ISSN: 2688-8653

Dental Age Comparison Between Adolescents with Impacted Maxillary Central Incisors and Those Without

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Abstract

Objective: This case-study is to use Willems method of dental age estimation on adolescents of 7-13 years old and compare their dental age between one group with impacted maxillary central incisors and another with normal dental development. Methods: A total of 335 panoramic radiographs of adolescents in the age range of 7-13 years in Wenzhou who met the inclusion criteria were selected, including an impaction group of 135 cases with impacted maxillary central incisors, 74 of which are males and 61 females, and a control group of 200 cases with normal dental development, 100 of which are males and 100 females. Dental age was assessed using Willems method. The differences between the dental age and actual age within and between groups are analysed.Results: The dental age of the impaction group was underestimated by（0.75±0.80） years on average compared to the chronological age, with males underestimated by （0.72±0.83）years and females by（0.78±0.75）years (P<0.001). The control group was underestimated by（0.45±0.76）years on average, with males underestimated by（0.36±0.82）years and females by (0.54±0.68）years (P<0.001). The difference between the dental age and chronological age is more important within the impaction group than the control group (t=3.441, P=0.001).Conclusion：The dental development of adolescents with impacted maxillary central incisors is slower than that of average adolescents.

Keywords

Willems method of dental age estimation; Impacted central incisor; Dental development; Dental age.

1. Introduction

Dental age is a method to determine the biological age of human beings based on tooth morphology. Adolescence being the fastest stage of the growth and development, the biological age determination of adolescence has received more and more attention in the field of clinical medicine, as well as its social significance in sports and forensic science. Among the many dental age assessment methods, Willems method [1] has been widely used thanks to its accuracy and ease of operation, and it is mainly suitable for adolescents who follow normal dental development[2-3].

Studies have shown that children with impacted maxillary canines may differ from average adolescents in their dental development [4-6]; the difference between the inferred dental age and the actual age is quite significant. The impacted central incisor is a common type of impacted teeth in clinical practice, and there are few articles on whether the dental development is consistent with that of average adolescents. This study intends to use Willems method to evaluate the dental age of children with impacted maxillary central incisors and that

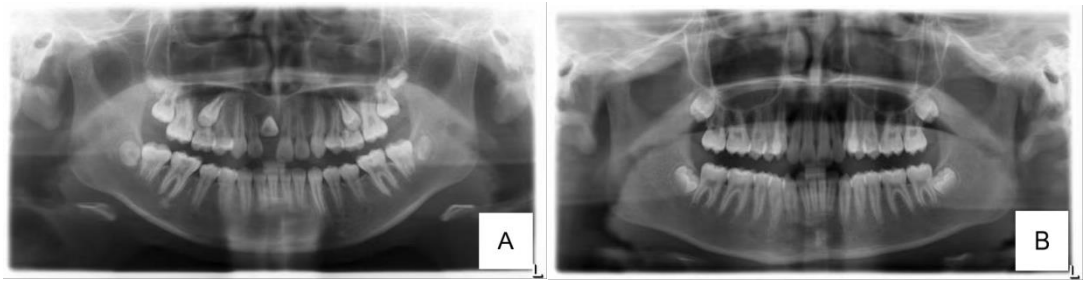
ISSN: 2688-8653

of average adolescents in Wenzhou, and to analyze whether children with impacted maxillary central incisors have abnormal dental development, to further improve the scope of application of Willems method, and at the same time to help grasp the timing of early orthodontic treatment of impacted central incisors.

2. Objects and Methods

2.1. The research subjects

335 dental panoramic radiographs of Han teenagers in the age range of 7-13, who visited the Radiology Department of Stomatological Hospital Affiliated to Wenzhou Medical University from January 2010 to April 2022. The impacted maxillary central incisor group included 135 cases, 61 female and 74 males. The control group of 200 cases were selected according to the sex and age composition ratio of the impaction group, including 100 females and 100 males (see Table 1). The panoramic radiograph(see Figure 1.) was taken by a radiologist with rich experience in dental X-ray, and the equipment used was ORTHOPHS XG5 curved surface tomography X-ray machine (90KV/12mA, Siemens, Germany). Inclusion criteria: (1) teenagers aged 7-13 from Han ethnic group. (2) Individuals whose birth date can be clearly confirmed. (3) Curved dental panorama radiographs are clear and reliable in quality. (4) The difference in the width of the left and right mandibular first molars in the panoramic radiograph was strictly within 20%. (5) The dentition in the panoramic radiograph was relatively neat. The impaction group had impacted maxillary central incisors. The control group had no impacted teeth, no dentition crowding, no loss of permanent teeth, and no barriers to replacement teeth. Exclusion criteria: (1) Diseases affecting the development of the jaw, such as cleft lip and palate, temporomandibular joint ankylosis, jaw tumor, chronic inflammation of the jaw, craniofacial bone deformity syndrome, etc., and other chronic diseases and endocrine diseases. (2) Congenital loss of permanent teeth, severe abnormal dental development, such as enamel hypoplasia, opalescent dentin, etc., severe jaw deformity, orthodontic surgery history.



