Length of anterior cranial base and Frankfort horizontal plane: A lateral cephalometric study in 11–16-year-old children

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Abstract. Cephalometric radiograph analysis, both linear and angular, are useful to diagnose and establish a treatment plan in cases of disharmony between dento-cranio-facial. The anterior cranial base, which is presented as a linear measurement of Sella Turcica to Nasion (S-N), and Frankfort horizontal plane (FHP) are two cephalometric reference planes to analyse the skeletal growth and development in children. This study included 202 cephalograms from 63 males and 139 females and divided into 11-13-year-old and >13-16-year-old groups. Both S-N and FHP were digitally analysed by measuring the length of certain points using cephalogram. The result showed the average length of S-N was higher in males compared with females at both age groups (p<0.005), while FHP length of males was higher than females at >13-16-year-old group (p<0.005). In conclusion, the S-N length was quite stable both in males and females older than 11-year-old, while FHP length may reach the peak of growth rate in males older than 13-year-old.

1. Introduction
Malocclusion in adolescents, who are aged between 12 to 14 years old, is very common in Indonesia (1,2). The malocclusion may occur due to a disharmony of the jaw, skeletal system, and/or teeth, which may affect functional and psychosocial aspects of individual (2). Therefore, it needs to be immediately diagnosed and correctly treated to prevent and/or minimize the severity level of disharmony. The growth pattern and timing in starting the treatment, however, should be carefully considered, as the growth pattern is unique among individuals and influenced by genetic and environmental factors (3). The treatment that is performed just before the beginning of pubertal growth spurt is less complicated and has a better outcomes.

The best tool to analyse the morphology and the growth pattern of dentocraniofacial is a cephalometric radiograph (4). This radiograph technique has been extensively used in growth studies,
orthodontic diagnosis, and treatment evaluation (5). At prior to linear and angular analysis, the cephalometric tracing needs to be performed using either manual or digital technique (6). The results of analysis will provide details of growth patterns and individual facial types as the reference values to diagnose a disharmony of dentocraniofacial and the needs for growth modification (7).

Several cephalometric analysis has been previously developed, including Downs, Steiner, Rickett, Tweed, Schwarz, McNamara, Simon, and others (2). The anterior cranial base, that is presented as a length between sella turcica and nasion (S-N), is commonly used to analyse dimension and growth direction of craniofacial. While Frankfort Horizontal Plane (FHP) is widely applied to estimate the true horizontal plane and it is drawn as a line from the inferior orbital margin to the outer surface of external meatus, which are known as orbitale and porion point at cephalogram, respectively (8). The difficulties in determining anatomic porion is a reason for many studies to use machine porion that is known as ear rod located in the external auditory meatus to stabilise the head position when the cephalogram was produced (9).

S-N has been reported as a stable reference plane. A recent study, however, demonstrated an increment of anterior cranial base size corresponds with the pubertal stage and is continually growing until early adulthood, but almost more than three quarter of anterior cranial base growth has been completed since the age of 4.5 years (9). While, the information on the alteration of FHP length related to age is limited.

In addition to the age, craniofacial growth and development are influenced by several factors, including age, race, and sex, thus, it needs to be explored before planning any malocclusion treatment (2,10). The majority of Indonesian population is classified as Deuteromalayid race and is distributed throughout western Indonesia, including Aceh, Minangkabau, Melayu, Betawi, Sunda, Java, Madura, Bali, Makasar, Bugis, and Manado (10,11). The craniofacial growth pattern of Deutroma layid race differs from other races, such as Caucasoid and Negroid. Instead of races, the differences of craniofacial growth pattern also observed between between boys and girls (12). Therefore, the aim of this study was to analyse any differences in S-N and FHP length at different age groups ranged from 11 to 16 years old.

