
(integrity of the motor response)

landmarks definition

displacement: distance

measurement: durations

Lateral view

PHARYNGEAL PHASE

Swallow Motor Response:

- . Sphincter opening
- . Sphincter closure

Glossopalatal sphincter opening

Velopharyngeal sphincter closure

Laryngeal vestibule closure

UES opening

1 ml=0,0sec

20 ml=0,2 sec



Pharyngeal reconfiguration

Ph. clearance

End riconf.

EVENT

Frame number

Glossopalatal sph opening

Velopharynx sph closure (release)

Hyoid burst initiation

LVC closure (aryts to base of epiglottis)

LVC ends (separation)

UES opens

UES close

Ends first swallow

Glossopalatal sphincter opening (GSO-C)

Velopharyngeal sphincter closure (VPSO-C)

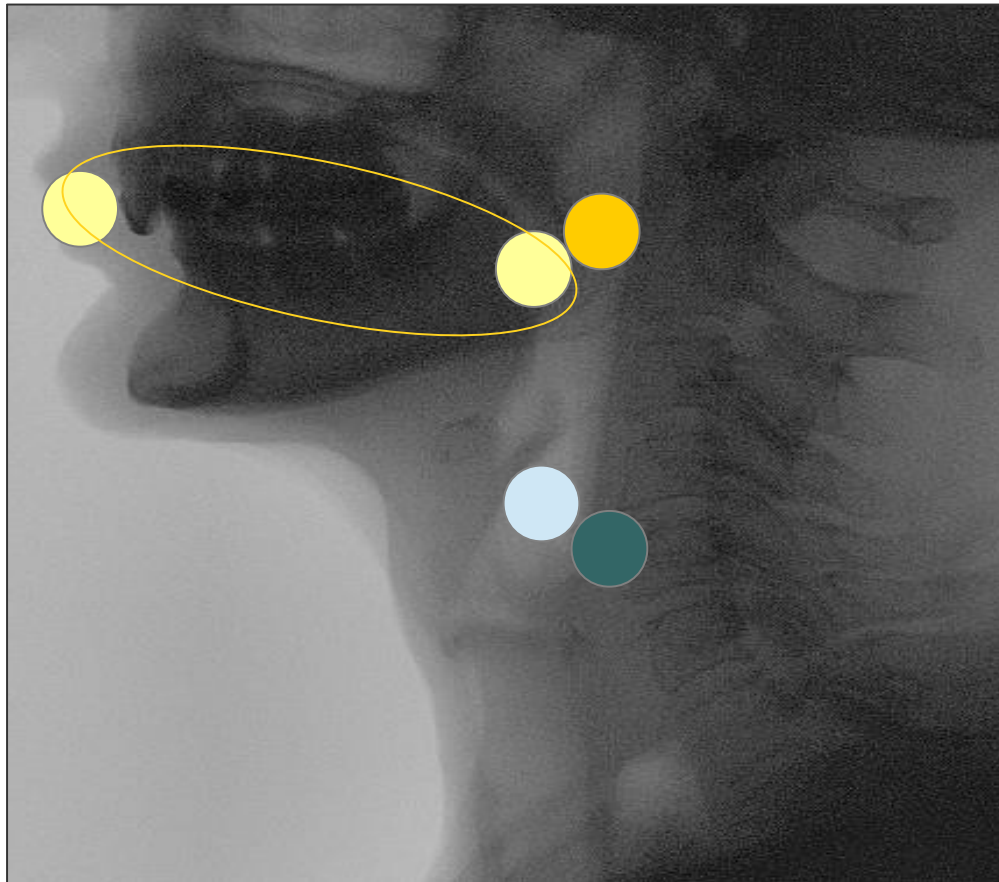
Laryngeal vestibule closure (LVC-O)

UES opening (UESO-C)

Pharyngeal reconfiguration

Ph. clearance

End riconf.



