UDK 616.314:618.1-053.6-055.25

Skeletal and Dental Maturity in Female Adolescents with Menstrual Disorders

Lyubov Smaglyuk, Anastasiia Liakhovska

Ukrainian Medical Stomatological Academy, Poltava, Ukraine

Introduction. Adolescence or puberty is a transitional period from childhood to maturity, when endocrinogical, metabolic, somatic, physical and psychological changes take place. This period is characterized of the appearance of secondary sexual characteristics, pubertal growth spurt. During this process, sequential phases mark the maturation of the complex endocrinological system that comprises the hypothalamus, pituitary gland, and ovary, and their interactions. Healthy reproductive function is the expected endpoint of this process [1]. The general growth model in the puberty is a reflection of the growth of various tissues and organs, that form a holistic organism. Adolescence is characterized of the acceleration in growth of all tissues, including bones, muscles and internal organs [1, 2]. Changes in the size and shape of the cervical vertebrae are also observed in growing subjects. Traditional method to identify pubertal stage of growth is cervical vertebral maturation (CVM), which is a biologic indicator of individual skeletal maturity [3-5]. Cervical vertebral maturation occurs during the entire pubertal growth period, entailing all the significant phases in craniofacial growth during adolescence [4, 6, 7]. Each of circumpubertal, as the pre-pubertal, pubertal and post-pubertal growth phase is characterised of differential growth of the maxillary and mandibular basal bones [8-10]. Nevertheless, successful orthodontic treatment in growing subjects depends on period of jaw growth, the eruption and formation of teeth and the skeletal maturation [5, 11]. Chronological age [6, 8] and teeth eruption [6, 12] during circumpubertal growth phases are known not to be reliable skeletal maturation indicator and treatment timing indicator [10, 11, 13].

On this basis, dental maturation has been proposed to be a clinically useful diagnostic aid in investigating of individual skeletal maturation stages [10, 14, 15]. Dental maturity, which can be easily assessed through the evaluation of tooth

formation [16], and can be carried out on panoramic radiographs that are routinely used by orthodontists and pediatric dentists. The data differ in relation to the degree of formation of teeth and stages of puberty growth. Most of the studies have approved dental maturation to be a reliable indicator of the individual skeletal maturition [15, 16]. The calcification stages of canines, premolars, and second molars are recommended because they occur in puberty [4]. Howewer, the data differ in relation to the dental maturity and stages of puberty growth (pre-, postpubertal).

On the other hand, in puberty, it is possible to observe differences in terms of growth and development in girls at the same age. The menstrual disturbances among adolescent girls, according to various authors, varied from 12% to 48.5% [7]. In its structure, the first place was disorders of the menstrual function - up to 60%. Such violations negatively affect the accumulation of bone mass. Howsoever, studies on estimation of skeletal and dental maturity in adolescent girls with reproductive health disorders are not found in literature.

The present study was aimed to determine skeletal and dental maturity in adolescent girls with menstrual disorders in comparison with girls without menstrual irregularity.

Material and methods. The study enrolled 57 girls in the age group of 12 to 15 years. All subjects were divided into two groups. The first (Study) group included 32 girls with menstrual disorders, established by a gynecologist, based on menstrual pattern characteristics, concerning their age at menarche, menstrual cycle length and regularity, duration and amount of flow, type and severity of pain related to menstruation, need for analgesia. The average age of girls of the study group was 14.7 ± 0.31 years. Girls of the study group according to menstrual disorders were divided as follows: 17 (53.1%) – with menstrual bleeding; 7 (21.9%) – with hypomenstrual syndrome; 5 (15.6%) - with olygomenorrhea; 3 (9.4%) – amenorrhea. The second (Control) group consisted of 25 girls with a regular menstrual cycle. The average age of the control group girls was 14.5 ± 0.33

years. The exclusion criteria for female of both groups were chronic health problems, psychiatric problems, thyroid and pelvic pathology.

The procedures received approval from the Bioethics Committee of the Ukrainian Medical Stomatological Academy (Poltava, Ukraine). All girls and their parents signed a statement of informed consent.

Assessment of skeletal maturity was carried out through the cervical vertebra maturation (CVM) method on lateral cephalograms according to Hassel and Farman [17]. The CVM method comprised six stages (CS1 to CS6) for cervical vertebral maturation. The growth phases were defined as prepubertal (CS1 and CS2), pubertal (CS3 and CS4), or postpubertal (CS5 and CS6) as shown on figure 1.

