# 行政院國家科學委員會專題研究計畫成果報告

## 利用口腔超音波研究舌前推異常功能及口顏肌功能復健治療研究室之建立

**Ultrasound Investigation of Tongue Thrust Dysfunction and the Establishment of an Orofacial Myofunctioal Therapy Research Center**

計畫類別： ☑ 個別型計畫 □ 整合型計畫

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# 目錄

前言

由於貴會補助本研究計劃之金額與申請有相當大的落差。然而在研究團隊克服萬難的情況下，仍然完成。對於研究舌前推功能異常之研究已撰寫完成英文論文，並投稿於 European Journal of Oral Science，目前正在審稿階段。

也希望未來國科會能再繼續協助第二階段肌顎功能復健研究室之成立及相關研究爲禱。

報告人：彭建綸

研究成果報告內容如下：

**ABSTRACT**

Many studies have proved that visceral swallowing, and tongue thrusting, play a significant role in the etiology of some orofacial deformities. In order to learn more about the relationship between tongue function and form of orofacial structures it is therefore of great importance to recognize patients with abnormal swallowing patterns. A self-constructed cushion ultrasound scanning technique was applied to measure and compare tongue movements between patients with somatic and visceral swallowing. Based on M-mode images the entire phase of swallowing was divided into 5 subphases (I, IIa, IIb, IIIa and IIIb). Duration, range, speed and reproducibility for each of the 5 subphases were calculated and compared respectively. It was found that visceral swallowers reveal a longer phase IIb than somatic swallowers ($p < 0.0009$), while the tongue speed with visceral swallowing in phase IIb ($p < 0.01$) and IIIa ($p < 0.05$) was found to be slower than with somatic swallowing. There are distinctly different movements that can be positively differentiated with the method used.

KEY WORDS – visceral swallowing, somatic swallowing, tongue function, cushion scanning technique

## INTRODUCTION

Tongue functions during swallowing are of interest to many ENT doctors, dentists, radiologists, neurophysiologists and speech pathologists. In case of normal deglutition the tip of the tongue rests on the lingual of the dentoalveolar area; the contraction of perioral muscles is minimal during deglutition, the teeth are in momentary contact during the swallowing, and there is neither a tongue thrust nor a constant forward posture.

Many studies have demonstrated that visceral swallowing, also known as infantile swallowing, plays a significant role in the etiology of some orofacial deformities. [1,2] In neonates the tongue is relatively large and located in the forward suckling position for nursing. The tongue lies between the anterior gum pads and assists in the anterior lip seal. This swallowing pattern is infantile or visceral (Fig. 1A). With eruption of the incisors at about 6 months, the tongue position starts to retract. Over a period of 12 to 18 months, as proprioception causes tongue postural and functional changes, a transitional period ensues. Between 2 and 4 years the functionally balanced, or mature, somatic swallowing prevails (Fig. 1B). Visceral swallowing can persist well beyond the fourth year of life, however, and is then considered dysfunctional or abnormal because of its association with certain malocclusive characteristics. [3]

The symptoms of a preserved visceral swallowing pattern usually include forward tongue posture and tongue thrusting during swallowing, contraction of the perioral muscles (hyperactive mentalis and orbicularis oris contraction), often excessive buccinator hyperactivity, and swallowing without the momentary tooth contact normally required.

Several methods for evaluation of tongue movements, such as the radiocinematography, electromyography and electromagnetic articulography have been used in previous studies. [4-7] However, these techniques are these days considered unsuitable for clinical usage because of their various disadvantages, such as prolonged chair time, and receiver coils and wires attached to the tongue which may have an impact on the swallowing or are ethically questionable due to the x-ray exposure.

Ultrasonography has been used in many studies for static imaging of the oral cavity, e.g. for studying tongue morphology as well as for diagnosis of sialolithiasis, cysts and tumours.[8] Also dynamic ultrasound investigation of tongue movement through submental scanning has been described by many researchers.[9-11] A major obstacle of these previous dynamic ultrasound studies is that they used direct transducer-skin coupling scanning to observe tongue movements which causes various artifacts resulting in inaccurate measurements of tongue movements. A cushion scanning method provides a solution to the problems described above. With a cushion scanning technique that consists of a cushion device, a head supporter, a probe holder and a head position-recording device the tongue dynamic can be correctly recorded and measured (Fig. 2). [12,13]

The use of M-mode ultrasound technique for interpretation of the tongue movement during swallowing has also been reported. [14] With M-mode images the swallowing phase can be divided into 5 subphases (I, IIa, IIb, IIIa and IIIb) that potentially give a more detailed analysis of swallowing (Fig. 3).

