

## Dental anomaly pattern (DAP): Agenesis of mandibular second premolar, distal angulation of its antimere and delayed tooth formation

Joana Navarro<sup>a</sup>; Maria Cavaller<sup>a</sup>; Estela Luque<sup>a</sup>; Maria Luisa Tobella<sup>b</sup>; Alejandro Rivera<sup>c</sup>

### ABSTRACT

**Objective:** To test the null hypotheses that children with unilateral agenesis of the mandibular second premolar (MnP2) do not show (1) greater distal angulation of the unerupted antimere and (2) delayed tooth formation compared with children without agenesis.

**Materials and Methods:** Panoramic radiographs of 38 patients with unilateral aplasia of MnP2 were retrospectively examined and compared to a non-agenetic control group of 82 patients. Ages ranged from 8 to 15 years. Contralateral mandibular deciduous second molars were present for all participants. Each unerupted MnP2 was traced, and its developmental stage and angulation were recorded (measured with the distal angle and the premolar-molar angle). Dental age was evaluated using the Haavikko method. Student's *t*-test was performed to identify significant differences between the compared groups. The significance level for statistical testing was set at  $P < .05$ .

**Results:** The results indicated a  $9.5^\circ$  decrease in the distal angle and a  $13.2^\circ$  increase in the premolar-molar angle for the unerupted MnP2 in the agenesis sample. This was a highly statistically significant difference ( $P < .001$  and  $P < .0001$ , respectively) compared with the MnP2 inclinations in the control sample. The delay in dental age was significantly greater in patients with agenesis (2.1 years) compared with the delay in the control group (1.5 years) ( $P < .001$ ).

**Conclusion:** Both null hypotheses are rejected. The results of this study statistically support the hypothesis that aplasia of MnP2, distally displaced MnP2s, and delayed tooth formation are part of a genetically related pattern of dental anomalies. (*Angle Orthod.* 2014;84:24–29.)

**KEY WORDS:** DAP; MnP2 agenesis; MnP2 distal inclination; Delayed tooth formation

### INTRODUCTION

Tooth agenesis is the most common human dental anomaly.<sup>1</sup> The human mandibular second premolar (MnP2) is highly variable developmentally and has been proven to be the most frequently absent tooth type, excluding third molars, in certain populations.<sup>1,2</sup>

There is considerable evidence suggesting that genes play a fundamental role in the etiology of tooth agenesis,<sup>3</sup> and absent teeth are often detected

together with other orthodontic abnormalities.<sup>4</sup> Hypodontia is often associated with other disruptions of the dental lamina and maxillofacial skeletal imbalances.<sup>3</sup> Abnormal conditions such as tooth agenesis, microform teeth, delayed tooth development, palatally displaced canines, infraocclusion of deciduous molars, and MnP2 distal angulation have been found to occur together much more frequently than would be expected by chance alone.<sup>4–16</sup> Combinations of these occurrences were named dental anomaly patterns (DAPs) by Peck,<sup>17</sup> and they are found in nearly 25% of orthodontic patients.

Many clinical orthodontists are excited about a DAP approach for better understanding and treatment of malocclusion. S. Peck,<sup>17,18</sup> S. Peck and colleagues,<sup>7,8,11,19</sup> Baccetti,<sup>10,12</sup> Baccetti and colleagues,<sup>16</sup> Garib and colleagues,<sup>4</sup> Shalish and colleagues,<sup>5,15,20</sup> and L. Peck and colleagues<sup>13</sup> are prominent among those who have contributed recently to an increased awareness of fundamental relationships among dental abnormalities.

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Previous studies have related MnP2 agenesis to increased incidence of dental anomalies.<sup>4</sup> Shalish et al.<sup>20</sup> demonstrated anomalous distal inclination of the second premolar bud on the contralateral side in subjects with aplasia of the MnP2. Daugaard et al.<sup>21</sup> showed considerable delay in tooth formation in dentitions with the same unilateral agenesis. Symons and Taverne<sup>22</sup> observed distal angulation of MnP2 tooth buds and delayed tooth development in individuals of the same family presenting multiple agenesis, including MnP2.

The present study is inspired by the work published by Shalish et al.,<sup>20</sup> which compared the distoangular inclinations of MnP2 in a small experimental agenesis group to those from an age- and sex-matched reference sample. This study was undertaken to identify the association between these three dental disturbances (agenesis of MnP2, distoangulation of unerupted MnP2, and delayed tooth formation) in a larger sample as additional evidence of a shared genetic mechanism for DAP.