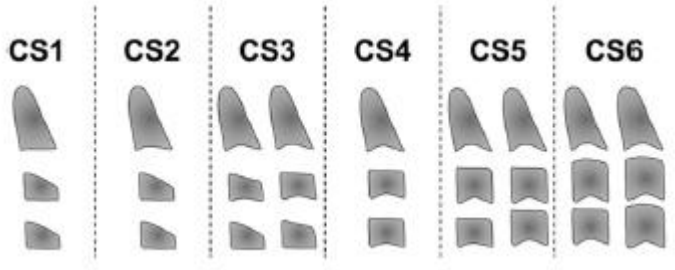

Figure 1. CVM stages

Assessment of dental maturity was carried out through the stages according to the method of Demirjian *et al.* (1973 ; stages D – H) from the panoramic radiographs of the left and right-side upper and low canines (C), the second premolar (P2), the second molar (M2) and the third molar (M3). The stages were defined as follows [15]:

Stage A: Cusp tips are mineralized but have not yet coalesced.

Stage B: Mineralized cusps are united so the mature coronal morphology is well defined.

Stage C: The crown is about half formed; the pulp chamber is evident and dential deposition is occurring.

Stage D: Crown formation is complete to the dentino-enamel junction. The pulp chamber has a trapezoidal form.

Stage E: Formation of the inter-radicular bifurcation has begun. Root length is less than the crown length.

Stage F: Root length is at least as great as crown length. Roots have funnel-shaped endings.

Stage G: Root walls are parallel, but apices remain pen.

Stage H: Apical ends of the roots are completely closed.

Statistical analyses. SPSS software 13.0 (SPSS ® Inc., Chicago, Illinois, USA) and "Microsoft Excel 2003" were used to perform the statistical analyses. The degree of correlation of the stages of dental maturity and growth phases was determined by Kendall nonparametric correlation criterion. The values of the correlation coefficient characterized the degree of proximity of the relationship between the values to the linear functional, which corresponds to ± 1 of the correlation coefficient. If rxy> 0, then the correlation was positive; that meant that with the growth of one of the values the second one also increased. The level of the P value (probability of error) depends on the magnitude of the correlation coefficient. The hypotheses were verified at the level of significance $p<0,05$ by using Student's t-test and Fisher's criterion X2. To establish the clinical performance of each dental maturation stage for diagnosing growth phases, positive likelihood ratios (LHRs) were calculated [19].

The authors of this manuscript have certified that they comply withthe principles of ethical publishing inInterventional Medicine & AppliedScience:Szél Á, Merkely B, Hüttl K, Gál J, Nemes B, Kom´ocsi A:Statement on ethical publishing and scientific authorship. IMAS 2,101–102 (2010).

Results. The distribution of the CVM stages in subjects of the sample are shown in the Table 1.

Table 1

CVM stages in girls of the study and control group

Groups	Age	Numbe	Distribution of girls by phases of growth and stages of CVM stages (abs., %)

	(years)	rs of girls	Prepubertal		Pubertal		Postpubertal	
			CVM stages					
			CVS1	CVS2	CVS3	CVS4	CVS5	CVS6
Study (n=32)	12 13 14 15 16 17	5 3 6 5 9 4	4(80,0%)* 1(33,3%)* 1(16,7%)*	1(20,0%) 2(66,6%) 2(33,3%)*	3(50,0%) 2(40,0%) 3(33,3%)*	2(40,0%) 6(66,7%)* 3(75,0%)*	1(20,0%) 1(25,0%)	
Control (n=25)	12 13 14 15 16 17	3 4 6 4 6 2		3(100,0%) 1(25,0%)	2 (50,0%) 3(50,0%)	1(25,0%) 3(50,0%) 1(25,0%)	3(75,0%) 3(50,0%)	3(50,0%) 2(100,0%)

Stages of maturation of permanent canines, premolars, the second and third molars of the lower groups are presented in Table 2.

