Genetic Aspects of Tooth Eruption: A Systematic Review

Iwany Amalliah Badruddin[1], Elza Ibrahim Auerkari[2], Risqa Rina Darwita[1], Febriana Setiawati[1], Melissa Adiatman[1], Diah Ayu Maharani[1]*, Anton Rahardjo[1]

1. Departement of Public Health, Faculty of Dentistry, Universitas Indonesia, Jalan Salemba Raya No.4, Jakarta Pusat, 10430, Indonesia.
2. Departement of Oral Biology, Faculty of Dentistry, Universitas Indonesia, Jalan Salemba Raya No.4, Jakarta Pusat, 10430, Indonesia.

Abstract

Tooth eruption is the movement of a tooth from its growth site in the alveolar bone to its functional place in the oral cavity. This process continues for life, and does not stop even when teeth have reached the occlusal plane. It is still unclear how and when proceeds in detail the process of teeth eruption into the oral cavity, and the related studies are still rare, especially from the genetic aspects. The aim of this study is to systematically review the latest studies on the genetic aspects of tooth eruption. A systematic search was conducted according to the PRISMA guidelines, using the Pubmed database using the keywords "genetic," "tooth eruption," and "tooth emergence." The activated Pubmed filtering criteria included the article type, publication time, subject study, and age. The filtering was carried out manually based on the factors of non-duplication, feasibility of the complete manuscript and physiological tooth eruption, and absence of disease. The articles used as a reference in the eleven articles were assessed for their feasibility to be included in this study. Overall, out of the studies of these eleven articles, six studies addressed the eruption period of primary teeth and five studies period of permanent teeth. Regarding the subjects, seven studies studied twin subjects, and four studies studied individual subjects (singletons).

Recent studies have greatly contributed to the identification of the genetic factors, loci and alleles controlling the tooth eruption process. This applies for example to the order of the erupted teeth, the age of a person when the teeth emerge in the oral cavity, and inter-jaw asymmetry, antimeric, and contralateral.

Review (J Int Dent Med Res 2020; 13(4): 1585-1591)

Keywords: Tooth eruption, genetic.
Received date: 08 October 2020 **Accept date:** 02 November 2020

Introduction

Tooth eruption involves tooth movement from its growth site in the alveolar bone to its functional place in the oral cavity[1]. The tooth eruptions takes place in three stages[2]. At the first stage, before the eruption movement**,** tooth bud moves to the position according to the type of tooth, inside the alveolar bone or jaw for eruption movement. This stage starts from the bell formation stage till the root formation begins. The second stage of eruption movement begins with the formation of the roots and ends with the emergence of the tooth in the oral cavity before the teeth function (pre-functional phase). The third stage, or movement after eruption**,** maintains the position of the tooth in occlusion by compensating for the occlusion plane gap through the use of the occlusal and proximal planes. This phase begins when the tooth becomes stable in the occlusion plane and continues as long as the teeth remain in the oral cavity (functional phase).

The theory of tooth eruption mechanisms, based on experimental research on animals and humans, suggest triggering stimulation from nerve pressures in the apical part of the tooth. This results in an eruption that requires continuous adaptation of the periodontal membrane and active movement of crown follicles, to destroy the overlying bone tissue. The periodontal membrane, crown follicles, and membrane that covers the apical part of the root are the three structures involved in the eruption process. These three structures are interrelated,

Corresponding author:
Diah Ayu Maharani
Public Health, Faculty of Dentistry,
Universitas Indonesia, Jalan Salemba Raya No.4,
Jakarta Pusat, 10430, Indonesia.
E-mail: raniabdillah@gmail.com

and it is possible that the apical pressure alters the periodontal membrane and simultaneously triggers the crown follicles to resorption of the surrounding tissue[3-7].

The current understanding of the etiology of dental eruption irregularities in humans is poor. The relationship between teeth eruption and various environmental factors that can influence the process has been carried out e.g. factors of growth, nutritional deficiencies, maternal, systemic condition, races, ethnicities, and social economics[8-15].

