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COMPUTER TOMOGRAPHY OF THE VOCAL TRACT

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At present, x-ray tomography is the only method for the direct observation of the cross-sectional shape of the vocal tract. However, with conventional x-ray tomography, it is difficult to obtain satisfactory image clarity. At the same time, the amount of x-ray exposure with x-ray tomography is too high for practical experimentation. Compared to conventional tomography, computer tomography gives a clearer image at a lower level of of x-ray dosage. For the observation of the vocal tract shape especially, differentiation only between the soft tissues and the air cavity is required and thus it is expected that sufficient information can be obtained at relatively low x-ray exposure.

We have reported on a preliminary experiment using a 'Dynamic Scanner', a special type of the CT-scanner which incorporates an electronic x-ray beam scan method of the computer controlled x-ray microbeam system.[1)2)] Compared to other CT-scanners, the 'Dynamic Scanner' operates with a lower x-ray exposure, and the cross-sectional images shown in Fig. 1 were recorded with an x-ray exposure of about 20mR per picture.[3)]

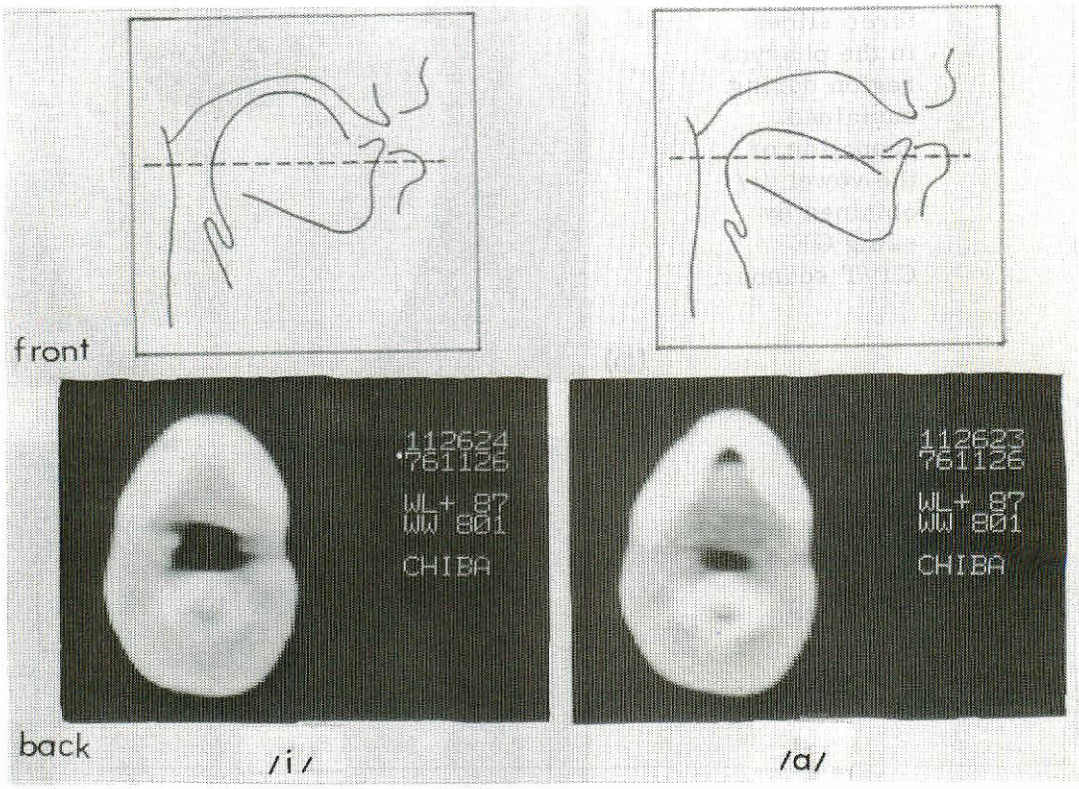
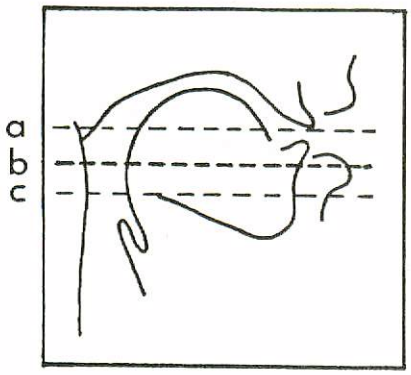
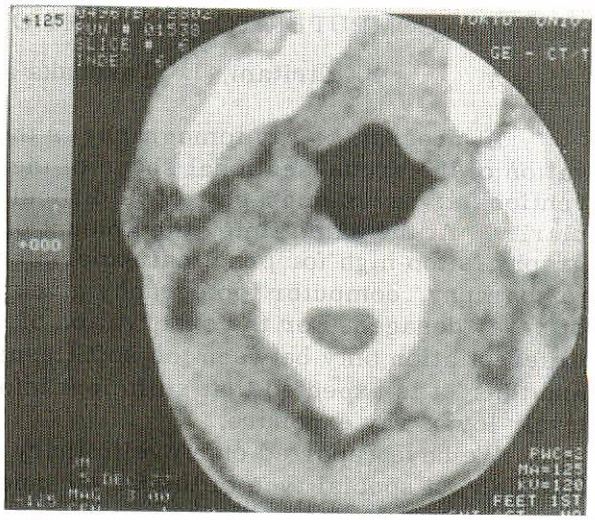
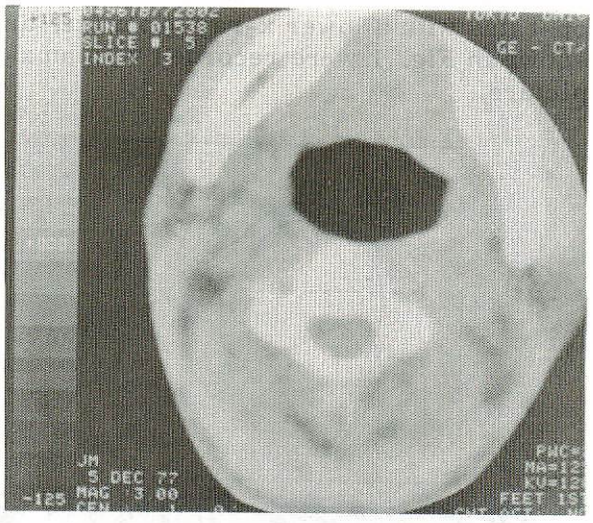