EFFICACY

Lip closure

Ejection

Bolus formation

Insensibility

Apraxia

SAFETY

***Glossopalatal junction
(holding)***

Glossopalatal sphincter opening (GSO-C)

Velopharyngeal sphincter closure (VPSO-C)

Laryngeal vestibule closure (LVC-O)

UES opening (UESO-C)

Pharyngeal reconfiguration

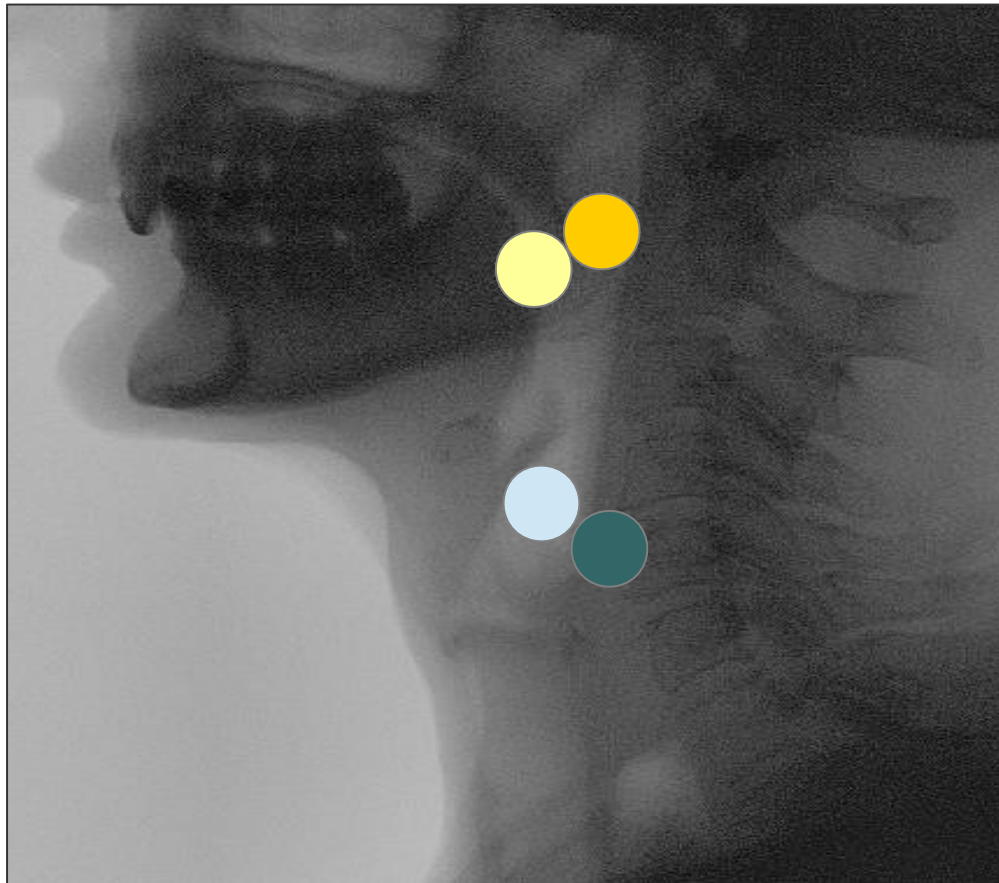
Ph. clearance

End riconf.

Breathig

Swallow

Breathing



EFFICACY

Nasopharynx Junction

Residue (vallecula, pyriforms)

UES opening

SAFETY

Penetration

Aspiration

Glossopalatal sphincter opening (GSO-C)

Velopharyngeal sphincter closure (VPSO-C)

Laryngeal vestibule closure (LVC-O)

UES opening (UESO-C)

