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MEASUREMENTS OF THE VOCAL FOLD LENGTH BY USE OF STEREOENDOSCOPE - A PRELIMINARY STUDY*

Masayuki Sawashima, Hajime Hirose, Seishi Hibi,
Hirohide Yoshioka, Noriko Kawase and Minoru Yamada**

In our previous paper (Honda et al., 1980), we reported on the use of a stereoendoscope designed to measure the laryngeal structures during phonation and in other conditions. After certain modifications, the endoscope is now in use for both clinical and research purposes. In this paper, we present a preliminary study of the length of the vocal fold measured during phonation and inspiration in teachers and students of a vocal music course at a college of musical arts in Tokyo.

Procedures

1. Photographic data assessment

Stereographic pictures were taken using a newly designed rigid steroendoscope attached to a 35 mm camera. The experimenter held the tongue of the subject with one hand, gripping the camera with the other hand. The tip of the scope was then inserted into the oral cavity of the subject sitting in a chair in a position similar to that used in indirect laryngoscopy. The experimenter adjusted the position of the tip of the scope so as to obtain the entire view of both vocal folds in various conditions.

2. Subjects and experimental conditions

Subjects were teachers and students of a vocal music course at a college of musical arts in Tokyo. They consisted of 27 males and 32 females. In each subject, attempts were made to take laryngeal photography in the following 3 conditions: during phonation at two different pitch levels, i.e. at G_3 (196 Hz) and C_4 (260 Hz)

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** Musashino Academia Musicae

in males and at G_4 (392 Hz) and C_5 (520 Hz) in females, and during inspiration after phonation. Simultaneous recordings of voice were made while the laryngeal pictures were being taken.

Films were processed in the usual manner and inspected under magnification before substantial measurement. In 13 males and 14 females in the present series, pictures obtained were judged to be unsuitable for further measurement because the necessary landmarks were not identifiable on the film. Therefore, these subjects were eliminated from the final data pool. As a result, measurements of laryngeal dimensions were made in the remaining 14 males (2 teachers and 12 students) and 18 female students. The voice types of the subjects were 6 tenors, 7 baritones and 1 basso among the males, and 15 sopranos and 3 mezzo sopranos among the females.

Separately from laryngeal photography, the height and neck circumference were measured and the lower limit of the vocal range was determined in each subject.

3. Data reduction

Each film frame was projected onto a screen using a conventional slide projector. Tracing of the film image was then made on a sheet of semitransparent paper, on which the anterior commissure and the bilateral vocal processes were identified and marked on the trace. The trace was subsequently placed on a tablet digitizer connected to a micro-computer, and the anatomical landmarks were plotted using a specially made pointer so as to calculate three-dimensional coordinate values of each landmark. Further calculation was made to obtain the distance between any given two points, e.g. the vocal fold length was estimated as the distance between the anterior commissure and the tip of the vocal process of either side, whereas the glottal width was obtained by calculating the distance between both vocal processes.

Results

Figure 1 illustrates an example of a laryngeal stereoimage obtained from a soprano student during inspiration. The vocal fold length was estimated to be 10.4 mm and the glottal width was 4.8 mm.

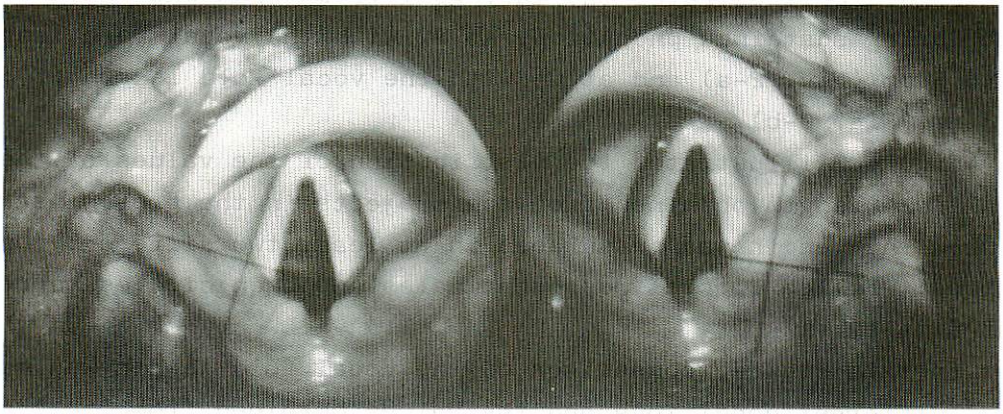

Fig. 1 Laryngeal stereoimage obtained from a soprano student.