A: impaction group, female, chronological age: 12.50 **B:** control group, female, chronological age: 12.58

Figure 1: Examples of panoramic radiographs of the impaction group and the control group

ISSN: 2688-8653

Table 1: Comparison of general data between the impaction group and the control group in Wenzhou area

Group	n	Male	Actual Age(years)	7-year-old(years)	8-year-old(years)	9-year-old(years)
Impaction group	135	74(54.8%)	9.26±1.60	7.49±0.28	8.44±0.25	9.41±0.27
Control group	200	100(50%)	9.27±1.60	7.42±0.24	8.39±0.27	9.42±0.30
c2/t		0.749	0.006	-1.245	0.81	0.118
Group	n	10-year-old(years)	11-year-old(years)	12-year-old(years)	13-year-old(years)	
Impaction group	135	10.48±0.29	11.31±0.28	12.47±0.29	13.72±0.21	
Control group	200	10.48±0.30	11.43±0.33	12.57±0.27	13.25±0.28	
c2/t		-0.079	0.955	0.769	-2.525	

P>0.05; data is represented by x±s or %

2.2. Estimation method of dental age and chronological age

The gender, date of birth, and date of radiographing of each research subject is recorded. The chronological age was the difference between the shooting date and the date of birth, and the dental age was measured by Willems method[1]. The seven teeth (except the molar), on the third quadrant in the panoramic view, were divided into 8 stages A-H[7] based on Demirjian method, and then according to the male and female gender-specific assignment table of Willems method, assigned values from 31 to 37 respectively, and the sum of the scores from 31 to 37 was the dental age. In this study, two dentists with rich clinical experience, having undertaken strict training and adopted the same standards, independently read the radiographs, and evaluated the measurement consistency. To begin with, 20 panoramic radiographs of dental surface were randomly selected, and the two dentists assessed the developmental stage of each tooth according to the staging standard of Demirjian method [7]. Then in two weeks' time, and the same radiographs were assessed again. After passing the consistency test, one dentist calculated the dental age of all the panoramic radiographs while shielding the personal information (gender, actual age) of the participants, and the other dentist selected randomly 30 pictures for reading. The results of 30 panoramic radiographs obtained by the two observers were tested for inter-group consistency. If the reliability was greater than 0.75, the reliability would be considered good. If the reliability was lower than 0.75, all previous panoramic radiographs would have to be re-examined.

2.3. Statistical methods

SPSS 23.0 software package was used to analyze the data. The inter-observer consistency test was analyzed using Kappa coefficient. Kappa coefficient was >0.81, indicating high consistency. In this study, the actual age of the two groups of samples followed normal distribution. The mean, standard deviation, and mean absolute error (MAE) were used for descriptive statistics, and the correlation analysis between dental age and actual age was carried out by Pearson correlation analysis. The prior correlation coefficient within the group (<0.4) was considered poor repeatability, and >0.75 was considered better repeatability. The independent sample t-test was used for the group comparison analysis, Analysis of Variance (ANOVA) was used for the comparison of each age group between the two groups, and the LSD-t test was used for multiple comparison. The enumeration data were expressed in %, and the $\chi 2$ test was used for group comparison. P<0.05 meant the difference was statistically significant.

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3. Results

3.1. Consistency test results

The reading results of 20 random dental panoramic radiographs confirmed that the internal consistency Kappa value of the readers was 0.921, and the inter-rater consistency Kappa value was 0.843. The reading results of 30 random dental panoramic radiographs confirmed that the Kappa value was 0.857. These results showed that Willems method had good repeatability, data reliability and high stability.

3.2. The basic situation of the samples and the results of dental age estimation by Willems method.

The Pearson correlation analysis test showed a significant correlation between the dental age and the chronological age of the two groups. The control group: r=0.91 (P<0.001); the impaction group: r =0.89 (P<0.001). The dental age estimated using Willems method in both groups were underestimated (P<0.001), and the difference was statistically significant, as shown in Table 2. The MAE in the normal group was 0.58 years old. 48% of the male group had an error range within ±0.5 years old, and 56% of the female group had an error range within ±0.5 years old. The MAE of the impaction group was 0.56 years old, with 45.9% of the male group having an error range within ±0.5 years. The overall MAE of the female group was 0.49 years old, 57.4% of which having an error range within ±0.5 years.

