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## Analysis of Dental Maturation in Relation to Sagittal Jaw Relationships

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### Background:

The degree of mineralization of permanent tooth germs in dental age assessment has been an area of interest among many authors for years. However, only recently have researchers attempted to determine the potential interdependencies between dental age and jaw relationships. The aim of this work was to compare dental maturation in patients with skeletal Class II to patients with skeletal Classes I and III.

### Material/Methods:

The study involved 150 patients who sought orthodontic treatment. Dental age was assessed from panoramic radiographs using the Demirjian's method. Skeletal class was evaluated according to the value of the ANPg angle from the Björk's analysis. We used the analysis of variance (ANOVA) and the Student's t-test.

### Results:

The mean dental age in patients with skeletal Class III was significantly higher than the mean dental age in patients with skeletal Class II ( $p < 0.0005$ ). A correlation between the dental age and chronological age was established. The weakest correlation was seen between the dental age and skeletal Class II. Among patients with skeletal Class II, the strongest correlation was found between chronological age and the formation of the germ of the second lower premolar ( $r = 0.67$ ;  $p < 0.001$ ).

### Conclusions:

Dental age among patients with skeletal Class II was the lowest.

### MeSH Keywords:

Age Determination by Skeleton • Age Determination by Teeth • Malocclusion, Angle Class II

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## Background

The age of the patient is one of the main factors that has to be considered by a specialist both during orthodontic diagnostics and when planning orthodontic treatment. There are numerous methods for determining the patient's age; some of the most frequently used include chronological age, biological age, bone age (assessed in a radiograph of the wrist and the hand and based on cervical vertebrae) and dental age [1–4].

In comparison to other known methods of determining the patient's age, dental age assessment is less dependent on extrinsic and intrinsic factors [1–3,5]. The research of Demirjian et al. [5] showed that mechanisms responsible for dental development are independent from somatic and/or sexual maturity. Dental age assessment can be carried out during an intraoral examination based on the tooth eruption process or the analysis of the developmental level of permanent tooth germs on a panoramic radiograph [1,6,7]. Assessing dental age based on tooth eruption is believed to be unreliable as it can only be performed during

those periods of a child's development when tooth eruption occurs [1,6,7]. This method is ineffective e.g. in full primary dentition before the exfoliation process starts [1]. Moreover, the tooth eruption process is influenced by many general and specific factors, including a premature loss of primary teeth [6,8], which makes adequate dental age assessment impossible. As opposed to dental age assessment methods based on the tooth eruption process, radiological methods evaluating the mineralization degree of permanent tooth germs may be used without the above-mentioned limitations and their diagnostic value is significantly higher [1,6,7].

Radiological methods of dental age assessment include those developed by: Demirjian [9,10], Willems [11,12], Haavikko [13] or Nolla [14]. Maber et al. [4] conducted a study comparing dental age assessments using the above-mentioned methods. The 95% confidence interval of the mean differences between the assessed dental age and chronological age was the smallest for the Haavikko method, and identical values were achieved by Demirjian's and Willems's methods. The authors claimed that the simplest, and at the same time, the most transparent method was that of Demirjian's [4]. Moreover, all methods with the exception of the Demirjian's method were more precise in assessing the age among boys than girls. For the studied group, the authors considered the Willems's method adjusted to the Demirjian's method to be the most appropriate [4].

The aim of this work was to compare dental maturation in patients with skeletal Class II to patients with skeletal Classes I and III.

## Material and Methods

The study involved 150 patients (75 females and 75 males) aged from 9 to 12 years who sought orthodontic treatment at the Specialist Orthodontic Practice in Mierzyn (Poland). The patients who were enrolled in the study met the following criteria: chronological age assessed since birth to the day of the orthodontic consultation between 9 and 12 years, normal growth and development, no serious medical conditions in medical history, no past trauma or disease of the head and neck, no earlier orthodontic treatment; on the examination: no dental disorders (including tooth transposition, reinclusion or aplasia), no extractions of permanent teeth.

The patients' panoramic and cephalometric radiographs taken before the start of the treatment were used in the study.

Dental maturation was assessed based on the Demirjian's method [9,10]. Panoramic radiographs were analysed to evaluate the mineralization degree of seven permanent teeth on the left side of the mandible (with the exception of the third permanent tooth). The degree of mineralization was classified as ranging from A to H (from initial mineralization centres of dental anatomic crowns to the closing of the apex). Each of the A-H stages was assigned a different number of points in accordance with Demirjian's tables. Dental maturation was assessed by adding the points corresponding to the mineralization of each of the seven examined permanent teeth.



