High-Speed Imaging (HDSI) of Vocalizations in Performing Artists: Implications For Vocal Fatigue and for Vocal Cost

presented by

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Abstract

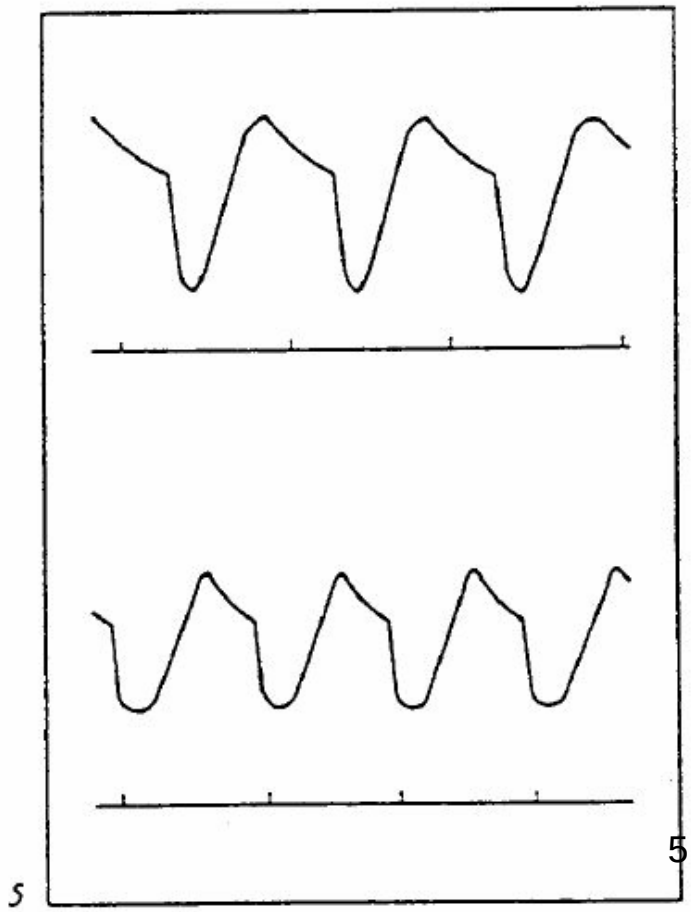
- HSDI of the vocal cords shows correct representation of their vibratory movement during vocalization. We used Wolf Ltd., Germany, HSDI unit to record and to analyse two seconds of phonation movements at the speed of 4000 frames per second.
- Analyses included segmentation and calculation of open quotients of the anterior, middle and posterior areas of the vocal cords, recorded together with acoustical and electroglottographic (EGG) signals online to enhance understanding of how vocalization is organized. Results are also presented for the left and the right vocal cords.
- Based on these analyses we conclude that HSDI in combination with EGG enhances diagnostics.

Abstract

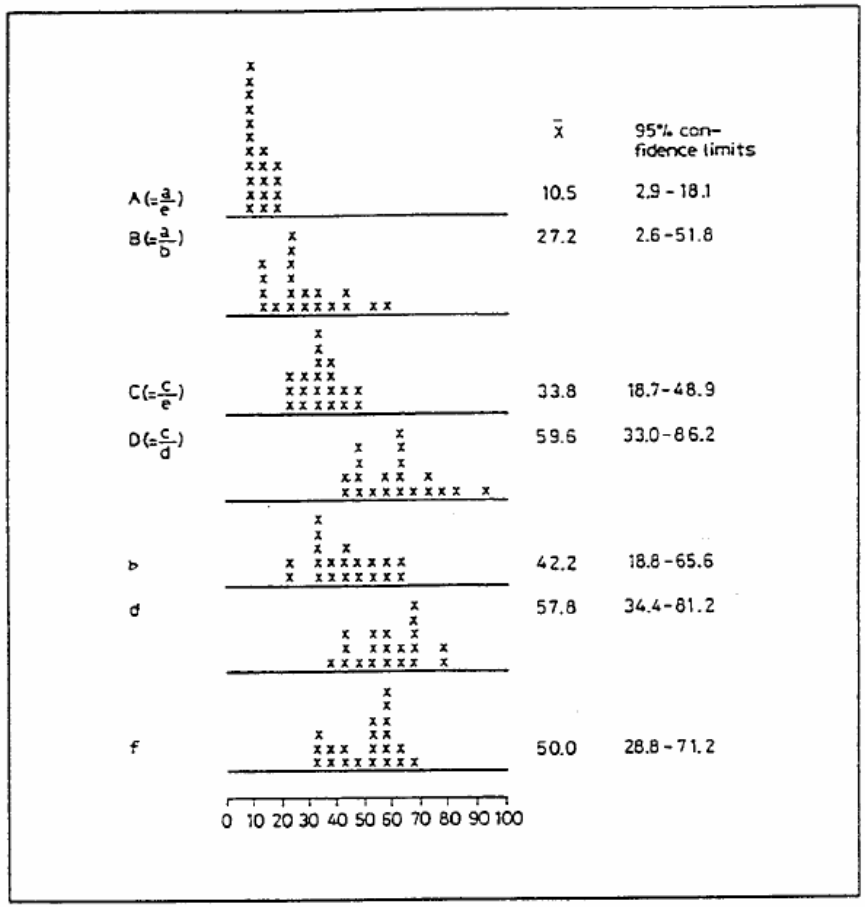
- Aspects of vocal training are also discussed and results from traditional videostroboscopy and HSDI are contrasted.
- High speed digital imaging of the vocal cords shows correct representation of their vibratory movement during vocalization.

Stroboscopy with synchronized electroglottography (EGG) 1977 in FoliaPhoniatrica by us, showing the stroboscopic open and closed phase as a marking on the EGG signal.

A short delay from the EGG phases to the acoustical signal was also found.

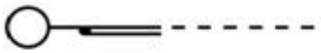


- At that time we also manually calculated and compared the EGG amplitude in 25 singers from Copenhagen Conservatory with 25 hospital employes. The amplitude was higher in singers.
- (Pedersen, M. (1978)) Electroglottography compared with synchronized stroboscopy in students of music. The study of sound, Tokyo 18: 423-434.