The null hypotheses were that:

- The distal angulation of unerupted MnP2 is not significantly greater in children with agenesis of its antimere.
- Delayed tooth formation is not significantly more frequent in children with unilateral agenesis compared with a non-genetic group.

## MATERIALS AND METHODS

For this retrospective study, which was approved by the institutional review board, two samples of patient pretreatment records were selected: an experimental and a control group. The experimental sample consisted of 38 patients with agenesis of one MnP2, a likely indicator of site-specific genetic disturbance. Premolar agenesis was confirmed by examining follow-up panoramic roentgenograms recorded at age 13 years or older. The control group comprised 82 patients without agenesis. When a control patient showed both MnP2 unerupted, the more distally angulated bud was chosen for analysis and included in this study. The inclusion criteria for both samples were (1) age between 8 and 15 years, (2) no previous orthodontic treatment, (3) presence of mandibular second deciduous molar, and (4) development of the MnP2 tooth bud in unerupted stages  $R_i$  to  $A_{1/2}$ , according to the Haavikko<sup>23</sup> classification. Unerupted stage  $R_i$  is defined as completed crown formation and initiated root formation, and unerupted stage  $A_{1/2}$  is defined as completed root formation and an apex that is still partially open.<sup>21</sup> When there was uncertainty about the maturation stage, the least mature stage was chosen.

The following structures in each panoramic radiograph were traced: the second deciduous molar, the bud of the MnP2, the neighboring mandibular first molar, and the lower border of the mandibular body near the second premolar and the first molar along with a line tangent to this lower border. The long axis of the MnP2 was determined as the line connecting the uppermost point of the pulp of this tooth with the point bisecting the distance between the mesial and distal points of the root canal. The long axis of the first molar was also traced.

To test the first hypothesis, the inclination of the MnP2 was assessed with two angular measurements and one qualitative variable:

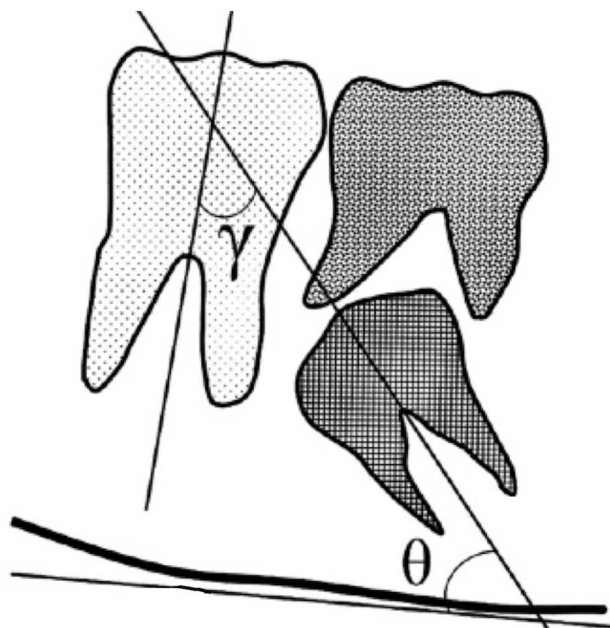
- The distal angle (theta,  $\theta$ ), previously described by Shalish et al.,<sup>20</sup> is the angle between the long axis of the MnP2 and the tangent to the lower border of the mandible on the panoramic x-ray (mandibular plane).
- The premolar-molar angle (gamma,  $\gamma$ ), previously described by Baccetti et al.<sup>16</sup>, is the angle between the long axis of the MnP2 and the long axis of the first permanent molar.
- The distal inclination of the MnP2 was found to be anomalous when the long axis of the premolar bud intersected the mesial border of the adjacent first molar. In that case, the variable "intersection on the first molar" was considered positive (yes). When the intersection of both teeth occurred beyond the limits of the first permanent molar, the variable was considered negative (no).

Figure 1 shows a standard drawing with assigned lines and the resulting angles, first published by Shalish et al.<sup>20</sup> in 2002 and further modified by Baccetti et al.<sup>16</sup> in 2010.

