Evaluation of Craniofacial Morphology of Children with Dental Fluorosis in Early Permanent Dentition Period

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ABSTRACT
Objectives: High intake of fluoride (>1.5 mg/L) for a prolonged period may lead to skeletal fluorosis as well as dental fluorosis. The aim of this study was to compare the craniofacial characteristics of children with dental fluorosis in early permanent dentition period to those without fluorosis.

Methods: Two hundred and sixteen children in early permanent dentition (girls:121, boys:95) were included in the study. Study group was composed of 124 children with dental fluorosis who was born and grew up in Isparta (girls:75, boys:49) whereas control group of children (n=92: 46 girls and 46 boys) had no dental fluorosis. Dental fluorosis was classified using Thylstrup Fejerskov Fluorosis Index. Radiological evaluation was performed by cephalometric tracing using Björk analysis. Statistical evaluation in between study and control groups was done by Independent Samples T test and comparison with Björk’s standards was done by One Sample T test analysis. The association between two quantitative variables was evaluated with Pearson’s correlation coefficient (rho).

Results: The mean dental fluorosis level was 4.6±1.8 for children with fluorosis. Systemic fluorosis affect girls no different than boys in the early permanent dentition period because none of the angular measurements show significant difference between boys and girls in the fluoridated group. Comparison of craniofacial angular values of boys with fluorosis show greater diversity compared to boys without fluorosis against Björk’s mean values for boys.

Conclusions: Craniofacial morphology of children with fluorosis did not show great diversity than the ones without fluorosis in the early permanent dentition period. None of the angular measurements were significantly different between boys and girls in the fluoridated group which might imply that systemic fluorosis did not show gender difference in the early permanent dentition. [Eur J Dent 2009;3:304-313]

Key words: Craniofacial morphology; Fluorosis; Cephalometrics; Björk analysis.

INTRODUCTION
Skeletal and dental fluorosis is an endemic public health problem in some regions of various countries around the world.1-3 Fluoride is mainly incorporated into calcified tissues (i.e., bones and teeth) because of its high affinity for calcium. It replaces the hydroxyl group of hydroxyapatite crystals to form fluorapatite which is less soluble and more compact. It increases metabolic turnover of the bone and stimulates bone cell proliferation. High intake of fluoride (>1.5 mg/L) for a prolonged...
period is known to cause dental and skeletal fluorosis while 1 ppm (parts per million) of sodium fluoride were reported to be safe level in drinking water.4

During research in the heavily fluoride-polluted area of the Ore mountains and their southern foreland, a high prevalence of pathological bone changes was also found in the mandibles of fluorotic red deer.5,6 Xu et al7 reported articular calcification and necrosis of articular chondrocytes in skeletal fluorosis. Czarnowsky et al8 showed that increased fluoride intake affects the fluoride levels in urine and hair and also has an impact on bone density. In mice exposed to a wide range of fluor in their diet, tooth fluoride concentration, confirms the use of tooth as a biomarker of skeletal exposure.9

In Turkey, the city of Isparta, located in the south Mediterranean region of Turkey, is one of the severe endemic fluorosis regions. Natural water supply is the major source of fluoride ions. The amount of fluoride in drinking water at some regions of the city is determined as high as 1.8-3.8 mg/l with a mean level of 2.7 ppm. Because of high fluoride intake, severe dental fluorosis is commonly encountered.2 Skeletal and joint deformities were also reported in the city.2

Orthodontic treatment in the early permanent dentition is a common treatment modality. Relative cephalometric normative standards for young individuals are essential in the diagnosis of and treatment planning for these age groups. The purpose of the study was to evaluate the craniofacial characteristics of children with fluorosis in the early permanent dentition period using Björk analysis10 and to investigate certain differences connected with the high fluor intake. We compared Turkish children with and without fluorosis living in different environmental conditions in different regions to determine the craniofacial differences. We also compared our results with the standard values of Björk.

MATERIALS AND METHODS

Subjects
A total of 216 (girls:121, boys:95) children in the early permanent dentition were included in the present study. The study group was composed of 124 children (girls:75, boys:49) who referred to Clinics of Dental Faculty, Suleyman Demirel University (in Isparta, endemic fluorosis region). Ninety two children (girls:46, boys:46) who applied to Okmeydani Dental Hospital (in Istanbul, non-endemic fluorosis region) was selected as the control group. Patients with any metabolic bone disease or inflammatory disease were excluded from the study. Patients who had undergone orthodontic treatment or with parafunctional habits were also excluded from the study (Table 1).