Pharyngeal reconfiguration

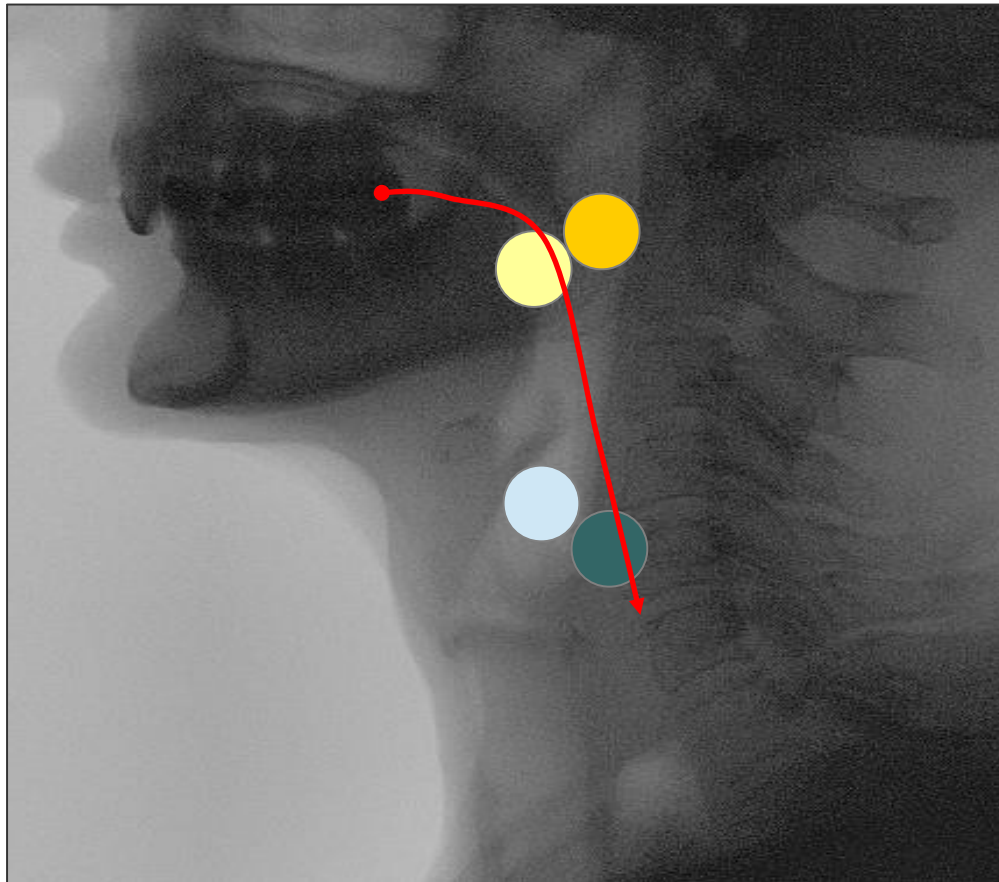
Ph. clearance

End riconf.

Breathig

Swallow

Breathing



8 key points

Glossopalatal sph
Velopharynx sph
Laryngeal vestibule
UES

measures

Opening
Closure
Duration

Total duration

Glossopalatal sphincter opening (GSO-C)

Velopharyngeal sphincter closure (VPSO-C)

Laryngeal vestibule closure (LVC-O)

UES opening (UESO-C)