Table 2

Maturation stages of teeth according to the pubertal growth phases

Tooth	**Maturation stage**	**Growth phase**		
		Pre-pubertal (CVS1+ CVS2)	**pubertal (CVS3+ CVS4)**	**Post-pubertal (CVS5+ CVS6)**

		Study group (n=11)	**Control group (n=4)**	**Study group (n=19)**	**Control group (n=10)**	**Study group (n=2)**	**Control group (n=11)**
		number of teeth					
Lower canine	F	-	2 (100%)	-		-	
	G	6 (46.2%)	2 (18.2%)	6 (46,.2%)	5 (44.5%)	1 (7.6%)	4 (36.3%)
	H	16(31.4%)	4 (10.8%)	32(62.7%)	15 (40.5%)	3 (5.9%)	18 (48.7%)
Upper canine	F	3 (100%)		-		-	
	G	13(65.0%)		6 (30.0%)		1 (5.0%)	
	H	16(31.4%)		32(62.7%)		3 (5.9%)	
Second premolar	E	9 (100%)	-	-	-	-	-
	F	15(93.8%)	15(75.0%)	1 (6.2%)	5 (25.0%)	-	-
	G	8 (25.0%)	5 (13.5%)	22(68.7%)	25(67.6%)	2 (6.3%)	7 (18.9%)
	H	6 (9.3%)	-	52(81.4%)	4 (9.8%)	6 (9.3%)	37(90.2%)

Second molar	E	7 (100%)	2 (100%)	-	-	-	-
	F	16(94.1 %)	10(55.5 %)	1 (5.9%)	8 (44.5%)	-	-
	G	8 (42.1%)	4 (13.3%)	10(52.6 %)	26(86.7 %)	1 (5.3%)	-
	H	10(12.2 %)	-	65(79.3 %)	4 (8.0%)	7 (8.5%)	46(92.0 %)
Third premolar	A	1 (100%)	-	-	-	-	-
	B	4 (100%)	2 (100%)	-	-	-	-
	C	5 (55.5%)	4 (57.1%)	4 (44.5%)	3 (42.3%)	-	-
	D	7 (17.5%)	10(26.3 %)	30(75.0 %)	21(55.3 %)	3 (7.5%)	7(18.4%)
	E	3 (10.3%)	-	24(82.8 %)	12(38.7 %)	2 (6.9%)	19(61.3 %)
	F	-	-	14(93.3 %)	1 (9.1%)	1 (6.7%)	10(90.9 %)
	G	-	-	2 (100%)	-	-	7 (100%)

We studied maturation of canines of the lower and upper jaw apart, which is explained by different terms of eruption of these teeth, and, accordingly, by the mineralization.

There was not difference between the stages of teeth formation on the upper and lower jaws except the third molars in girls of the both groups. The upper third molars were ahead of the formation of the lower molars approximately 1 stage.

In the control group there was a strong positive correlation between the stages of skeletal maturity and the stages of dental maturation. The correlation coefficients between maturation stage G and CVM stages (CVS3 and CVS4) ranged from 0.52 to 0.58 for lower and upper canine respectively ($p<0.001$, $p<0.01$). Moreover, the correlation between maturation stages F and G of the second molar and the pubertal growth phases was also similar and ranged from 0.51 to 0.57. The correlation between maturation stage H and the post-pubertal growth phases (CVS5 and CVS6) ranged from 0.62 to 0.68 for the second premolar and molar respectively ($p<0.001$). As for the third molar, just maturation stage D can be used as significant identication of pubertal spurt ($r=0,53$, $p<0.01$).

In the study group, there was not significant correlation between dental maturation stages and pubertal, post-pubertal growth phases. We defined the various maturation stages of the third molars, regardless of the CVM stages.

The LHRs values associated with each dental maturation stage were used for determent the diagnostic accuracy for each growth phase and are illustrated in Table 3.

Table 3

Positive likelihood ratios (LHR) of dental maturation stages for identifying growth phases

Tooth	Maturation stage	Growth phase		
		Pre-peak	Peak	Post-peak
Control group				
Second premolar	F	11.7(4,83-28.35)		
	H			11.35(4.38-29.4)
Second molar	G		10.61(4.01-28.04)	
	H			13.5 (5.26-34.66)

Study group				
Second premolar	F	32.6(4.49-239.09)		
Second molar	F	28.88(3.97-209.99)		

We observed positive LHR value greater than 10 for second premolar and molar in the control and the study group. According to the research results, the clinical diagnostic accuracy of the dental maturation in identifying pre-, post- and peak stages was found in the control group, in contrast to the study group, where high LHRs values are established only in conjunction with the prepubertal growth phase. The second premolar had positive LHR values exceeding 10 to identify the pre-peak growth phase (stage F, positive LHR of 11.7) and post-peak growth phase (stage H, positive LHR of 13.35). The second molar (stage E) revealed the highest diagnostic reliability for identifying peak (stage G, positive LHR of 10.6). In the study group we observed LHR values greater than 10 in conjunction with identifying pre-peak growth phase (second premolar, stage F, positive LHR of 32.6, second molar, stage G, positive LHR of 28.8).