The studies on humans are limited to clinical and radiological methods, while the conclusions of several of the experimental studies conducted on animal experiments are not directly applicable to humans. Most of the etiologies of dental eruption irregularities are associated with pathological conditions that can have genetic origin. The variety of pathological conditions related to the genetic factors may help to understand the relationship of these factors with physiological or normal tooth eruption. Therefore, the purpose of this review is to discuss current understanding of the genetic aspects of tooth eruption as they appear in the results of recent research.

Materials and methods

For the review, the article search for studies on the genetic aspects of tooth eruption, was carried out in the Pubmed database with the keywords "tooth eruption", "tooth emergence", and "genetic." The activated filtering criteria in the database were to include (1) type of articles—case reports, clinical studies, clinical trials, comparative studies, journal articles, systematic reviews, and twin studies; (2) publications from the last 15 years; (3) studies in humans subjects; (4) English language; (5) subject age from birth to five years old. Subsequent filtering was performed to sort the titles and abstracts based on non-duplication, the feasibility of accessing the complete text, and addressing the physiological eruption process of teeth or no disease. The reference lists of the related articles were manually filtered to identify other relevant articles. Although one of the inclusion criteria was primary dentition period, articles on permanent dentition eruption were also included.

Results

Article Selection

An initial search with the keywords "tooth eruption" "tooth emergence" and "genetic" yielded 366 articles. After filtering them using the Pubmed database with the activation of five filtering features, 27 articles were obtained. Then, 17 articles were excluded manually based on the absence of relevance to the topic in the title and abstract, which were forensic cases (n = 1), studies of bacteria (n = 1), and studies in which subjects had certain systemic disorders or syndromes (n = 15). The follow up searches on selected article references resulted in one additional article for inclusion, bringing the total to 11 articles (Figure 1).

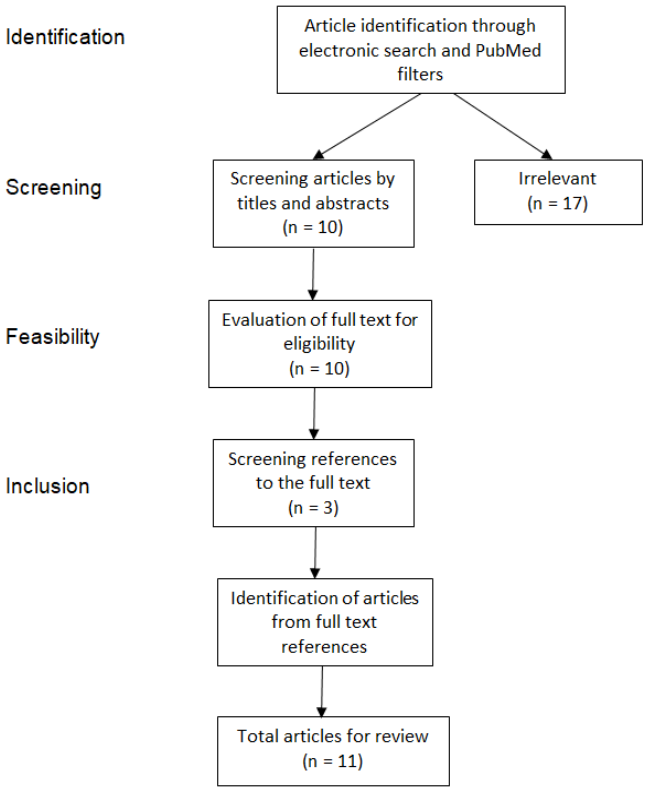

Figure 1. Article screening to review based on PRISMA guidelines[16]

Article description

From the 11 included articles, six studies addressed the time of eruption for primary teeth, and five studies the time of eruption for permanent teeth. Regarding the subjects, seven studies considered twin subjects and four studies individual subjects (singletons). All studies had longitudinal study designs with large samples,

including a total of 1,549 pairs or 3,099 people (one pair of triplets) from seven studies with twin subjects, plus 18,968 people from four studies with individual subjects.