Pharyngeal reconfiguration

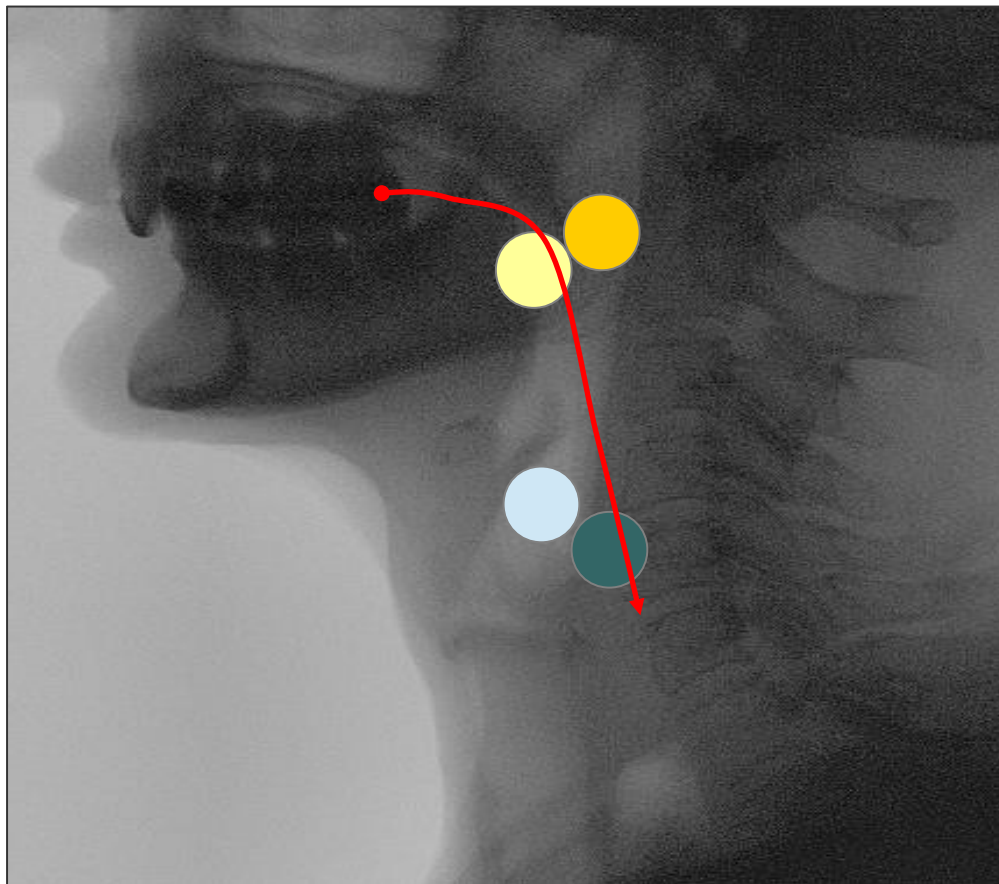
Ph. clearance

End riconf.

Breathig

Swallow

Breathing



8 key points

measures

Glossopalatal sphincter:

OPENING: Time 0 (start of response)

First frame showing opening of the glossopalatal junction

CLOSURE:

1st frame showing contact between the soft palate and the tongue base

Associated with tongue propulsion

Glossopalatal sphincter opening (GSO-C)

Velopharyngeal sphincter closure (VPSO-C)

Laryngeal vestibule closure (LVC-O)

UES opening (UESO-C)

Pharyngeal reconfiguration

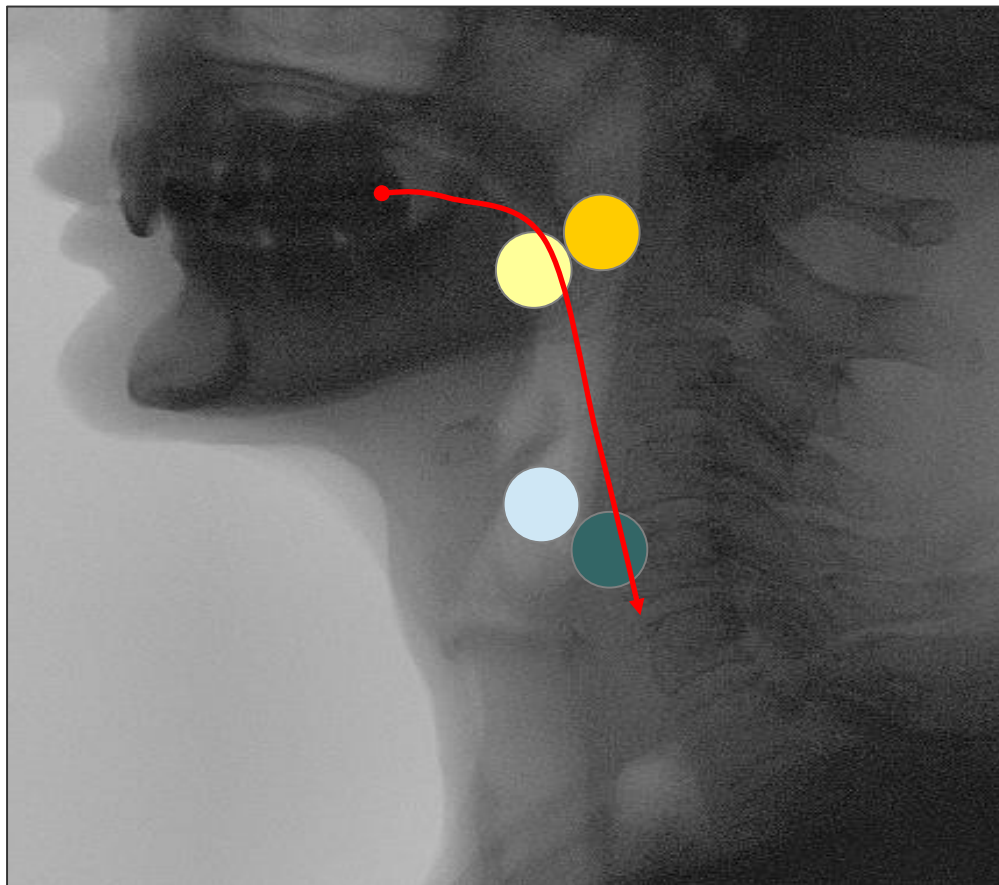
Ph. clearance

End riconf.