To prove the second hypothesis, dental age was calculated from the orthopantomogram of all subjects according to the Haavikko<sup>23</sup> method. Delay in dental age was obtained by subtracting the chronological age of each subject from the previously calculated dental age. The resulting value was negative in patients with delayed dental formation and positive in those with accelerated maturity.

To quantify the error of the method, a second set of data was traced and measured 1 month later by the same examiner. The method error found for angular measurements was  $<1^\circ$ . Reproducibility was 100% for the intersection on the first molar variable, and the error for dental age and delay in dental age was 0.3 years for both, which was within reasonable limits in the context of the study.

The developmental stage of the unerupted MnP2 was subclassified into type A (early developmental stages: from  $R_i$  to  $R_{1/4}$ ) or type B (later developmental stages: from  $R_{1/2}$  to  $A_{1/2}$ ) (Figure 2) to evaluate the



**Figure 1.** Angular measurements of MnP2 bud inclination in panoramic radiograph. (Published in Baccetti T, Leonardi M, Giuntini V. Distally displaced premolars: A dental anomaly associated with palatally displaced canines. *Am J Orthod Dentofacial Orthop.* 2010;138(3):318–322.<sup>16)</sup>

angular change rate of those teeth in the different stages of development.

**Statistical Methods**

The  $\chi^2$  test and Student’s *t*-test for unpaired samples were performed to identify significant differences between the compared groups. The variables influencing the inclination of MnP2 in each group were also evaluated. The significance level for statistical testing was set at  $P < .05$ .

**RESULTS**

Table 1 shows the intergroup analysis, which compares the homogeneity and differences in angular and age values between the experimental and the control groups. No significant differences between the compared samples were found in gender, side

affected, or developmental stage of the unerupted MnP2, except for chronological age, which was 1.2 years older in the agenesis group.

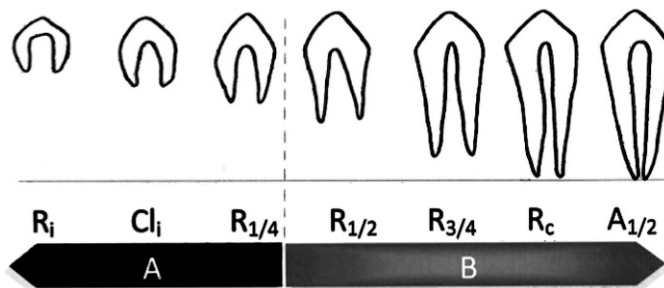
Statistical differences in angular values between groups are also presented in Table 1. The distal angulation of MnP2 was significantly greater in children with agenesis. The results indicate a  $9.5^\circ$  decrease in the distal angle and a  $13.2^\circ$  increase in the premolar-molar angle in the agenesis group. This is a highly statistically significant difference ( $P < .001$  and  $P < .0001$ , respectively), compared with the MnP2 inclinations in the control sample. A significantly greater majority of no intersection on the first molar was found in the control sample compared with the agenesis group. Thus, the first hypothesis, that the distal angulation of the MnP2 is not significantly greater in children with unilateral agenesis, is rejected.

The delay in dental age was 0.5 years greater in the agenesis group ( $-2.1$  years) compared with the control sample ( $-1.5$  years) ( $P < .001$ ). Thus, the second hypothesis, that delayed tooth formation is not significantly more frequent in children with unilateral agenesis compared to a non-agenetic group, is also rejected.

Table 2 shows the intragroup analysis in which we evaluated the variables influencing the inclination of MnP2 in each group. The variables analyzed were gender and developmental stage. In the agenesis sample, girls showed greater distally positioned MnP2 than boys, but in the control group, boys presented more distally displaced premolar buds. When the developmental stage was evaluated, results showed that teeth became more upright during developmental changes in both groups.

**DISCUSSION**

This study was designed to test the hypothesis that angular malposition of a developing MnP2 was not related to agenesis of its antimere. The data point to a significant relationship between these two conditions, thus contributing to the definition of the genetic basis for developing this feature.