It was the purpose of this study to apply this new ultrasound measurement technique to investigate and compare tongue functions during swallowing between subjects with somatic and visceral swallowing pattern

## MATERIAL AND METHOD

Forty subjects with somatic swallowing pattern (average age 21.8 ± 6.1 years) and 15 subjects with visceral swallowing pattern (average age 13.6 ± 6.6 years) were enclosed in this study. The cushion scanning technique was used to measure their tongue movements during swallowing. Swallowing of both, somatic and visceral subjects was investigated with B- and M-mode ultrasound technique (SIEMENS, Sonoline SL-250 with 3,5 MHz, 100° mechanical sector transducer; Berlin, Germany)(Fig. 2). The B-mode image yields 2-D images allowing to scrutinize the tongue movement in slow motion or as still video sequences. In addition, the M-mode gives a time-amplitude diagram revealing simultaneously duration and amount of movements of the tongue and submental tissues (Fig. 4). In this study, the scan line for M-mode (M-position) was set in the middle of tongue in the median sagittal plane.

Immediately before the ultrasonic registration started, the participants were asked to swallow 3-5 ml of water with a straw, to wait 10 sec, and then swallow again without water. These swallowing cycles were repeated three times with at least 20-sec intervals. Totally 120 somatic swallowings and 45 visceral swallowing were registered. Based on these swallowings the standard deviation of the two groups were calculated according to each subphase and considered a measure for reproducibility.

The ultrasound signals of the (standard) swallowing without water from each participant were recorded on a video recorder (SONY EV-C45E, Tokyo, Japan) and then transferred into an IBM-compatible personal computer (Intel Pentium 200, 64 MB RAM, with Windows 95 as operating program) through a video card (VIGA Window, Visionetics International, Taipei, Taiwan; with 28-pin TDA 8709 chip for S-Video input) for digital assessment (Fig. 5).

The M-mode classification of the swallowing phase was used in this study. The tongue movements of the visceral group and the somatic group during swallowing were compared within each subphase (phase I, IIa, IIb, IIIa, IIIb) as well as in the entire swallowing phase.

Student's t-test was used to analyze the difference of tongue movements during swallowing between somatic and visceral swallowers. Levene's test for equality of variances was applied to examine the variability of tongue movements during swallowing between the two compared groups. All statistic analysis was performed by the Statistic Package for Social Sciences (SPSS for Windows, Version 6.0, SPSS GmbH Software, Munich, Germany)

## RESULTS

Mean and standard deviation of duration, range, speed and reproducibility for each of the 5 subphases as well as the entire swallowing were calculated and illustrated in table 1, 2 and 3 respectively. The results revealed a great difference between somatic and visceral groups in the duration of phase IIb ($p < 0.0009$). To the contrary, the range of tongue motions of the two groups showed no difference. The speed of tongue movement in phase IIb and IIIa demonstrated significant differences between the two groups compared ($p = 0.006$, $p = 0.037$).

The visceral swallowing group revealed also a greater variability in the range of tongue movement ($p = 0.035$) and tongue velocity ($p < 0.0009$) in phase IIIa (Tab. 4). On the contrary, in phase IIb the visceral swallowing group showed less variability than the somatic swallowers.

**DISCUSSION**

Many previous ultrasound studies failed to obtain a correct registration of the tongue movements, because a hand-held ultrasound probe cannot be kept in a constant position held in direct contact with the moving submental skin during swallowing. Besides, patient's head position was not stabilized in these studies. Thus, the scanned tongue motions did not yield from a defined scanning position.[12, 13] With the cushion scanning technique used in this investigation it is possible to overcome the difficulties mentioned above and to examine the tongue movement correctly.