Discussion. In recent centuries there was a general acceleration in the growth rate of adolescents, accompanied by a decline in age of onset of puberty, that is, children grew faster and ripened earlier. During this period, the menarche's age in girls dropped on the average of one year. At present, the tendency to reduce the age of puberty and to increase the rate of growth has stabilized, and according to some data, there is even a delay in growth rates. Therefore, the chronological age is not always a reliable indicator of individual development and physical growth [17, 18]. The “skeletal maturity” provides an important snapshot of the developing skeleton. It can signal the delay or acceleration of maturation, inform the clinician of underlying hormonal or other constitutional issues. Skeletal maturity assessment provides information on a child's and adolescent`s physical development and expectations based on chronological age. Given by many authors recently recognized trends for earlier maturity in a variety of systems, most notably

puberty, examination of individual trends in skeletal maturation is important [19, 20].

Data, obtained in the study, indicated that in the control group growth phases, included the stages of skeletal maturation, correspond to the physiological norm and have a significant direct correlation between the chronological age ($r = 0.78$, $p < 0.01$), appearance and the severity of secondary sexual characteristics ($r = 0.76$, $p < 0.01$). Thus, the age of 12 years showed the significant accuracy of the pre-pubertal growth phase (CVS2). Correlation between age of 13, 14 years and phase of pubertal peak (CVS3, CVS4) was found. The post-pubertal phase was indicator of the age of 15, 16 and 17 years old.

In spite of the correlations between skeletal maturation stages and age in the control group, there was not such data among adolescents in the study group. Consequently, girls with menstrual disorders were observed a significant lag in the stages of skeletal maturity and pubertal phases of growth ($p < 0.01$). This is confirmed by the correlation between pre-pubertal growth phase and the age of 12 and 13 years. Girls of the age of 15, 16, 17 years showed distributions to the pubertal (CVS3, CVS4) and post-pubertal stages (CVS5) without significant difference. CVS6 was not observed in any girl of the study group. These results indicate that girls of the study group had a delay in the stages of skeletal maturity and their inconsistency in chronological age. Such results can be explained by opinions of some researches, that in femle adolescents with menstrual disorders have significantly lower mineral density of bone tissue than healthy girls of the same age. Decreasing bone mineral density were observed in 7.1% of girls with uterine bleeding, 16.7% with hypothalamic syndrome, 35% with congenital hypoplasia of the adrenal cortex, 70.8% with primary amenorrhea and 75% with delayed sexual function maturation. Mineralization of bones and mineral bone density correlate with the indicators of physical development, stages of puberty and age of menstruation [21, 22]. Therefore, the decreasing of mineral density, can cause the lag in skeletal maturity of vertebrae among girls in the study group.

This means that data from the tooth formation stage are reliable indicators of the corresponding stages of skeletal maturity and growth phases in girls of puberty age.

Chronologic age estimation by dental emergence has been used over a long period [23]. In the adulthood it is important to determine puberty growth stage using stages of dental maturity, especially in the clinical practice of orthodontics. They are guided by the growth of the jaws and the time of certain treatment interventions on the biological age of the patient during puberty [24, 25].

Dental maturity assessment offers the advantage of being a simple procedure that can be carried out on panoramic radiographs that are routinely used for different purposes, and intra-oral radiographs can be taken with minimal irradiation to the patient. Moreover, the method described by Demirjian et al. [15] has the advantage of being little influenced by dimensional distortions that might be associated with panoramic radiographs. For this reason, several investigations [6, 10, 12, 13] have been focused on such indicators of skeletal maturity. All of these studies have reported considerably high correlation coefficients between the dental maturational stages and the skeletal maturation/growth phases [12].

However, in many studies there are differences in the correlation between the puberty growth stage and the stages of dental maturity. Perinetti et al. found only the dental stages F for the mandibular canine and D and E for the second molar to be satisfactory diagnostic performance in the identification of the pre-pubertal growth phase [16].

Although, according to other researchers, the signifacant relationship between the stages of the formation of crowns and tooth roots and skeletal maturity is so minimal that using stage data to evaluate puberty stages of growth is unreliable [26].