The descriptions of each article, based on the type of study, number of subjects, zygosity, sex, age, period of the dentition, analysis, and conclusion of genetic influence are shown in Table 1.

Discussion

Studies with twin subjects

The contribution of genetic factors could be investigated using the phenotype characteristics of twin subjects divided into three groups, namely monozygotic, dizygotic same sex, and dizygotic opposite sex. Monozygotic twins are derived from one egg, so the two subjects have the same genes and similar environment of growth and development. In contrast, dizygotic twins come from two eggs, which gives the two subjects approximately half of the same genes and the same environment. The dizygotic twins can provide subjects with the same or different sexes. Previously, studies with twin subjects and conducted to see the genetic contribution to tooth eruption had been done for a long time but with conflicting results[17].

Cohort studies in Australia on twin subjects began in the early 1980s suggest a strong genetic contribution to the variation in incisor eruption time, with an estimation of 82–94% for men and 71–96% for women[18-19]. The influences of external environmental factors are significant but small.

The study by Mihailidis et al. [20] aimed to describe the asymmetrical eruption patterns in twin subjects. In addition, it differentiated the gender and zygotic groups. There are two kinds of asymmetry: directed (directional) and always changing (fluctuating). In Directional Asymmetry (DA), one side grows larger or earlier than normal for functional purposes. Fluctuating Asymmetry (FA) implies the inability of individuals to adapt to growth disorders. Although a trend of left-sided tooth eruption was indicated earlier, it was not statistically significant. A relatively low type of FA asymmetry was noted in all primary teeth, with the highest value being for the lateral incisors, but there was no evidence of genetic influence. Dental asymmetry studies provide insight into the biological basis of lateralization in humans, and the results can also help doctors distinguish between normal and abnormal development patterns.

To model for the genetic contribution in the age of primary teeth eruption, the dental development was observed in about 200 pairs of Australian twins[21]. The tooth eruption time is not the occurrence of each tooth eruption alone but a chain process and is stimulated by a series of molecular and cellular events that are inter- and intra-connected with the types of teeth and jaws. The genetic models of this study implied strong genetic contribution in the range of 60–90%, although only 50% for right lower lateral incisors and lower canines. The results therefore confirmed that genetic factors strongly influence the age variation of primary teeth eruption.

In a parallel study on the order of tooth eruption in 216 Australian twins pairs, the first primary teeth appeared around 8.6 months and the last around 27.9 months[22]. The order of eruption was the usual first incisors, lateral incisors, first molars, canines, and second molars. The anterior primary teeth appeared to erupt slower than in previous 1984 and 2003 studies, but the order of eruption remained unchanged. Left-sided antimeric teeth appeared more likely to emerge before the right-sided ones, but this was not statistically significant. At least 35% of all antimeric pairs had emerged within two weeks, which serves as a useful guide for assessing symmetric rather than asymmetrical development[22].

Pechnikova et al. [23] used three methods of measuring tooth eruption age in European subjects, and only one method was comparable with previous studies using the Demirjian method. The age for tooth eruption was not the same in the monozygotic twin group even though they had the same genes. The mean difference in the age of erupted teeth in the monozygotic group was lower than that in the dizygotic group, but it was almost the same as that of the dizygotic same sex group. The dizygotic opposite sex group exhibited the greatest differences compared to the monozygotic and dizygotic same sex group. The conclusion was that both individual and environmental factors have strong influence on the age variation of tooth eruption[23].

A longitudinal study on twin subjects in Chandigarh, India, found that there was a difference in the time of tooth eruption between the upper and lower jaws as well as between

men and women. Genetic factors were estimated to contribute to 60% of the total phenotypic variation in the time lapse between the two active eruption stages (first molars and incisors), in subjects aged five and seven[24].