A simple and common clinical method to recognize a visceral swallowing pattern is a forced opening of the lips during swallowing. Interdental tongue positioning can be commonly observed with visceral swallowing pattern. However, since tongue movement is known to be linked with the perioral muscles' functions during swallowing.[15, 16] Consequently, opening of patient's lips to observe the tongue thrust will not only disturb the lip functions but may also affect the tongue movement pattern during swallowing. Therefore, a non-mouth-opening examination, such as ultrasonography, is to be preferred for a routine examination of visceral swallowing.

Most authors divide the deglutition cycle into four stages.[9-11, 17] In the present paper the classification of the swallowing phases is performed by dividing the different movements of tongue during a swallowing on a M-mode image.[14] The resulting phases I, IIa, IIb, IIIa, IIIb can be regarded as shovel phase, early transport phase, late transport phase, early final phase and late final phase, respectively, in the previous four stages definition.

In phase I and IIa, (shovel and early transport phase) of the visceral swallowing pattern the tongue stretched out and contacted upper and lower teeth or inserted between them to seal the opening between teeth. In phase IIb the tongue pressed against the anterior teeth or into the gap between upper and lower teeth. Therefore, the tongue did not move much forward and stayed a few microseconds on the anterior teeth. Consequently, a stretched tongue needed more time to transport considering the distance from anterior to posterior part of the tongue. The two reasons given above may explain why an elongated duration of phase IIb was evident in this study. After the elongated phase IIb the tongue in phase IIIa moves more quickly than usually. As a result, no differences were found in the entire duration, range and speed of swallowing. The rebounding tongue movement in phase IIIa is less reproducible in visceral swallowers so that the standard deviation of range and speed of tongue movements was greater than in the group with somatic swallowing.

Ultrasound has the advantages of actually visualizing the soft tissues of the tongue and the floor of the mouth rather than the bolus as is the case with radiography. With technique refinement, it should be possible to employ coronal viewing or even 3D imaging to yield additional information. Furthermore, because of the lack of negative biological side effects, ultrasound studies of swallowing can be of long duration and can be repeated as often as necessary. Ultrasound real-time scanning, although not yet as widely applied as the conventional techniques of radiography and manometry, appears promising and should be capable of providing further information about the swallowing mechanism and the effect of various exercises and appliances on the swallowing pattern.

**SUMMARY AND CONCLUSIONS**

1. Visceral swallowing was found to be associated with a prolonged duration of phase IIb of swallowing.
2. Range and speed in phase IIIa were found to be greater with visceral than with somatic swallowing.
3. The cushion scanning technique in combination with B+M-mode-ultrasonography provides quantitative information of tongue movement with no biological side effects, and therefore is ideal for routine evaluation of tongue functions.

Acknnowledgements –

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# TABLES

| | Duration (s) | | |
|---|---|---|---|
| ***Phase*** | ***somatic*** ***n = 120*** | ***visceral*** ***n = 45*** | ***Difference of means*** |
| **I** | 0.49 ± 0.31 | 0.45 ± 0.30 | -0.04 |
| **IIa** | 0.24 ± 0.16 | 0.21 ± 0.10 | -0.03 |
| **IIb** | 0.47 ± 0.29 | 0.67 ± 0.34 | 0.20*** |
| **IIIa** | 0.31 ± 0.16 | 0.26 ± 0.12 | -0.05 |
| **IIIb** | 0.93 ± 0.48 | 0.86 ± 0.45 | -0.07 |
| **Entire** | 2.43 ± 0.64 | 2.45 ± 0.60 | +0.02 |

Tab. 1: Mean duration of tongue motions during swallowing in different subphases and average differences between somatic and visceral swallowing pattern. ***: significant at 0.1 % level

| Range (mm) | | | |
|---|---|---|---|
| ***Phase*** | ***somatic*** ***n = 120*** | ***visceral*** ***n = 45*** | ***Difference of means*** |
| **I** | 5.09 ± 3.87 | 4.45 ± 3.39 | -0.64 |
| **IIa** | 10.53 ± 4.86 | 11.27 ± 3.95 | +0.74 |
| **IIb** | 1.18 ± 1.84 | 0.90 ± 1.25 | -0.28 |
| **IIIa** | 4.16 ± 4.13 | 5.33 ± 5.57 | +1.17 |
| **IIIb** | 2.98 ± 3.24 | 2.41 ± 2.61 | -0.57 |
| **Entire** | 23.94 ± 10.02 | 24.36 ± 10.04 | -0.42 |