- The various parts of the EGG

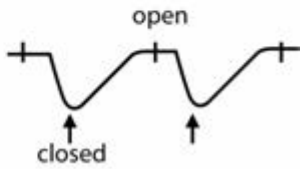
Laryngeal mirror with photocell

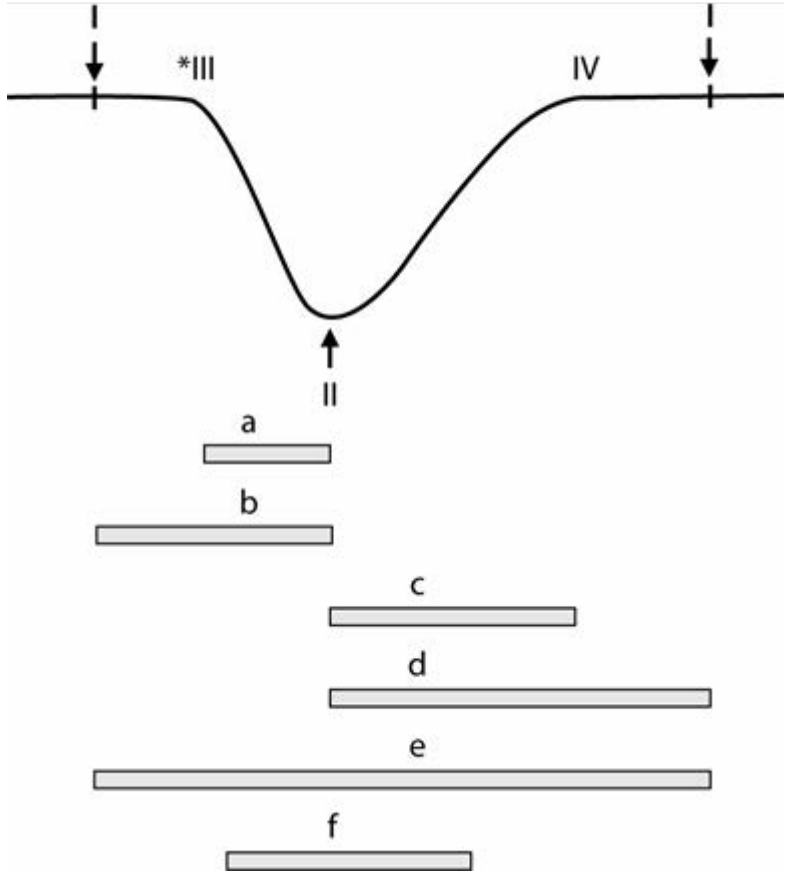


Stroboscopic light

El - glottograph

Oscilloscope



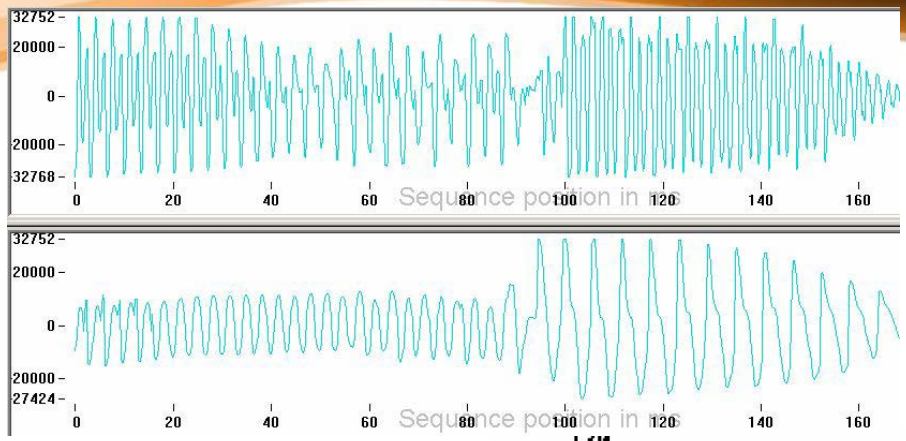


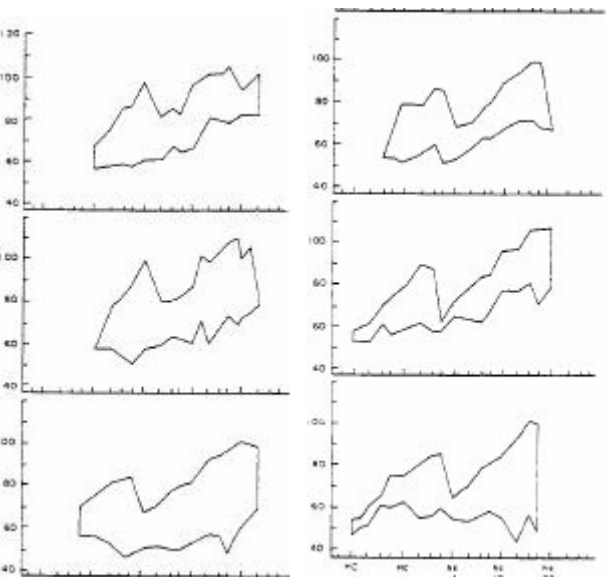
Quotients		I 20 hospital employees		II 26 music students	8 exam. of 4 students
a/e	av. %	10,5	X	21,2	23,8
	s	3,88		3,38	4,59
	95% single obs.	2,9-13,1		4,8-37,6	-
	95% of mean	8,7-13,3		17,9-24,5	-
a/b	av. %	27,2	X	47,6	23,8
	s	12,54		19,41	13,16
	95% single obs.	13,7-43,9		9,8-35,8	-
	95% of mean	21,3-33,1		40,0-63,8	-
c/e	av. %	33,8		35,3	40,9
	s	7,72		10,81	5,54
	95% single obs.	13,7-48,9		6,3-64,3	-
	95% of mean	30,1-48,9		30,9-39,7	-
c/d	av. %	59,6		59,1	67,3
	s	13,58		24,33	23,0
	95% single obs.	33,0-36,2		10,4-100	-
	95% of mean	53,2-66,0		49,0-69,1	-
b/e	av. %	42,6		44,6	33,8
	s	11,93		3,02	6,1
	95% single obs.	13,8-65,6		29,1-30,5	-
	95% of mean	37,2-43,2		41,6-48,0	-
f/e	av. %	50,0	X	38,5	34,2
	s	10,83		10,34	5,12
	95% single obs.	28,8-71,2	diff.	19,4-59,8	-
	95% of mean	44,9-55,1	P<0.001	39,3-42,7	-

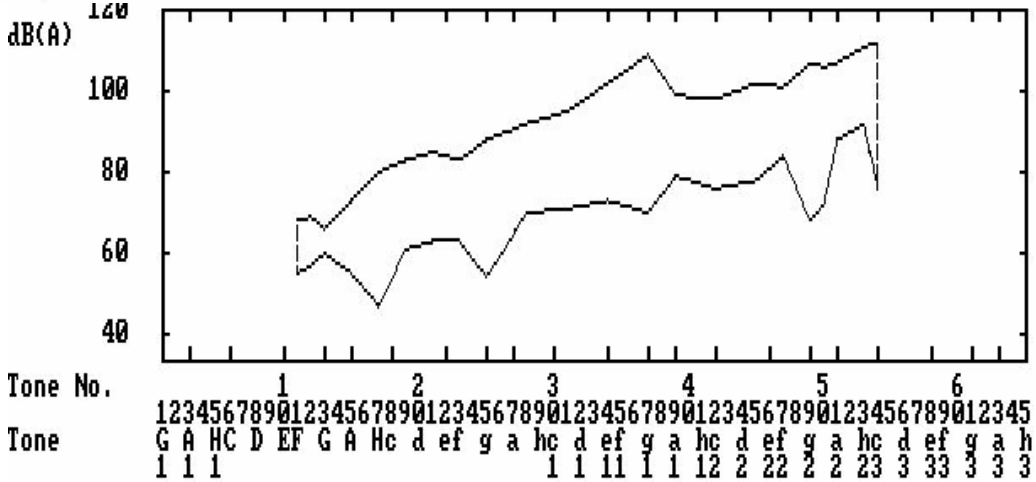
- Register change in puberty especially in males was seen in the EGG and phonetograms, but not on videostroboscopy, as presented at the Voice symposium in NY in 1988, made and edited for sale at Medizinische Hochschule Hannover

- On highspeed films with segmentation the register shift is of course clearly seen since all movements are shown and not only averages as published in:

  Pedersen M (2008). Register measurements in puberty. Deutsche Gesellschaft für Akustik e.V. *Congress report 2nd workshop COST 2103 Aachen.*



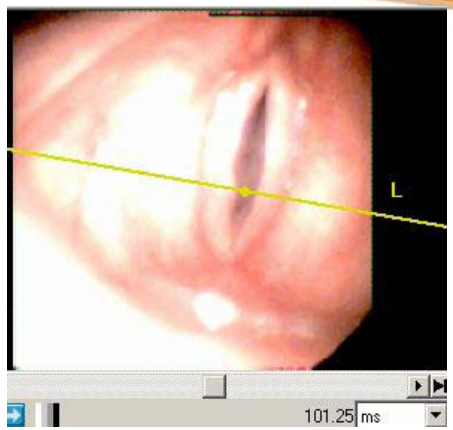


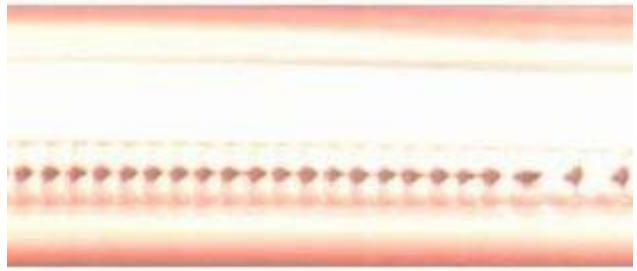


1. Save recording on disk.
2. Print recording as chart.
3. Print recording in table.
X. Return to main menu.
_ Select function.

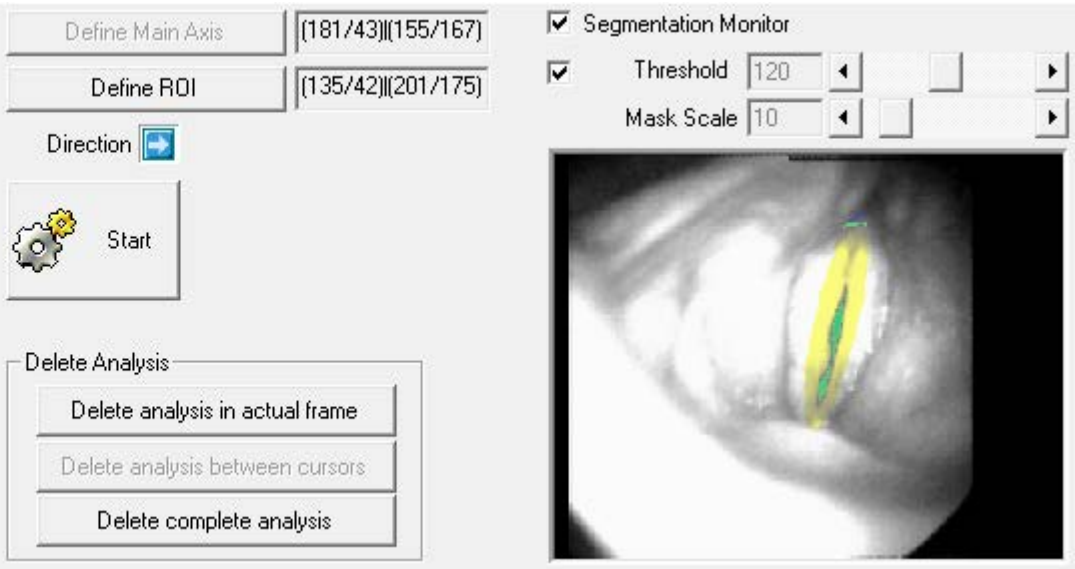
Name
Area 1069 dB x semitones
Dynamic range 0039 dB
Lowest tone F = 87.3 Hz
Highest tone c3 = 1047 Hz
Identification A:010890.01