Chorion type in twin pregnancies can affect the fetal growth environment. The relationship between chorion type differences in gestational age, infant birth weight, infant birth length and age of first primary teeth eruption was addressed in a study on Caucasian twins in Australia and the Netherlands[25]. The most common condition is monochorionic type in monozygotic twin pregnancies that will produce differences in birth weight between the two babies exceeding 20%, called birth weight discordance (BWD), and this difference in body weight affects the age at which primary teeth erupt. The results showed no significant relationship between chorion type and eruption time directly, but only through the occurrence of BWD. Monochorionic of chorionic types are associated with BWD events rather than dichorionic types, and BWD events are associated with differences in the time of eruption of primary teeth in their twin pairs. The mean difference in time of eruption of primary teeth was 14 days, and was significant in twins in Australia, but not in the Netherlands[25].

Polymorphism of eruption tooth sequence and gender

Polymorphism is the occurrence of two or more different forms of phenotypes in the population. Since all polymorphism has a genetic basis, *genetic polymorphism* has a particular meaning. "Genetic polymorphism is the occurrence in the same population of two or more alleles at one locus, each with appreciable frequency", where the minimum frequency is typically taken as 1%[26]. In the variety of tooth eruption order, for example, there were cases of children who experienced the eruption of the mandibular canine before maxillary canine. This occurs for less than 5% of the general pattern of tooth eruption[27].

Shaweesh studied the diversity of dental eruption patterns in Jordanian individuals for clinical interest in pedodontics and orthodontics[28]. In the maxilla, the diversity of dental eruption sequences was similar to that in the studies in Australia[29] and in white subjects in American Caucasians[30], for example in maxillary central incisors, first and mandibular second molars, and second premolars. The diversity in the lower jaw often occurred in the sequence of single-canine premolars, in contrast to that found in the studies on Australian and North American children who exhibit sequence diversity in central incisors. The diversity was also seen in the context of gender. Shaweesh found that the diversity of dental eruption sequences between men and women was not too different in the maxilla from that in the mandible. In the lower jaw, the biggest difference was in the premolar-canine teeth, particularly in men[28].

Sindelarova[31] examined the diversity in permanent tooth eruption sequences in Czech subjects and found more frequent diversity between jaw arches than within them, for example in the lower and upper second premolars. The lower jaw presented diversity in eruption sequences in the first molars and central incisors. In terms of gender diversity, women experienced greater diversity in canine-second premolar teeth than men. However, the diversity in the maxillary canine eruption sequence in the maxilla for both genders was more or less the same[31].

Cross-genomic association studies

The heritability of primary teeth emergence is estimated to be more than 70%[11] and can have significant implications for the risk of malocclusion, crowding, and periodontal disease. The Genome-Wide Association studies (GWAs) are observational studies of cross-genome series of genetic variants in different individuals to identify genetic variation associated with e.g. physiological traits, development process, or susceptibility to disease. GWAs may focus on the relationship between single nucleotide polymorphisms (SNPs) and traits such as major human diseases, but it can also be applied to other genetic variants[32-33].

Pillas et al. [34] identified the genetic determinants of the primary teeth development process to assess whether the genetic variants influencing these traits might relate to later dental problems. GWAs was used to identify the genetic loci to regulate the growth of primary teeth in 6,082 individuals from the 1966 Northern Finland Birth Cohort (NFBC1966) and the Longitudinal Study of Parents and Children (ALSPAC). Five genetic loci with strong links and five other genetic loci with weaker but significant

associations were indicated. Certain genes played a role in the development and growth of teeth and other organs, but nearly half presented an association with the development of cancer. Variants in the HOXB gene group were associated with occlusion defects that required orthodontic treatment at the age of 31.

A study by Geller et al. [35] applied GWAs on the order and time of permanent teeth eruption. Four loci exhibited a significant relationship, which were then replicated in four independent study groups from the United States and Denmark with a total of 3,762 individuals. Two loci were found to be consistent with previous findings regarding the eruption of primary teeth, and were also known to affect factors such as body height and breast cancer. The combined effect of the four genetic variants was most prominent between the ages of 10 and 12, where children with 6 to 8 tooth alleles with delayed eruption [mean 3.5 teeth (95% CI: 2.9–4.1)] were fewer than children with 0 or 1 tooth eruption allele.