Breathig

Swallow

Breathing



8 key points —————> **13 measures**

Velopharyngeal sphincter:

CLOSURE: Time 0 (start of response)

1st frame showing contact between the uvula and the posterior pharyngeal wall

OPENING:

1st frame showing separation between the uvula and the posterior pharyngeal wall

Associated with apnea

Glossopalatal sphincter opening (GSO-C)

Velopharyngeal sphincter closure (VPSO-C)

Laryngeal vestibule closure (LVC-O)

UES opening (UESO-C)

Pharyngeal reconfiguration

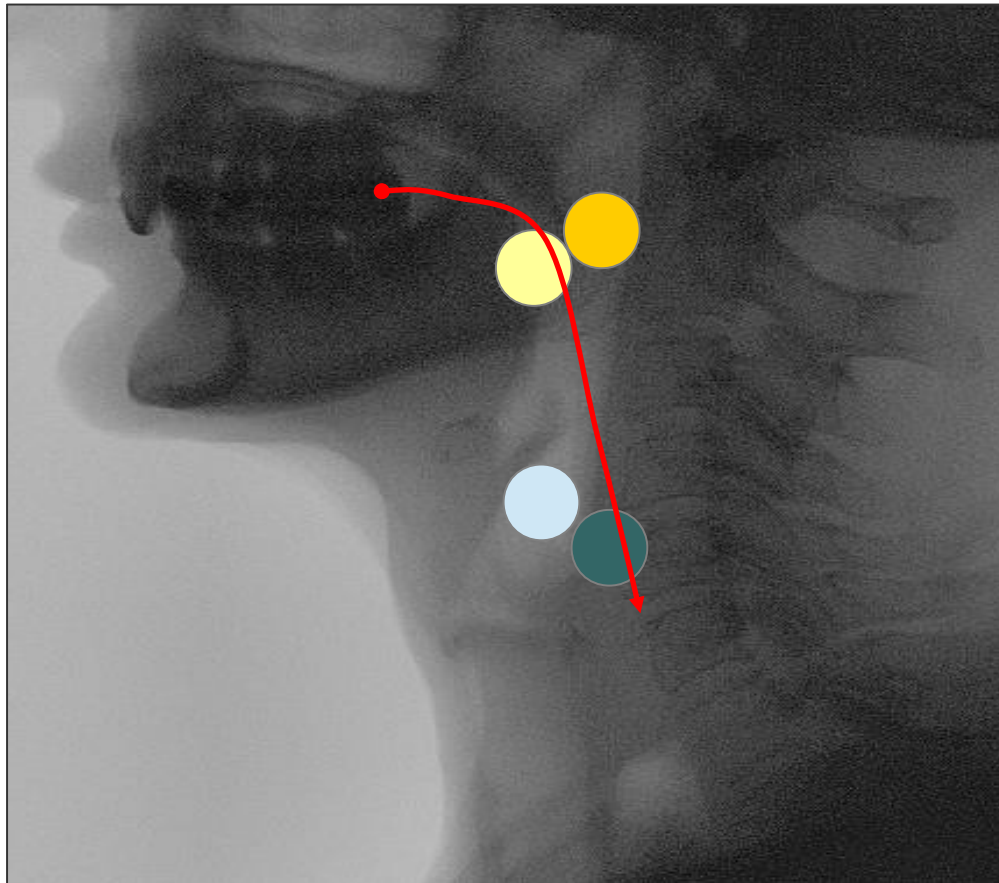
Ph. clearance

End riconf.