Kymography

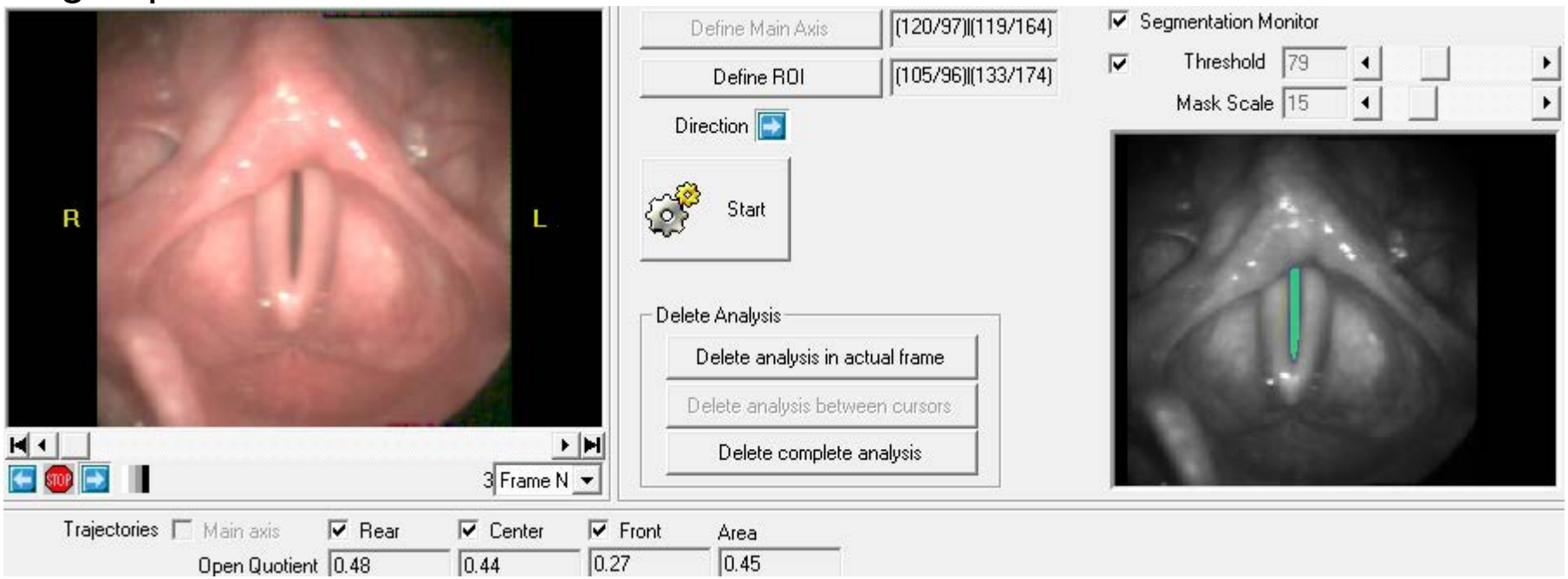




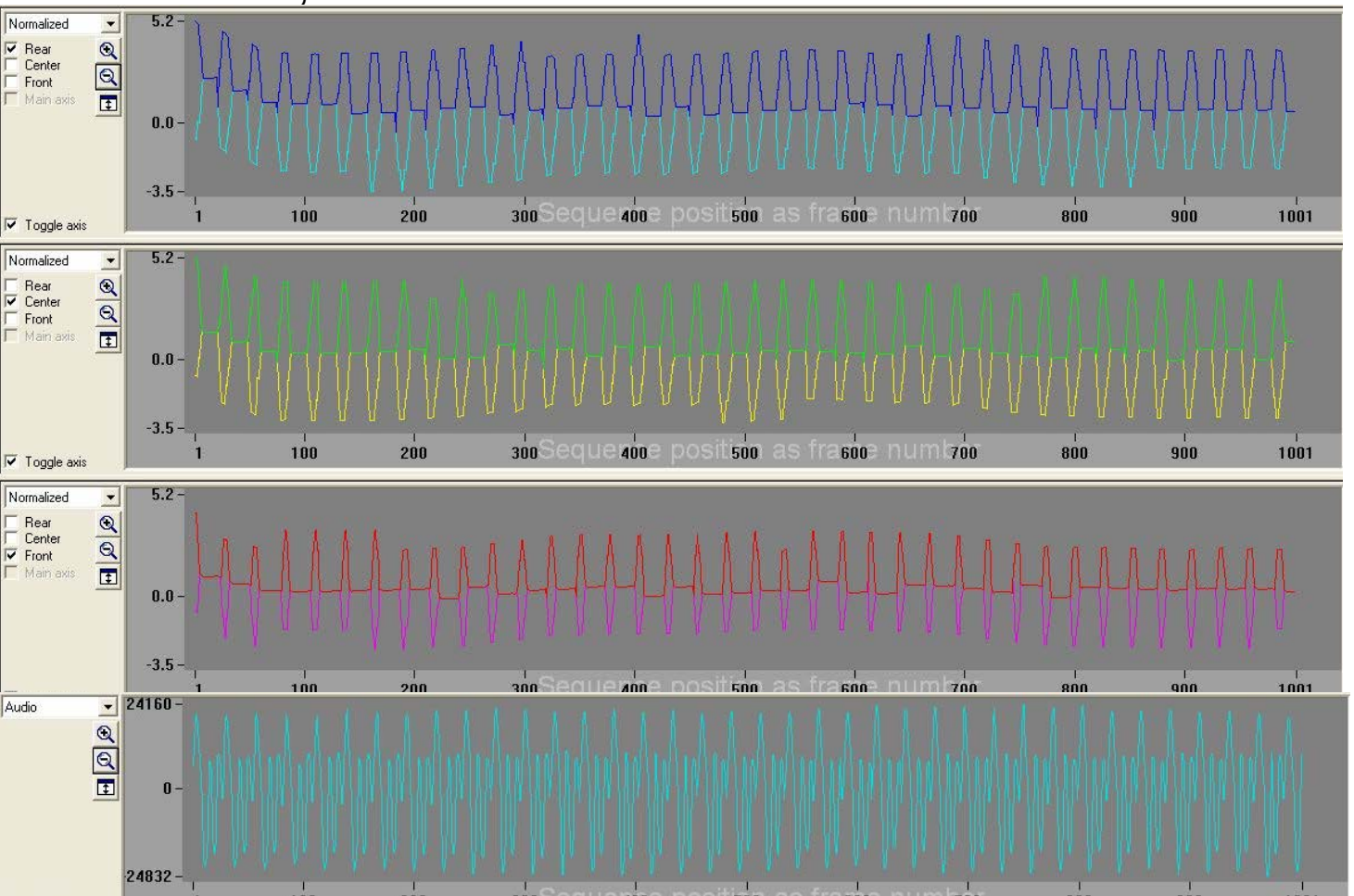
Segmentation



- Here is the HSDI video of a 20 year old male with minor throat irritation – he is normal but the irritation is seen as a very small reddening and edema of the arytenoids, the vocal cords are red but with normal configuration. How does this look with the possible online analysis of the high speed film.

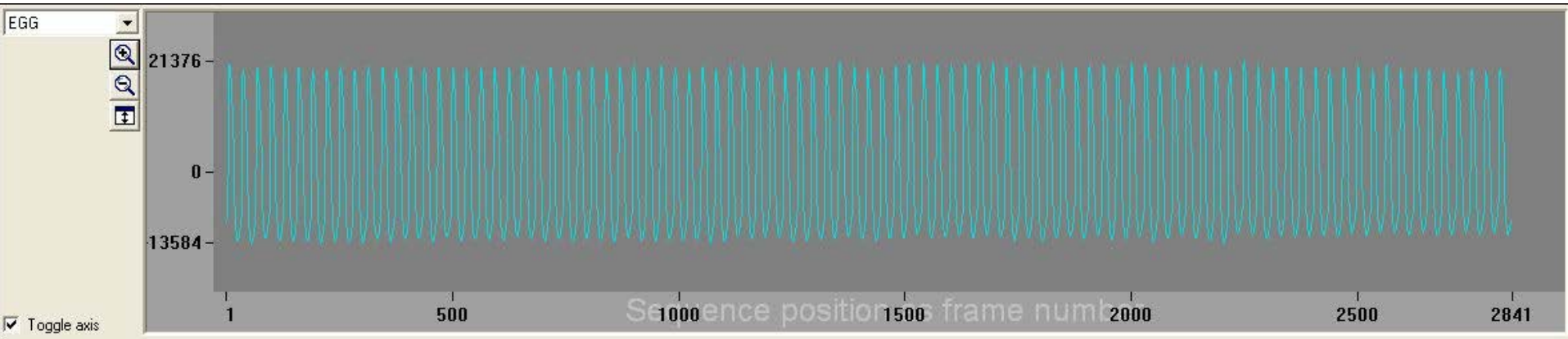


Slightly irregular movement of the vocal cords in the front, center and rear. Audio in the bottom.