The clinical diagnosis and classification of dental fluorosis was established using the Thylstrup Fejerskov Fluorosis Index.11 Representative photographs showing different levels of dental fluorosis were presented in Figure 1.

Cephalometric analysis
The cephalometric radiographs were taken with the subjects standing with their teeth occluded and the lips in a relaxed position. The films were traced on acetate paper. Björk analysis10 were used for the evaluation of cephalograms to determine cranio-facial morphology. Björk analysis established for the Swedish children was used to serve the standard values. Angular (Figure 2) and linear (Figure 3) measurements were performed to determine the facial characteristics of the children with and without fluorosis.

Statistical analysis
Data were analyzed using the SPSS (version 11) for Windows (SPSS; Chicago, Illinois, USA) statistical package. The results were expressed as the minimum, maximum, mean and standard deviation for quantitative variables and as frequencies for categorical findings. Independent Samples T test analysis was used to compare the angular and linear measurements of children with and without fluorosis. The difference between angular measurements on male population in Björk study and in our study group was done by using One Sample T test. The association between two quantitative variables was evaluated with Pearson’s correlation coefficient (rho). Significance levels were set at 0.05.

Reliability
A replicate measurement trial was performed on 10 randomly selected cephalograms of children in the early permanent dentition period. A second set of tracings was carried out after an interval of
at least two weeks. In order to estimate the measurement error, Dahlberg’s formula $Se=\sqrt{\frac{\sum d^2}{2n}}$ was used, where $d$ is the difference between repeated measurements and $n$ is the number of paired measurement.12

RESULTS

In general, measurement errors were small; no variable reached the 5 per cent level of significance in the paired t-test. The mean age of the children included in the study was 13.8±1.2 (14.4±0.9 for children with fluorosis; 12.9±1.2 for children without fluorosis). The distributions of individuals in each group were shown in Table 1.

The mean dental fluorosis level was found 4.6±1.8 (minimum 2; maximum 9) according to Thylstrup Fejerskov Fluorosis Index for children with fluorosis.

Values of cephalometric measurements of children with and without fluorosis are given in Tables 2-5. Table 2 shows the differences of angular and linear measurements of the two groups according to gender. Differences of craniofacial morphology of individuals with and without fluorosis were shown in Table 3 and separately for girls and boys, in Tables 4 and 5. The results showed that angular or linear measurements were not statistically significant between children with and without fluorosis. The only exception was the angle of convexity (NAPog) which was significantly higher in children without fluorosis than children with fluorosis (Tables 3-5).

For all angular measurements, the differences between the genders were not statistically significant for children with and without fluorosis except Saddle (NSAr) and Gonial angle (ArGoGn) ($P<.05$). Linear variables, such as anterior cranial base (SN) ($P<.05$), posterior cranial base (SAr) ($P<.01$), anterior facial height (NMe) ($P<.01$), lower facial height (MePMe) ($P<.01$) were consistently larger in boys than in girls at both groups having and not having dental fluorosis (Table 2).

Girls showed statistically significant difference in NSAr ($P<.05$), NAPog ($P<.05$), and ramus height (Arkk) ($P<.01$) in between two groups (Table 4) whereas articular angle (SArGo) ($P<.001$), ArGoGn ($P<.05$), chin angle (IdPog-MGo) ($P<.001$) and NA-

![Figure 1. Thylstrup and Fejerskov Fluorosis Index (TFI) samples.](image)

Table 1. Fluorosis, gender cross tabulation.

| Gender               | Girls   |   | Boys   |   | Total |   |
|----------------------|---------|---|--------|---|-------|---|
|                      | N       | % | N       | % | N     | % |
| Without fluorosis    | 46      | 21.3 | 46      | 21.3 | 92    | 42.6 |
| With fluorosis       | 75      | 34.7 | 49      | 22.7 | 124   | 57.4 |
| Total                | 121     | 56  | 95      | 44  | 216   | 100 |
Pog \(P<.01\) (Table 5) showed significant difference in boys for different groups.

