Original Article

Relationships Between Dental and Skeletal Maturity in Turkish Subjects

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Abstract: The aim of this study was to investigate the relationships between the stages of calcification of various teeth and skeletal maturity stages among Turkish subjects. The samples were derived from dental panoramic and hand-wrist radiographs of 500 subjects (215 males and 285 females). Calcification of the mandibular canines, first and second premolars, and second and third molars was rated according to the system of Demirjian. To evaluate the stage of skeletal maturation of each hand-wrist radiograph, nine ossification events were determined according to the systems of Björk, and Grave and Brown. Statistically significant relationships were determined between dental calcification and skeletal maturity stages according to Spearman rank-order correlation coefficients. Correlations between dental development and skeletal maturity ranged from .490 to 0.826 for females and .414 to .706 for males ($P < .01$). The second molar showed the highest correlation and the third molar showed the lowest correlation for female and male subjects. For both sexes, root formation of the canine as well as the first premolar was completed in the majority of the subjects at the $MP3_{cap}$, $PP1_{cap}$, R_{cap} stages. Because of the high correlation coefficients, this study suggests that tooth calcification stages from panoramic radiographs might be clinically useful as a maturity indicator of the pubertal growth period. It is appropriate to put these skeletal and dental maturation relationships into daily orthodontic diagnostic practice, when treating a Turkish patient. (*Angle Orthod* 2004;74:657–664.)

INTRODUCTION

The degree of skeletal development is a reflection of the degree of physiological maturation of a subject.[1,2] Bone age was shown to be as important as chronological age in evaluating an adolescent‘s physical development.[3] In addition, the determination of skeletal age indicates how much further growth a child will attain and allows the prediction of final height.[1] Also, the assessment of skeletal maturity is an important method in the evaluation, follow up, and timing of therapy in children with growth disorders, such as constitutional growth retardation and growth hormone deficiency, as well as endocrinological diseases, such as hypothyroidism, congenital adrenal hyperplasia, and precocious puberty.[4–6]

Certain skeletal developmental stages of the hand and wrist have been shown to be closely associated with the pubertal growth spurt,[7–10] and hand radiographs have been used as an indirect method for the assessment of somatic maturity stage. However, the routine use of hand radiographs has lately been questioned from the radiation-hygiene, safety point of view.[7]

Dental maturity can be determined by the stage of tooth eruption or by the stage of tooth formation.[11–26] Tooth formation is proposed as a more reliable criterion for determining dental maturation.[12,13] The ease of recognition of dental development stages, together with the availability of periapical or panoramic radiographs in most orthodontic or pediatric dental practices are practical reasons for attempting to assess the physiologic maturity without resorting to hand-wrist radiographs.[14]

In the literature, little is known about the relationship between the onset of puberty and dental maturation.[11] Some studies have shown that correlations between tooth mineralization and other parameters of physical development are generally low,[15,16] whereas there is little more than slight covariation between tooth eruption and the adolescent growth spurt.[17] Interestingly, the correlation between calcification stages of individual teeth and skeletal maturity has also been reported previously.[18–20] Garn et al[21] showed only weak correlations between third molar and skeletal development; Engström et al[22] reported stronger relation-

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TABLE 1. Tooth calcification in Eight Stages of Calcification, A to H, According to the Method Described by Demirjian et al[27]

Stage A: Calcification of single occlusal points without fusion of different calcifications.
Stage B: Fusion of mineralization points; the contour of the occlusal surface is recognizable.
Stage C: Enamel formation has been completed at the occlusal surface, and dentine formation has commenced. The pulp chamber is curved, and no pulp horns are visible.
Stage D: Crown formation has been completed to the level of the amelocemental junction. Root formation has commenced. The pulp horns are beginning to differentiate, but the walls of the pulp chamber remain curved.
Stage E: The root length remains shorter than the crown height. The walls of the pulp chamber are straight, and the pulp horns have become more differentiated than in the previous stage. In molars, the radicular bifurcation has commenced to calcify.
Stage F: The walls of the pulp chamber now form an isosceles triangle, and the root length is equal to or greater than the crown height. In molars, the bifurcation has developed sufficiently to give the roots a distinct form.
Stage G: The walls of the root canal are now parallel, but the apical end is partially open. In molars, only the distal root is rated.
Stage H: The root apex is completely closed (distal root in molars). The periodontal membrane surrounding the root and apex is uniform in width throughout.

