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MORPHOLOGICAL VARIATIONS OF THREE-ROOTED MANDIBULAR MOLARS IN ANCIENT ANATOLIAN POPULATIONS (DILKAYA MOUND, VAN, TURKEY): A LITERATURE REVIEW ON WORLD POPULATIONS

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ABSTRACT

This study reports the first recorded discovery of three-rooted mandibular molars (3RM) from a Middle Age archaeological population unearthed in Van, Eastern Anatolia. A historical context is given for the research site, Dilkaya Mound, which has a history of approximately 2500 years. In total 462 permanent first and second teeth, 219 deciduous teeth, and a total of 682 mandibular teeth belonging to 358 individuals from Early Iron Age and Middle Age populations were included in this study. The earliest recorded population on site which dates to the Early Iron Age shows no sign of 3RM1 and 3RM2. The 3RM1 feature first appears in Anatolia at a rate of 1,05% by the Middle Age. The frequency of 3RM2 was found at a rate of 0,67%, and 3RM3 at a rate of 2,44 % in the population. Three rooted deciduous lower first molar teeth (3rm1) were observed at a rate of 2,44%; a new feature in the literature. The results of our study support the existing explanation that genetic drift plays a significant role in the distribution of 3RM via the wave of migration to the west from Asia during the Middle Age.

KEYWORDS: 3RM1 (Three-rooted Mandibular First Permanent Molars), 3RM2 (Three-rooted Mandibular Second Permanent Molars), 3RM3 (Three-rooted Mandibular Third Permanent Molars), 3rm1 (Three-rooted Mandibular First Deciduous Molars), Anatolia

INTRODUCTION

The relative durability of teeth and surrounding tissues to other skeletal material makes them more reliable and informative materials in paleoanthropological studies. Also, their properties are more stable than most morphological features. Due to this stability they have central application for examining genetic components, sexual dimorphism, and age. Three-rooted first molar teeth (here after 3RM1) have a high genetic penetrance and are more common in Asian and Asian derived populations (Ming-Gene Tu *et al.*, 2007). Studies have revealed that this morphological feature is more stable than other variations in tooth morphology and has a high genetic component. Mandibular first permanent molar teeth are commonly formed by two different roots; mesial and distal. The most common anomaly is the occurrence of 3RM1. Although its mode of heritance is not known in detail, it is concluded to be the cause of a recessive or dominant mutation. Variational studies concerning the anatomical root numbers of teeth and its genetic distribution from Asia to Europe, Europe to America, and finally from America to the Oceania islands are commonly referenced in scientific literature (Taylor, 1899; Tratman, 1938; Pederson, 1949; Turner, 1971; Ming-Gene Tu *et al.,* 2007; and Drusini and Swindler, 2009).

In order to perform successful clinical tooth extraction and treatment of root channels, dentists sought comprehensive information about root channel morphology and root system variations (Vertucci, 1984). A series of studies on this subject shows the occurrence of differences in tooth root numbers according to geographic variations (Turner II 1971). Discovered variations lead to curiosity and interest in tracing the geographic differences among populations. Literature records generally consist of clinical studies on modern populations, while studies performed on skeletal material of ancient populations are scarce. There are a handful of clinical studies conducted on different groups within the population of Turkey that focus on tooth root morphology. To date there is no anthropological study on tooth root morphology of ancient Anatolian populations. Our study presents the first report of the results from Dilkaya Mound—which with its novel findings—should contribute considerably to what is known about this under studied archaeological population of Anatolia as well as to paleoanthropological knowledge of the region.