Tab. 2: Mean range of tongue motions during swallowing in different subphases and average differences between the somatic and visceral swallowing pattern. Non of the differences was significant at the 5 % level.

| *Speed (mm/s)* | | | |
|---|---|---|---|
| ***Phase*** | ***somatic n = 120*** | ***visceral n = 45*** | ***Difference of means*** |
| **I** | 14.76 ± 14.60 | 14.53 ± 14.35 | -0.23 |
| **IIa** | 60.15 ± 43.84 | 66.27 ± 39.66 | +0.12 |
| **IIb** | 4.19 ± 9.98 | 1.48 ± 2.09 | 2.71** |
| **IIIa** | 14.64 ± 16.52 | 25.95 ± 34.06 | 11.31* |
| **IIIb** | 3.58 ± 4.07 | 2.56 ± 3.05 | -1.02 |
| **Entire** | 10.48 ± 5.12 | 10.29 ± 4.40 | -0,19 |

Tab. 3: Mean speed of tongue motions during swallowing in different subphases and average differences between somatic (S) and visceral (V) swallowing patterns. *: 5 % level of significance, **: 1 % level of significance.

**Levene´s Test for Equality of Variances**

| *Phase* | *Duration* | *Range* | *Speed* |
|---|---|---|---|
| **I** | ns | ns | ns |
| **IIa** | ns | ns | ns |
| **IIb** | ns | ns | SD: S > V*<br>DSD = 7.89 mm/s |
| **IIIa** | ns | SD: S < V*<br>DSD = 1.44 mm | SD: S < V***<br>DSD = 17.54 mm/s |
| **IIIb** | ns | ns | ns |
| **Entire** | ns | ns | ns |

Tab. 4: Comparison of the variances of the two swallowing patterns (somatic and visceral) with Levene's test. S = somatic swallowing, V = visceral swallowing, ns = not significant, SD = standard deviation, DSD = Difference between standard deviations. *: 5 % level of significance, ***: 0.1 % level of significance

**Legends**

Fig. 1 A) Visceral (infantile) type of swallowing. 1B) Somatic (mature), type of swallowing.

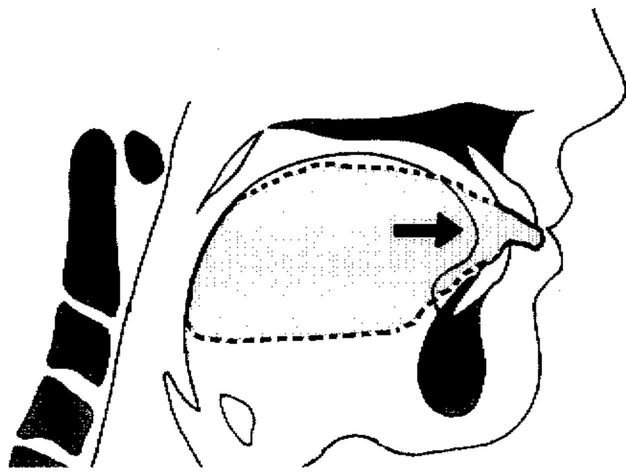


Fig.1A

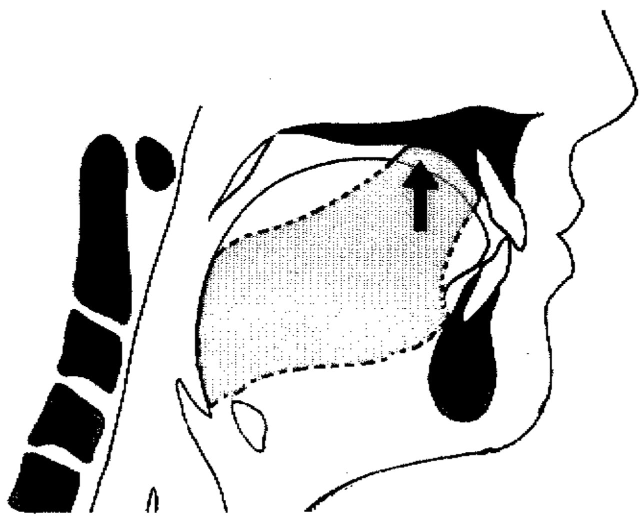


Fig.1B

Fig. 2 The cushion scanning technique in combination with the computer-aided-B+M-mode-ultrasonography. 1 = cushion device, 2 = head supporter, 3 = ultrasound transducer holder, 4 = head position recording device.