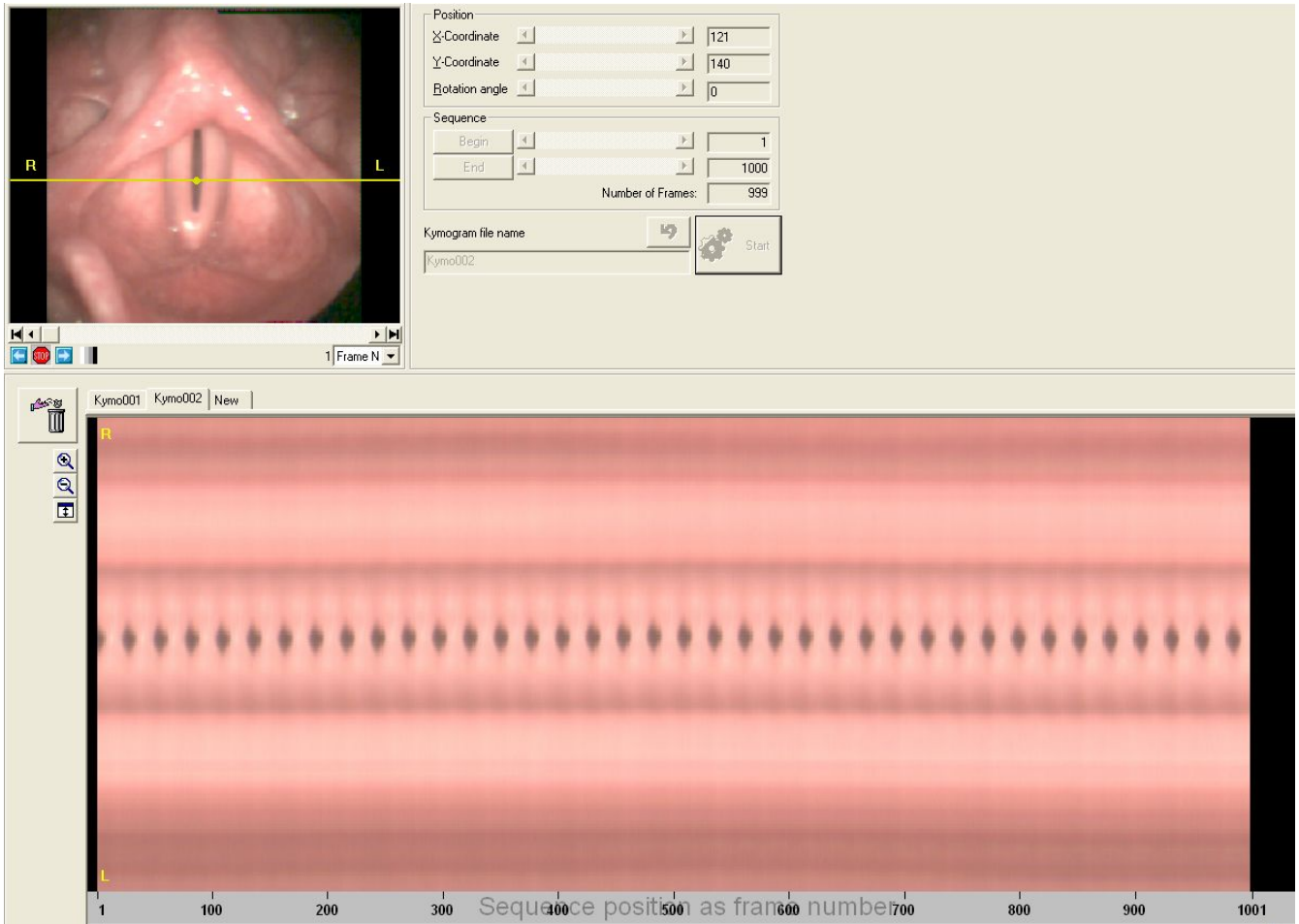


Open Quotients:
Front: 0.48
Center: 0.44
Rear: 0.27

EGG



Kymography


R
L
Position
X-Coordinate
121
Y-Coordinate
140
Rotation angle
0
Sequence
Begin
1
End
1000
Number of Frames:
999
Kymogram file name
Kymo002
Start
1
Frame N
Kymo001
Kymo002
New
R
L
1
100
200
300
400
500
600
700
800
900
1001
Sequence position as frame number

- 24 years old rock singer at his first visit 3 months before he won the Danish grand prix. We will help him to win the European one!

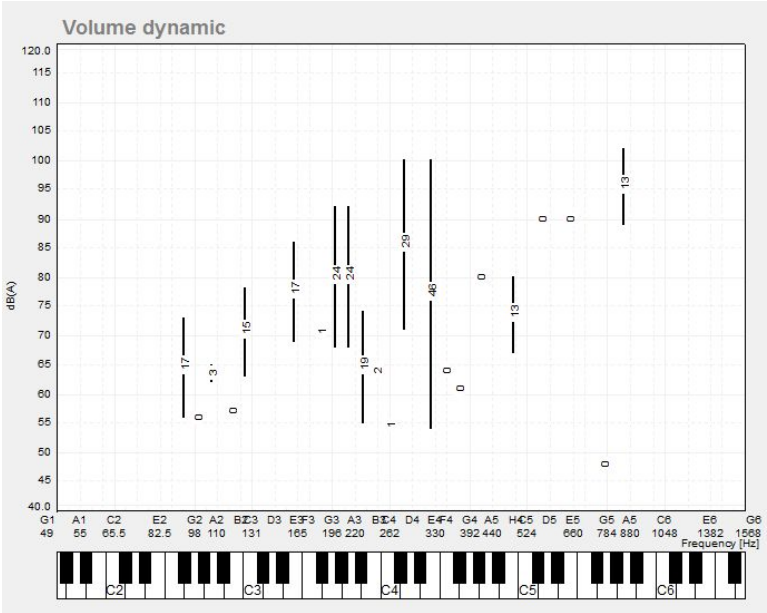
23/11 2010 – Azithromycin for bacterial infection

25/11 2010 – Less oedema, ongoing treatment

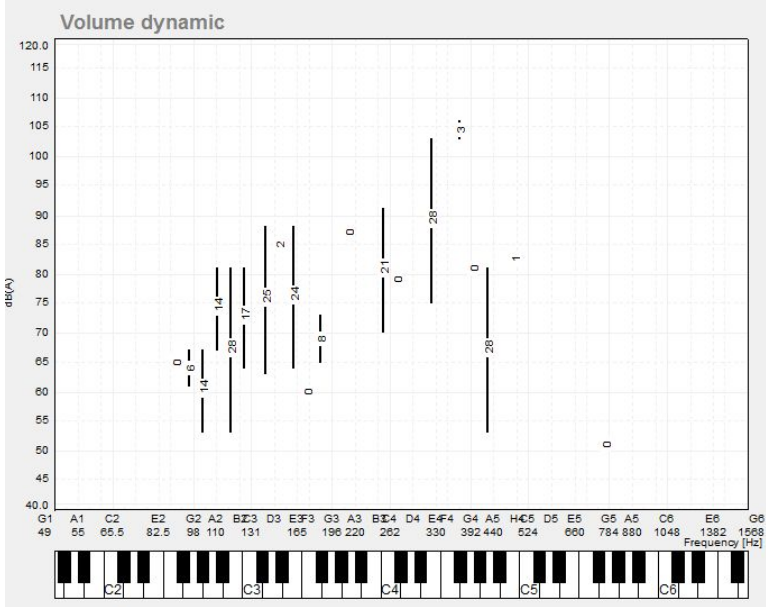

R
L
Define Main Axis
(120/80)|(116/139)
Define ROI
(96/78)|(145/139)
Direction
Start
Delete Analysis
Delete analysis in actual frame
Delete analysis between cursors
Delete complete analysis
Segmentation Monitor
Threshold
57
Mask Scale
15
2 Frame N
Trajectories
Main axis
Rear
Center
Front
Area
Open Quotient
0.60
0.52
0.40
0.59

- When the rock singer came to the clinic his complaint was vocal fatigue. He ment that he had lost hight (4 tones on the phonetogram)and intensity (reduced to half) as well as having pain in the throat (edema and reddening of the mucosa in the larynx), the result being STRAIN because the normal frequency and intensity had to be maintined during singing

4th Jan 2011



25th Jan 2011



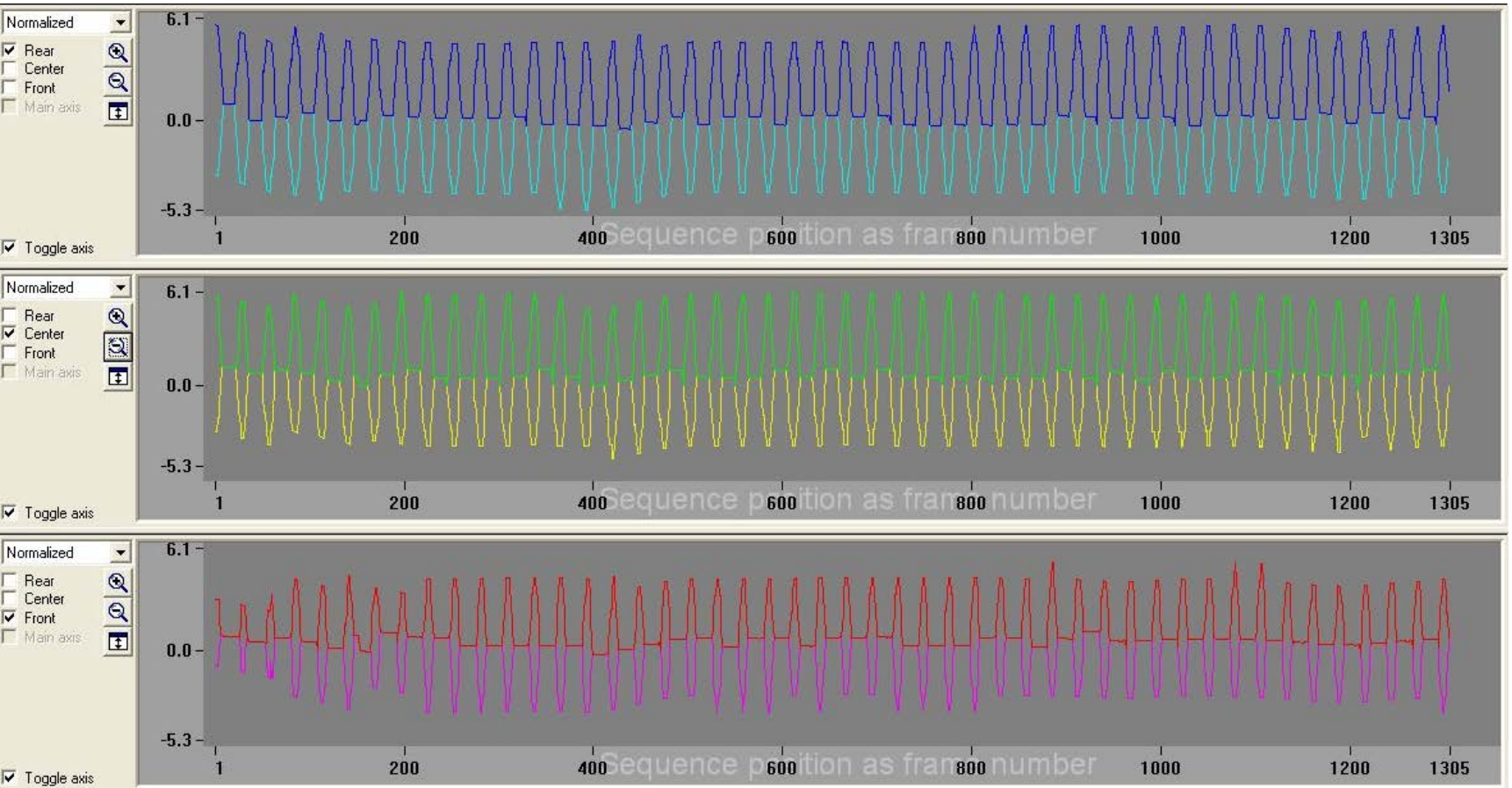
- The cost aspects are related to
- Lost concerts
- Lost career
- Lost quality of life
- The solution in England is :
- A specific professional voice insurance
- Voice related possibility for public complaints (eg indoor climate in halls)