**Figure 1.** Cephalometric radiograph of a patient with skeletal class I (ANPg=1.1°).

Skeletal class was assessed on the basis of the A-N-Pg angle from the Björk's analysis [15]. The A-N-Pg angle is contained between the Downs' A, Nasion and Pogonion points. Skeletal Class I was diagnosed when the value of the A-N-Pg angle was between  $-0.5^\circ$  and  $4^\circ$ , skeletal Class II when the A-N-Pg angle was over  $4^\circ$  and skeletal Class III when the A-N-Pg angle measured less than  $-0.5^\circ$ , respectively. The studied patients were divided into three groups of 50 subjects each (25 females and 25 males) who were diagnosed with skeletal Classes I, II and III. Figures 1–3 present exemplary cephalometric radiographs of skeletal class I (Figure 1), skeletal class II (Figure 2) and skeletal class III (Figure 3).

The vertical jaw relationship (the NL/ML angle) in all patients was between  $19^\circ$  and  $33^\circ$ .

To evaluate the dependency between dental maturation and the sagittal relationship of the jaws, the analysis of variance (ANOVA) and Student's t-test were used.

## Results

The mean dental age was: in skeletal Class I – 9.55 years, in skeletal Class II – 9.51 years, in skeletal Class III – 10.44 years, respectively. The mean dental age for the whole group was 9.83 years.

The mean dental age in the group of patients with skeletal Class III was significantly higher than that in the group of patients with skeletal Class II ( $p < 0.0005$ ). No statistically significant differences between the mean dental ages in patients with skeletal Class I and II were found ( $p = 0.87$ ).

A correlation was found between the assessed dental age and chronological age, both in the whole studied population ( $r = 0.59040$ ;  $p < 0.00001$ ) and within each of the sexes (boys:  $r = 0.53439$ ;  $p < 0.00001$ ; girls:  $r = 0.63549$ ;  $p < 0.00001$ ). The correlation between the assessed dental and chronological age was stronger among girls than boys.



**Figure 2.** Cephalometric radiograph of a patient with skeletal class II (ANPg=5.5°).



**Figure 3.** Cephalometric radiograph of a patient with skeletal class III (ANPg=-3.4°).

The correlation between dental age and skeletal class was: for skeletal Class I ( $r=0.66852$ ), skeletal Class II ( $r=0.60290$ ), skeletal Class III ( $r=0.62792$ ), respectively. The weakest correlation was found between dental age and skeletal Class II.

Among patients with skeletal Class II, the strongest correlation was seen between chronological age and the formation of the germ of the second lower premolar ( $r=0.67$ ;  $p<0.001$ ). At the same time, in the group of patients with skeletal Class II, the weakest correlation was found between chronological age and the formation of the germs of the central incisor ( $r=0.45$ ;  $p<0.001$ ), the lateral incisor ( $r=0.42$ ;  $p<0.003$ ) and the canine ( $r=0.42$ ;  $p<0.002$ ).

## Discussion

Demirjian [9] states that dental age is an area of special interest for orthodontists as far as planning of orthodontic treatment of particular malocclusions in relation to the growth of viscerocranium structures is concerned. Różyło-Kalinowska et al. [16] compared the dental age assessed using the Demirjian's method with skeletal maturation determined by a radiograph of the cervical vertebrae. In the authors' opinion, the strongest correlation with the CVM classification was manifested by the second premolar (among females) and the canine (among males). The weakest correlation in both sexes was found to be for the central incisor. The authors believe that both dental and skeletal maturation should be assessed in order to fully evaluate the maturity of the child. The work also states that the assessment of the mineralization degree of permanent tooth

germs may be the first and the main source of information on skeletal maturation of a child [16].

In Poland, the most common group of malocclusions, according to Orlik-Grzybowska's classification, are distocclusions constituting 28.2–70.2% of malocclusions diagnosed in children in the developmental age [17]. So far, there are few studies in the available literature that have assessed the dependency between dental age and skeletal jaw relationships with a special consideration to Class II malocclusions.