Many genetic disorder may cause dental developmental disturbance, thus can delay the tooth eruption as well, e.g. Down Syndrom[36], sickle cell anemia[37], thallasemia[38], autism[39], etc.

Conclusions

The variable contribution of genetic factors to the processes of tooth eruption has been confirmed in multiple longitudinal studies on both twin and individual subjects. The order and age of tooth eruption, and eruption asymmetry and symmetry are among the most studied aspects of tooth eruption in the context of associated genetic factors. The approaches and tools that have developed rapidly over the past ten years include the genome-wide association studies (GWAs) to identify the genetic loci and alleles associated with tooth eruption and related processes. The remaining unknowns about tooth eruption and its genetic control will continue to require further research effort, particularly on aspects of irregularities with pathogenic or other unwanted consequences.

.

Acknowledgement

This study was supported by a 2020 PUTI Grant from the Research and Community Development Center of Universitas Indonesia. The authors confirm that they have no commercial associations that might represent a conflict of interest in association with the submitted manuscript.

Declaration of Interest

The authors report no conflict of interest.

Author	Study type	n	Zygosity group	Sex	Age	Period	Analysis method	Result: Genetic influence
Hughes, 2007	Twin	98 pairs (Australia)	46 MZ, 33 DZss, 19 DZos	M = 111 F = 85	1–3 years	Primary dentition	Fitting model, SEM	Strong
Mihailidis, 2009	Twin	131 pairs (Australia)	59 MZ, 40 DZss, 32 DZos			Primary dentition	Parental recording, DA, FA	Strong
Bockmann, 2010	Twin	219 pairs (Europe)	92 MZ, 67 DZss, 58 DZos	M = 226 F = 208	2–6 years	Primary dentition	Fitting models of genetics and environment	Very strong
Woodroffe et al., 2010	Twin	216 pairs (Australia)	91 MZ, 67 DZss, 58 DZos			Primary dentition	Parental recording, DA, FA	Strong
Pechníková et al., 2014	Twin	64 pairs (Europe)	21 MZ; 30 DZss, 15 DZos	M = 67 F = 61	5, 8–22, 6 years	Permanent dentition	Demirjian, Cameriere, Mincer	Individuals and environment also contributed
Sharma, 2014	Twin	111 pairs (India)	39 MZ, 72 DZ	M = 317 F = 275	5–25 years	Permanent dentition	Multifactorial model	Strong in maxilla
Mihailidis et al., 2015	Twin	409 pairs (Australia) 301 pairs (Netherlands)	198 MZ, 122 DZss, 89 DZos 127 MZ, 113 DZss, 61 DZos			Primary dentition	Chorion type, BWD	Very strong
Shaweesh, 2013	Singleton	2,650 children (Jordan)		M = 1,232 F=1418	4–16 years	Permanent dentition	Polymorphism of tooth eruption sequence	More varied in upper jaw and males
Sindelarova, 2019	Singleton	1,370 children (Czech)		M = 674 F = 696	4–15 years	Permanent dentition	Polymorphism of tooth eruption sequence	More varied in upper jaw and males
Pillas et al., 2010	Singleton	6,082 children (Finland)			< 1 year	Primary dentition	GWAS	Very strong (identified 10 loci)
Geller et al., 2011	Singleton	5,104 children (Denmark) 3,762 children (Denmark and USA)		Female	6–14 years	Permanent dentition	GWAS	Very strong (identified 6 loci)

Table 1. Summary of the articles on tooth eruption and related genetic aspects.

