Association Between Facial Length and Width and Fundamental Frequency

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Summary: Objective. This study aimed to evaluate the association between facial width and length and fundamental frequency (F0) and habitual frequency.
Study design. Prospective cross-sectional study.
Subjects. A total of 50 subjects (35 females;15 males) were included in this study.
Methods. Lateral and posteroanterior cephalometric measurements included: facial height (N–Me); widths of the maxilla (J–J), mandible (AG–AG), and face (Zyg–Zyg); ratios J–J to AG–AG, N–Me to Zyg–Zyg, and lower face to total face heights. All subjects underwent acoustic analysis using Visi-Pitch IV. Sample was stratified according to age and gender.
Results. In the total group (mean age: 14.19±6.49 years; range 6-35 years), a significantly moderate negative correlation existed between Zyg–Zyg, J–J, and AG–AG, and F0 and habitual pitch. Similarly, N-Me moderately correlated with habitual pitch. In males, there was a significant moderate negative correlation between Zyg–Zyg and J–J, and habitual pitch, and between J–J and F0 (−0.571;p=0.026). In females, a significant moderate correlation existed between Zyg–Zyg and AG–AG, and habitual pitch, and between AG–AG and F0 (−0.347;p=0.041). In the prepubertal group (n=25), a negative moderate correlation occurred between J–J and AG–AG, N–Me and habitual frequency, and between J–J and F0 (−0.407;p=0.043). In the postpubertal group, there was a significant moderate correlation only between AG–AG and F0 (−0.403;p=0.046).
Conclusion. Facial length correlates significantly with habitual frequency, and facial width correlates significantly with both F0 and habitual pitch. A larger sample of adult subjects is needed to substantiate this conclusion.
Key Words: Acoustics–Mandible–Puberty–Cephalometric–Maxilla.

INTRODUCTION

Phonation is a complex process that involves different systems in the body. It starts with breathing as the main power supply that energizes the oscillator and sets the vocal cords into vibration. As the airflow travels through the trachea and across the glottis, it is shopped into glottal pulses and converted into acoustic energy. The result is the propelling of various harmonics whose values differ with the shape and configuration of the vocal tract. The latter is determined primarily by the head and neck anatomy and its corresponding cephalometric measurements.

Despite the fact that facial morphology is an integral part of the upper airway geometry, which in turn is a major determinant of several acoustic parameters, little has been reported on the correlation between facial skeletal measurements and voice. There are numerous investigations on the articulatory characteristics of speech in relation to jaw opening indicating vowel-related variation in jaw and vocal fold vibrations.[1,2] The magnitude of jaw opening has been shown to be inversely related to the average fundamental frequency (F0). There are also reports on the effect of palatal and orthognathic surgery on voice, speech, and velopharyngeal status.[2–7] Jorge et al[2] has reported on the influence of orthognathic surgery on the F0 in a single patient. The result of their investigation indicated that F0 increases after surgery and corresponds to the vertical movement of the hyoid bone. Only one study has explored the relationship between maxillary dental arch and voice classification. This was a pilot study on nine professional singers, evaluating the depth, length, width, and volume of the palate in relation to the different vocal registers.[8] In the same line of thoughts, Roers et al had investigated the relationship between vocal tract dimensions and voice classification by examining 132 images obtained by X-ray material. By looking at the relationship between voice classification and total vocal tract length, the authors noted that variations in the total vocal tract length were more dependent on the length of the pharynx cavity than on the length of the mouth cavity, defined as the upper incisor-atlas distance.[9]

Given that facial morphology is demarcated by the shape and position of the underlying facial skeleton,[10] the purpose of this investigation is to report on the correlation between facial width and length and F0 and habitual frequency using craniofacial cephalometric measurements in a group of subjects presenting to the orthodontic clinic. The hypothesis is that there is an association between F0 and the facial skeletal measurements evaluated on cephalometric radiographs.

In this paper, we will be reporting the data collected, to date, from recruited patients. An ongoing multi-aspects investigation is being pursued, which includes a baseline association evaluation between voice parameters and craniofacial morphology (jaw positions, malocclusions, hyoid bone, etc) and an assessment of different orthodontic or orthognathic procedures on voice parameters.

