SHORT COMMUNICATION

THE FRONTAL SINUS ENLARGEMENT AS AN INDICATOR OF GROWTH MATURITY IN CLASS III PATIENTS – A PILOT STUDY

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ABSTRACT

Background: Diverse indicators have been used to predict growth in children. Skeletal parameters, such as hand wrist bones ossification, have been considered to cause an additional radiation exposure. To avoid such situation, new approaches as the cervical vertebrae maturation have been proposed.

Aims & Objective: The aim of this study was to investigate a correlation between the enlargement of the frontal sinus and the body height peak in Angle Class III patients, and whether a sinus peak would serve as an indicator of growth maturity.

Material and Methods: 20 Class III female patients were selected. Records of body height and serial lateral cephalograms taken for orthodontic treatment from 7 to 17 years old were used. By using the method of Ertük, the Nasion – Sella line was oriented and the peripheral border of the sinus was traced. The highest (Sh) and the lowest (Sl) points related to S-N line were located. A perpendicular line to Sh-Sl was drawn and the maximum width of the sinus was assessed. Tracings were analyzed and the sinus growth was determined.

Results: The frontal sinus enlargement was closely related to body height. One year after the body height peak occurred, the frontal sinus also reached a peak that coincided with the maximum amount of sinus width enlargement. The frontal sinus growth peak velocity was about 1.02mm/yr. Nevertheless, there was a small remaining growth one year after the sinus peak in few cases.

Conclusion: Because of the close relationship between the body height growth and the enlargement of frontal sinus during puberty, the frontal sinus development could be used as an indicator of growth maturity.

KEY-WORDS: Frontal Sinus Development; Growth Peak; Growth Spurt; Method of Ertük

Introduction

Over many years, researchers have tried to find different indicators in order to predict skeletal growth in children. Malgorzata, has reported that the classical parameters are body height, body weight, menarche period, chronological age, dental age and skeletal maturity.[1] Skeletal maturity involves the hand wrist bones ossification, cervical vertebral maturation, and the assessment of the elbow.[2-4] Hand wrist bones ossification has been used as the most accurate method, with the exception that it requires an additional exposure of radiation.[5,6]

In an attempt to prevent this additional radiation exposure, Lamparski, reported that cervical vertebral maturation was correlated to skeletal maturation.[7] Likewise, Ruf and Pancherz, analyzed and confirmed that the frontal sinus growth is related to somatic maturity.[8]

In addition to this, there have been few reports that have tried to study more about the correlation of the development of the frontal sinus and skeletal growth, especially in Angle Class II malocclusion patients.[9-11]

The frontal sinus is part of the anterior ethmoidal cells which evaginate from the frontal recess directly to the frontal bone. These are two irregular cavities, which extend backward, upward, and lateral ward for a variable distance between the two tables of the skull; they are separated from one another by a thin bony septum. They are absent at birth but they come to become evident as the child grows.[6]

Moreover, previous investigations have stipulated that the frontal sinus vertical growth begins during the second year and it extends laterally to the orbital roof.[12] Furthermore, the frontal sinus is identified around the fifth year, and it is radiographically evident at the age of 8 years, with

the appearance of being well expanded at the age of 12.[6,9]

Previous studies have stated that the area of frontal sinus increases up to 19 years of age, and such growth is synchronous with general craniofacial growth. In addition to craniofacial growth, this enlargement follows general bone growth.[6]

Despite the fact that several reports on the development of the frontal sinus are found, there are few studies that have investigated the relationship of the frontal sinus with other growth parameters. Brown has confirmed that the main enlargement of the frontal sinus was completed according to the annual height increments in children. A previous study carried out on Australian aboriginals has also revealed that there is a close relationship between certain hand wrist ossification events and peak growth velocity in stature and frontal sinus dimensions.[11]

Considering that most of the previous studies have been carried out especially in Angle Class II patients, the aim of this study was to investigate a correlation between the enlargement of the frontal sinus, and the body height peak in Angle Class III Japanese patients and whether a sinus growth peak will serve as an indicator of growth maturity without additional radiation exposure. The skeletal growth spurt is evaluated to determine the timing of orthodontic treatment in Angle Class III puberty patients, which led our attention to the present study.