Description:
MZ: Monozygotic DA: Directional Asymmetry GWAS: Genome-Wide Association Study
DZss: Dizygotic same sex FA: Fluctuating Asymmetry SEM: Structural Equation Modelling
DZos: Dizygotic opposite sex BWD: Birth Weight Discordance

References

1. Srinath SK, Sahana S, Vishwanath SK, Ritu S. Mechanism of tooth eruption & its clinical significance – A systematic review of literature. Elixir Dentistry 2013;65:19676–80.
2. Nanci A. Ten Cate's oral histology: Development, structure and function. 8th ed. 2013. Elsevier. 233-252.
3. Kjær I. Mechanism of human tooth eruption: Review article including a new theory for future studies on the eruption process. Scientifica 2014;1–13.
4. Becktor KB, Hansen BF, Nolting D, Kjaer I. Spatiotemporal expression of NGFR during pre-natal human tooth development. Orthodontics and Craniofacial Research 2002;5(2): 85–89.
5. Miles TS, Nauntofte B, Svensson P. Clinical oral physiology. Quintessence. 2004.
6. Berkovitz BKB, Holland GR, Moxham BJ. Oral Anatomy, Histology and Embryology. 4th ed. Mosby, Elsevier. 2009. p362–365.
7. Bille ML, Thomsen B, Kjær I. Apoptosis in the human periodontal membrane evaluated in primary and permanent teeth. Acta Odontol Scand 2011;69(6):385–388.
8. Suri L, Gagari E, Vastardis, H. Delayed tooth eruption: Pathogenesis, diagnosis, and treatment. A literature review. Am J Orthod Dentofacial Orthop 2004;126(4): 432–45.
9. Aktoren O, Tuna EB, Guven Y, Gokcay G. Studi on neonatal factors and eruption time of primary teeth. Community Dental Health 2010;27:52-56.