Table 2: Comparison of chronological age and dental age between the impaction group and the control group

Group	Gender	n	Actual age	Dental age	Deltaa	t	MAE
Impaction group	Male	74	9.39±1.61	8.67±1.71	0.72±0.83	7.428**	0.61
	Female	61	9.11±1.59	8.33±1.78	0.78±0.75	8.096**	0.49
	Total	135	9.26±1.60	8.52±1.74	0.75±0.79	10.913**	0.56
Control group	Male	100	9.40±1.62	9.04±1.88	0.36±0.82	4.39**	0.61
	Femal	100	9.13±1.57	8.59±1.75	0.54±0.68	7.859**	0.54
	Total	200	9.27±1.60	8.82±1.83	0.45±0.76	8.363**	0.58

Note: [a]is the difference between the dental age and actual age. **P<0.01.

3.3. 3.3. Comparison of the impaction group and the control group

The independent sample t test of the difference between the impaction group and the control group showed a statistically significant gap between the dental age and the actual age, and the average difference between the impaction group and the control group was (0.30±0.09) years. For the statistical results, see table 3. After grouping by age, statistics showed that the main effect of the impacted central incisor (F=12.361, P<0.001) and the main effect of age grouping (F=2.333, P<0.05) were significantly different, and the interaction effect between the two was not significant (F=1.677, P>0.05). Further multiple mean comparison LSD-t test for age groups showed that there were statistical differences between the 10-year-old group & 7-year-old group, 11-year-old group, and 12-year-old group, and there were no significant statistical differences among the other groups, see Figure 2.

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Table 3: Mean differences between chronological age and dental age between the impaction group and the control group

	Variance (Dental age vs. Actual age)(`x±s)		
	Male	Female	Total
Impaction group	-0.72±0.83	-0.78±0.75	-0.75±0.79
Control group	-0.36±0.82	-0.54±0.68	-0.45±0.76
t	2.807**	2.112*	3.441**

**P<0.01; *P<0.05

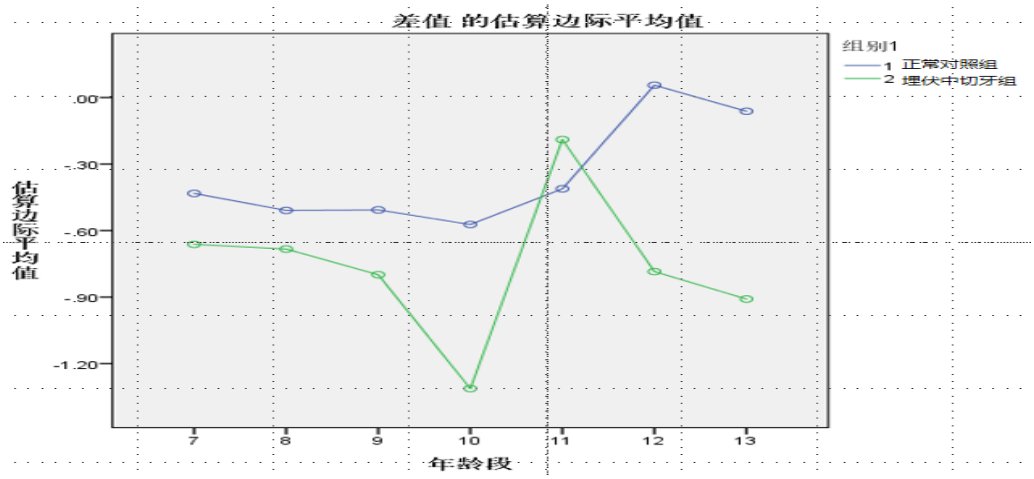

Figure2: Comparison chart of the difference between dental age and actual age in each age group

4. Discussion

4.1. Willems method

Willems method [1] is for estimating the dental age according to the degree of tooth calcification; a method based on the Demirjian method [7] (1973), modified and improved by Willems.G, taking into account the growth and development characteristics of children in the 21st century. This method has been applied and practiced by scholars at home and abroad. Different scholars have found that the applicable population is slightly different in the process of applying the method [2-3]. Different races and different regions may have different results when applying this method. Chinese scholar Meng Shan et al. [12] studied the applicability and accuracy of Demirjian, Willems, and Haavikko methods for estimating the age of children in Nanjing and found Willems method the most accurate. Shi Lei et al. [13] also used Willems method to assess the average difference between the dental age and the actual age of adolescents in Shanghai and found that the mean difference was the smallest and the average absolute error was also the smallest. From the results of our case-study, Willems method has proved good operability and repeatability in the test. The average absolute error of the control group is 0.58, indicating that the Willems method has high accuracy in estimating the dental age of adolescents in Wenzhou area.