Turner II (1971) in his study of the American Indians, points out that the morphological property of mandibular first molar roots has a more stable character and a high genetic component. Curzon (1974) expands on this idea, suggesting that the prevalence of 3RM1 has a high genetic penetrance, and observation of this trait is more common in Eskimo and Caucasian-Eskimo populations. Most of the studies on Caucasians show that two rooted first and second molars with roots placed on distal and mesial sides are common (Barker *et al.*,1974; Vertucci, 1984) whereas 3RM1 was observed in lower than 5% of Caucasian (England, Germany and Finland), African (Bantu and Bushmen), Eurasian and Indian populations. However, Mongoloids including Chinese, Eskimo and American Indians, show a prevalence of 3RM1 of over 40% (Gulabivala et al., 2001). Scott and Turner II (1997) state that this anomaly (presence of 3RM1) is observed in as much as 20% to 30% of some Sino-American groups (North and East Asians and Eskimo-Aleuts,1971). Prevalence of 3RM1 in South Siberians, Jomons and North and South American Indians is lower than 10% while the rate is around 15% in Northwest American Indians in this century. Lower that 5% of the Sahul pacific population shows the anomaly, whereas a more extreme value of 15% is found in the Sunda pacific population (Turner II,1971). This value is more closely related to populations of Southeast Asia and Polynesian Indians compared to North and East Asian populations and North American Indians.

MATERIALS AND METHODS

Dilkaya Mound is remarkable among Anatolian historical sites due to its history of inhabitance of over 2500 years, from its settlement during the Early Iron Age through to the Ottoman Empire (Table 1). The area on which the site is located was once under Urartian reign, and is positioned in the eastern part of Anatolia bordered by the Lake Sevan to the north and the Urumia and Van lakes to the south. Intercrossing mountain chains juxtaposed with volcanic mountains make this region the highest in Anatolia (Figure 1). Another important feature of the area is the presence of agricultural fields on lower lands creviced between the bordering mountains. Lack of rivers or other sources of fresh water hindered agricultural productivity in the region, leading to the dependence of some of the population on semi-nomadic animal husbandry. This semi-nomadic lifestyle continued until the dawn of the Iron Age, 1400-1350 B.C., brought on by migrations of people coming from West Iran to the Lake Urumia catchment. Starting from the Early Iron Age, mining was added to husbandry and agriculture as a means of production. People of the catchment began taking advantage of seasonal migration, alternatively leaving their settlements on the plains for grazelands in high altitudes. This region was resettled in the Middle Age after a long hiatus following the Urartian period. Turkish tribes migrating from Asia initiated another settlement period for the area. Bronze Age Byzantine coins obtained from the Dilkaya Mound suggest that this settlement occurred around the 10th century A.D. Middle Age layers in the Mound are divided into some sub levels (Table 1). These layers include a very long period that reaches until the Ottoman Empire. Archeological excavations commenced in 1983 with a surface survey and lasted for 8 years. Dilkaya Mound and necropolis excavations have yielded remarkable results (Figure 2). With its 358 skeleton specimens Dilkaya Necropol formed a rare archeological necropol in Anatolia (Table 2) (Çilingiroğlu, 1993; Belli, 2003; Sevin, 2005).

Table 1: Chronological Layers of Van Dilkaya Settlements

LAYER	PERIOD	CHRONOLOGICAL
I	Middle Age	A.D. 10.Century
	Not Settlement	
II	Middle Early Iron Age (Urartu Kingdom Period)	B.C. 800-600
III	Early Iron Age (Urartu Principalities Period)	B.C. 1100-800
	Not Settlement	
IV	Early Bronze Age III (Early Transcaucasia III)	B.C. 1900-1400/1300
VA	Early Bronze Age II	
VB	Early Bronze Age I (Early Transcaucasia II)	
	Earth (Sand)	