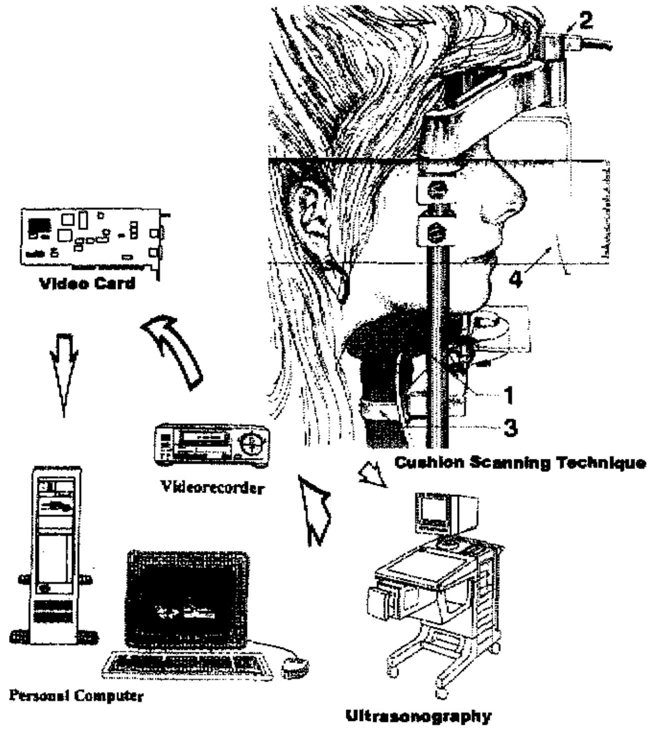


Fig. 3 Swallowing (sub) phases and their corresponding tongue movements during swallowing.

R = rest phase, TS = tongue surface, m = mesial, d = dorsal

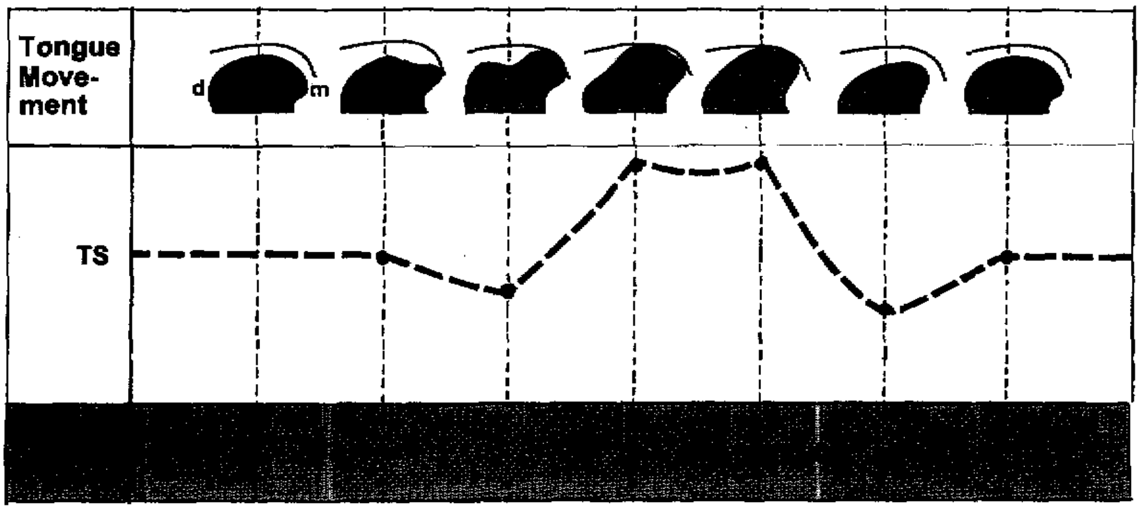


Fig. 4 B+M-mode ultrasonogram of a somatic swallowing. The left side shows the B-mode image with an arbitrarily chosen scanline (SL). The M-mode image (right side) illustrates movements of various anatomic structures along this SL. HB = hyoid bone, GG = genioglossus muscle, GH = geniohyoid muscle, MH = mylohyoid muscle, MS = mandibular symphysis, TS = tongue surface, TT = tongue tip, and UP = ultrasound probe (transducer).