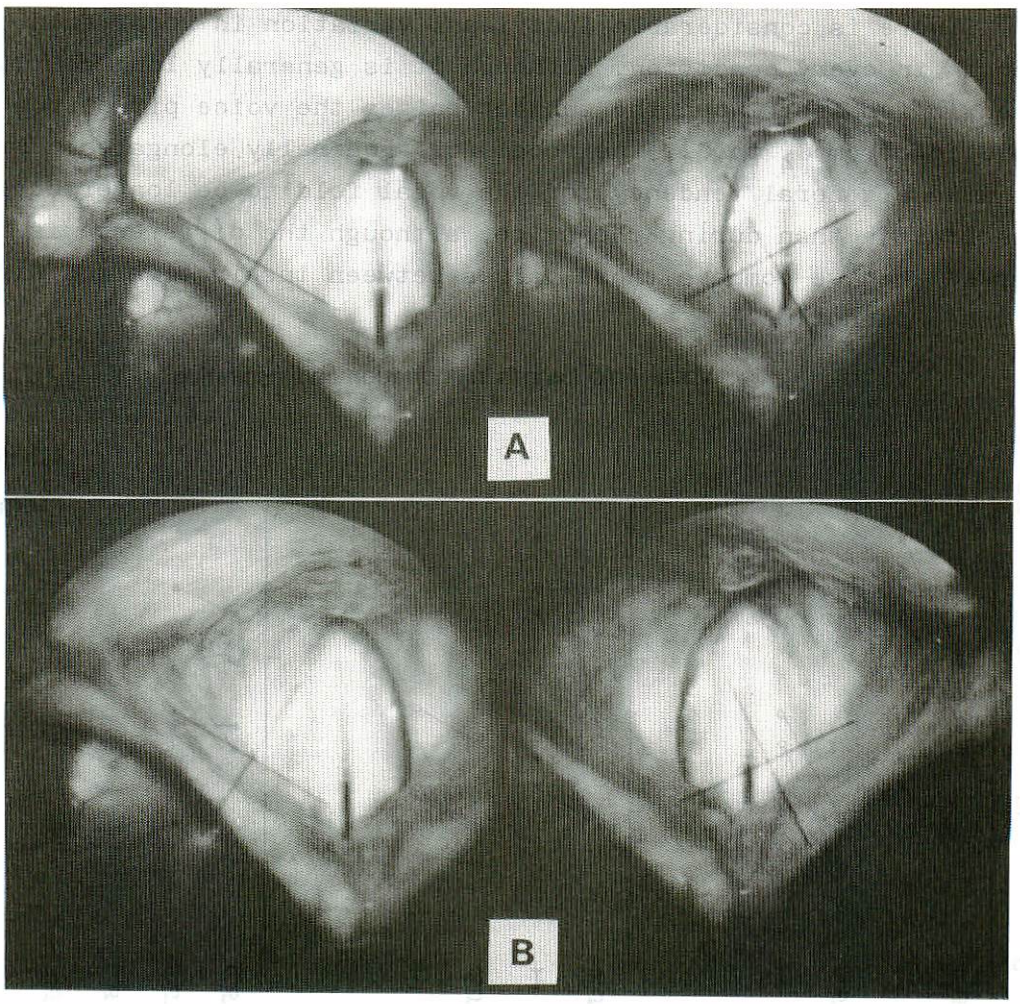

Fig. 2 Laryngeal views of a baritone student during sustained phonation at G_3 (A) and at C_4 (B).

Figure 2 illustrates the laryngeal views of a baritone student during sustained phonation, at G_3 with the vocal fold length of 16.5 mm (Fig. 2-a) and at C_4 with the vocal fold length of 17.3 mm (Fig. 2-b).

Figure 3 illustrates the distribution of the values of the vocal fold length obtained from the subjects in the present series in whom the length was measurable in at least two different conditions. Filled circles represent males and open circles represent females.

In this figure, comparison of the vocal fold length was made among different conditions and the values obtained from the same subject were connected by a solid line to provide paired comparisons.