Breathig

Swallow

Breathing



8 key points → **13 measures**

Laryngeal vestibule:

CLOSURE: Time 0 (start of response)

1st frame of contact between the epiglottis and arytenoids

OPENING:

1st frame showing separation between the epiglottis and arytenoids

Associated with apnea

Glossopalatal sphincter opening (GSO-C)

Velopharyngeal sphincter closure (VPSO-C)

Laryngeal vestibule closure (LVC-O)

UES opening (UESO-C)

Pharyngeal reconfiguration

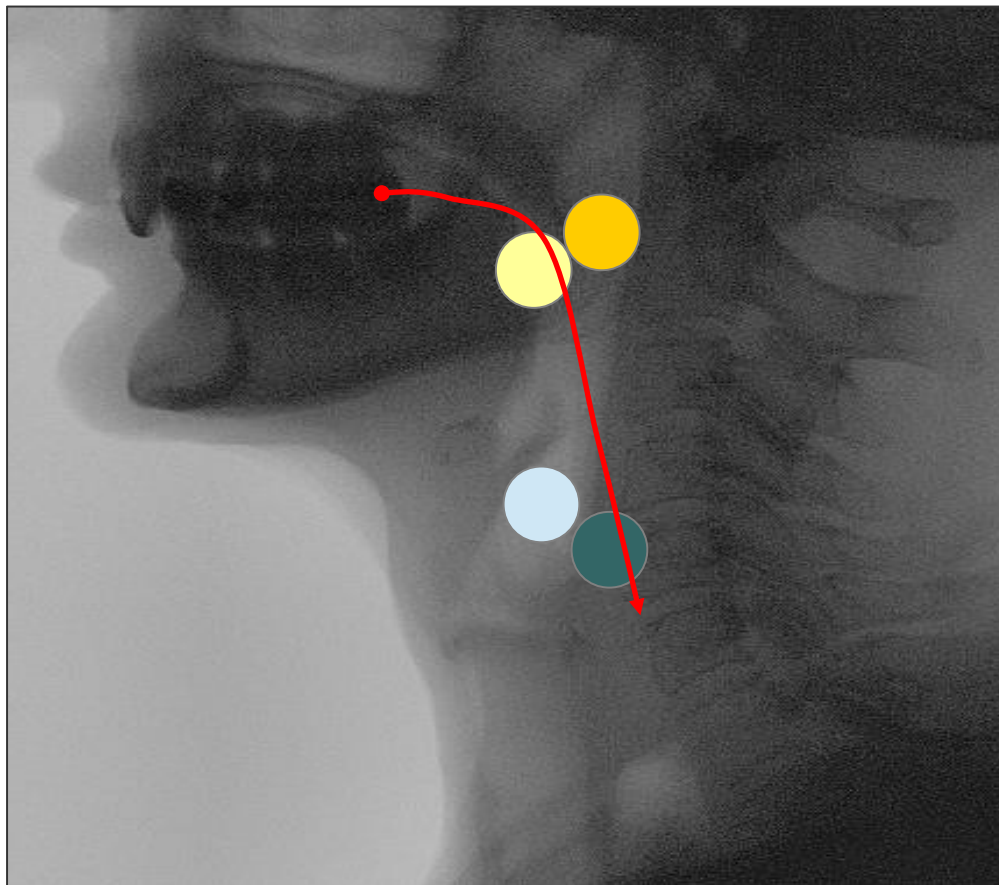
Ph. clearance

End riconf.

Breathig

Swallow

Breathing



8 key points → **13 measures**

UES sphincter:

OPENING: Time 0 (start of response)