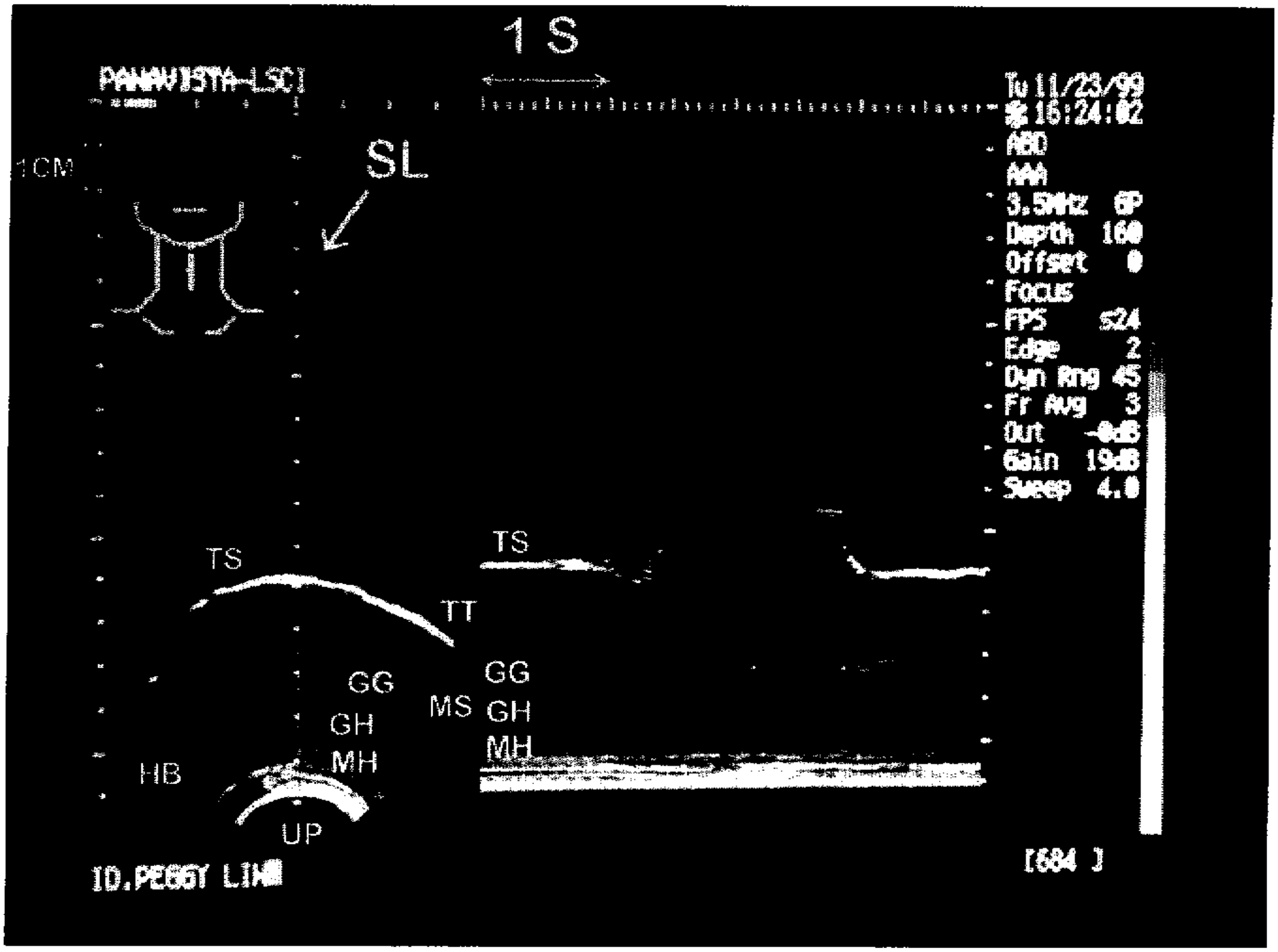
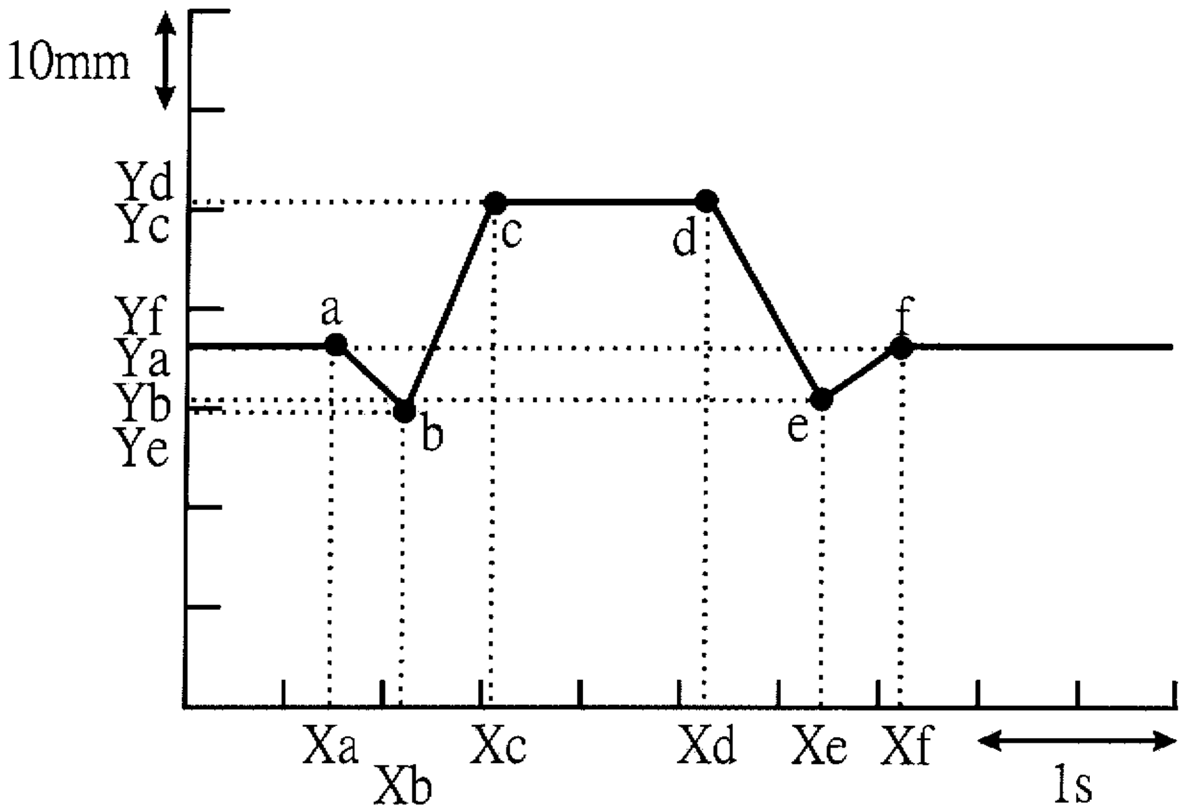


Fig. 5 Duration (D) and range (R) of tongue movement in each phase were determined by a graphic program. a ~ f: turn points between different directions of tongue movement during swallowing. Xa - f: corresponding points of turn points a ~ f on X axis which represents the time. Ya - f: corresponding points of turn points a ~ f on Y axis which represents the range of tongue movement.




| | D (s) | R(mm) | S (mm/s) |
|---|---|---|---|
| Phase I | Xb - Xa | ∣ Yb - Ya ∣ | ∣ Yb - Ya ∣ / Xb - Xa |
| Phase IIa | Xc - Xb | ∣ Yc - Yb ∣ | ∣ Yc - Yb ∣ / Xc - Xb |
| Phase IIb | Xd - Xc | ∣ Yd - Yc ∣ | ∣ Yd - Yc ∣ / Xd - Xc |
| Phase IIIa | Xe - Xd | ∣ Ye - Yd ∣ | ∣ Ye - Yd ∣ / Xe - Xd |
| Phase IIIb | Xf - Xe | ∣ Yf - Ye ∣ | ∣ Yf - Ye ∣ / Xf - Xe |

D = Duration. R = Range of tongue movement. S = Speed.