- Here is the rocksinger again, after the first treatment with the highspeed film with segmentation and calculation of opening quotients during intonation in front, centre and rear parts of the vocal cords.

- A comparison is made of acoustical curve, EGG, area, front, centre and rear curves of the right and left vocal cords in the treated singer.

A comparison is made before and after treatment on Kymography

The Grand Prix singer before treatment

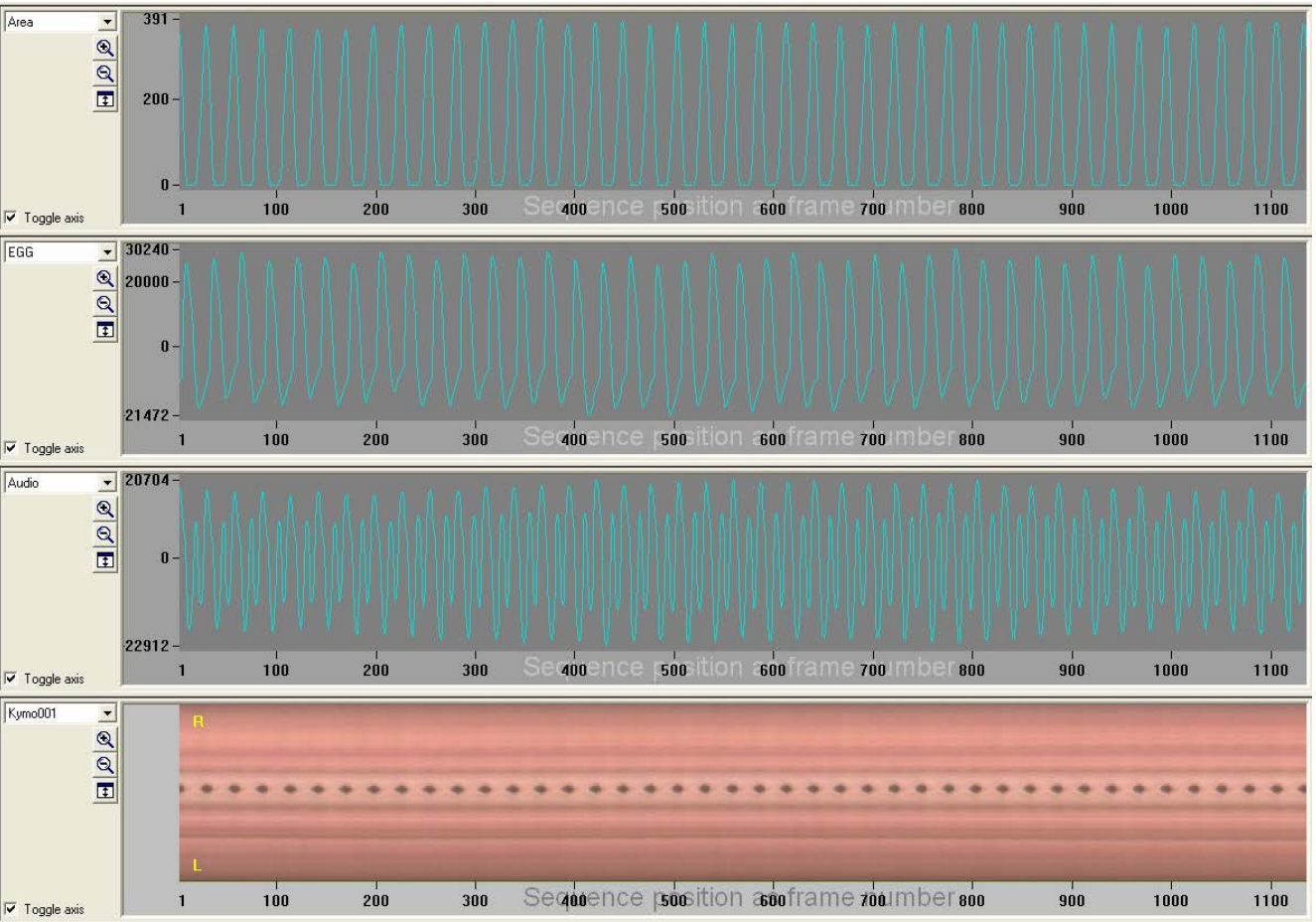


Front: 0.53

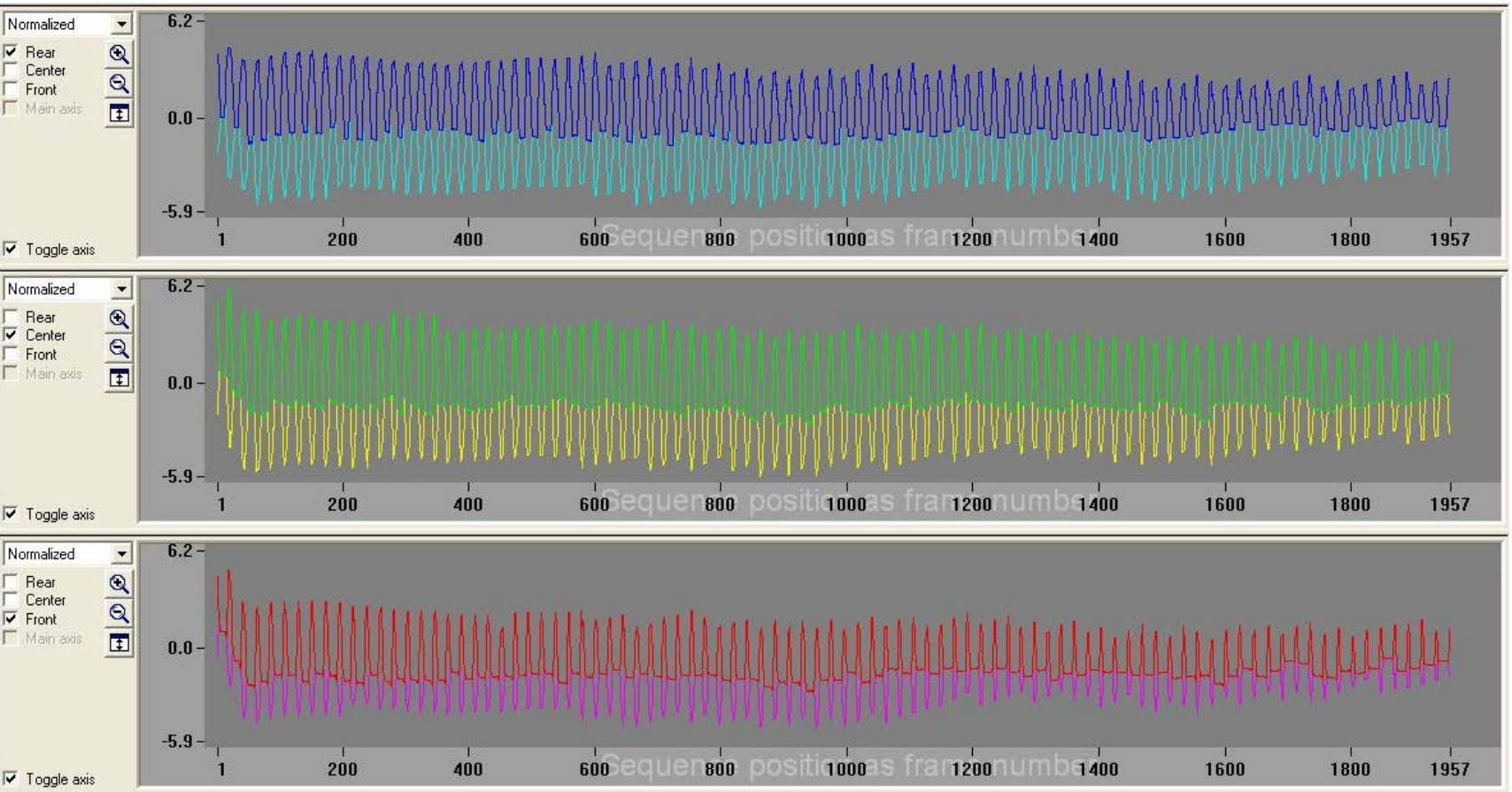
Center: 0.48

Rear: 0.36

- Grand Prix Singer area, EGG, audio and kymography



- Grand Prix singer after treatment

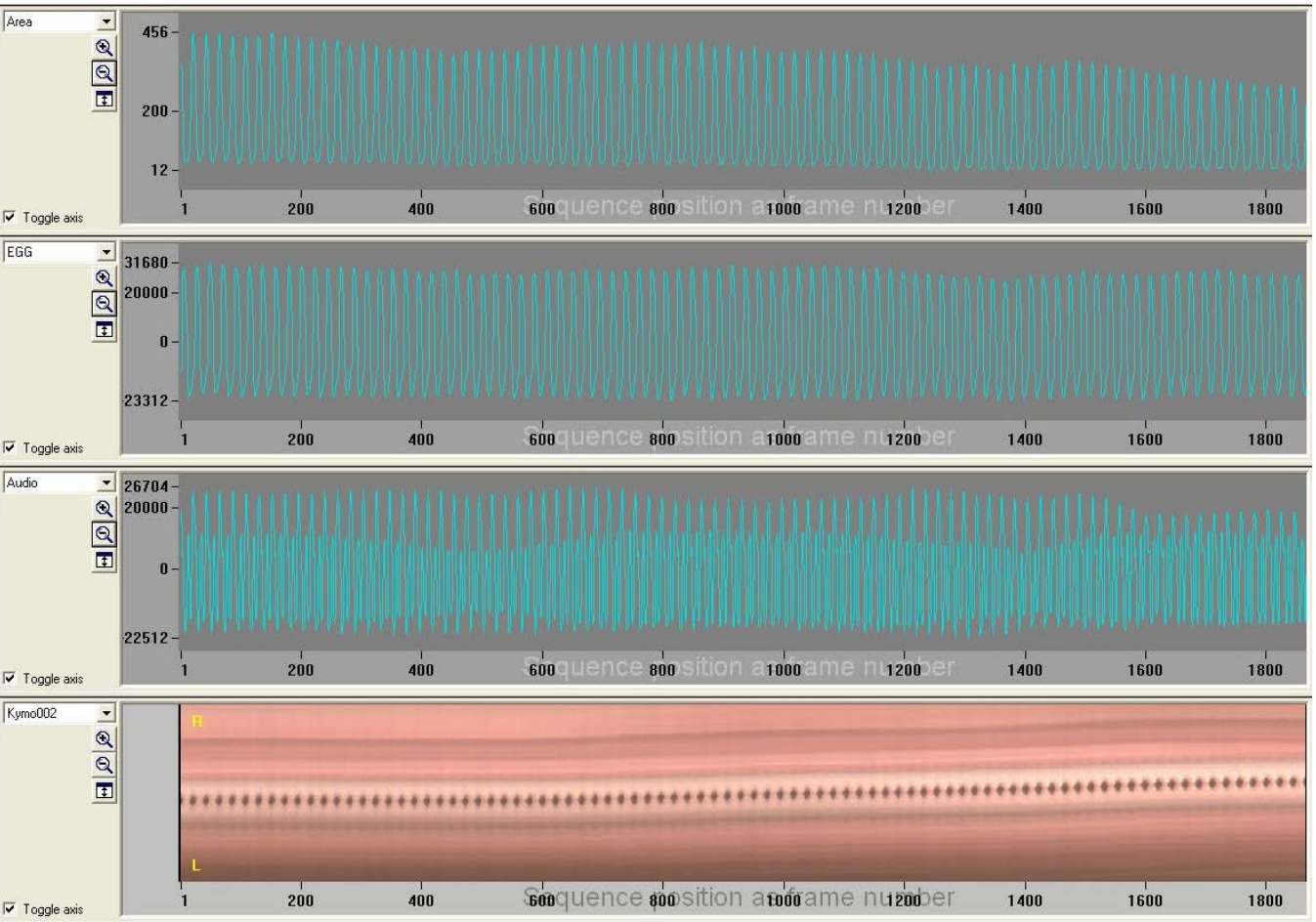


Front: 0.56

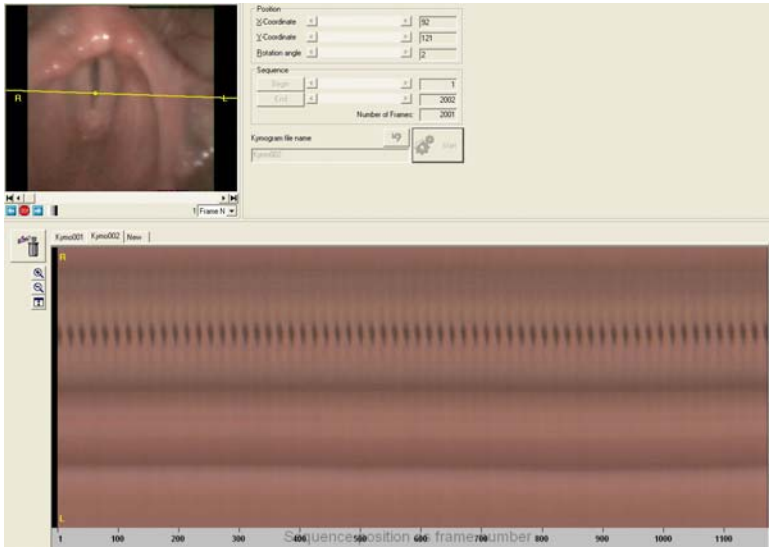
Center: 0.44

Rear: 0.31

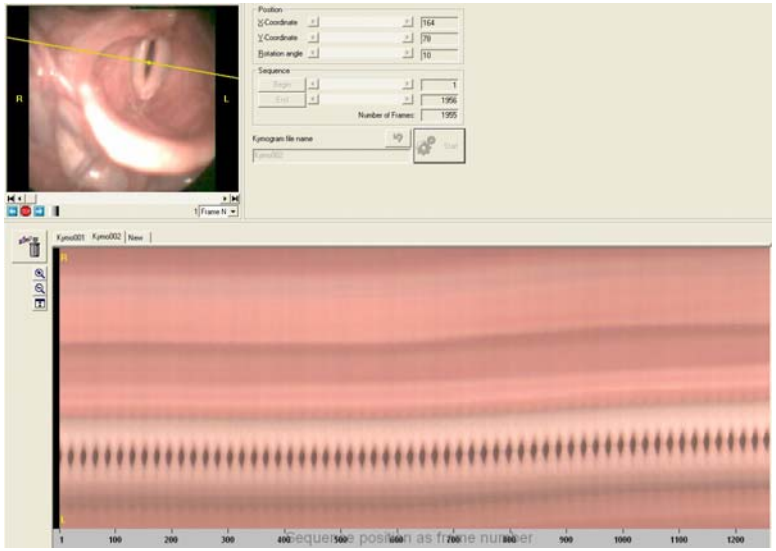
- Grand Prix singer area, EGG, audio and kymography