TABLE 2. Skeletal Maturation of each Hand-wrist Radiograph According to the Method Described by Björk[28] and Grave and Brown[29]

Stage 1 (PP2): The epiphysis of the proximal phalanx of the index finger (PP2) has the same width as the diaphysis.
Stage 2 (MP3): Epiphysis of the middle phalanx of the middle finger (MP3) is of the same width as the diaphysis.
Stage 3 (Pisi-H1-R): Pisi, visible ossification of the pisiform. H1, ossification of the hamular process of the hamatum. R, same width of epiphysis and diaphysis of the radius.
Stage 4 (S-H2): S, first mineralization of the ulnar sesamoid bone of the metacarpophalageal joint of the hamatum. H2, progressive ossification of the hamular process of the hamatum.
Stage 5 ($MP3_{cap}$-$PP1_{cap}$-R_{cap}): During this stage, the diaphysis is covered by the cap-shaped epiphysis. In the $MP3_{cap}$ the process begins at the middle phalanx of the third finger, in the $PP1_{cap}$ at the proximal phalanx of the thumb, and in the R_{cap} at the radius.
Stage 6 ($DP3_u$): Visible union of epiphysis and diaphysis at the distal phalanx of the middle finger (DP3).
Stage 7 ($PP3_u$): Visible union of epiphysis and diaphysis at the proximal phalanx of the little finger (PP3).
Stage 8 ($MP3_u$): Union of epiphysis and diaphysis at the middle phalanx of the middle finger is clearly visible (MP3).
Stage 9 (R_u): Complete union of epiphysis and diaphysis of the radius.

ships. Relationships between the stages of tooth mineralization of the mandibular canine appear to correlate better with ossification stages than do the other teeth.[23–25]

Racial variations in the relationship have also been suggested.[11,24] Mappes et al[26] indicated that the predominant ethnic origin of the population, climate, nutrition, socioeconomic levels, and urbanization are causative factors of these racial variations.

At the start of this study, we thought that Turkish children may have a rhythm of skeletal and dental maturation during pubertal development that is different from that of children from other countries from whom the standards were derived. Therefore, the aim of this study was to investigate the relationships between the stages of calcification of various teeth and the stages of skeletal maturity among Turkish subjects.

MATERIALS AND METHODS

This descriptive study was designed as a cross-sectional research project. The samples were derived from dental panoramic and hand-wrist radiographs of 500 subjects (215 male and 285 female) registered as patients at the Faculty of Dentistry, Department of Orthodontics, Selcuk University. The present sample ranged in age from seven to 20 years with a mean age of 12.01 ± 3.03 years (11.11 ± 2.10 years for males and 13.06 ± 3.03 years for females).

The selection criteria were subjects who (1) were all Turkish; (2) were well nourished and free of any known serious illness; (3) had normal growth and development and dental conditions, for example, no impaction, congenitally missed, or transposition of teeth; (4) had no previous history of trauma or injury to the face and the hand and wrist region; and (5) had not had extraction of any permanent teeth.

All assessments were performed in a darkened room with a radiographic illuminator to ensure contrast enhancement of the bone and tooth images. Tooth calcification was rated according to the method described by Demirjian et al[27] in which one of eight stages of calcification, A to H, was assigned for each tooth (Table 1). Skeletal maturation of each hand-wrist radiograph was determined according to the method described by Björk[28] and Grave and Brown[29] (Table 2).

The conventional roentgenograms of left hands and wrists were taken, and skeletal ages were rated by two orthodontists separately without any knowledge about the children's chronological ages. The average of the two results was accepted as the bone ages of children.

Statistical method

All statistical analyses were performed using the SPSS software package (SPSS for Windows 98, version 10.0, SPSS Inc, Chicago, Ill). Descriptive statistics were obtained by calculating the means and standard deviations of the

TABLE 3. Distribution of Chronological Ages for all Subjects Grouped by Skeletal Maturity Indicators