Materials and Methods

Selection of the Participants

The sample comprised of 20 female subjects whose occlusion was diagnosed as Angle Class III. The selection of the subjects was based on the accessibility of the data that were used for this study. Stature recordings and lateral cephalogram taken once a year from 7 to 17 years of age were used as inclusion criteria. During the analysis of the data, some patient's radiographies were excluded whenever the quality of the cephalogram would not enable us to see the definition of the borders of the sinus.

Evaluation of Lateral Cephalogram

All lateral cephalograms were evaluated according to the method by Ertuk and Bonn. [10] The tracing of the radiographs was made by hand and then scanned. The scanned tracings were analyzed and measured by using NIH image software for a precise data collection.

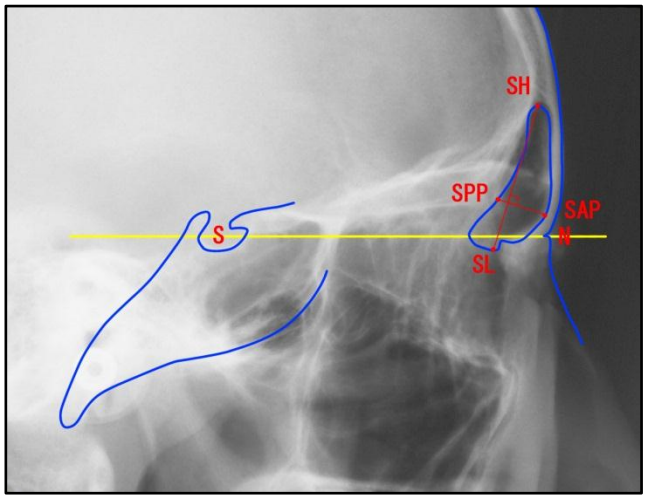

Figure-1: Evaluation of Frontal Sinus Width Enlargement

Lateral cephalograms were analyzed according to the following description (Figure 1). First, the nasion – sella line was oriented for later superimposition. After orienting the S- N line, the frontal sinus was traced by following the areas of high radiopacity as the peripheral areas. The highest point (SH) and the lowest point (SL) were identified and connected by drawing a line (SH-SL). In order to calculate the width, a second line perpendicular to the SH-SL line was drawn and the widest line was calculated as the sinus width. The widest line was measured from the sinus posterior point (SPP) and the sinus anterior point (SAP).

Error of Method

Lateral scanned cephalogram were evaluated twice by the same researcher with an interval of one week difference. Error in the calculation of the sinus width size was analyzed by choosing the data of 5 randomly selected subjects. By using the formula of Dahlberg Houston (1983), the reassessment of sinus width size was defined by re-defining the SH – SL line. Since the error of sinus width size ranged from 0.01 to 0.05, the reproducibility of the SH-SL line was considered high for assessment.

Results

Frontal Sinus Width Size

At the end of the observation, the frontal sinus showed an average width of 10.78mm, varying from 8 to 13.56 mm (Table 1).

Frontal Sinus Growth

In this study, 17 of the frontal sinus were not radiographically identified until late 8 years old. This is the reason for which most of the evaluations were carried out from the lateral cephalogram taken at the age of 9 years.

The way that the frontal sinus increased in width was characterized by a gradual increment that occurred as the girl grew taller. A final enlargement was identified one year after the child passed the body height peak (Table 2).

16 of the cases exhibited an increment in growth that synchronously had occurred later to the pubertal period. On the other hand, three cases showed a small sinus growth that it was not clearly correlated to the body height (Table 2).

Figure 2, 3, and 4 show a typical case where the frontal sinus increased in years and how its enlargement was gradually similar to body height.

Even though there is a variance in sinus growth velocity and the final sinus enlargement, it will be possible to identify a peak that coincides with the maximum amount of enlargement. At the end, this maximum enlargement was followed by a small remaining growth (Figure 2).