Comparison of craniofacial angular values of boys with and without fluorosis with Björk’s mean values shows different significance for NSAr, SArGo, mandibular prognathism (SNId) and NAPog (Table 6).

Correlations of angles for children with fluorosis in the early permanent dentition period are shown in Table 7. NSAr shows negative correlation with SArGo, SNPr, SNId angles for boys and girls. For total children and girls SArGo shows negative correlation with ArGoGn and ArNPPr. ArGoGn have negative correlation with only IdPog-MGo for all of the children. ArNPPr is positively correlated with SNPr, SNId, IdPog-MGo whereas it is negatively correlated with NAPog. SNPr is also positively correlated with SNId and IdPog-MGo. IdPog-MGo shows negative correlation with NAPog for all of the children.

**DISCUSSION**

Endemic fluorosis is a chronic metabolic bone and joint disease caused by intake of large amounts of fluoride. Marked increase in bone formation, with irregular deposition of osteoid tissue, induced by fluoride results in osteosclerosis, exocytose formation and calcification of tendons and ligaments. Skeletal fluorosis may cause pain, deformities, and limited movement of the joints of the spinal skeleton and major joints of extremities. Savas et al² observed that high number of female patients living in Isparta who had dental fluorosis also complained of knee pain. They found that radiological severity of knee osteoarthritis was greater and atypically located osteophytes were more frequent in patients with endemic fluorosis. They implied that endemic fluorosis might be responsible for the increased severity of degenerative changes in the bone.

Washington, DC: National Academy¹³ concluded that the severity of the disease appears to be directly related to the magnitude and duration of high-fluoride exposure. In an animal model, it was shown that tooth fluoride content was correlated with bone fluoride content where animals were exposed to a wide range of fluor in their drinking water. However, in the same study it was also shown that in humans and mice exposed to narrow ranges of fluoride ingestion, no correlation existed between tooth fluor concentration and bone fluoride concentration. A strong positive correlation between the degree of dental fluorosis and mandibular bone fluoride content was found in a sample of red deer exposed to elevated levels of fluoride, thus demonstrating the usefulness of dental fluorosis as a biomarker of increased fluoride exposure for biomonitoring studies.¹⁴ As for shown in clinical and experimental animal studies, prolonged uptake of increased amounts of
fluoride leads to osteomalacia and decreased biomechanical competence of bone.15–19 Miyagi et al.20 examined the effect of fluoride intake on the mineral content in rat alveolar bone. They concluded that fluoride intake might have a protective effect on rapidly progressing alveolar bone resorption. However, laboratory studies have demonstrated that fluoride does not readily diffuse into already-formed bone but is incorporated as bone remodels or develops in children.21 Therefore, dental fluorosis was used as a biomarker to evaluate the effects of high fluoride intake on bony components.

Table 2. Gender difference of the craniofacial morphology of Turkish children with and without fluorosis.