Maturation Stage	Sex	Number of Subjects	Chronological Age Mean ± SD (y)
PP2	Male	50	11.03 ± 2.12
	Female	44	08.11 ± 2.01
MP3	Male	39	12.01 ± 2.08
	Female	36	09.06 ± 1.04
Pisi-H1-R	Male	40	13.00 ± 2.09
	Female	36	10.05 ± 1.02
S-H2	Male	17	13.05 ± 2.03
	Female	23	11.01 ± 2.10
$MP3_{cap}$-$PP1_{cap}$-R_{cap}	Male	20	13.11 ± 3.01
	Female	44	12.03 ± 1.00
$DP3_u$	Male	10	15.01 ± 1.04
	Female	13	13.02 ± 1.01
$PP3_u$	Male	10	15.02 ± 1.03
	Female	13	13.10 ± 1.06
$MP3_u$	Male	12	15.05 ± 2.05
	Female	22	13.07 ± 0.10
R_u	Male	17	16.10 ± 2.08
	Female	54	17.02 ± 3.03
Total		500	12.01 ± 3.03

chronological ages for the nine stages of skeletal maturity indicators. To study the relationship between the stage of mineralization of the teeth and the stage of skeletal maturation, the percentage distribution of the stages of calcification for each tooth was calculated. The Spearman rank-order correlation coefficients were estimated to measure the association between skeletal maturational indicators and dental calcification stages of individual teeth, and the statistical significance of the correlation was tested. To evaluate the reproducibility of the interpretation, the first and second skeletal and dental maturity assessments were tested using a Spearman Brown formula.

To test the reproducibility of the assessments of skeletal maturity and dental development stage, the same two investigators reevaluated randomly selected hand-wrist and panoramic radiographs from 15 of the same male and female subjects eight weeks after the first evaluation. The differences between double interpretations were statistically tested.

RESULTS

The distribution of chronological ages for all the subjects, grouped by skeletal maturity indicators, is shown in Table 3. The appearance of each stage is consistently earlier in female subjects than in the male subjects, except for the Ru stage.

The reproducibility of all the assessments was found to be good, with high coefficient values. The coefficients of reliability were found to be between .985 and .997 for the dental calcification stage assessments and between .990 and 1.000 for the skeletal maturity assessments.

TABLE 4. Correlation Coefficients between Skeletal and Dental Maturity Stages of Subjects

Tooth	Correlation Coefficients			
	Female Subjects		Male Subjects	
	r	Significance	*r*	Significance
Canine	.691	**	.633	**
First premolar	.797	**	.634	**
Second premolar	.804	**	.659	**
Second molar	.826	**	.706	**
Third molar	.490	**	.414	**

** $P < 0.01$.

Spearman rank-order correlation coefficients between the skeletal maturity stages of hand-wrist radiographs and the developmental stages of the five individual teeth are shown in Table 4. All the correlations between skeletal and dental stages were statistically significant at the $P < .01$ significance level. The correlations ranged from .490 to .826 for females and from .414 to .706 for males. In Turkish female subjects, the tooth sequence in order of the lowest to the highest correlation was third molar, canine, first premolar, second premolar, and second molar. The corresponding sequence in male subjects was third molar, canine, first premolar, second premolar, and second molar. The second molar showed the highest correlation, as indicated by an *r* value of .826 and .706 ($P < .01$) for female and male subjects, respectively. The third molar showed the lowest correlation for both sexes ($r = .490$ for female subjects, and $r = .414$ for male subjects).

The percentage distributions of the stages of calcification for each of the studied teeth except the third molars are shown in Table 5. Sex differences in the pattern of mineralization of the various teeth were noted.

The percentage distribution of the stages of calcification for each of the teeth studied and the stages of skeletal maturity was calculated. These findings are shown in Tables 6 through 14. Because of their poor correlation with skeletal maturity, data on the third molars were excluded from these tables. In female subjects, the second molar stage D showed the highest percent distribution (100%) at stage 1 (PP2) (Table 6). For both male and female subjects, the canine stage F (88% for males, and 84% for females) and for female subjects the first premolar stage E (82%) also presented the highest distribution. All the remaining teeth had a scattered distribution.

At stage 2 (MP3) (Table 7), wide distribution of tooth calcification stages was seen in all the teeth for male and female subjects, with less than 60% in each stage. For male subjects, the second premolar stage F demonstrated the highest distribution (59%). In female subjects, no tooth calcification stages in any teeth studied had a distribution greater than 50%.