**Figure 2.** Developmental stages of unerupted MnP2. Subclassification into type A or B.

**Table 1.** Intergroup Analysis: Homogeneity of Samples and Differences in Angular and Age Values Between Groups<sup>a</sup>

Variable	Experimental Group (Mean ± SD)	Control Group (Mean ± SD)	Statistical Test	P
Gender	Boys, 19; girls, 19	Boys, 44; girls, 38	$\chi^2$ test	NS
Side affected	Right, 16; left, 22	Right, 38; left, 44	$\chi^2$ test	NS
Developmental stage	A, 19; B, 19	A, 27; B, 55	$\chi^2$ test	NS
Chronological age (years)	12.5 ± 1.5	11.3 ± 1.3	Student's <i>t</i> -test	***
$\theta$ angle (°)	72.8 ± 20.3	82.3 ± 12.8	Student's <i>t</i> -test	**
$\gamma$ angle (°)	21.7 ± 19.4	8.4 ± 9.9	Student's <i>t</i> -test	***
Intersection on the first molar	Yes, 12; no, 26	Yes, 4; no, 78	$\chi^2$ test	***
Dental age (years)	10.4 ± 0.9	9.8 ± 1.1	Student's <i>t</i> -test	**
Delay in dental age (years)	-2.1 ± 1.0	-1.5 ± 0.9	Student's <i>t</i> -test	**

<sup>a</sup> SD indicates standard deviation; NS, not significant.

\*\* *P* = .01 \*\*\* *P* = .001.

Of all dental anomalies, tooth agenesis has been subject to the most extensive scientific scrutiny.<sup>7</sup> The significance of genetic mechanisms in the origins of dental agenesis is now incontrovertible.<sup>3</sup> A sixfold elevation of the frequency of MnP2 agenesis was found in subjects with palatally displaced canines (PDCs) or maxillary canine-first premolar transposition.<sup>19</sup> Garib et al.<sup>4</sup> evaluated the prevalence of dental anomalies in patients with MnP2 agenesis and concluded that agenesis of other permanent teeth, microdontia, deciduous molar infraocclusion, and certain dental ectopias such as PDCs and distoangulation of MnP2 are all products of the same genetic mechanism that causes second premolar agenesis. PDC and MnP2 malposition have also been proven to be significantly related, suggesting a common genetic etiology, despite taking place on opposite jaws.<sup>15,16</sup>

Agenesis of MnP2 and distally displaced premolars have been previously associated in other studies<sup>4,20</sup> (Figure 3). The study that inspired us, by Shalish et al.,<sup>20</sup> showed an almost 10° mean distal angle increase in the agenetic sample compared with an age- and sex-matched control group. In their study, the mean distal angle in the experimental group was 75.6°, compared with our 72.8° mean angle. In both studies, the control group showed a statistically greater mean distal angle, 85.5° and 82.3° respectively. We improved the work of Shalish and colleagues<sup>20</sup> by analyzing larger samples and examining additional parameters. The results of Garib et al.<sup>4</sup> revealed that 7.9% of patients in a sample of Brazilian patients with

agenesis of one or more second premolars presented distoangulation of MnP2, representing a 40-fold increase in occurrence compared with the general population. Distoangulation in the general population is rare, with a prevalence of 0.2%.<sup>24</sup> Based on previous studies, Garib and colleagues<sup>4</sup> believed this type of association was similar to the classical clinical situation of microdontia of maxillary lateral incisors in patients with unilateral agenesis of this tooth.

Distally displaced premolar has been defined as a specific and transitory developmental tooth anomaly that usually self-corrects when the second premolar erupts in the dental arch.<sup>16,25</sup> It also responds well to orthodontic or surgical intervention.<sup>26</sup> In rare, extreme instances, the distoangular MnP2 has been seen to migrate distally through the bone below the molar roots and become irreversibly impacted.<sup>18,24</sup>

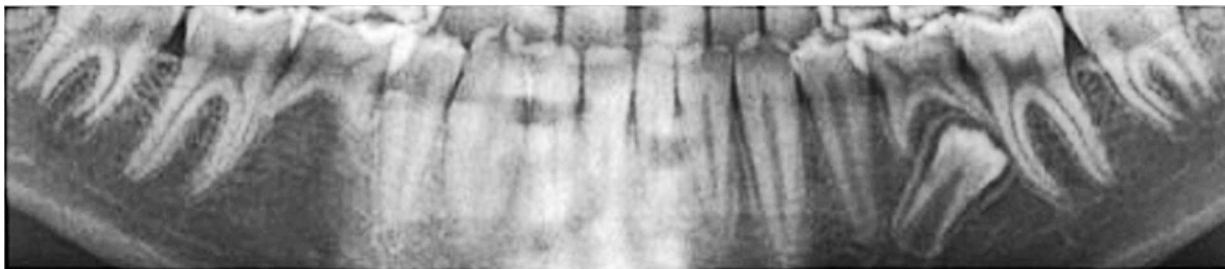
This study was also designed to test the hypothesis that children with aplasia of MnP2 did not show delayed tooth formation compared with a non-agenetic group. The results obtained in our study also appear to reject the hypothesis and corroborate this association.