| Measurements          | Girls                      | Boys                      | P1  |
|-----------------------|---------------------------|---------------------------|-----|
|                       | N  | Mean | SD | N  | Mean | SD |     |
| Angular measurements  |    |      |    |    |      |    |     |
| With fluorosis        |    |      |    |    |      |    |     |
| NSAr                  | 75 | 124.8| 5.8| 49 | 123.1| 5.3| .109|
| SARo                  | 75 | 143.9| 6.3| 49 | 145.8| 5.3| .277|
| ArGoGn                | 75 | 128  | 6.3| 49 | 129.7| 5.5| .713|
| ArNPr                 | 75 | 64.4 | 4.1| 49 | 63.5 | 3.6| .200|
| SNPr                  | 75 | 82.9 | 4.5| 49 | 82.3 | 4.1| .664|
| SNld                  | 75 | 78.7 | 4.5| 49 | 79.9 | 4.2| .791|
| IdPog-MGo             | 75 | 70.6 | 7.1| 49 | 70.9 | 6.1| .797|
| NAPog                 | 75 | 176  | 7.4| 49 | 175.3| 7.8| .608|
| Without fluorosis     |    |      |    |    |      |    |     |
| NSAr                  | 46 | 127.1| 5.6| 46 | 124.7| 5.1| .041*|
| SARo                  | 46 | 141.8| 6.6| 46 | 138.9| 20.2| .366|
| ArGoGn                | 46 | 129.4| 6.4| 46 | 132.3| 6.4| .386*|
| ArNPr                 | 46 | 64.5 | 2.9| 46 | 63.4 | 3  | .087|
| SNPr                  | 46 | 83   | 6.2| 46 | 81.2 | 4  | .090|
| SNld                  | 46 | 77.4 | 6.4| 46 | 77.6 | 3.5| .801|
| IdPog-MGo             | 46 | 68.8 | 5.8| 46 | 66.8 | 4.9| .076|
| NAPog                 | 46 | 178.8| 6  | 46 | 179.7| 6.4| .499|
| Linear measurements   |    |      |    |    |      |    |     |
| With fluorosis        |    |      |    |    |      |    |     |
| SN                    | 75 | 70.3 | 3.7| 49 | 71.8 | 3.9| .032*|
| SAR                   | 75 | 35.1 | 4.1| 49 | 37.2 | 3  | .002**|
| Arkk                  | 75 | 47.2 | 4.5| 49 | 47.6 | 4.1| .551|
| Kkdd                  | 75 | 78.8 | 5.6| 49 | 80.7 | 5.7| .068|
| Iddd                  | 75 | 35.1 | 4.2| 49 | 36   | 4.5| .287|
| NMMe                  | 75 | 119.7| 6.9| 49 | 124.5| 8.4| .001**|
| NPMn                  | 75 | 53.9 | 4.6| 49 | 54.4 | 4.4| .548|
| MePMn                 | 75 | 63   | 4.8| 49 | 66.2 | 5.3| .001**|
| Without fluorosis     |    |      |    |    |      |    |     |
| SN                    | 46 | 69.2 | 4.7| 46 | 73.7 | 3.5| .032*|
| SAR                   | 46 | 34.9 | 3  | 46 | 36.6 | 3.5| .002**|
| Arkk                  | 46 | 44.6 | 4.5| 46 | 47.1 | 5  | .551|
| Kkdd                  | 46 | 79.8 | 5.2| 46 | 82.4 | 5.8| .068|
| Iddd                  | 46 | 34.8 | 3.4| 46 | 35.6 | 3  | .287|
| NMMe                  | 46 | 119.3| 6.7| 46 | 124.9| 7.4| .001**|
| NPMn                  | 46 | 52.8 | 4  | 46 | 55.3 | 3  | .548|
| MePMn                 | 46 | 64   | 4.7| 46 | 66.8 | 4.3| .001**|

*: P<.05; **: P<.01
of face. For this reason, our experimental group was selected from children living in endemic fluorosis region; Isparta, since birth.

In this study, craniofacial morphology of children with severe dental fluorosis in the early permanent dentition period were investigated. Boys consistently showed larger values for all of the linear variables, but the angular variables were usually not found to be different between the sexes (Table 2). This finding is in agreement with other studies dealing with children of the same age.22-23 In children with fluorosis, ArNPr and SNId shows negative correlation with NSAr which are frequently used in cephalometric tracings.24 Maxilla and mandible indicated anterior displacement when NSAr decreases in children with fluorosis, which shows parallelism with Björk’s standarts.19 None of the angular values showed statistical difference between boys and girls in the fluoridated group at the early permanent dentition period which might imply that systemic fluorosis had similar effect in both gender in the early permanent dentition period (Table 2). Facial and maxillary prognatism were slightly higher in the girls than in the boys both for children with and without fluorosis but the differences were not statistically significant which is comparable to the results reported by Johannsdottir et al.21 Regarding the linear measurements, the significantly larger SN, SAr, NMe and MePMe in boys (P=.001) both with and without fluorosis shows parallelism with the study of Johannsdottir et al21 (Table 2).