Wide distribution of tooth calcification stages was seen clearly in all the teeth for both male and female subjects,

TABLE 5. Percent Distribution (%) of the Stages of Calcification for each of the Studied Teeth Except the Third Molars

Calcification Stage	Canine				First Premolar				Second Premolar				Second Molar			
	Female		Male		Female		Male		Female		Male		Female		Male	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
D	56	19.6	0	0	35	12.3	6	2.8	8	2.8	27	12.6	1	0.4	41	19.1
E	47	16.5	10	4.7	47	16.5	34	15.8	57	20.0	34	15.8	7	2.5	42	19.5
F	46	16.1	64	29.8	43	15.1	63	29.3	43	15.1	53	24.7	70	24.6	36	16.7
G	71	24.9	57	26.5	57	20.0	39	18.1	39	13.7	34	15.8	50	17.5	60	27.9
H	65	22.8	84	39.1	103	36.1	73	34.0	138	48.4	67	31.2	157	55.0	36	16.8
Total	285	100	215	100	285	100	215	100	285	100	215	100	285	100	215	100

TABLE 6. Percent Distribution of Calcification Stages of Individual Teeth at Stage 1 (PP2)

Calcification Stage	Stage 1 (PP2)							
	Canine		First Premolar		Second Premolar		Second Molar	
	Female (%)	Male (%)	Female (%)	Male (%)	Female (%)	Male (%)	Female (%)	Male (%)
D	0	0	18	8	80	35	100	55
E	16	12	82	46	20	49	0	45
F	84	88	0	46	0	16	0	0

TABLE 7. Percent Distribution of Calcification Stages of Individual Teeth at Stage 2 (MP3)

Calcification Stage	Stage 2 (MP3)							
	Canine		First Premolar		Second Premolar		Second Molar	
	Female (%)	Male (%)	Female (%)	Male (%)	Female (%)	Male (%)	Female (%)	Male (%)
D	0	0	3	0	28	13	48	15
E	5	0	42	18	25	18	36	44
F	47	46	36	54	39	59	11	41
G	32	54	11	28	3	10	5	0
H	16	0	8	0	6	0	0	0

TABLE 8. Percent Distribution of Calcification Stages of Individual Teeth at Stage 3 (Pisi-H1-R)

Calcification Stage	Stage 3 (Pisi-H1-R)							
	Canine		First Premolar		Second Premolar		Second Molar	
	Female (%)	Male (%)	Female (%)	Male (%)	Female (%)	Male (%)	Female (%)	Male (%)
D	0	0	3	0	8	0	22	0
E	0	0	25	3	25	3	28	23
F	36	10	31	32	37	40	33	25
G	36	43	28	32	22	30	17	48
H	28	47	14	33	8	27	0	5

at stage 3 (Pisi-H1-R) (Table 8). In male subjects, the canine stages H and G, the second premolar stage F, and the second molar stage G demonstrated marked distinction of the percent distribution (47, 43, 40, and 48%, respectively).

At stage 4 (S-H2) (Table 9), in male subjects, the canine stage H showed the highest percent distribution (66%), whereas all the remaining teeth had a scattered distribution. Most of the studied teeth were dispersed among the F, G, and H calcification stages at this stage.

For both sexes, root formation of the canine as well as the first premolar was completed in the majority of the subjects (71–80%) at stage 5 ($MP3_{cap}$, $PP1_{cap}$, R_{cap}) (Table 10). The development of the second molar became highly dense in stage G for males and females, and the development of the second premolar became highly dense in stage H for males.

At stage 6 ($DP3_u$) (Table 11), calcification stages D and E were not seen among Turkish subjects. Root formation of the canine as well as the first premolar was completed in the majority of the subjects (75–100%). The second premolar development was highly concentrated in stage H for males (75%).

TABLE 9. Percent Distribution of Calcification Stages of Individual Teeth at Stage 4 (S-H2)

Calcification Stage	Stage 4 (S-H2)							
	Canine		First Premolar		Second Premolar		Second Molar	
	Female (%)	Male (%)	Female (%)	Male (%)	Female (%)	Male (%)	Female (%)	Male (%)
D	0	0	0	0	4	0	9	0
E	0	0	13	5	26	0	30	0
F	26	5	30	18	17	18	35	24
G	35	29	43	24	48	41	26	53
H	39	66	13	53	4	41	0	23

TABLE 10. Percent Distribution of Calcification Stages of Individual Teeth at Stage 5 ($MP3_{cap}$-$PP1_{cap}$-R_{cap})

Calcification Stage	Stage 5 ($MP3_{cap}$-$PP1_{cap}$ R_{cap})							
	Canine		First Premolar		Second Premolar		Second Molar	
	Female (%)	Male (%)	Female (%)	Male (%)	Female (%)	Male (%)	Female (%)	Male (%)
D	0	0	0	0	0	0	3	0
E	0	0	2	0	7	0	7	0
F	5	0	7	5	16	5	23	5
G	16	20	20	15	43	30	59	60
H	79	80	71	80	34	65	8	35

