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Original article

The effects of sex, skeletal age, and sagittal skeletal pattern on pharyngeal airway dimensions and related structures in growing Thai orthodontic patients

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ABSTRACT

Purpose: To evaluate the effects of sex, skeletal age, sagittal skeletal pattern, and the interaction among these three factors on the pharyngeal airway widths and areas, and the positions and dimensions of surrounding structures.

Materials and methods: Pretreatment lateral cephalometric radiographs of 418 growing orthodontic patients (183 males, 235 females); 6–20 years old (mean age, 13.95 ± 3.62 years), were collected from 2007–2014, Department of Radiology, Faculty of Dentistry, and divided into 3 skeletal ages according to cervical vertebral maturation stages, pre-pubertal (cervical stages (CS) 1,2), pubertal (CS 3,4), and post-pubertal (CS 5,6). Ten angular, 13 linear, and 3 cephalometric area measurements were analyzed. Three-way ANOVA and Factor analysis were applied to compare sex, skeletal age, and sagittal skeletal pattern differences in the pharyngeal airway dimensions and the surrounding structure dimensions and positions.

Results: Sex–skeletal age interactions existed in the nasopharyngeal and oropharyngeal airway dimensions, and dimensions and positions (vertical, horizontal) of surrounding structures. Skeletal age–sagittal skeletal pattern interactions also affected the pharyngeal airway dimensions. In the post-pubertal period, male and skeletal Class III subjects tended to have larger pharyngeal airway, tongue, and soft palate dimensions; more anterior positions of the hyoid and tongue; and less obtuse soft palate angulation. The post-pubertal males also had more inferior positions of the hyoid and tongue.

Conclusion: Interactions between sex–skeletal age and skeletal age–sagittal skeletal pattern affected the pharyngeal airway dimensions. The surrounding structure positions and dimensions varied according to sex–skeletal age interaction and sagittal skeletal difference.

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1. Introduction

Orthodontic treatment involves the alignment of the teeth, modifying growth patterns, and surgically changing the jaw position. Orthodontic treatment affects the soft tissue profile, hyoid and tongue positions, and the pharyngeal airway dimensions [1–6]. A close relationship of the craniofacial and dentofacial structures and the pharyngeal airway and structures, e.g. tongue and hyoid bone, explains the changes of the pharyngeal airway dimensions and the surrounding structure positions from orthodontic treatment [6], orthopedic treatment [7–9], and orthognathic surgery [1]. The pharyngeal airway may be increased or decreased following orthopedic treatment [7,9] or orthognathic surgery [2,3], which, in the long term, might cause treatment relapse. Gu et al. [2] suggested that forward relapse of the mandible correlated with the changes of the hyoid position. The tension of the suprahyoid and infrahyoid muscles from mandibular setback procedures created a force to pull mandible forward and upward to its original position. Moreover, a decreased pharyngeal airway may result in the development of obstructive sleep apnea (OSA) [1,10]. Riley et al. [10] reported 2 cases who developed early stage OSA 18 months after mandibular setback surgery. The nasopharynx and oropharynx have important locations and functions, playing vital roles in respiration and deglutition [11]. Therefore, it might be useful to include the pharyngeal examination in orthodontic diagnosis and treatment planning as well as the functional, positional, and structural assessment of the dentofacial pattern [11]. Previous studies, including those of Thai populations, aimed to establish airway dimension norms, and compared the differences in airway dimensions between skeletal patterns, or between normal subjects and OSA patients in non-growing patients [4,12,13]. The few studies on the pharyngeal airway in growing subjects [5,11,14–17] mostly evaluated the nasopharyngeal region of specific age ranges. Studies on the effects of sex [11,14] and sagittal skeletal pattern [5,14,18] on the pharyngeal airway and structures have been inconsistent. Several studies of the pharyngeal airway dimensions based on chronological age reported no sexual dimorphism [14,15], however, another study demonstrated sexual dimorphism [19]. In contrast, Preston et al. [16] found different nasopharyngeal growth patterns between sexes based on skeletal age. The purpose of this study was to retrospectively assess the interactions of 3 factors; sex, skeletal age, and sagittal skeletal pattern, on the upper pharyngeal airway dimensions, and the surrounding bony and soft tissue structures in growing Thai orthodontic patients.

2. Materials and methods

Four hundred and eighteen pretreatment lateral cephalometric radiographs (183 males, 235 females) taken with a Kodak 8000C or 9000C Digital panoramic and cephalometric system (Caresteam, Rochester, New York) at the Department of Radiology, Faculty of Dentistry, Chulalongkorn University, were collected in a digital format (JPEG file) from 2007–2014. During radiograph taking process, each patient was asked to stand up right and look straight forward in natural head position (NHP) with the head fixed with ear rods and cephalostat. The teeth were in centric occlusion with relaxed lips. The patient was instructed not to swallow or move during taking the radiograph. The inclusion criteria were growing patients (age $\leq$20 years old) [20,21] with complete records from the Orthodontic Department, Faculty of Dentistry, Chulalongkorn University, with skeletal normal bite (FMA = 21°–29°) [22]; no history of nasopharyngeal pathology, tonsillectomy, or adenoidectomy; no history of systemic, congenital disease, or accidents affecting the maxillofacial structures; no history of orthopedic treatment, orthodontic treatment, or orthognathic surgery. The lateral cephalometric radiographs with unclearness, abnormal shape of the soft palate [23], and craniocervical angle (OPT-SN angle) below 90° or exceeding 110° [24,25] were excluded.

The radiographs were divided into 3 groups according to the ANB angle determined by Thai norms [22], i.e., skeletal Class I (ANB = 2°–6°), skeletal Class II (ANB > 6°), and skeletal Class III (ANB < 2°). Each group was divided into 6 subgroups according

Table 1 – Landmarks and reference planes used in Figs. 1–2.

Landmarks	
A	A-point
ANS	Anterior nasal spine
B	B-point
Cv2tg	Tangent point at the superior, posterior extremity of the odontoid process of the second cervical vertebra
Cv2ip	Most infero-posterior point of the second cervical vertebra
H	Most superior point of the tongue in relation to line from V to T
Hy	Most antero-superior point of hyoid
LPW	Lower pharyngeal wall; posterior pharyngeal wall intersection of a line parallel to PP at the level of V
Me	Menton
MPW	Middle pharyngeal wall, posterior pharyngeal wall intersection of a line parallel to PP at the level of U
N	Nasion
Or	Orbitale
PNS	Posterior nasal spine
Po	Porion
S	Sella turcica
T	Tip of the tongue
U	Uvula tip
UPW	Upper pharyngeal wall; posterior pharyngeal wall intersection of the extension line from PP
V	Vallecula; intersection of epiglottis and base of the tongue
Reference planes	
FH	Frankfort horizontal plane
MP	Mandibular plane; tangent line to the lower border of the mandible from Me
OPT	Odontoid process tangent; line passing through Cv2tg and Cv2ip
PP	Palatal plane; line passing through ANS and PNS
SN	Sella-Nasion plane; line passing through S and N
Sper	A perpendicular to FH from S

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