End of Frontal Sinus Growth

It was not possible to determine when the frontal sinus stopped growing due to the data in this analysis. In this study, it was only analyzed the enlargement of the frontal sinus from 8 years until 2 years passed the maximum body height record (Figure 3).

Frontal Sinus Growth Pattern

During the analysis of sinus growth in relation to body height peak, it was noticed that the frontal sinus presented a growth pattern that was observed in the patients with not significantly differences. An example of this is on fig. 4, which describes the growth pattern of the frontal sinus in one subject.

Table-1: Frontal Sinus Width changes according to Age

Age (years)	N	Mean	Min	Max
8	7	7.15	5.54	8.76
9	16	8.295	6.08	10.51
10	14	8.835	6.23	11.44
11	14	9.37	6.65	12.09
12	13	9.895	7.23	12.56
13	14	10.345	7.31	13.38
14	15	10.47	8.21	12.73
15	11	10.565	7.99	13.14
16	5	10.94	8.65	13.23
17	5	10.78	8	13.56

Table-2: Sinus Growth Velocity, before (-), at and after the Sinus Pubertal Peak; SP

Years	Sinus Growth Velocity (mm/yr)				Body Height Velocity (cm/yr)			
	N	Mean	Max	Min	Mean	Max	Min	N
-4	6	0.40	0.80	0				
-3	9	0.55	1.10	0	5.42	9.15	1.75	9
-2	13	0.52	1.00	0.04	4.92	8.60	1.25	14
-1	16	0.95	1.90	0	5.85	11.50	0.20	17
SP	17	1.02	1.94	0.10	5.75	11.50	0	18
1	10	0.91	1.80	0.02	3.75	7.50	0	13
2	6	0.34	0.60	0.09	2	4.00	0	5
3	3	0.29	0.50	0.09	1	2.00	0	3

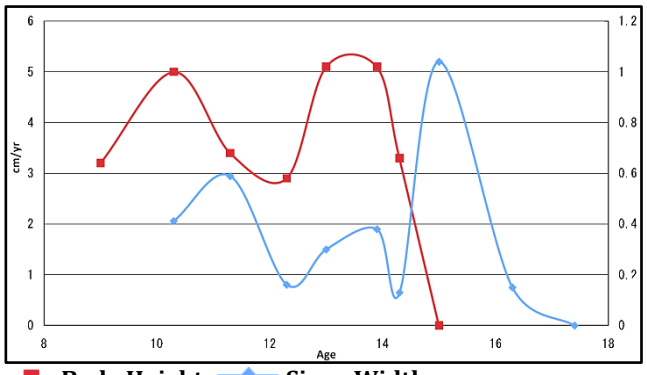

Figure-2: Case 1: Pubertal Body Height Growth Velocity (cm/yr) and Sinus Growth Velocity (mm/yr) in a Girl. Followed from 10 – 18 Years Old.