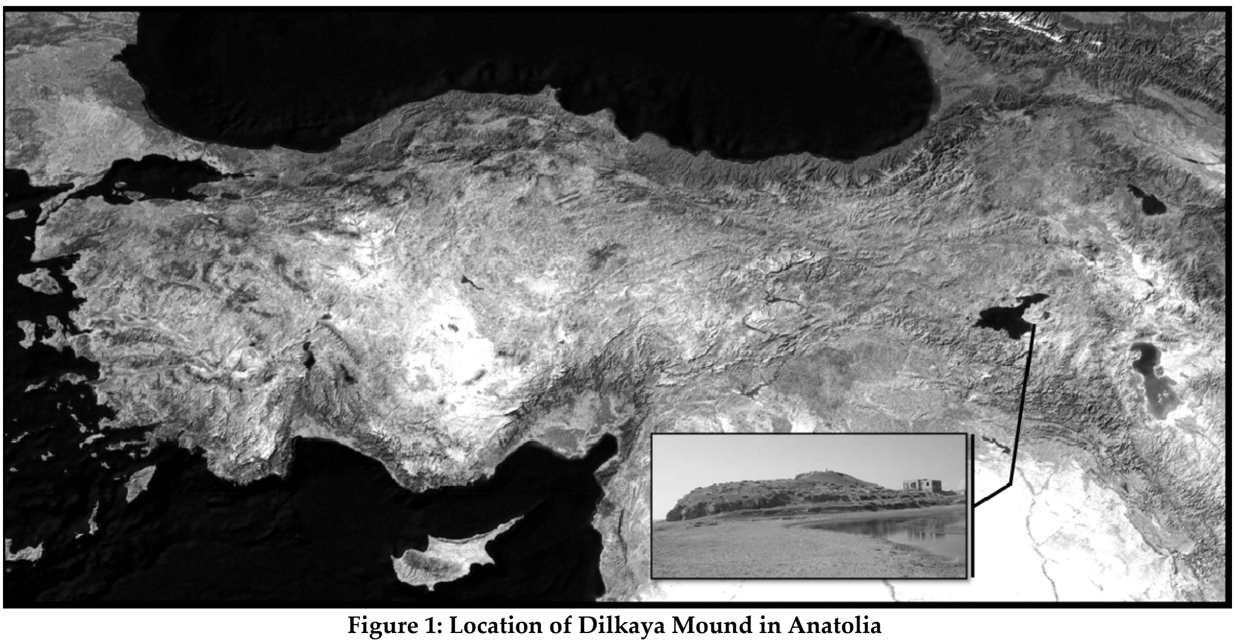

Figure 1: Location of Dilkaya Mound in Anatolia

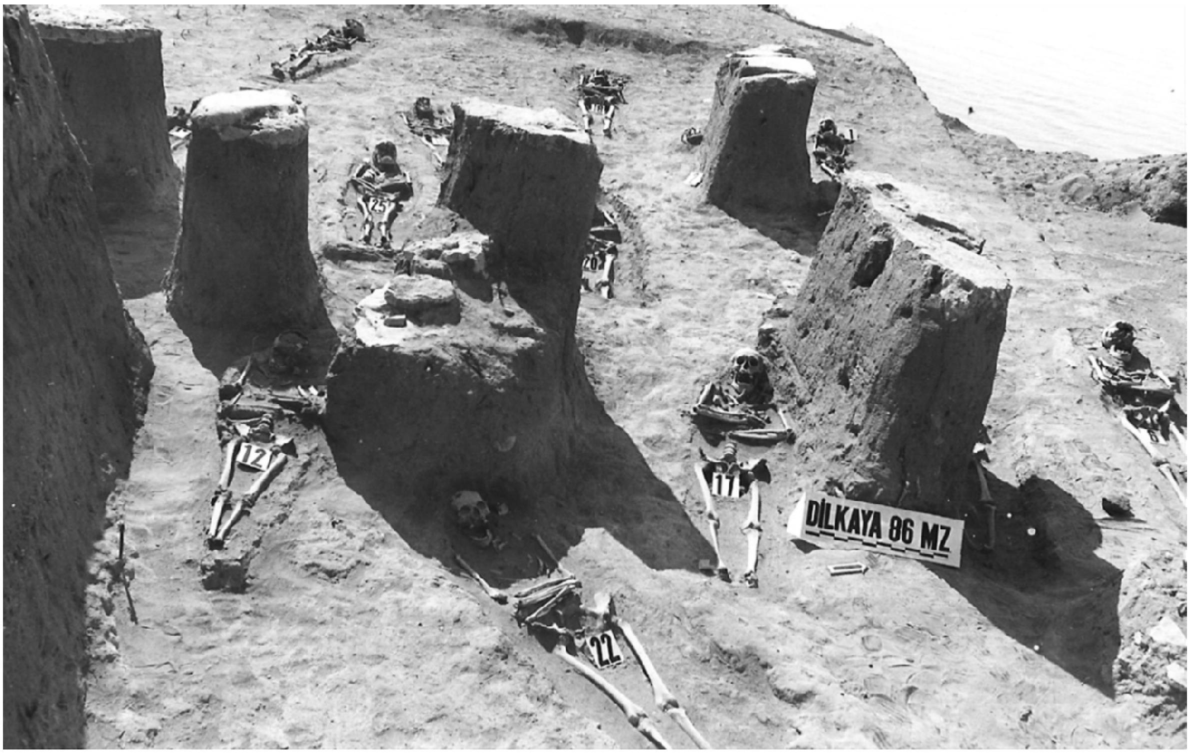

Figure 2: Necropolis of Dilkaya in Anatolia

In total 462 permanent first and second teeth, 219 deciduous teeth, and a total of 682 mandibular teeth belonging to 358 individuals from Early Iron Age and Middle Age populations were included in this study (Table 3). For the identification of teeth, the methodologies of Ubelaker (1984), Bass (1987), Burns (1999), White (2000), Matshes (2005), and Özbek (2007) were used. For the determination of properties, Arizona State University Dental Anthropology System standard (ASUDAS) references were used (Scott and Turner, 1997). Paleodemographic, morphologic, and paleopathological investigations of the reskeletons were performed by Erksin Güleç at the paleoanthropology laboratory of Ankara University (Güleç, 1986, 1989; Ozer, 1999).