In addition to regions and races, the difference between the dental age obtained by different scholars using Willems method and the actual age is also variable. In this study, Willems method was used to infer the dental age of adolescents aged 7-13 in Wenzhou area. The overall results showed underestimation. The average underestimation of the control group was (0.45±0.76)

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years, and the average underestimation of the impaction group was (-0.75±0.80) years. Wang Miaochen et al. [14] used Willems method to infer the dental age of adolescents aged 8-15 in Shanghai, with an average underestimation of 0.75 years for males and 1.05 years for females, which is similar to the results of this study. When Ye Xiuxia et al[15] used Willems method to study the dental age of adolescents aged 7-14 in Shanghai, the results showed an overall overestimation of 0.16 years, with boys overestimated by 0.36 years and girls underestimated by 0.02 years. These variations may be caused by the selection of sample age, sample size, or sample errors (such as sample distribution, race, researcher training, quality of tomographic panoramas, etc.) [16]. In this study, there were variations among the 10-year-old group & the 7-year-old group, the 11-year-old group, and the 12-year-old group. Due to the characteristics of adolescents with impacted central incisors, more than 72% of the samples in the impaction group were 7-9 years old, so the sample size of the 10-year-old, 11-year-old, 12-year-old, and 13-year-old in the impaction group and the proportionally selected control group is too small, which may not fully reflect the differences in these age groups.

4.2. The importance of biological age inference

In recent years, human biological age inference has played an important role in the fields of dentistry, pediatrics, forensic anthropology, and even archaeology. For example, the confirmation of the age of the suspect or the victim directly affects the court judgment, the confirmation of the actual age of the athlete is helpful to promote the fair competition of sports [8], the confirmation of the biological age of children is conducive to the early diagnosis of clinical treatment, and the formulation of appropriate treatment options [9]. In our study, early diagnosis and early treatment of impacted maxillary central incisors are more likely to obtain better clinical results. Studies have shown that early orthodontic treatment of impacted maxillary central incisors can promote root development and obtain better root morphology, reducing the risk of labial alveolar bone resorption [21]. Dental age has become an important element in the estimation of biological age [10-11]. The dental development can be used as an indicator to evaluate the age of an adolescent, mainly due to below reasons: the dental development is slow, and it runs through the entire growing period of an adolescent; the enamel is the hardest tissue in the human body, resistant to many physical and chemical factors, and its development is mainly decided by genes. With the development of radiographic technology, the age can be inferred by observing the dental development patterns through imaging technology. This method also has two advantages: high accuracy and non-invasiveness.

4.3. Impacted maxillary central incisor group

The average age of maxillary central incisor eruption is from 6 to 9 years old [17], so most children with embedded central incisors see a doctor after the age of 7. The research subjects in this study are adolescents aged 7-13, which are in line with the applicable age of Willems method.

Impacted permanent teeth are a common pathology in adolescents in the dental transitional period. It is still unclear whether the affected children are accompanied by other abnormal dental development. Newcomb (1959) first proposed that children with impacted canines often showed delayed dental development. In recent years, Adrian Becker et al. [18] studied children with impacted canines and found that patients with impacted canines on the palatal side had slow dental development. Mai Lin Lovgren et al. [19] found that the dental age of 12 to 13-year-old female patients and patients with palatal impacted canines was significantly lower than that of the control group, and the difference was remarkable but still small. Impacted maxillary central incisors are also a common type of impacted teeth in clinical practice, with an incidence rate of 0.06%-0.2% in my country [17]. However, there are few studies on the permanent teeth development in children with impacted maxillary central incisors. From the results of this study, the overall dental age of the impaction group was lower than that of the control group, and both

ISSN: 2688-8653

female and male groups were underestimated. The dental development of the impaction group was delayed on average by (0.30±0.09) years, and the difference was statistically significant.

Patients with impacted maxillary central incisors were slower than the average population in both early and late stages of permanent dental development, and their developmental delay may be related to potential developmental abnormalities. Studies have shown that [20], the tooth germ comes from the neural crest cell migration. If the migration of neural crest cells is disturbed in the early embryo, it can directly affect the formation, differentiation, and development of the dental plate, resulting in abnormal dental development. Secondly, environmental factors may also contribute to delayed dental development, among which, the musculoskeletal system abnormalities can be caused by extra teeth, odontomas, deciduous teeth trauma, or occlusal disorders. The specific associated risk factors require further research.

5. Conclusion

In summary, Willems method has proven good repeatability, and has provided reliable data and high stability in the study of adolescent dental age in Wenzhou area. It has proven to be a suitable method for adolescent dental age estimation in the area. The dental development of children with impacted maxillary central incisors is slower than that of the normal population. Therefore, when Willems method is used in clinical treatment, justice, sports, etc., on children with impacted maxillary central incisors, the assessment of the dental age should be adjusted accordingly to improve the accuracy.

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