TABLE 11. Percent Distribution of Calcification Stages of Individual Teeth at Stage 6 ($DP3_u$)

Calcification Stage	Stage 6 ($DP3_u$)							
	Canine		First Premolar		Second Premolar		Second Molar	
	Female (%)	Male (%)	Female (%)	Male (%)	Female (%)	Male (%)	Female (%)	Male (%)
F	0	0	0	0	8	0	15	0
G	8	0	23	10	46	25	31	50
H	92	100	77	90	46	75	54	50

TABLE 12. Percent Distribution of Calcification Stages of Individual Teeth at Stage 7 ($PP3_u$)

Calcification Stage	Stage 7 ($PP3_u$)							
	Canine		First Premolar		Second Premolar		Second Molar	
	Female (%)	Male (%)	Female (%)	Male (%)	Female (%)	Male (%)	Female (%)	Male (%)
G	8	0	8	0	23	20	56	50
H	92	100	92	100	77	80	44	50

TABLE 13. Percent Distribution of Calcification Stages of Individual Teeth at Stage 8 ($MP3_u$)

Calcification Stage	Stage 8 ($MP3_u$)							
	Canine		First Premolar		Second Premolar		Second Molar	
	Female (%)	Male (%)	Female (%)	Male (%)	Female (%)	Male (%)	Female (%)	Male (%)
G	4	0	5	0	13	0	46	50
H	96	100	95	100	87	100	54	50

Calcification stages D, E, and F were not seen at stage 7 ($PP3_u$) (Table 12). For males, root formation of the canine and the first premolar was completed in all the subjects. Most of the canine and first and second premolar teeth were in stage H (92, 92, and 77%, respectively) in female subjects. The development of the second molar was approximately equally distributed between stages G and H.

Similar to stage 7, calcification stages D, E, and F were not seen in stage 8 ($MP3_u$) (Table 13). Additionally, root formation of the canine and the first and second premolar

TABLE 14. Percent Distribution of Calcification Stages of Individual Teeth at Stage 9 (R_u)

Calcification Stage	Stage 9 (R_u)							
	Canine		First Premolar		Second Premolar		Second Molar	
	Female (%)	Male (%)	Female (%)	Male (%)	Female (%)	Male (%)	Female (%)	Male (%)
G	0	0	0	0	6	0	15	0
H	100	100	100	100	96	100	85	100

teeth was completed in all male subjects. The development of the canine and the first and second premolar teeth was highly concentrated in stage H for females (87–95%).

All the studied teeth in male subjects and the canine and the first premolars in female subjects had completed root formation at stage 9 (R_u) (Table 14). In female subjects, 6% of the second premolars and 15% of the second molars showed stage-G calcification.

DISCUSSION

Conventional prediction schemes of maturation indicators would overestimate the developmental stage of the child and, consequently, underestimate the growth potential.[30] Conversely, comparisons of a child's status against published standards from other countries[31,32] may overestimate a patient's degree of developmental delay[33,34] or the precocity.[35,36] Racial variations in the relationships between the calcification stages of individual teeth and skeletal maturity have been reported previously. Therefore, this study was carried out to investigate the relationship between the stages of calcification of various teeth and skeletal maturity stages among Turkish individuals.

It has long been contended that dental eruption, which is the most conspicuous and easily determined indicator of dental maturation, is much more variable in its timing than skeletal maturation.[13,37] According to Nolla,[13] dental eruption has also been reported to be more variable than the calcification sequence in the dentition. Dental eruption is a fleeting event that is under greater environmental influence.[27] In the present study, calcification stages of teeth instead of eruption were preferred because tooth formation is proposed as a more reliable criterion for determining dental maturation.[12,13] Therefore, the dental maturity assessment stages of Demirjian et al[38] were used. This method's criterion consists of distinct details based on shape criteria and proportion of root length, using the relative value to crown height, rather than on absolute length. Therefore, foreshortened or elongated projections of developing teeth will not affect the reliability of assessment.[11]

Krailassiri et al[11] and Coutinho et al[14] reported that the associations between the tooth calcification stages and the skeletal maturity indicators probably allow the clinician to more easily identify the stages of the pubertal growth period from the panoramic radiograph. From this study, ease of recognition of the stage of development of the tooth, together with the free availability of intraoral or panoramic radiographs in an orthodontic or pedodontic practice, would make the assessment of onset of puberty possible in children of Turkish origin without resorting to the use of hand-wrist radiographs or serial recordings of annual increases in stature.