Negative correlation of SArGo for children with fluorosis with ArNPr, IdPog-MGo showed parallelism with Björk analysis. In our study in which a possible reduction of the angle between the rear portion, or vertical part, of the cranial base and the ramus [SArGo], would be accompanied by an equal increase in the degree of prognathism, as the ramus and the profile are nearly parallel. A diminution of the SArGo would have the secondary effect of shortening the frontal facial height, thus diminishing the change in the angle of prognathism.25

According to Björk, a possible reduction in ArGoGn had little effect on the degree of prognathism. Negative correlation was found between ArGoGn and IdPog-MGo. A change in IdPog-MGo, the angle between the lower horizontal and anterior...
### Table 4. Comparison of craniofacial morphology of girls with and without fluorosis.

| Measurements   | With fluorosis [Isparta] | Without fluorosis | P1   | MD  | 95% CI  |
|----------------|--------------------------|-------------------|------|-----|---------|
|                | N  | Min | Max | Mean | SD  | N  | Min | Max | Mean | SD  | P1   | MD  | 95% CI        |
| NSAr           | 75 | 110 | 138 | 124.8 | 5.8 | 46 | 112 | 137.5 | 127.1 | 5.6 | .037* | -2.3 | -4.4 | -0.1 |
| SArGo          | 75 | 125 | 156 | 143.9 | 6.3 | 46 | 140.5 | 152 | 148.1 | 6.6 | .086 | 2.1  | -0.3 | 4.5  |
| ArGoGn         | 75 | 112 | 141 | 128 | 6.3 | 46 | 119 | 143.5 | 129.4 | 6.4 | .251 | -1.4 | -3.7 | 1    |
| ArNPr          | 75 | 48.5 | 74.5 | 64.4 | 4.1 | 46 | 58 | 69 | 64.5 | 4.2 | .85 | -0.1 | -1.5 | 1.2  |
| SNPr           | 75 | 71.5 | 94.5 | 81.9 | 4.5 | 46 | 73.5 | 101 | 83 | 6.2 | .263 | -1.1 | -3 | 0.8 |
| SNld           | 75 | 69 | 91 | 78.7 | 4.5 | 46 | 60 | 90 | 77.4 | 6.4 | .199 | 1.3 | -0.7 | 3.3  |
| IdPog-MGo      | 75 | 57 | 87 | 70.6 | 7.1 | 46 | 58.5 | 83 | 68.8 | 5.8 | .155 | 1.8 | -0.7 | 4.2  |
| NAPog          | 75 | 119 | 154.5 | 176 | 7.4 | 46 | 170 | 191 | 178.8 | 6 | .029* | -2.9 | -5.4 | -0.3  |
| SN             | 75 | 63 | 79 | 70.3 | 3.7 | 46 | 61 | 80 | 69.2 | 4.7 | .152 | 1.1 | -0.4 | 2.6  |
| SAr            | 75 | 23 | 47 | 35.1 | 4.1 | 46 | 27.5 | 41.5 | 34.9 | 3 | .781 | 0.2 | -1.2 | 1.6  |
| Arkk           | 75 | 35 | 63 | 47.2 | 4.5 | 46 | 36.5 | 55 | 44.6 | 4.5 | .003** | 2.5 | 0.9 | 4.2  |
| Kkdd           | 75 | 66 | 91 | 78.8 | 5.6 | 46 | 71.5 | 90 | 79.8 | 5.2 | .33 | -1 | -3 | 1    |
| Iddd           | 75 | 21.5 | 47 | 35.1 | 4.2 | 46 | 29 | 46 | 34.8 | 3.4 | .663 | 0.3 | -1.1 | 1.8  |
| NMe            | 75 | 104 | 136 | 119.7 | 6.9 | 46 | 110 | 134.5 | 119.3 | 6.7 | .736 | .4 | -2.1 | 3    |
| NPn            | 75 | 44 | 69 | 53.9 | 4.6 | 46 | 45 | 61 | 52.8 | 4 | .201 | 1.1 | -0.6 | 2.7  |
| MePMe          | 75 | 52 | 72 | 63 | 4.8 | 46 | 56 | 74 | 64.7 | 4.7 | .284 | -1 | -2.7 | 0.8  |

1 Independent samples T test. SD=Standard deviation, MD=Mean difference, CI=Confidence Interval of the difference. ***:P < .001; **:P < .01; *:P < .05.