Esenlink et al. [18] analysed panoramic and cephalometric radiographs of 321 patients (165 females and 156 males) aged between 7 and 15.9 years. Dental age was assessed using the Demirjian's method and the SNA, SNB, ANB and GoGnSN angles were marked in cephalometric radiographs. The patients were divided into three groups depending on their skeletal class determined according to the value of the ANB angle (Class I – 107 patients, Class II – 152 patients, Class III – 62 patients). In all of the studied groups, the estimated dental age was significantly higher than chronological age. The authors showed a statistically significant difference between the dental age and chronological age, which was higher among females than males both in skeletal Class I ( $p=0.029$ ), and in skeletal Class II ( $p<0.001$ ). No statistically significant correlation between dental age and the SNA or GoGnSN angles was found. A weak, linear and statistically significant negative correlation between dental age and the SNB angle was found ( $p=0.205$ ,  $p<0.001$ ) and a weak, linear, statistically significant correlation between dental age and the ANB angle was discovered as

well ( $p=0.313$ ,  $p<0.001$ ). However, the authors remarked that while analysing the dependencies between dental age and skeletal class in relation to gender, the presence of a weak, linear, statistically significant correlation between dental age and the ANB angle ( $p=0.346$ ,  $p<0.05$ ) was found only in the group of males.

Celikoglu et al. [19] conducted a retrospective study of 525 patients (269 females, 256 males) aged from 9 to 15 years. The authors analysed the patients' panoramic and cephalometric radiographs and assessed dental age using the Demirjian's method. According to the value of the ANB angle, the patients were divided into three groups: skeletal Class I (ANB  $0-4^\circ$ ; 162 patients), skeletal Class II (ANB  $>4^\circ$ ; 186 patients) and skeletal Class III (ANB  $<0^\circ$ , 177 patients). Dental age in all studied groups was significantly higher than chronological age ( $p=0.000$ ). The mean difference between dental age and chronological age in skeletal Class I was 0.63 years among girls and 0.58 years among boys. Mean differences between dental and chronological age in patients with skeletal Class II or III were almost twice as high as in patients with skeletal Class I (girls: Class II – 1.08 years, Class III – 1.38 years; boys: Class II – 1.10 years, Class III – 1.15 years). Mean differences between dental age and chronological age in the groups of all studied girls and all studied boys were similar ( $p>0.05$ ). The mean difference between dental age and chronological age in the group of girls with skeletal Class III was significantly higher than in the group of girls with skeletal Class I ( $p=0.021$ ); among boys with skeletal Classes I and III, these differences were similar ( $p=0.155$ ). Mean differences between dental and chronological age between skeletal Classes I and II for both genders (girls:  $p=0.154$ , boys:  $p=0.215$ ) were similar.

Nakas et al. [20] studied a group of 231 patients (127 males, 104 females) aged from 5.9 to 15.8 years. Panoramic and cephalometric radiographs of the patients taken for diagnostic purposes before orthodontic treatment were analysed. Based on panoramic radiographs, dental age was assessed twice: using the Demirjian's and Willems's methods. According to the value of the ANB angle, the patients were divided into three groups: skeletal Class I (ANB  $0-4^\circ$ ; 66 patients), skeletal Class II (ANB  $>4^\circ$ ; 122 patients) and skeletal Class III (ANB  $<0^\circ$ ; 63 patients). The mean dental age assessed with the use of both methods was significantly higher than chronological age in the group of boys as well as in girls ( $p<0.05$ ). The authors found no statistically significant differences between the estimated dental age and chronological age with respect to skeletal classes.

Brin et al. [21] conducted a study with 221 patients (129 females, 92 males). According to the value of the ANB angle, evaluated on the basis of cephalometric radiographs, the patients were divided into two groups: skeletal Class I (ANB between  $2^\circ$  and  $4.5^\circ$ ; 41 patients) and skeletal Class II (ANB  $\geq 5^\circ$ ; 180 patients). Moreover, patients with skeletal Class II were further subdivided into two subgroups: skeletal Class II with a maxillary disorder (SNA  $\geq 84^\circ$ , SNB  $\geq 78.5^\circ$ ) and skeletal Class II with a mandibular disorder (SNA  $\leq 83.5^\circ$ , SNB  $\leq 78^\circ$ ). Panoramic radiographs of the patients were used to assess the position of the germs of second molars in the maxilla and the mandible in relation

to predetermined reference lines, second molar developmental stages according to Nolla and dental age. The authors found no relationship between skeletal class and the developmental stage of the second molar or between skeletal class and the position of the germ of the second molar in relation to the predetermined reference line. Having independently analysed the maxilla and the mandible, the authors showed a significantly lower (closer to the occlusal surface) position of the germs of second molars among patients over 12 years with skeletal Class II and a maxillary defect ( $p=0.02$ ) in comparison to patients with skeletal Class II and a mandibular defect or with skeletal Class I.

Sasaki et al. [22] compared two groups of 25 girls aged 8 years with Class II and Class III malocclusions with a control group that consisted of girls with skeletal Class I. The authors analysed panoramic and cephalometric radiographs, radiographs of the wrist and the hand and intraoral photographs. The study showed that mineralization of lower teeth, especially molars, progressed faster in patients with skeletal Class III in comparison to patients with skeletal Class II. In the authors' opinion, the sagittal jaw relationships may influence the time of formation and eruption of permanent teeth.