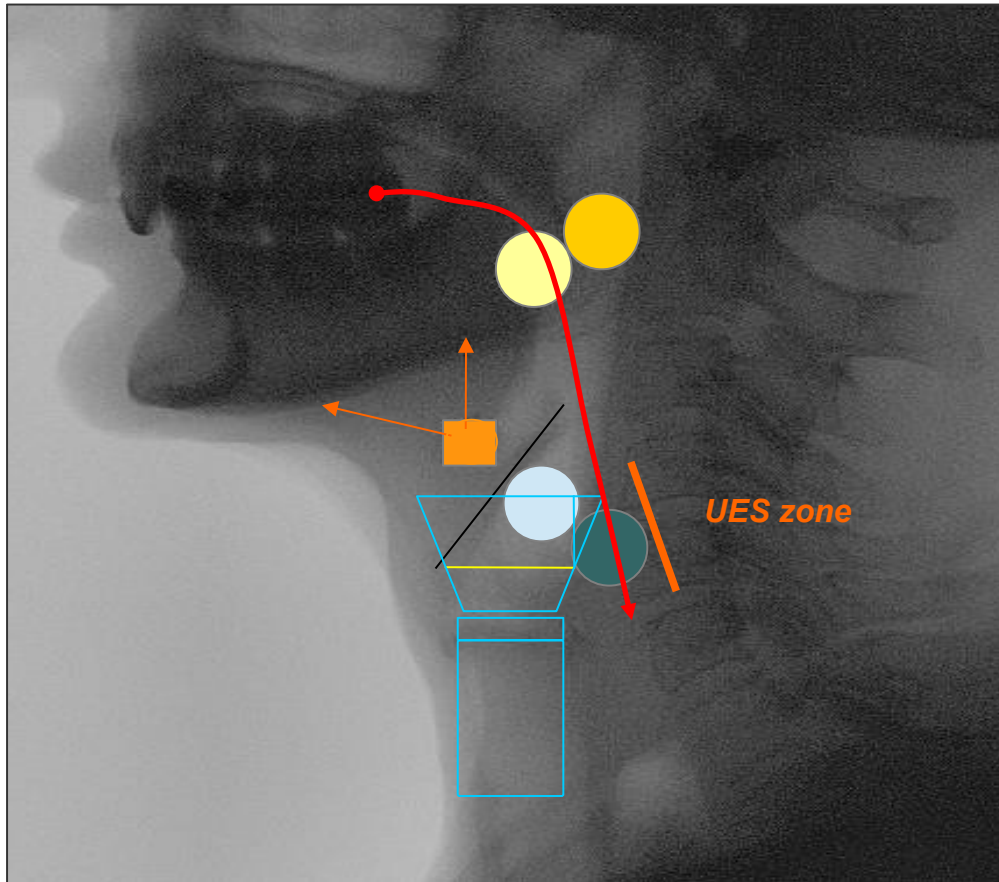
1st frame of separation between the UES
(opening of the sphincter)

CLOSURE:

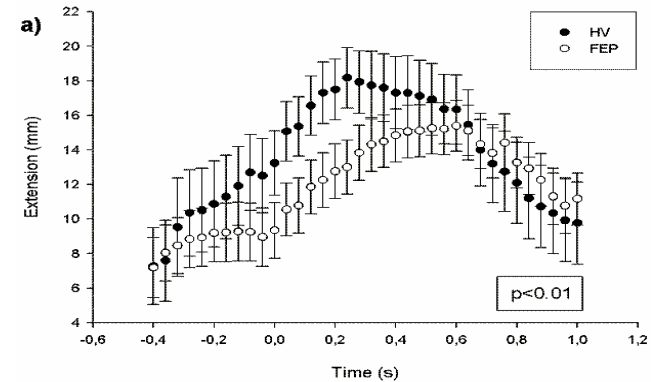
1st frame of UES closure/contact

Associated with tongue propulsion

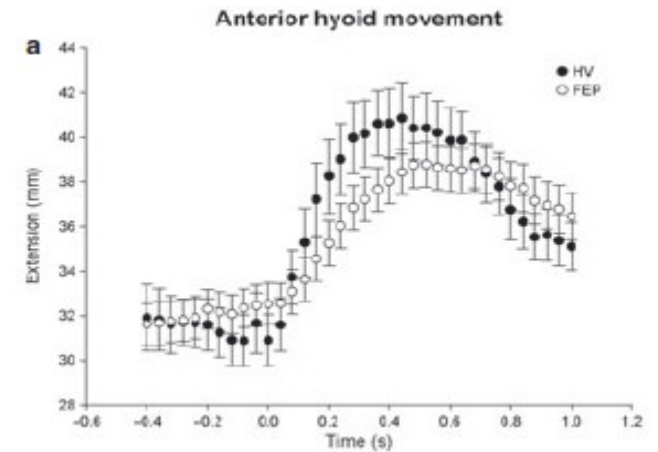
Hyo-laryngeal excursion (biomechanics)



A) VERTICAL HYOID MOVEMENT



Vertical movement → **Airway closure**



Anterior movement → **UES opening**

Glossopalatal sphincter opening (GSO-C)

Velopharyngeal sphincter closure (VPSO-C)

Laryngeal vestibule closure (LVC-O)

UES opening (UESO-C)