### Table 5. Comparison of craniofacial measurements of boys with and without fluorosis.

| Measurements   | With fluorosis [Isparta] | Without fluorosis | P1   | MD  | 95% CI  |
|----------------|--------------------------|-------------------|------|-----|---------|
|                | N  | Min | Max | Mean | SD  | N  | Min | Max | Mean | SD  | P1   | MD  | 95% CI        |
| NSAr           | 49 | 113 | 133 | 123.1 | 5.3 | 46 | 113 | 132 | 124.8 | 5.1 | .129 | -1.6 | -3.7 | 0.5  |
| SArGo          | 49 | 130 | 156 | 145.8 | 5.3 | 46 | 13 | 160 | 141.5 | 6.9 | .001** | 4.3 | 0.9 | 6.9  |
| ArGoGn         | 49 | 118 | 140 | 129.7 | 5.5 | 46 | 122 | 145 | 132.3 | 6.9 | .042* | -2.6 | -5.2 | -0.1 |
| ArNPr          | 49 | 54 | 72.5 | 63.5 | 3.6 | 46 | 57.5 | 71 | 63.4 | 3 | .969 | -1 | -3 | 1    |
| SNPr           | 49 | 73 | 92 | 82.3 | 4.1 | 46 | 74.5 | 90 | 81.2 | 4 | .182 | 1.1 | -0.5 | 2.8  |
| SNld           | 49 | 71 | 86 | 78.9 | 4.2 | 46 | 72.5 | 89.5 | 77.6 | 3.5 | .125 | 1.2 | -0.3 | 2.8  |
| IdPog-MGo      | 49 | 60 | 87 | 70.6 | 6.1 | 46 | 56 | 80 | 66.8 | 4.9 | .001** | 4.1 | 1.8 | 6.4  |
| NAPog          | 49 | 159.5 | 192 | 175.3 | 7.8 | 46 | 161 | 190 | 179.7 | 6.4 | .003** | -4.4 | -7.4 | -1.5 |
| SN             | 49 | 59 | 83 | 71.8 | 3.9 | 46 | 69.5 | 82 | 73.7 | 3.5 | .17 | -1.9 | -3.4 | -0.3  |
| SAr            | 49 | 30 | 44 | 37.2 | 3 | 46 | 31 | 45 | 36.6 | 3.5 | .318 | 0.7 | -0.7 | 2    |
| Arkk           | 49 | 40 | 59 | 47.6 | 4.2 | 46 | 37.5 | 60 | 47.1 | 5 | .541 | 0.6 | -1.3 | 2.5  |
| Iddd           | 49 | 71 | 95 | 80.7 | 5.7 | 46 | 74 | 93.5 | 82.4 | 5.8 | .141 | -1.8 | -4.1 | 0.6  |
| NMe            | 49 | 110 | 140 | 124.5 | 8.4 | 46 | 112 | 143 | 124.9 | 7.4 | .786 | -0.4 | -3.7 | 2.8  |
| NPN            | 49 | 44 | 61 | 54.4 | 4.4 | 46 | 49 | 60.5 | 55.3 | 3 | .243 | -0.9 | -2.5 | 0.6  |
| MePMe          | 49 | 53 | 75 | 66.2 | 5.3 | 46 | 61 | 76 | 66.8 | 4.3 | .548 | -0.6 | -2.6 | 1.4  |

1 Independent samples T test. SD=Standard deviation, MD=Mean difference, CI=Confidence Interval of the difference. ***:P < .001; **:P < .01; *:P < .05.
### Table 6. Comparison craniofacial angular values of boys with and without fluorosis by Björk values.

| Angular measurements | Björk values N:322 | With fluorosis N:49 | Without fluorosis N:46 |
|----------------------|---------------------|---------------------|------------------------|
|                      | Mean SD  | Mean SD  | P1       | Mean SD  | Mean SD  | P1       |
| NSAr                 | 122.9 4.9 | 123.1 5.3 | .769     | 124.8 5.1 | .017*    |
| SArGo                | 143 6.2 | 145.8 5.3 | .001**   | 141.5 6.9 | .154     |
| ArGoGn               | 131.1 6.1 | 129.7 5.5 | .073     | 132.3 6.9 | .25      |
| ArNPr                | 65.5 3.2 | 63.5 3.6 | .000***  | 63.4 3 | .000***  |
| SNPr                 | 83.7 3.7 | 82.3 4.1 | .018*    | 81.2 4    | .000***  |
| SNId                 | 78.9 3.6 | 78.9 4.2 | .957     | 77.6 3.5 | .019*    |
| IdPog-MGo            | 68.6 5.4 | 70.9 6.1 | .012*    | 66.8 4.9 | .016*    |
| NAPog                | 173.9 5.6 | 175.3 7.8 | .224     | 179.7 6.4 | .000***  |