Table 2: Paleodemographic structure of Dilkaya Mound

	Babies and Children	Adults	Total
Early Iron Age	9	30	39
Middle Age	163	156	319
Total	172	186	358

RESULTS

Rates for the Middle Age Dilkaya population were found as 1,05% for 3RM1, respectively 0,67% for 3RM2 and 2,13% for 3RM3 and 2,44% for 3rm1. Such dental features were not observed in the Early Iron Age population (Table 3).

Table 3: The root findings of Dilkaya population

	3RM1	3RM2	3RM3	$3rm_1$	$3rm_2$
Middle Age					
Observation	191	150	94	82	122
Determination	2	1	2	2	0
Ratio (%)	1,05	0,67	2,13	2,44	0
Early Iron Age					
Observation	66	55	23	8	7
Determination	0	0	0	0	0
Ratio (%)	0	0	0	0	0

Figure 3: LM3 (approximately 65 years old male)

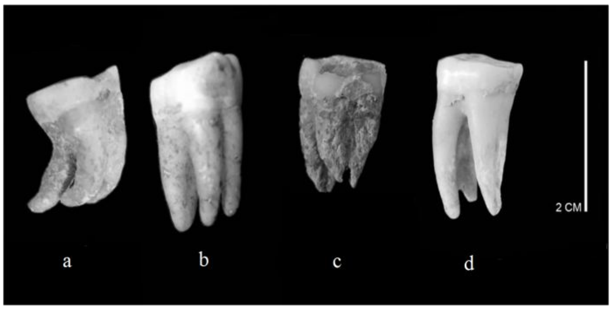

Figure 4: a- RM3 (approximately 60 years old male) b- LM1 (approximately 40 years old male) c- LM1 (approximately 30 years old woman) d- RM2 (approximately 40 years old male).