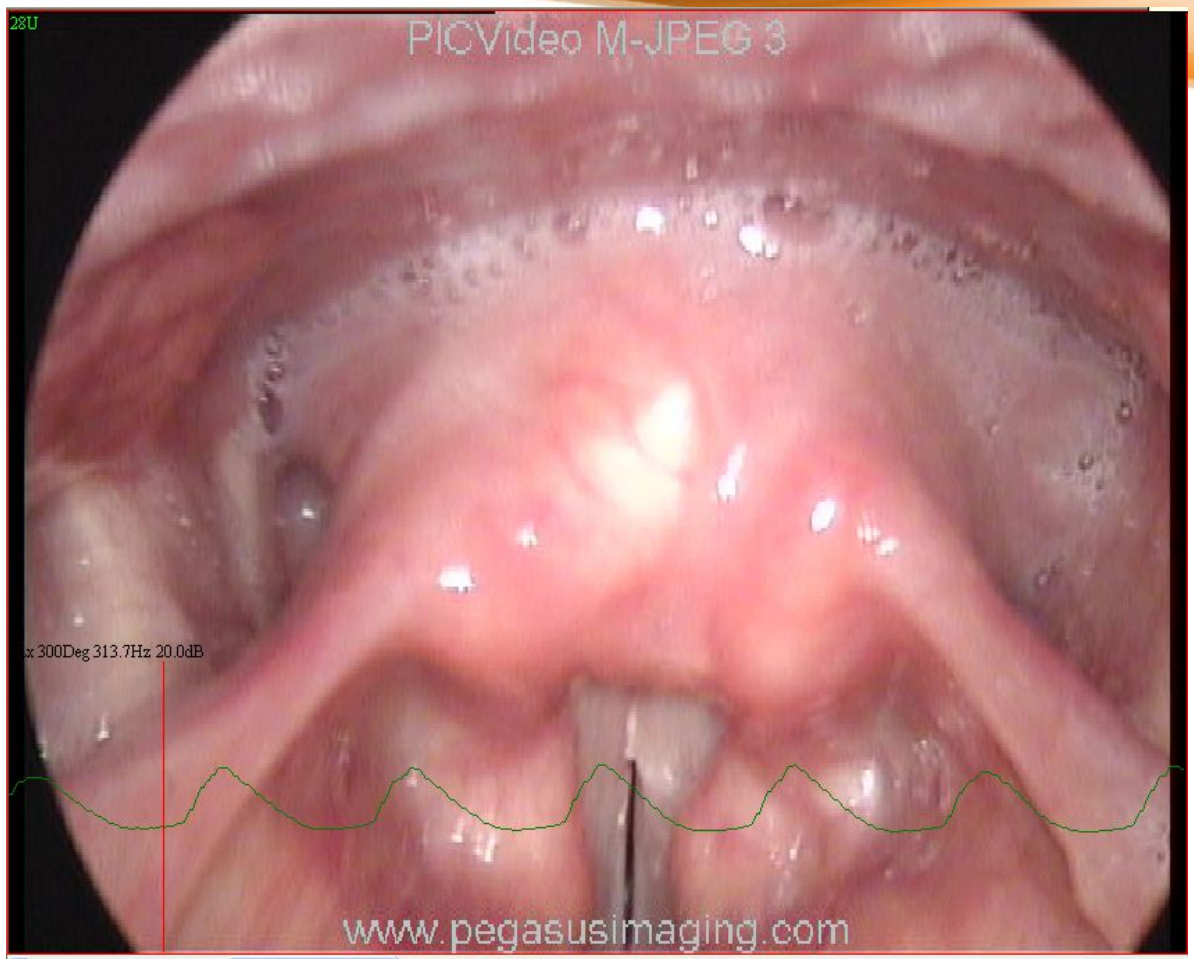
Kymography before treatment



Kymography after treatment



- Visually the curves were regular qualitatively, the refinement of quantitative measures related to online results of high speed films have to be made.
- The singers get conscious where the faults are by looking at the curves. This is of course not the case using video stroboscopy which as we show – is only an anatomic average of 6 EGG movements in the next picture


28U
PICVideo M-JPEG 3
x 300Deg 313.7Hz 20.0dB
www.pegasusimaging.com

- Here are 6 highspeed films made during the period up to the grand prix competition of our rock singer – apart from the first infection he ”mangaged” to have several other strain periods, demanding our knowledge to help.

29/12 – Corona virus OC 43

25/1 2011 – second Corona virus NL 63

13,15,17 Dec 2010 Reflux diagnosis and treatment

22/2 2011 – Bacterial infection 5 days before Grand Prix. Treated with Moxifloxacin

22/3 2011 - Minor relapse of infection after concert tour in Canada. Treated with Azithromycin

From 16/12 2010 constantly treated with pantoprazol and fexofenadin

- 23.Nov 2010 steptococs type A were found treated with azitromycin 6 days
- 29. Dec 2010 corona virus OC43 virus and influenza symptoms treated with tamiflu
- 25.Jan 2011 corona virus NL 63 and influeza symptoms treated with tamiflu
- All treatments combined with fexophanadin 180 mg x3 daily

- A gastro esophageal hernia with reflux was suspected because of ongoing throat pain. It was diagnosed 15. December 2010 with distal oesophagitis with reddening of the mucosa. Life style was changed - Proton pump inhibitor was given for a pharmacological correction as a 3 month supplement, and help to change of lifestyle

- Edema of the arytenoids can be seen due to gastro esophageal hernia.
- A film is presented of what happens as for acid mucus ”visiting the arytenoids” for 0.2 seconds.

- A grading was presented of edema of the arytenoid region depending of acid and mucin provocation from the stomach for videostroscopy which can also be used for HDSI.

(MAVEBA 2007).

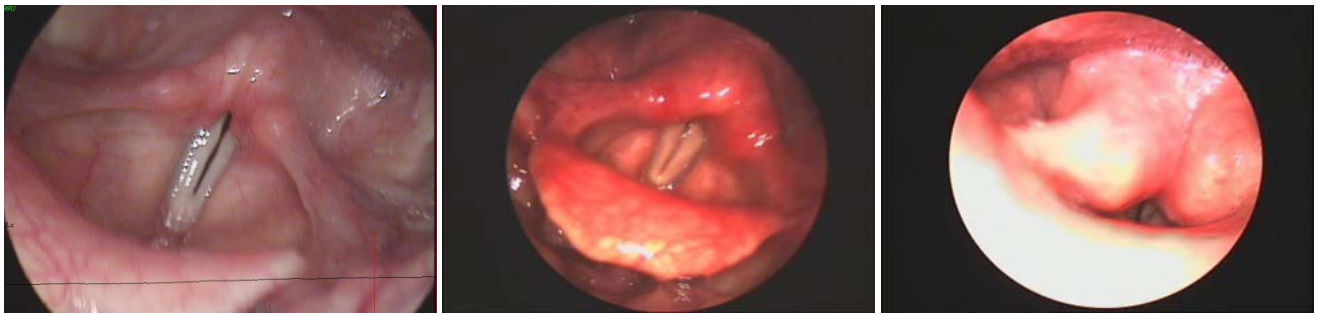


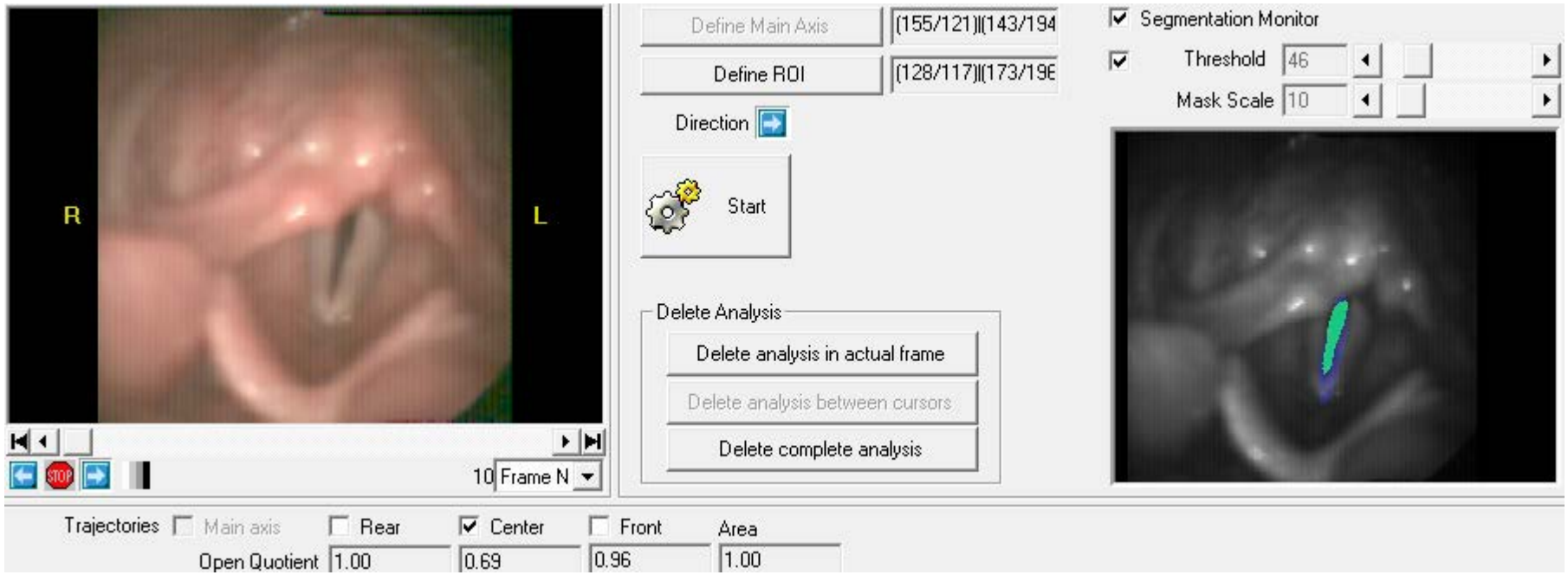
Fig. 1A	Fig. 1B	Fig. 1C
Score 1	Score 3	Score 5

- Our gastro enterologist at the university of Copenhagen gives further information by grading the gastro oesophageal hernias in maximum opening to the esophagus, moderate and a little opening. He seldom finds reflux without a hernia.
- Our rock singer had only a small hernia, grade 1:
- The life style change included no smoking, no fatty and smoked food, no coffein and chocolate intake, no spicy food, no eating 2-3 hours before bed time and lying with the head at least 30 degrees up at night

- Other important reasons for vocal fatigue are inhalation and food allergies. A film of a highly allergic girl with a moderate esophageal hernia is presented. She has just been accepted for Odense artist school as 1 of 8 out of 700 – she starts 1. August 2011 – so we have time to make her conscious of her riscs and vocal borders.