10. Almonaitiene R, Balciuniene I, Tutkuviene J. Factors influencing permanent teeth eruption. Part one–general factors. Stomatologija 2010;12(3):67–72.
11. Badruddin IA, Putri MR, Darwita RR, Rahardjo A. The Relation of Mothers' Nutritional Status to Primary Teeth Eruption Timing. J Int Dent Med Res 2017;10(Special Issue):569-573.
12. Alshukairi H. Delayed tooth eruption and its pathogenesis in paediatric patient: a review. J Dent Health Oral Disord Ther 2019;10(3):209–212.
13. Badruddin IA, Putri MR, Rahardjo A. Factors Associated with Primary Teeth Eruption Pattern in Children Under Three Years Old in Beji Depok, West Java. Journal of International Dental and Medical Research 2017;10(Special Issue):564-568.
14. Badruddin IA, Putri MR, Darwita RR, Rahardjo R. The Relation of Mothers' Nutritional Status to Primary Teeth Eruption Timing. Journal of International Dental and Medical Research 2017;10(Special Issue):569-573.
15. Prijatmoko P, Zakiyah F. Role of Body Composition on the Eruption Time of First Permanent Molars. Journal of International Dental and Medical Research 2019;12 (4):1563-1567.
16. Moher D, Shamseer L, Clarke M, Ghersi D, Liberati A, Petticrew M, Shekelle P, Stewart LA, PRISMA-P Group. Preferred reporting items for systematic review and metaanalysis protocols (PRISMA-P) 2015 statement. Syst Rev 2015;4(1):1-9.
17. Pelsmaekers B, Loos R, Carels C, Derom C, Vlietinck R. The genetic contribution to dental maturation. J Dent Res 1997;76:1337–1340.
18. Townsend G, Hughes T, Luciano M, Bockmann M, Brook A. Genetic and environmental influences on human dental variation: A critical evaluation of studies involving twins. Archives of Oral Biology 2009;54s:545–551.
19. Hughes TE, Bockmann MR, Seow WK, Gotjamanos T, Gully N, Richards LC, Townsend GC. Strong genetic control of emergence of human primary incisors. J Dent Res 2007;86(12):1160–1165.
20. Mihailidis S, Woodroffe SN, Hughes TE, Bockmann MR, Townsend GC. Patterns of asymmetry in primary tooth emergence of Australian twins. Front Oral Biol 2009;13:110–155.
21. Bockmann MR, Hughes TE, Townsend GC. Genetic modeling of primary tooth emergence: A study of Australian twins. Twin Res Hum Genet 2010;13(6):573–581.
22. Woodroffe S, Mihailidis S, Hughes T, Bockmann M, Seow WK, Gotjamanos T, Townsend G. Primary tooth emergence in Australian children: Timing, sequence and patterns of asymmetry. Aust Dent J 2010;55(3):245–251.
23. Pechníková M, De Angelis D, Gibelli D, Vecchio V, Cameriere R, Zeqiri B, Cattaneo C. Twins and the paradox of dental-age estimations: A caution for researchers and clinicians. Homo 2014;65(4):330–337.
24. Sharma K. Genetic determinants and dynamics of permanent teeth emergence in Northwest Indian twins: A chronogenetic study. Homo 2014;65(6):450–463.
25. Mihailidis S, Bockmann M, McConnell E, Hughes T, van Beijsterveldt TC, Boomsma DI, McMaster M, Townsend G. The influence of chorion type on health measures at birth and dental development in Australian and Dutch Twins: A comparative study. Twin Res Hum Genet 2015;18(4):368–374.
26. Hedrick P. Genetics of Populations. 2011. Jones & Bartlett Learning. p. 104. ISBN 978-0-7637- 5737-3.
27. Al-Batayneh OB, Shaweesh AI, Alsoreeky ES. Timing and sequence of emergence of deciduous teeth in Jordanian children. Arch Oral Biol 2015;60(1):126-33.
28. Shaweesh AI. Polymorphisms in sequence of permanent tooth emergence: A cross-sectional study on Jordanian children and adolescents. Acta Odontol Scand 2013;71(1):32–37.
29. Diamanti J, Townsend GC. New standards for permanent tooth emergence in Australian children. Aust Dent J 2003;48:39–42.
30. Smith BH, Garn SM. Polymorphisms in eruption sequence of permanent teeth in American children. Am J Phys Anthropol 1987;74:289–303.
31. Sindelarova R, Broukal Z. Polymorphism in sequence of permanent tooth emergence in Czech children. Cent Eur J Public Health 2019;27(2):165–169.
32. Bush WS, Moore JH. Chapter 11: Genome-wide association studies. PLoS Comput Biol 2012;8(12):e1002822.
33. Dehghan A. Genome-wide association studies. Genetic Epidemiology 2018;37–49.
34. Pillas D, Hoggart CJ, Evans DM, O'Reilly PF, Sipilä K, Lähdesmäki R, Millwood IY, Kaakinen M, Netuveli G, Blane D, Charoen P, Sovio U, Pouta A, Freimer N, Hartikainen AL, Laitinen J, Vaara S, Glaser B, Crawford P, Timpson NJ, Ring SM, Deng G, Zhang W, McCarthy MI, Deloukas P, Peltonen L, Elliott P, Coin LJ, Smith GD, Jarvelin MR. Genome-wide association study reveals multiple loci associated with primary tooth development during infancy. PLoS Genet 2010;26;6(2):e1000856.
35. Geller F, et al. Genome-wide association study identifies four loci associated with eruption of permanent teeth. PLoS Genetics 2011;7(9);1–9.
36. Lim JX, Soewondo W, Sasmita, IS. Delayed Eruption of Primary Teeth Among Children with Down Syndrome. Journal of International Dental and Medical Research 2018;11(1):76-80.
37. Lopes CMI, Cavalcanti MC, Luna ACAE, Marques KMG, Rodrigues MJ, Menezes VADE. Enamel defects and tooth eruption disturbances in children with sickle cell anemia. Braz Oral Res 2018;32(0):e87:1-8.
38. Imtiaz H, Akbar W, Jadoon OK, Ali U, Ambreen S, Javed S, Shaheen F, Anwar J. A Comparison of Skeletal Age of Thalassaemic Patients of 9-15 Years with Chrionological Age by Radiography. J Ayub Med Coll Abbottabad 2018;30(4 Suppl 1):642-646.
39. Gozes I, Van Dijck A, Hacohen-Kleiman G, Grigg I, Karmon G, Giladi E, … Bedrosian-Sermone S. Premature primary tooth eruption in cognitive/motor-delayed ADNP-mutated children. Translational Psychiatry 2017;7(2):e1043–e1043.