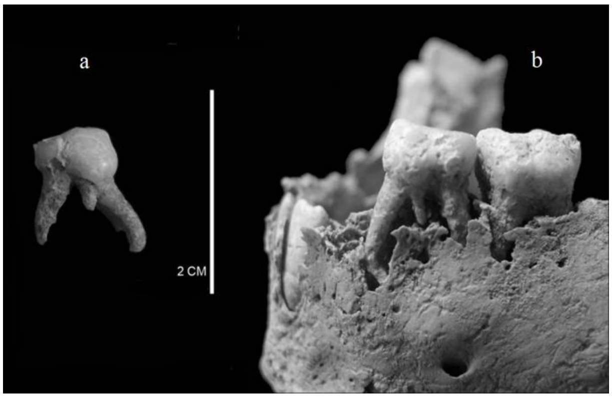

Figure 5: a- lm1 (approximately 8 years old child) b- lm1 (approximately 6 years old child).

THE HISTORY OF THREE-ROOTED MANDIBULAR FIRST MOLARS SURVEY OF AVAILABLE STUDIES

The first described study of tooth root variation was concerned with counting the number of roots in teeth by a dentist (Taylor, 1899). Since this study was performed at Cambridge Downing College in England, teeth were presumably of English origin. However, the rate of 3RM1 as 3.4% was considered to be very high for English people by Turner II (1971), and he therefore stated that this calculation, attributable to Taylor's misidentification of first molars, was in error. Tratman's (1938) study on 3RM in different Asiatic populations is the first comprehensive and reliable study available in the literature. Tratman also calculated root numbers of mandibular first molars when he was a practitioner dentist in Singapore. However, his findings were found to have a low percentage according to more recent studies. Pedersen (1949) determines the ratio of 3RM1 as 12.5% (8/64) in Greenland Eskimos. It is noticeable that this value is also lower than further studies in later periods (Table 4). This situation probably arose due to different calculation techniques and the fact that three rooted teeth are more resistant to extraction in clinical applications. Another important study includes Gabriel's (1966) calculation of bilateral symmetrical root numbers of white Australian monozygotic twins.

Among clinical radiographic studies, Ferraz and Pecora's (1992) research on Asian, white, and black populations in the Ribeira Preto region of Sao Paulo, Brazil is remarkable. Their findings identify the third root in the first big mandibular molar in the Mongolian (15.2%), African (7.5%) and Caucasian originated populations (6.8%) in Brasil. Rou (1994) reports the presence of a third root in the mandibular molars of the Chinese population at a rate of 20%. Lucaine, in his morphological study (1996) on mandibular permanent big molars obtained from the Brazilian population, found three roots at a rate of 5% over 232 lower permanent big molars and three roots at second molars at a rate of 1% over 396 lower second molars.

Pucci and Reig (1944) report 3RM1 rate as 5.5% for Uruguay population. De Deus (1960) found 2 this as 5% in southeastern living Brasilian patients. Teixeira (1963) notes 10% of the extra roots appear smaller than normal roots in the distal-lingual position. Using radiographic methods, Sousa-Freitas (1971) determines 3RM1 as 17.8% in patients with Japanese origin and as 4.3% in patients with European origin. Al-Nazhan's (1999) study, following treatment of channels, reports 6% of 251 mandibular lower first permanent molar teeth with three roots in his Saudi Arabian patient group. Fabra-Campos (1989) determines three roots in 13 over 760 (1.71%) of first lower molar teeth in Spain. Gulabivala's (2001) results show 3RM1 at a rate of 10.1% (14/139) in Burmanian patients. Additionally, his study points out potential endodontic effects when compared to Donnison's (1970) earlier study that argues the composition of Burmanian population has Chinese and Indian origin with their Mongoloid features showing 70% dominancy. Rashid (2006) finds 3RM1 at 8.1% (121/1483) in his clinical study conducted in Mosul, Iraq. One of the most important skeletal studies is Lukacs's (1983; 1988) research on the dental morphology of Neolithic and Iron Age populations in Pakistan. Lukacs reports 3RM1 from the Neolithic period (5.6%) and from the Iron Age (5%). In Turner II's (1990) investigation of 3275 teeth from 42 series of East Asian skeletons from the Late Pleistocene and Holocene he notes that the presence of 3RM1 is common in Aleuts, found at a rate of 40.7%. Lovell (2006) does not detect any 3RM1 (0/4) in his study of Bronze Age populations from Tell Leilan, Syria.