2. Methods
The study was conducted from August to December 2012 in the Department of Pediatric Dentistry, Faculty of Dentistry, Universitas Indonesia. This was a cross-sectional descriptive study using lateral-digital cephalograms from a clinical laboratory selected through a consecutive sampling technique. At prior to the analysis, the cephalograms were digitally traced (UTHSCSA ImageTool V.3 software). The anterior cranial base was analysed by measuring the length from Sella Turcica to Nasion point (S-N), while the length of Frankfort Horizontal Plane (FHP) was measured from Porion (machine) to Orbitale point. Each measurement was carried out three times and the results were average value of S-N and FHP length, which were then statistically tested using independent sample t-test and Mann–Whitney test (SPPS Statistic 17.0) with significance level was less than 0.05 (p<0.05).

3. Results
In total, there were 202 lateral-digital cephalograms from 63 boys and 139 girls concluded in this study. The age was divided into 11-13-year-old and >13-16- year-old group
Table 1. Comparison of mean S-N lengths between boys and girls by age group.

| No. | Age Group (year) | Mean of S-N length (mm) | p     |
|-----|------------------|-------------------------|-------|
|     |                  | Males                   | Females |       |
| 1.  | 11-13            | 62.32 ± 3.36            | 60.86 ± 3.30 | 0.026** |
| 2.  | >13-16           | 63.92 ± 3.04            | 60.82 ± 3.01 | 0.000** |

** Significance levels of S-N length between boys and girls at different age group (p<0.005)

In average, the S-N length was not significantly different between age groups in boys as well as in girls. It was, however, significantly higher in boys than girls at both age groups (p<0.005) as shown in Table 1. Interestingly, the average of FHP length in male was significantly different between >13-16-year-old group and the younger group (unpaired t-test; p=0.009), and it was significantly higher in boys than girls only at >13-16-year-old age group as presented in Table 2.

Table 2. Mean of FHP length in both groups

| No. | Age Group (year) | Mean of FHP length (mm) | p     |
|-----|------------------|-------------------------|-------|
|     |                  | Males                   | Females |       |
| 1.  | 11-13            | 69.52 ± 4.86*           | 70.08 ± 4.56 | 0.557 |
| 2.  | >13-16           | 72.51 ± 3.47*           | 69.21 ± 3.40 | 0.000** |

* Significance levels of FHP length in each gender between both age group (p<0.005)

** Significance levels of FHP length between boys and girls at different age group (p<0.005)

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4. Discussion

The S-N and FHP length measured in this study was carried out in Indonesian population, that is dominated by Deutromalayid race. The value of both S-N and FHP are important in analysing the growth and development pattern of craniofacial, which, however, differs between races (11,12). Thus, this study may provide a valuable information to assist the dental practitioner in planning a treatment for Indonesian population.

In this study, the differences of S-N length between both age groups were not significant in male as well as female. As previously reported, neurocranium has reached 90% of adult volume at 7-year old. Thereafter, the growth rate will be reduced and stopped when the final size of neurocranium has been reached (6,13). In accordance to the maturation of cervical vertebrae, Malta et al showed the highest increment of S-N length occurs during peak and post-peak of puberty without a significant difference between genders (14).

This study demonstrated the average length of S-N in males was significantly higher compared with females at both age groups. This finding is consistent with a recent study in Colombia that revealed a significant difference of S-N length between gender in 8-12-year-old children (12). In contrast, a sexual dimorphism has been shown to be implicated in growth pattern and rate between male and female as the size of head circumference and bone in male is larger than female (15,16).

The peak of growth rate is at 15–16 years old for male and at 12–13-year of age for female (17). The FHP length measured in this study, interestingly, was significantly higher in male compared with female
at >13-16-year-old group, but not at 11-13-year-old group. The present result indicated an acceleration of growth rate in male after 13-year-old of age. While, it may be happened before 11-year-old in female, thus, the difference of FHP length between both age groups was not significant in female. The cross-sectional method used in this study, however, should be considered and a longitudinal study from 7 to 16-year-old of age may provide an additional information for better understanding in growth rate of craniofacial related to sexual dimorphism.

5. Conclusion
The anterior cranial base that was represented as S-N length in this study may reach the peak of growth before 11-year-old both in male and female, while the highest growth rate of FHP length in male may begin after 13-year-old.

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