Fig. 1. Tomographic images of the vocal tract for the sustained phonation of vowels /a/ and /i/ by the 'Dynamic Scanner'.[3)] The position of the picture slice is schematically shown in the upper figures.







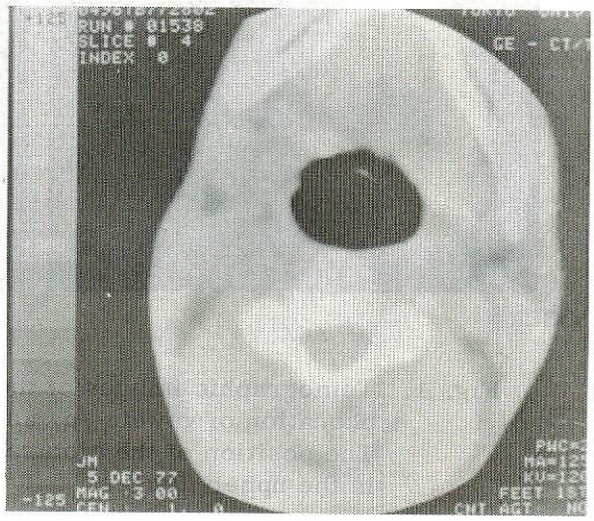


Fig. 2. Tomographic images of the three slices in the pharynx region during sustained phonation of the vowel /i/ obtained by using GE CT/T scanner.