Other important studies include more recent ones on American Indian and Eskimo dental morphology. Nelson (1938) doesn't notice any third roots in American Indians (0/72) whereas Turner (1971) reports a rate of 6.27% (88/1402). Pedersen (1949) finds a rate of 12.5% (8/64) in his dental study on Greenland Eskimo skeletons. Irish (2005) finds the presence of third root to range between 0 to 2.6% in his study of five populations from ancient Nubia, situated in areas between south of Ancient Egypt and north of Sudan and dating three to two thousand millennia B.C.

Table 4: Prevalence of three-rooted mandibular first molars—survey of available studies

Study		Year	Origin	Total number of teeth	Number of teeth with three roots	Percentage of total (%)
Tylor	Recent	1899	United Kingdom	119	4	3,4
Bolk	Recent	1915	Netherlands	1713	18	1,05
Cambell	Recent	1925	Australian Aborgines	176	0	0
Fabian	Recent	1928	Germany	-	-	1,6
Hjeimman	Recent	1929	Finland	-	-	0,9
Drennan	Recent	1929	South Africa Bushmann	23	0	0
Leigh	Recent	1929	Guam-Prehistoric	83	2	2,41
Shaw	Recent	1931	African Bantu	68	0	0
Nelson	Historic	1938	American Indian	72	0	0
Tratman	Recent	1938	Chinese	853	74	8,67
	Recent		Malay	271	32	11,81
	Recent		Javanese	55	11	20
	Recent		İndians	453	1	0,2
	Recent		Eurasian	141	8	5,67
	Recent		Asiatic Indians	302	1	0,33
Laband	Recent	1941	Malay in N.Borneo	134	11	8,2
Pucci & Reig	Recent	1944	Uruguay	-	-	5,5
Pedersen	Historic	1949	Greenland Eskimo	64	8	12,5
Dr Deus	Recent	1960	Southeastern Brazil	-	-	2,5
Merbs	Recent	1969	Huston's Bay Eskimo	60	15	25
Somogyi-Csizmazia et.al	Recent	1971	Canadian Indians	250	39	16
De Souza-Freitas et al.	Recent	1971	European	422	27	3,2
	Recent		Japanese	233	83	17,8
Skidmore &Bjorndahi	Recent	1971	Caucasian	45	1	2,2
Turner II	Recent	1971	Aleut	87	38	43,68
	Recent		Alaska Eskimo	116	31	26,72
	Recent		American Indian	582	28	4,81
	Historic		American Indian	1402	88	6,27
Curzon &Curzon	Recent	1971	Keewatin Eskimo	98	28	27
Skidmore and Bjorndal	Recent	1972	Caucasians	-	-	2,2
Curzon	Recent	1973	United Kingdom	377	13	3,4
Curzon	Recent	1974	Baffin Eskimo	69	15	21,7
Curzon	Recent	1974	Greenland Eskimo	29	4	13,8
Vertucci & Williams	Recent	1974	Not stated	100	0	0
Hochstetter	Recent	1975	Guam	400	52	13
Jones	Recent	1980	Chinese	52	7	13,4
	Recent		Malaysian	149	25	16
Reichart & Metah	Recent	1981	Thai	364	70	19
Lukacs	Neolitik	1983	Pakistan	-	-	5,6
Walker & Quakenbush	Recent	1985	Hong Kong Chinese	213	70	19
Lukacs	Neolithic	1988	Pakistan	-	-	5
Walker	Recent	1988	Hong Kong Chinese	100	15	15