Many studies have attempted to determine whether there is a relationship between the level of skeletal maturity and the maturation of the permanent dentition. Demisch and Wartmann[18] report a high correlation between dental and skeletal ages, Chertkow,[24] Coutinho et al,[14] Krailassiri et al,[11] and Engström et al[22] report similar high correlations. On the other hand, Lewis and Garn,[16] Garn et al,[21] and Tanner[39] have reported low or insignificant correlations between the level of skeletal and dental maturation. The lack of concordance among the results of previous studies may be attributed, at least in part, to the different methods used for assessing skeletal and dental maturity. Because the same methods were used, we compared most of our results with the findings of Krailassiri et al[11]. Statistically significant correlations were found between dental calcification stages and skeletal maturity indicators in Turkish subjects, similar to Thai individuals.[11]

The mean chronological age for each skeletal maturity level shown in Table 3 indicated that the appearance of each skeletal stage is consistently earlier in the females than in the males except the R_u stage, and this finding was in accordance with the information published in several studies.[8,11,29] Tooth mineralization relative to stages of skeletal maturation is considered separately for male and female subjects. The findings of Krailassiri et al[11] indicated that maturation patterns of tooth development in male subjects tend to be more advanced as compared with female subjects in relation to skeletal maturity stages. Chertkow[24] reported that a markedly more advanced trend in tooth calcification was evident among the boys in both black and white racial groups. In this study, it was determined that at the same skeletal maturity stage, males had a more advanced trend in tooth calcification, and the opposite pattern was present in females. These findings confirm previous reports.[11,24]

Correlation coefficients between skeletal and dental maturity stages of subjects are shown in Table 4. These correlation coefficients indicate that the second molars show the highest relationship and the third molars show the lowest correlation for both sexes among Turkish subjects. However, in male and female Thai individuals, the second premolar teeth showed the highest correlation coefficients between skeletal and dental development stages.[11] Similar to the present findings, the third molars showed the lowest correlation in Thai individuals.

The relationship between skeletal maturity and peak adolescent height velocity (PHV) is well established.[8,29,38] Björk[8] found that $MP3_{cap}$ stage was very closely related to the age of pubertal maximum growth velocity. Studies reporting low correlations between dental age and the pubertal growth spurt have found the maturity of the canines to be more closely related to PHV than to the other teeth.[17,22] The relationship between calcification of the canine and skeletal maturity indicators was quite high, .691 for females and .633 for males, in our study. The findings of Chertkow and Fatti[23] and Chertkow[24] show a close relationship between mandibular canine calcification stage G and various skeletal indicators of the pubertal growth spurt. These investigators found that the mandibular stage G coincided with the early appearance of the sesamoid bone in 77% of their male and female samples. In this study, no uniformity in canine development was found relative to stage S. Krailassiri et al[11] and So[40] found a low relationship between early ossification of the sesamoid bone and dental calcification stage G, and our findings were in accordance with these findings.

Krailassiri et al[11] suggested that the interpretation of the relationship between the stage of dental and skeletal development of the canine teeth and the late stages of skeletal maturity was not meaningful because they found that a large number of canines and first premolars had already attained apical closure since the $MP3_{cap}$ stage for males and $DP3_u$ stage onward for females. In this study, root formation of the canine as well as the first premolar was completed in the majority of the subjects at stage 5 ($MP3_{cap}$, $PP1_{cap}$, R_{cap}), supporting the suggestions of Krailassiri et al.[11]

CONCLUSIONS

The appearance of each skeletal stage is consistently earlier in the females than in the males, except for the R_u stage. At the same skeletal maturity stage, males had a more advanced trend in tooth calcification. In Turkish subjects, the tooth sequence in order of the lowest to the highest correlation for female subjects was third molar, canine, first premolar, second premolar, and second molar. The corresponding sequence in male subjects was third molar, canine, first premolar, second premolar, and second molar. The second molar showed the highest and the third molar showed the lowest relationship for female and male subjects. The distribution of calcification stages was widely dispersed with evidence of significant sexual dimorphism. The findings of this study indicate that in children of Turkish origin the completion of root formation of the canine and first premolar teeth may be used as a maturity indicator of the pubertal growth spurt with a degree of confidence similar to some of the other indicators described in the use of the hand-wrist radiograph. It is appropriate to put these skeletal and dental maturation relationships into daily orthodontic diagnostic practice when treating a Turkish patient.

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