There is considerable individual variation in vocal fold length in every condition, although it is generally longer in males than in females. When the subject raises the voice pitch from G_3 to C_4 or from G_4 to C_5, the vocal fold generally elongates. There is also a general tendency for the vocal fold to be longer during inspiration than during phonation, although the difference is less marked when we compare those values between inspiration and high-pitched phonation.

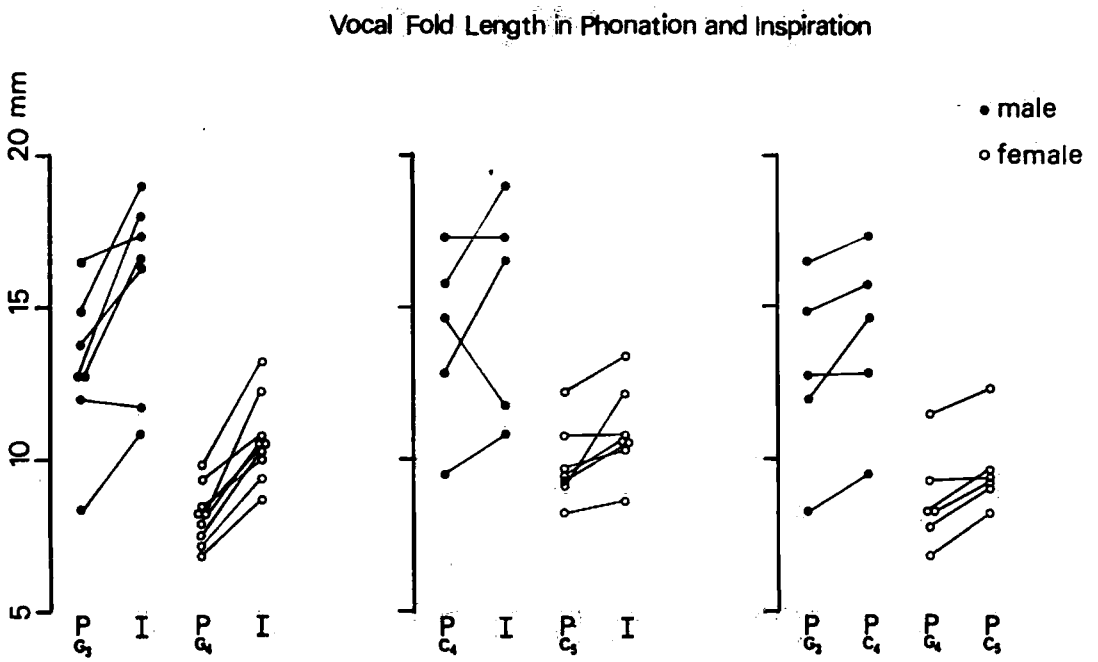

Fig. 3 Distribution of the values of the vocal fold length among different conditions.