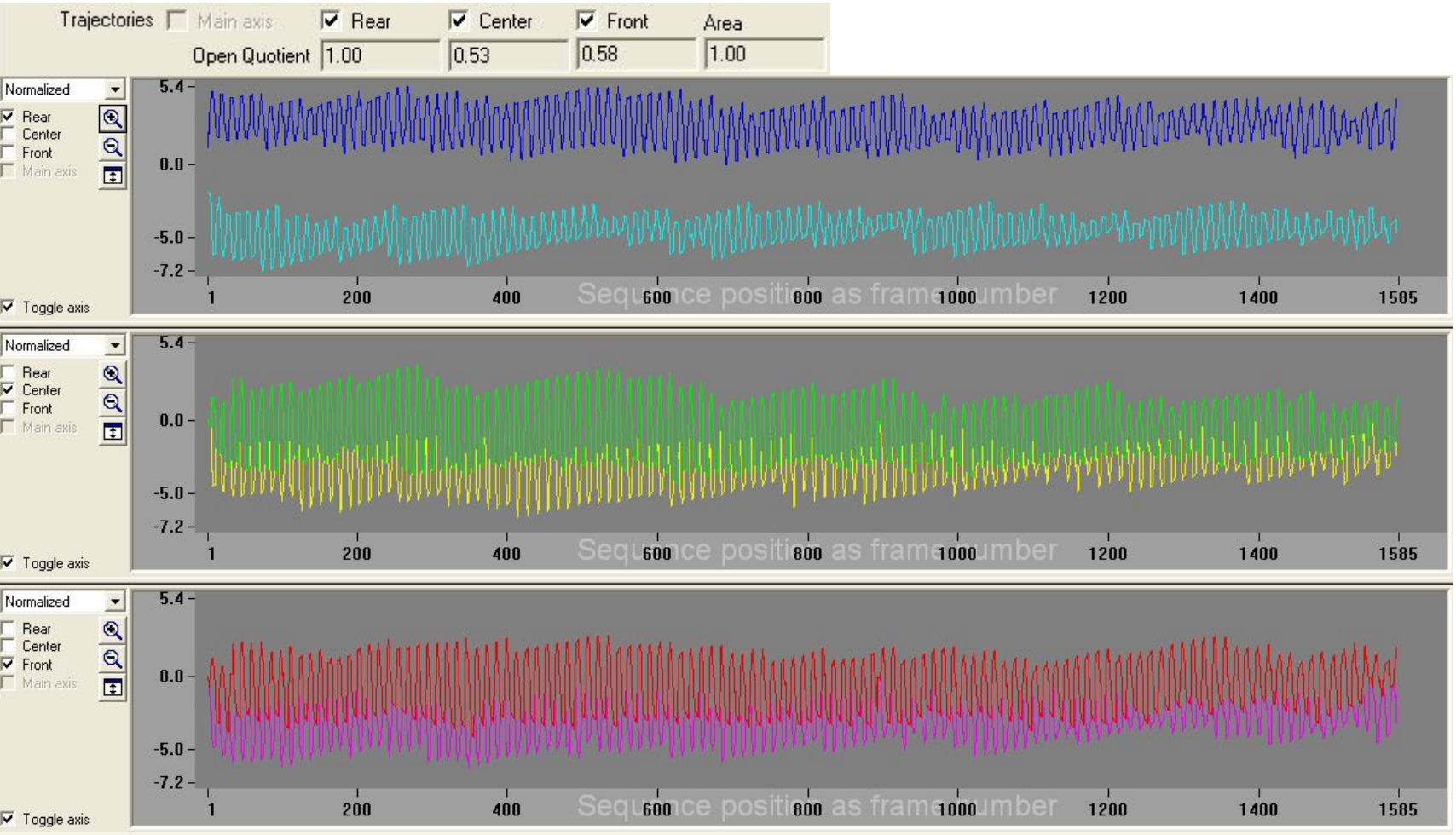
2 days after start of allergy treatment

- Segmentation before Treatment:
- With opening quotients

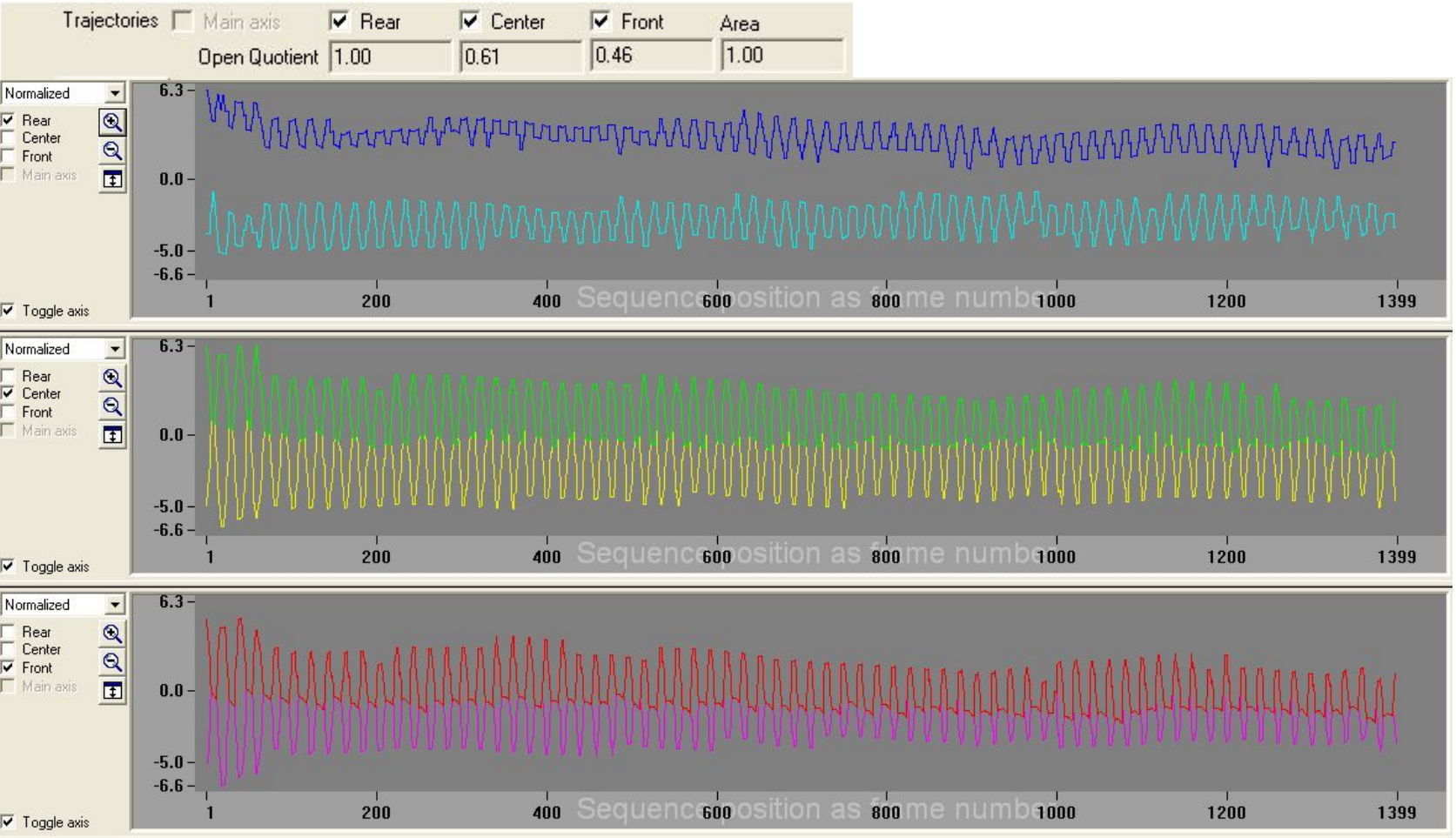


- Segmentation after treatment for 2 days:

- Before treatment

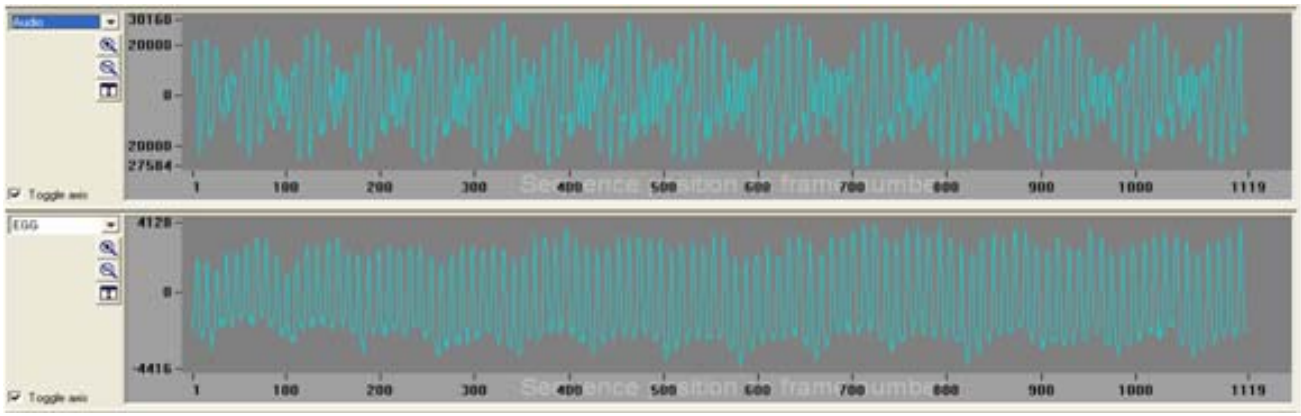


- One week after beginning of treatment of the allergy



- Genetic lactose intolerance with edema of the arytenoids is seen in 12% of the performers in the clinic. It changes the artist life to get a correct genetic diagnosis, just a blod test..

- In conclusion:
- High speed films give the correct picture of the functional vocal cords. Better segmentation options are on their way from Erlangen in Germany (prof. Döllinger) with more pixels and quantitative calculations of the online parametres including vibrato.



Thanks to:

The audience

The co workers of the clinic:

Anders Jønsson for making the videos

Mike Ellingsen

Christian Larsen

Philip Andersen

Line Jønsson

Sarah Øst Jensen

Shahzleen Rajan