Pharyngeal reconfiguration

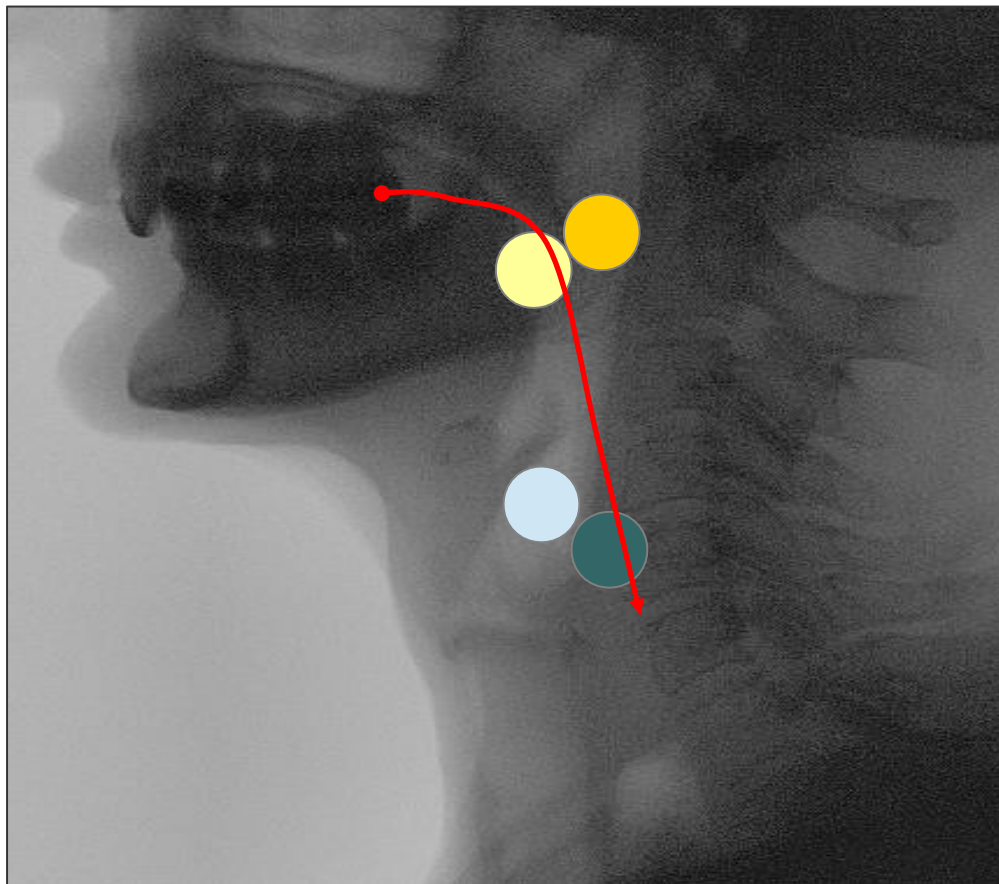
Ph. clearance

End riconf.

Breathig

Swallow

Breathing



ESAMPLE: 30 frms/sec

Glossopalatal sph: 27

Velopharynx sph

Laryngeal vestibule: 35

UES

Opening

Closure

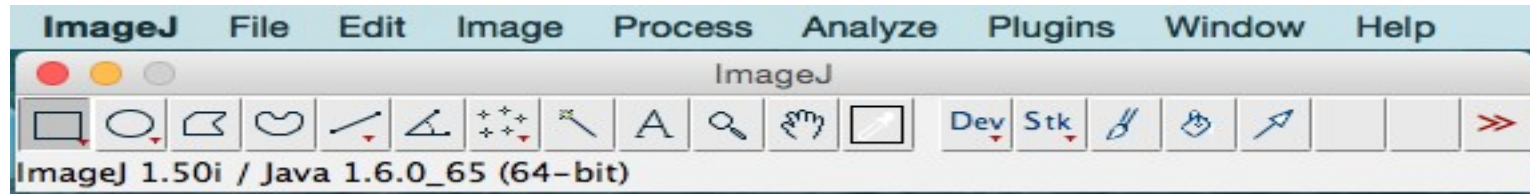
Duration

GSO-LVC: -8 frames (0.8)

$1/30 = 0,033 \times 0,8 = 0.226 \times 100 = 260 \text{ msec}$

EXCEL FILE

ImageJ



Free software:

<http://imagej.nih.gov/ij/download.html>

It calculates area and pixel value statistics of user-defined selections

It measures distances and angles

Only supports uncompressed AVIs

MicroDicom



GRAZIE