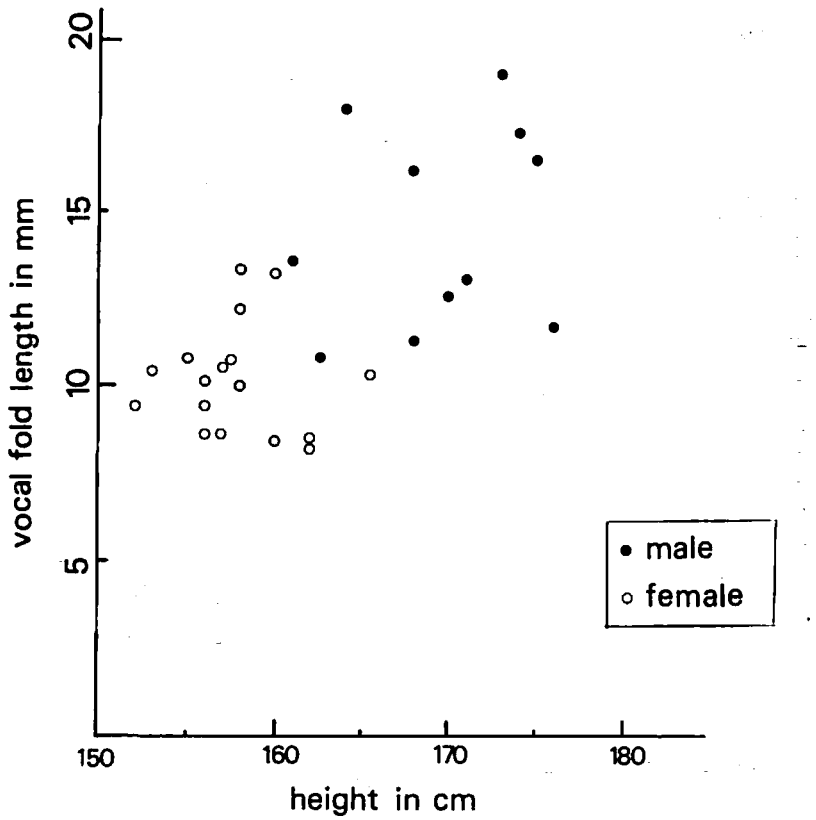

Fig. 4 Relationship between the vocal fold length during inspiration and body height.

In Figure 4, the relationship between the vocal fold length during inspiration and body height of the subjects is plotted. It is indicated that there is no significant correlation between these two parameters in either the male or the female group.

Figure 5 shows the relationship between vocal fold length and neck circumference. There appears to be a positive correlation between these two parameters at least in female subjects.

Figure 6 shows the relationship between the vocal fold length during inspiration and the lower limit of the vocal range. There is a tendency, at least in males, indicating that the longer the vocal fold, the lower the lower limit of the vocal range.

Comment

The present study demonstrates that the steroendoscope can provide useful information on the laryngeal dimensions. The system is easy to use and the data reduction procedures are fairly simple. For further simplification of the procedures, a film image can be directly projected onto a digitizer tablet. In our experi-

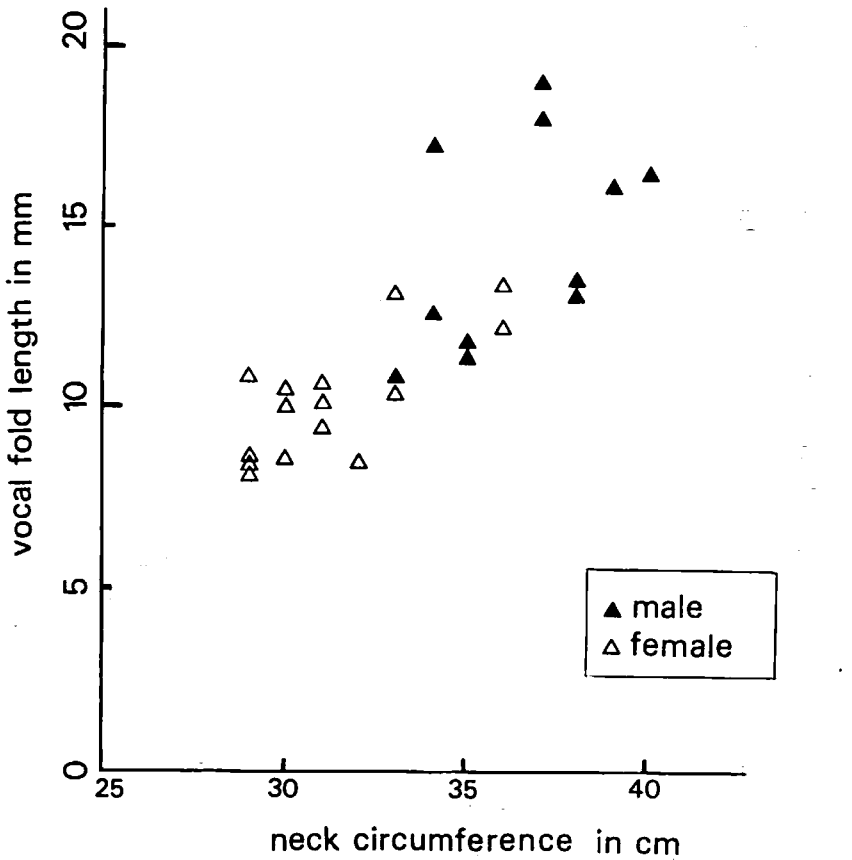

Fig. 5 Relationship between the vocal fold length and neck circumference.