According to some authors, there is a correlation of the formation of teeth of the lower and upper jaws with skeletal maturation [12, 27]. Other researchers consider that there is a positive likelihood ratios of the formation of teeth of the lower jaw, except the third molars [25] T. Baccetti points to a correlation of the

dental maturation stages only of the upper teeth [28], or the lower teeth with skeletal maturity [29]. Giuseppe Perinetti and indicated that dental maturity and skeletal maturity are significantly correlated [12]. The stage F of the second molar was found the identification of the beginning of peak-growth phase (CVS3). In other studies stage E of the second molar, stages F and G also of the second molar were clear indacators for identification of pre-pubertal and pubertal growth phase respectively. Dental maturation stage H of the second molar indicated post-pubertal growth [6, 27] . The positive likelihood ratios was found between maturity stage F of the second premolar and stage E of the second molar and pre-pubertal growth phase.

Although the data have divergences of the stages of the teeth formation and stages of skeletal maturation, most studies indicate that dental maturation is indicator to determine only the pre-puberatal phase of growth [16, 28]. Other authors point to the reliability of the definition of the pre-pubertal phase pubertal peak of growth. [27, 30].

For more proper clinical accuracy for growth phase we analyzed the LHRs values associated with each dental maturation stage. These positive LHRs provide estimates of how much a certain dental maturation stage changes the odds of being in a specific growth phase [4]. Positive LHRs values more than 10 were observed for stage F and stage H of the second premolar in conjunction with the pre-peak and post-peak growth phases respectively in the control group. On the basics of LHR value the stage G of the second molar is the reliable predictor of peak growth phase. In the study group we foud positive LHRs values of the second premolar and molar for identifying pre-peak (prepubertal) growth phase. The absence of positive LHR values in conjunction wit peak and post-peak growth phases can be explained by delay of the skeletal maturity and discrepancy of age with the terms of teeth eruption of the female adolescents in the study group.

Our data partially coincide with the data of Litsas et all. He poited also on the diagnostic reliability of maturation stage of the second premolar and molar in clinical identifying of the growth phase. They indicated other stages for the second

premolar (stage E) and the second molar (stage F) in conjunction with the pre-peak and peak growth phase. The research is different in that it involved teenagers of both sexes aged 8-18 years, that is, with a large age range.

Conclusion. According to our data, the dental maturation stages have a high clinical diagnostic accuracy of the dental maturation in identifying pre-, post- and peak growth stages in female adolescents without menstrual disorders at puberty. The high LHRs of dental maturation values are established only in conjunction with the prepubertal growth phase in the girls with menstrual disorders. The data can be used in treatment planning of malocclusion in female adolescents by orthodontics and general dentists.

References

1.Rajiwade SR, Sagili H, Soundravally R, Subitha L. Endocrine Abnormalities in Adolescents with Menstrual Disorders. J Obstet Gynaecol India. 2018 Feb;68(1):58-64. doi: 10.1007/s13224-017-1035-y.

2. Rigon F, De Sanctis V, Bernasconi S, Bianchin L, Bona G, Bozzola M.et al. Menstrual pattern and menstrual disorders among adolescents: an update of the Italian data. Ital J Pediatr. 2012 Aug 14;38:38. doi: 10.1186/1824-7288-38-38.

3. Soliman A, De Sanctis V, Elalaily R, Bedair S. Advances in pubertal growth and factors influencing it: Can we increase pubertal growth? Indian J Endocrinol Metab. 2014 Nov;18(Suppl 1):53-62.

4. Litsas G, Athanasiou AE, Papadopoulos MA, Ioannidou-Marathiotou I, Karagiannis V. Dental calcification stages as determinants of the peak growth period. J Orofac Orthop. 2016 Sep;77(5):341-9.

5. Hagg U, Pancherz H. Dentofacial orthopaedics in relation to chronological age, growth period and skeletal development. An analysis of 72 male patients with Class II division 1 malocclusion treated with the Herbst appliance. Eur J Orthod. 1988; 10:169–76.