Sukkhia et al. [23] conducted a retrospective study with including 264 participants (153 females, 111 males) aged between 7 and 17 years. The authors analysed radiographs of the patients (panoramic and cephalometric pictures) taken before orthodontic treatment was commenced. Dental age was assessed from panoramic radiographs using the Demirjian's method. The whole studied population was divided into three groups according to the ratio of lower anterior face height (LAFH, measured from ANS to Me) to total anterior face height (TAFH, measured from N to Me): patients with an increased lower face height (LAFH/TAFH  $>59\%$ ; 88 patients), average lower face height (LAFH/TAFH  $56-58\%$ ; 88 patients) and a short lower face height (LAFH/TAFH  $<55\%$ ; 88 patients). Moreover, according to the value of the ANB angle, the studied population was divided into patients with skeletal Class I (ANB  $0-4^\circ$ ; 132 patients) and skeletal Class II (ANB  $>4^\circ$ ; 132 patients). The authors found that dental age of patients with skeletal Class I and II was similar. Moreover, no statistically significant differences between dental ages of patients with an increased, average and short lower face height were discovered. In addition, the authors compared the dental age of 40 patients with the longest lower face height to the dental age of 40 patients with the shortest face height. Dental age in the studied groups was similar. The study showed a significantly higher dental age in the group of girls in comparison to the group of boys. Chronological age of the boys and girls was similar.

Gottimukkala et al. [24] conducted a study in a group of 100 participants (50 males, 50 females) aged 9 to 12 years. The authors analysed panoramic and cephalometric radiographs as well as radiographs of the left wrist and the left hand. Based on cephalometric pictures, the patients were divided into two groups: those with vertical and horizontal growth. Panoramic radiographs were used to determine dental age according to the Demirjian's method. Skeletal

maturation was assessed using the radiographs of the wrist and cervical vertebrae. It was established that in the group of patients with vertical growth, the mean dental age was higher than in patients with dominant horizontal growth, which indicates a faster mineralization of permanent tooth germs in patients with dominant vertical growth. Moreover, in patients with dominant vertical growth, the mean skeletal age and the mean dental age were significantly higher than the mean chronological age. Among patients with dominant horizontal growth, the mean chronological age and the mean skeletal age were significantly higher than the mean dental age.

Kamble et al. [25] studied a group of 60 patients aged 8-14 years. Cephalometric and panoramic pictures as well as radiographs of the hand and the wrist were analysed. The patients were divided into three 20-person groups: Group I (average growth), Group II (vertical growth), Group III (horizontal growth). Dental age was assessed using the Demirjian's method. In comparison to patients with vertical growth, a significantly lower dental age was discovered in the group of patients with horizontal growth. Among patients with horizontal growth, skeletal maturation was significantly decreased when compared to patients with average growth.

Goyal et al. [26] conducted a study in a group of 150 patients (75 males, 75 females) aged from 8 to 10 years. According to cephalometric radiographs and the direction of growth, the studied patients were divided into three 50-person groups (each group containing 25 males and 25 females): Group I (average growth), Group II (vertical growth), Group III (horizontal growth). Dental age was assessed using the Demirjian's method on the basis of panoramic radiographs. The authors established a statistically significant difference between the mean dental age in Groups II and III – patients with dominant vertical growth

had more advanced dental maturation when compared to patients with dominant horizontal growth. At the same time, no statistically significant differences between Group II and Group I or between Group III and Group I were seen.

In summary, the results of studies on the interdependencies between dental age and sagittal jaw relationships are not fully consistent. There is a need to perform further studies in larger populations and assess dental age using more than one method, since the main observation from the majority of the studies was that dental age, evaluated with the use of the Demirjian's method, was significantly higher than chronological age. As opposed to studies on sagittal relations, the studies concerning interdependencies between dental age and vertical jaw relationships present similar conclusions. The authors showed that patients with vertical growth manifest an accelerated mineralization of permanent tooth germs.

## Conclusions

1. The mean dental age among patients with skeletal Class II was the lowest (the difference between skeletal Class II and skeletal Class III was statistically significant, the difference in comparison to skeletal Class I was not significant).
2. The strongest correlation between dental age and skeletal class was observed among patients with skeletal Class I.
3. In the group of girls, the correlation between dental age and chronological age was stronger than in the group of boys.
4. In patients with skeletal Class II, chronological age could be most accurately estimated on the basis of formation of the germ of the second lower premolar, and least accurately based on formation of germs of incisors and lower canines.

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