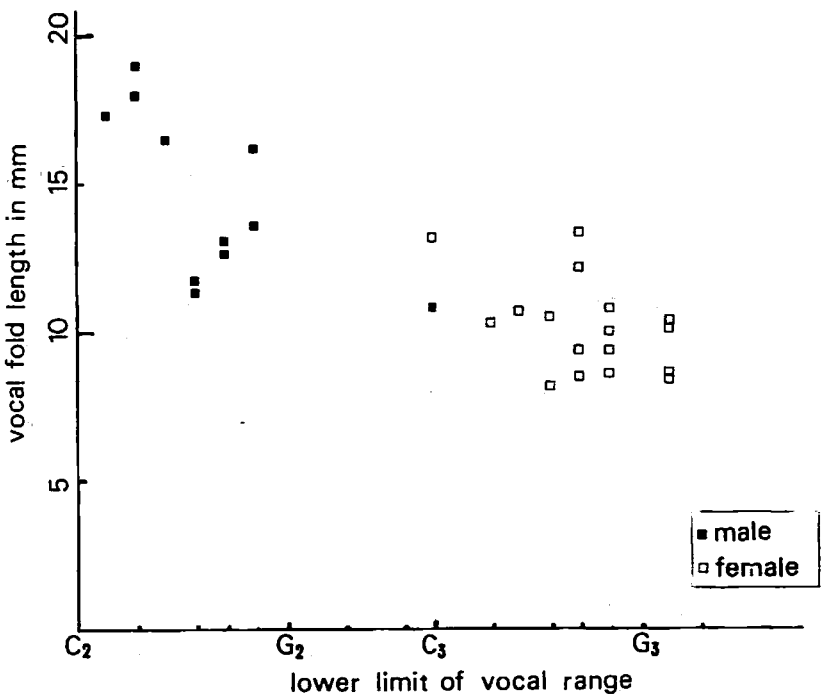

Fig. 6 Relationship between the vocal fold length and the lower limit of the vocal range.

ence, however, fine mesh structure of the tablet often obscures good visualization of the film image and identification of necessary anatomical landmarks is sometimes difficult. Therefore, tracing of the film image seems preferable as the first step of data reduction.

There are various kinds of attempts reported in the literature for estimating the laryngeal dimensions. In particular, the vocal fold length has been measured in living humans or in cadaver larynges by many investigators. The relationship between the vocal fold length and the change in voice pitch (F_0) has often been explored and the difference in the vocal fold length with reference to age or growth has also been an important topic of previous studies.

As for the method of measuring the vocal fold length, radiographic observation of the lateral view of the neck was often applied (Sonninen, 1954; Ardran and Kemp, 1966; Damste, Hollien, Moore and Murry, 1968; Fink, 1975). In other non-radiographic approaches, the laryngeal view has been obtained using specially designed optical systems with or without an accompanying photographic system and the vocal fold length estimated either on the film image or on the viewing screen (Farnsworth, 1940; Fujita, 1944; Hollien, 1960; Hollien and Moore, 1960; Pfau, 1961; Wender, 1965; Hollien, Brown and Hollien, 1971; Honda et al., 1980).

Most investigators found that the vocal fold length increased when F_0 became higher especially in chest or modal register and the maximum elongation has been reported to be within the range of 4 - 5 mm, although the absolute value of the length of the vocal fold is not always comparable among the different reports because the definition of "vocal fold length" has not found unanimous agreement. In the present study, the vocal fold length is defined as the distance between the anterior commissure and the tip of the vocal process, i.e. the length of the so-called membranous portion of the vocal fold, since this portion is actually responsible for the change in the length of the vocal fold.

Our preliminary data show that the vocal fold tends to elongate when it moves to the abducted position from the phonatory position. This tendency was also found by Hollien and Moore (1960) who considered that the vocal fold was in "resting" condition during abduction and longest then. Fink (1975) reported that the vocal fold was 4 mm longer during the inspiratory phase than dur-

ing the expiratory phase. The elongation of the vocal fold in abduction was also observed in animal experiments in which the posterior cricoarytenoid muscle was selectively stimulated (Hirano, 1975).

To compare the difference in vocal fold length among different subjects, the value obtained during inspiration was used. The values are generally larger in males than in females, but there is some overlapping between the two groups. Although there is a tendency, particularly in males, for the vocal fold length to be larger when the lower limit of the vocal range is lower, the relationship between the vocal fold length and the voice type of the subject was not statistically examined in this preliminary study because the number of the subjects was too small. Further study using the present stereoscopic system is in progress to answer unsolved problems in voice physiology.

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