1 One sample T test. SD=Standard deviation, MD=Mean difference, CI=Confidence Interval of the difference

### Table 7. Björk Analysis correlations of angular measurements of individuals in general, boys, girls with dental fluorosis.

| Angular measurements | NSAr | SArGo | ArGoGn | ArNPr | SNPr | SNId | IdPog-MGo | NAPog |
|----------------------|------|-------|--------|-------|------|------|-----------|-------|
| Total                |      |       |        |       |      |      |           |       |
| Girls                |      |       |        |       |      |      |           |       |
| Boys                 |      |       |        |       |      |      |           |       |
| Total                | -.642(***)|-.224[*]|-.373[**]|-.220[*]|-.280[*]|     |           |       |
| Girls                | -.646(***)|-.327(**)|-.558(***)|-.369(**)|-.566(***)|      |           |       |
| Boys                 | -.609(***)|-.408(***)|-.189[*]|       |-.444[*]|       |           |       |
| Total                |-.347(***)|-.346(***)|.344[*]|.346[*]|.344[*]|.643[***]|           |       |
| Girls                |-.327(**)|.714[***]|.801[***]|.656[***]|      |       |           |       |
| Boys                 |-.558(***)|.393[***]|.303[***]|.303[***]|.631[***]| .801[***]|           |       |
| Total                |-.437(***)|.340[***]|.346[*]|.669[***]|.346[*]|.344[*]|.631[***]|       |
| Girls                |-.404(**)|.415[***]|.477[**]|.330[***]|.477[**]|.631[***]|           |       |
| Boys                 |-.249[*]|.393[***]|.303[***]|.303[***]|.303[***]|.303[***]|           |       |
| Total                |-.294(**)|.415[***]|.477[**]|.330[***]|.477[**]|.631[***]|           |       |
| Girls                |-.249[*]|.393[***]|.303[***]|.303[***]|.303[***]|.303[***]|           |       |
| Boys                 |-.404(**)|.415[***]|.477[**]|.330[***]|.477[**]|.631[***]|           |       |
| Total                |-.217[*]|-.379[***]|-.271[**]|-.210[*]|-.602[***]| .705[***]|           |       |
| Girls                |-.324[**]|.210[**]|.544[***]|       |       |       |           |       |
| Boys                 |-.495[***]|-.400[***]|-.705[***]|       |       |       |           |       |

***: P<.001; **: P<.01; *: P<.05.
or vertical boundaries on the cephalogram, would have a pronounced effect on the alveolar section. How great the effect on the angle of prognathism will be, depends upon whether the change in the chin angle is accompanied by a corresponding change in the upper jaw. Chin angle showed positive correlation with facial prognatism and maxillary prognathism as in Björk’s. The reason may be the posterior growth of condyles and the resorption in the anterior bone surface of mandibular incisors as mentioned in Björk and Skiller’s study. Mandibular prognathism increases by the increment of facial and maxillary prognatism as Björk mentioned in his thesis. Nevertheless, NAPog decreases with all this incremental values of prognathism angles. This can be the result of posterior rotation of mandible. Schudy and Björk explained this situation like this: the growth of corpus antero-posteriorly more than expected yield to the inclination of gonial angle downwards so as the large mandible can be placed. This is accepted as naturally compensation mechanism so as the anatomical complex can be harmonized. As the mandible grows antero-posteriorly, gonial angle found to be greater. But in our study, gonial angle did not increase with the increment of facial and maxillary prognathism which might be the result of posterior growth of condyle as in the second theory of Björk’s growth development. The increment of IdPog-MGo is the other important compensation mechanism for the decrement of NAPog by the increment of prognathism angles. Increment of chin angle yields to mandibular prognatism and maxillary and facial prognatism.

Although studies relating fluoride to bone have been rather inconclusive, it has been stated that ‘sodium fluoride has clearly been shown to have pronounced effects on the skeleton’. For this reason, studies of this type continue to be important especially on facial growth and development studies.

CONCLUSIONS

- Craniofacial morphology of children with fluorosis did not show great diversity than the ones without fluorosis in the early permanent dentition period.
- None of the angular measurements were significantly different between boys and girls in the fluoridated group which might imply that systemic fluorosis did not show gender difference in the early permanent dentition.

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