6. Perinetti G, Baccetti T, Di Leonardo B, Di Lenarda R, Contardo L. Dentition phase and chronological age in relation to gingival crevicular fluid alkaline phosphatase activity in growing subjects. Prog Orthod. 2011; 12:100–6.
7. Latysh OA. Features of treatment of menstrual function disorders in adolescent retaliation. Reproductive endocrinology. 2014; 6: 37-40.
8. Bjork A, Helm S. Prediction of the age of maximum puberal growth in body height. Angle Orthod. 1967; 37:134–43.
9. Baccetti T, Franchi L, De Toffol L, Ghiozzi B, Cozza P. The diagnostic performance of chronologic age in the assessment of skeletal maturity. Prog Orthod. 2006; 7:176–88.
10. Perinetti G, Di Lenarda R, Contardo L. Diagnostic performance of combined canine and second molar maturity for identification of growth phase. Prog Orthod.2013 May 20;14:1. doi: 10.1186/2196-1042-14-1. PubMed PMID: 24326062; PubMedCentral PMCID: PMC3847850.
11. Baccetti T, Franchi L, McNamara JAJ. The cervical vertebral maturation (CVM) method for the assessment of optimal treatment timing in dentofacial orthopedics. Semin Orthod. 2005; 11:119–29.
12. Hagg U, Taranger J. Maturation indicators and the pubertal growth spurt . Am J Orthod. 1982; 82:299–309.
13. Chertkow S. Tooth mineralization as an indicator of the pubertal growth spurt. Am J Orthod. 1980; 77:79–91.
14. Coutinho S, Buschang PH, Miranda F. Relationships between mandibular canine calcification stages and skeletal maturity. Am J Orthod Dentofacial Orthop. 1993; 104:262–8.
15. Demirjian A, Goldstein H, Tanner JM. A new system of dental age assessment. Hum Biol. 1973; 45:211–27.
16. Perinetti G, Contardo L, Gabrieli P, Baccetti T, Di Lenarda R. Diagnostic performance of dental maturity for identification of skeletal maturation phase. Eur J Orthod. 2011; 34:487–92.

17. Hassel B, Farman AG. Skeletal maturation evaluation using cervical vertebrae. Am J Orthod Dentofacial Orthop. 1995; 107:58–66.
18. Deeks JJ, Altman DG. Diagnostic tests 4: likelihood ratios. *BMJ : British Medical Journal*. 2004;329(7458):168-169.
19. Duren DL, Nahhas RW, Sherwood RJ. Do Secular Trends in Skeletal Maturity Occur Equally in Both Sexes? Clin Orthop Relat Res. 2015 Aug;473(8):2559-67.
20. Perinetti G, Contardo L, Gabrieli P, Baccetti T, Di Lenarda R. Diagnostic performance of dental maturity for identification of skeletal maturation phase. Eur J Orthod. 2012 Aug;34(4):487-92.
21. Vovk IB, Povoroznyuk VV, Ababkova GM. Вовк І.Б. The features of hormonal homeostasis and structural and functional status of bone tissue in adolescent girls with amenorrhea. Bukovinian Medical Herald J. 2000; 4(2-3): 30-33.
22. Ivanov II, Popova EV. Influence of sexual maturation disorders on the structural and functional properties of bone tissue in girls of pubertal age. Tavrian Medical and Biological J. 2006; 9(2): 37-40.
23. Cameron N. Can maturity indicators be used to estimate chronological age in children? Ann Hum Biol. 2015;42(4):302-7.
24. Marroquin TY, Karkhanis S, Kvaal SI, Vasudavan S, Kruger E, Tennant M. Age estimation in adults by dental imaging assessment systematic review. Forensic Sci Int. 2017 Jun;275:203-211.
25. Patel PS, Chaudhary AR, Dudhia BB, Bhatia PV, Soni NC, Jani YV. Accuracy of two dental and one skeletal age estimation methods in 6-16 year old Gujarati children. J Forensic Dent Sci. 2015 Jan-Apr;7(1):18-27.
26. Gandhi N, Jain S, Kumar M, Rupakar P, Choyal K, Prajapati S. Reliability of third molar development for age estimation in Gujarati population: A comparative study. J Forensic Dent Sci. 2015 May-Aug;7(2):107-13.
27. Surendran S, Thomas E. Tooth mineralization stages as a diagnostic tool for assessment of skeletal maturity. Am J Orthod Dentofacial Orthop. 2014 Jan;145(1):7-14.

28. Baccetti T, Franchi L, De Toffol L, Ghiozzi B, Cozza P. The diagnostic performance of chronologic age in the assessment of skeletal maturity. Prog Orthod. 2006;7(2):176-88.
29. Uysal T , Sari Z , Ramoglu S I , Basciftci F A 2004 Relationships between dental and skeletal maturity in Turkish subjects . Angle Orthodontist 74: 657 – 664.
30. Cericato GO, Franco A, Bittencourt MA, Nunes MA, Paranhos LR. Correlating skeletal and dental developmental stages using radiographic parameters. JForensic Leg Med. 2016 Aug;42:13-8.