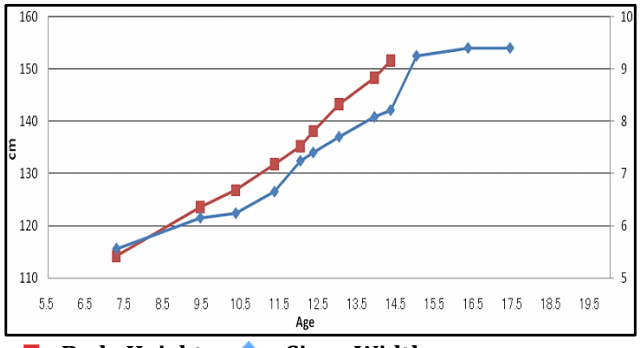

Figure-3: Case 1: Growth Increment for Both Body Height and Sinus Width

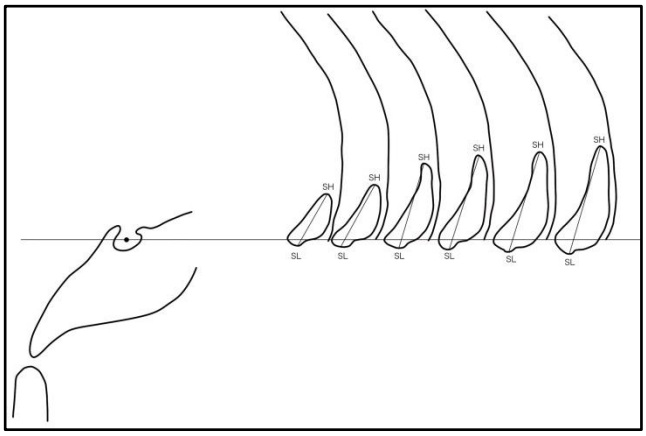

Figure-4: Case 1: Frontal Sinus Growth Pattern (Age 8, 9, 10, 12, 14 and 16 Years Old)

Discussion

During this analysis, we could observe the enlargement of the frontal sinus and the relation of this one with the body height. This enlargement was noticeable from 8 years old and continued until the body height peak was reached. It was also noticed that this enlargement was in forward and upward direction.

The understanding of the relationship between somatic growth, skeletal maturity and also the development of the frontal sinus may be of great value for orthodontic treatment. This means that the timing of orthodontic treatment in cases where it is expected to improve the jaws relationship, it is necessary to evaluate the growth spurt.

Considering previous investigations about the frontal sinus development, this study was designed to mainly investigate the enlargement of the frontal sinus in Japanese girls, and correlate this one to body height growth.[9,11,13]

In most previous studies, subjects comprised patients with Angle Class II relationship. However, in some cases, no treatment can be usually done in a child with mandibular prognathism until the end of growth spurt since late growth will possibly make Orthodontics treatment uncertain.[14] We therefore decided to include only Class III patients in the present study.[6,8,9]

During the data analysis we found that the frontal sinus was radiographically seen around 8 and 9 years old cephalogram. This finding coincided with previous studies who confirmed that the frontal sinus was detectable in radiographies during or around seven years old.

In comparison to other studies, the frontal sinus width size was found to be smaller in contrast to the frontal sinus of Australian aboriginals. In this study, we found that the frontal sinus width in Japanese girls ranged from 10.78 to 13.56 mm.

In addition, we have also found that the frontal sinus growth pattern is similar to body height, and has a peak that occurred one year after body height peak. The sinus peak growth velocity was about 1.02 mm/yr. This finding was slightly similar to Ruf's study where the frontal sinus grew at a 1.3mm/yr rate.[9] Furthermore, after the frontal sinus reached the Sp, very little additional growth was seen (Figure 3).

The frontal sinus follows craniofacial growth, and its enlargement is stimulated by the brain growth and various hydrodynamic conditions that occur in the endocraneum.[6,15]

The enlargement of the frontal sinus occurred gradually and this was noticed during the analysis in this study. It seemed that the frontal sinus had a growth pattern that begins on early age as a round shape, that becomes larger in height and finally its width enhanced. It is believed that when the girl reaches the body height peak, the frontal sinus becomes wider, and has a more pronounced anterior border (figure 4). Thus, the growth pattern of frontal sinus appears to be in an anterior – superior direction. This finding was analogous to Gagliardi.[11]

In contrast, the shape of aboriginals frontal sinus seems to be wider in the anterior surface compared to the shape found on the subjects in this study. According to Rossouw patients with a large ANB angle had the longest mandible and the largest frontal sinus. Thus, he concluded that the size of the frontal sinus was one factor that might help the clinician to determine whether he would be able to attain stability by treating a Class III malocclusion.[13]

Further research is needed to investigate more about the frontal sinus development. We believe

that by identifying the specific shape in which the frontal sinus enlargement is related to the growth spurt might be useful to predict skeletal or somatic maturity. This may be an advantage relevant to the decrease of radiation exposure.

However, the results obtained in this study revealed that the frontal sinus presented an enlargement and it is related to body height growth.

Conclusion

There is a close relation between the enlargement of the frontal sinus and body height growth. As a result, it is showed that the frontal sinus development can be used as one of the growth maturity indicators. This study has demonstrated that the sinus growth peak would be helpful in evaluating in particular whether the body height growth is over. In clinical practice, this might also be helpful especially during the evaluation of growth spurt and for determining the time of Orthodontics treatment.

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