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MATERIALS AND METHODS

Patients

A total of 50 patients (35 females and 15 males) between the age of 6 and 35 years presenting for the first time to the division of Orthodontics and Dentofacial Orthopedics, at the American University of Beirut Medical Center, were invited to participate in this study. All patients have read and signed the informed consent approved by the institutional review board. Patients with congenital facial malformations, namely cleft lip, cleft palate, and hemifacial microsomia, and patients with history of orthodontic manipulation, treatment, or orthognathic surgery were excluded from the study. Patients with recent history of respiratory tract infection, laryngeal manipulation, or dysphonia at the time of presentation were also excluded from this study. Dysphonia was perceived by the speech language pathologist (senior faculty with master's degree in speech-language pathology and more than 10 years of experience) as change in voice quality, timbre, pitch, or loudness.

Cephalometric measurements

Before the initiation of any orthodontic treatment, a set of records was taken for every patient including lateral and posteroanterior cephalographs using the digital cephalostat (GE, Instrumentarium, Tuusula, Finland) in a standardized fashion and in natural head position[11,12] or true horizontal position. Digitization was done on *Dolphin Imaging* (Dolphin Imaging and Management Solutions, La Jolla, California) program version 11, and angular and linear measurements were performed. On lateral cephalometric radiographs, the following measurements were evaluated: N–Me and lower face height-to-total face height (LFH-to-TFH) ratio (Figure 1). The width of the face (Zyg–Zyg), maxillary, and mandibular widths (L–L and AG–AG) were measured on posteroanterior cephalograph (Figure 2). Height-to-width ratio of the face (N–Me-to-Zyg–Zyg) and jaws (J–J-to-AG–AG) were calculated.

Acoustic analysis

All subjects underwent acoustic analysis using Visi-Pitch IV (Model 3300, KayPENTAX, Montvale, NJ) between 2 PM and 5 PM to minimize the time influence and daily variations on the acoustic measurements. While the patient is seated in a quiet office, the patient's vocal signal was recorded directly into the system using a condenser microphone (SHURE SM48 [SHURE, Granjas San Antonio, Mexico City, DF, Mexico], coupled to the KayPENTAX Visi-Pitch IV 3950B) at a distance of 15 cm from the mouth. The average F0 was measured by asking the subject to sustain the vowel "ah" for 2 seconds at a comfortable pitch and loudness. The habitual frequency was measured by asking the subject to count to 10 in a normal voice, again at a comfortable pitch and loudness.

Statistical analysis

Descriptive statistics was used to compute the mean ± standard deviation of the bone age and the cephalometric measures in the total group, in the males and females, and in the prepubertal and postpubertal groups. The cutoff bone age used was 13.6 for men and 11.6 for boys according to Tanner and Davies.[13] Independent *t* test was used to compare the difference in the means of these measurements between males and females. As for the acoustic measures, the F0, and the habitual pitch, Mann-Whitney *U* test was used to compare the difference in the means between the different subgroups. Spearman correlation was

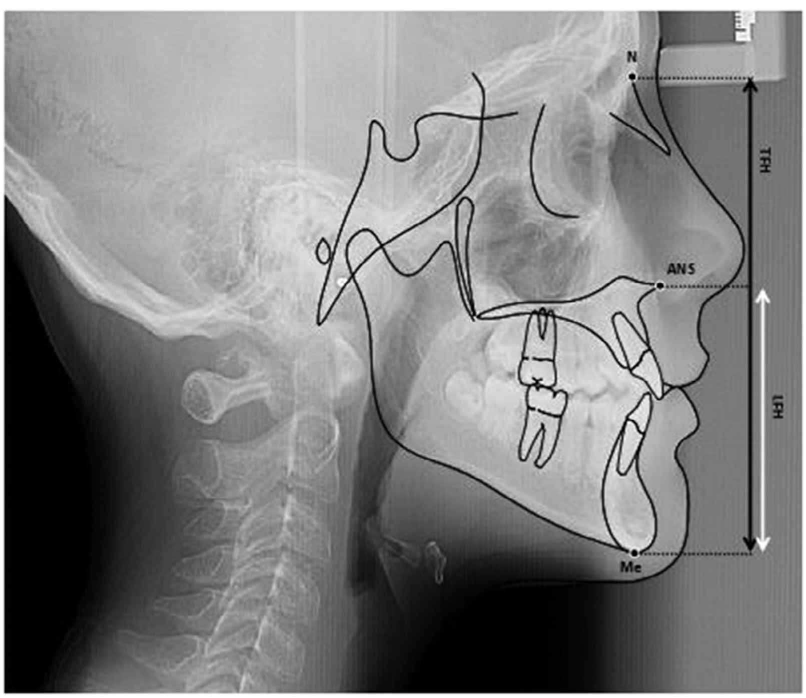

FIGURE 1. Landmarks and measurements on lateral cephalometric radiograph: ANS, anterior nasal spine; LFH: lower facial height; Me: menton; N, nasion; TFH: total facial height.