Delayed tooth formation has been reported in children with cleft palate,<sup>27</sup> PDC,<sup>28,29</sup> and malposition of MnP2.<sup>30</sup> A recent study shows that the development of permanent teeth in children with dental agenesis is delayed compared with a matched control group.<sup>31</sup> Shalish et al.<sup>15</sup> demonstrated a greater average delay in children showing both PDC and MnP2 malposition, compared with children showing PDC but normal inclination of MnP2. Wasserstein et al.<sup>30</sup> proved that

**Table 2.** Intragroup Analysis: Variables Influencing Angular Measurements (Mean ± Standard Deviation)

Gender	Experimental Group		<i>P</i>	Control Group		<i>P</i>
	Boys	Girls		Boys	Girls	
$\theta$ angle (°)	73.9 ± 13.9	71.6 ± 25.4	**	79.7 ± 13.6	85.3 ± 11.2	*
$\gamma$ angle (°)	17.4 ± 15.3	25.9 ± 22.3	*	10.4 ± 11.0	6.1 ± 8.1	*
Developmental stage	A	B		A	B	
$\theta$ angle (°)	66.4 ± 17.4	79.2 ± 21.3	*	77.7 ± 15.2	84.5 ± 10.8	*
$\gamma$ angle (°)	28.3 ± 20.3	15.1 ± 16.3	*	12.3 ± 12.5	6.6 ± 7.9	*

\* *P* = .05 \*\* *P* = .01.



**Figure 3.** Example panoramic film detail with agenesis of MnP2 and distal angulation of its antimere.

in the early developmental stage, more MnP2s are normally distally inclined (56.5%) than mesially (25.0%) inclined. In agreement with our results, Daugaard et al.<sup>21</sup> also proved a considerable delay in tooth formation in dentitions with unilateral agenesis of MnP2.

This study is important for orthodontic treatment planning for children with agenesis, as the age for onset of treatment and the duration of treatment are factors that depend on dental maturity. As Peck<sup>17</sup> previously stated, the ability to apply the DAP concept to clinical orthodontics should provide a feeling of new mastery the next time an 8-year-old with delayed tooth development sits in a consultation chair.

The Haavikko<sup>32</sup> method has been proven as the most accurate for analyzing dental age in patients with agenesis. In our study, it resulted in an underestimation of age, with dental age being almost a year less than the chronological age for most of the subjects analyzed. This is consistent with findings from other studies, several of which reported underestimation of age using the Haavikko method.<sup>32,33</sup>

When the developmental stage in the intragroup analysis was assessed, the results showed that teeth became more upright during developmental changes in both groups. Overall results obtained from previous studies also demonstrated that over time and during developmental changes, teeth become more upright in a statistically significant manner.<sup>30,34</sup> Because no statistically significant differences were found between the readings of boys and girls or between the right and left sides, previous angular measurement studies for each reading were pooled. Our results showed intragroup differences for gender.

Peck<sup>17</sup> made a list of nine conditions that should be included as components of biologically related DAPs. Absent teeth, delayed tooth formation (generalized or localized), and distal angulation of unerupted MnP2 were included on the list. We agree that anomalous dental conditions should no longer be interpreted simply as isolated local phenomena.

In summary, the clinical implications of patterns of associated dental anomalies are important, as early detection of a single dental anomaly (such as

radiographic evidence of second premolar agenesis) may alert professionals to the possible development of other associated anomalies, thus allowing for timely orthodontic intervention.

### CONCLUSIONS

- Both null hypotheses are rejected. The results of this study statistically support the hypothesis that aplasia of MnP2, distally displaced MnP2s, and delayed tooth formation are part of a genetically related pattern of dental anomalies.
- New knowledge of these significant relationships in dental developmental biology should make clinicians feel significantly more empowered in their diagnostic acumen of DAPs.

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