The pictures in Fig. 1 show the cross-sectional images at a selected point along the axis of the vocal tract. If the cross-sectional images are recorded at several different points along the axis of the vocal tract, an entire profile of the three dimensional shape of the vocal tract can be drawn. Fig. 2 shows such an attempt. In this case, the subject repeated sustained phonations of the vowel /i/ three times. Between phonations, the patient table was mechanically moved 1.5 cm, and the three parallel pictures in the pharynx region were taken. Because these pictures were taken by the commercially available whole body CT-scanner (a GE CT/T fan-beam type scanner using Xenon detector array and pulse exposure method), the x-ray exposure was higher than that for the pictures in Fig. 1. The scan time per picture was 9 second with the rating of 120 kV - 125 mA. The change in the vocal tract shape at different levels of the pharynx can be seen clearly. The uppermost slice intersects the tongue dorsum, and the tongue surface shows a kind of groove around the midsagittal plane.

Fig. 3 (b) and (c) shows the spatial variation in the tissue density along the selected scan lines depicted in (a). The ordinate is the x- or y-coordinate along the scan line and the abscissa is the 'EMI number'. The distance between the sample points is 1.5 mm. It can be seen that the spatial variation in the recorded tissue density was sharp, and the position of the vocal tract wall can be located with an accuracy of about 1mm.

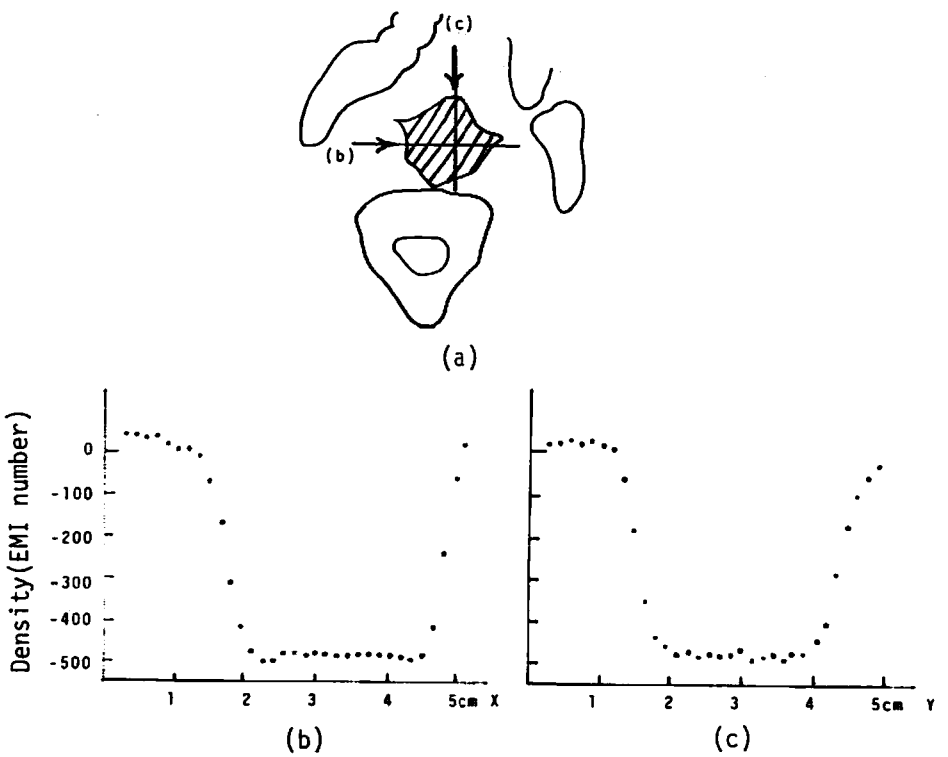


Fig. 3. Spatial Variations in the tissue density along the two scan lines depicted in (a).

One of the apparent limitations of the presently available CT-scanner is that the slices to be pictured must be nearly perpendicular to the body axis. Thus, direct recording of cross-sectional images of the oral cavity is impossible. At the same time, when the slices to be pictured are located close to the upper surface of the tongue, the resolution in the position of the vocal tract wall becomes low, because the tongue surface or other parts of the vocal tract wall intersect the picture slice at an small angle. In these cases, the effectiveness of the three dimensional reconstruction method using the x-ray transmission data of the successive multi-slices [4] should be further explored.

References

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