Yones et al	Recent	1990	Saudi	-	-	2,92
Loh	Recent	1990	Chinese (Singapore)	-	-	7,9
Turner II	BC 4000 to AD 200	1990	Early Thailand	237		9,3
	Neolithic- Mesolithic		Early Laos and Vietnam	21		9,5
	Historic		Cambodia and Laos	42		9
	Mesolithic		Early Malay	50		6
	BC 4000		Leang Tjadang	92		6,5
	BC3000		Philippines	121		17,4
	BC2000		Taiwan	25		4
	BC 2500 to 300		Jomon	100		5
	BC 3000		Borneo	94		13,8
	AD 1750 to AD 1900		Ainu Hokkaido	96		11,5
	Neolithic		Lake Baikal	30		23,3
	AD 1200 to AD 1300		Japan Kamakura	85		21,2
	AD 1910 to AD 1920		Japan Kanto	45		24,4
	BC 200		Northeast Siberia	164		23,2
	BC 1000 to recent		Aleut	273		40,7
	Earliest Jomon		Jomon Hokkaido	103		5,8
	Historic		Japan Hiogo	85		23,5
	Historic		Japan	119		26,9
	Recent		Japan	95		24,2
	Historic and Recent		Eskimo and Greenland	598		26,9
	BC1000		An-yang China	172		38,4
	Recent		Hong Kong	95		18,9
Ferraz & Pecora	Recent	1992	Japanese (Living in Brasil)	105	12	11,4
	Recent		Negroid	106	3	2,8
	Recent		Caucasian	117	5	4,2
Yew & Chan	Recent	1993	Chinese	832	179	21,5
Rou et al.	Recent	1994	Chinese	-	-	20
Sperber & Moreau	Recent	1998	Senegalese	480	15	3
Gulabivala et al	Recent	2001	Burmese	139	14	10,1
Irish et.al.	BC2500-1750	2005	Kawa Nubia	25	0	0
	BC2000-1650		C-Group Nubia	39	1	2,6
	BC1750-1500		Kerma Nubia	49	1	2
	BC1650-1350		Pharanic Nubia	15	0	0
	BC1550-1380		Soleb Nubia	16	0	0
Rashid et al.	Recent	2006	Iraq	1483	121	8,1
Lovell et.al.	Bronze Age	2006	Tell Leian (Syria)	4	0	0
Tu et al.	Recent	2007	Taiwanese	-	-	21,1
Jayasinghe et al.	Recent	2007	Hong Kong	203	44	21,67
Ming et al.	Recent	2010	Taiwanese	121	6	5,00
Garg et al.	Recent	2010	Indian	1054	48	4,55
Present study	Early Iron Age		Turkey	66	0	0
Present study	Middle Age		Turkey	191	2	1,05

In general, the frequency of 3RM1 varies among populations, but is typically higher in Asian populations. In particular, Aleut, Eskimo, and Japanese series have higher and more continuous polymorphisms in 3RM1. Dental studies on primates demonstrate many variations, but no sample is known with 3RM (Turner II, 1990). Such a feature is not present in the literature concerning *Australopithecus, Homo erectus, Neanderthal,* or similar fossil humans (Turner II, 1990). The presence of three-rooted mandibular first molar teeth is an anatomically unique characteristic of modern *Homo sapiens*. Evidence suggests that these supernumerary features have arisen since the late Pleistocene (Turner & Bird, 1981). Present data reiterates that this feature is the result of mutation.

DISCUSSION AND CONCLUSIONS

Recent advances in genetics provide better understanding of hereditary anomalies and gene mutations responsible for tooth development. Different teeth malformations can be seen because of products synthesized by detective genes in key time periods of teeth development. Although the exact mode of inheritance is not fully understood it is considered to be the result of a recessive or dominant mutation. Supernumerary roots may be related with the differences in developmental genes themselves or their products during root growth period of teeth development. Research indicates that genes on the sex chromosomes are involved in various facets of dental ontogeny (Scott &Turner II, 1997). For example, the structural gene for amelogenin is located on the X and Y chromosomes (Lau *et al.*,1989). Their properties are even more stable than most morphological characteristics. They have a high genetic component that attenuates effects of environmental differences, sexual dimorphism, and age.

Alvesolo (1997) hypothesized that observed differences in teeth morphology, as males have larger and robust teeth, may arise due to sexual dimorphism. In addition, he concluded that this situation occurs because of "Y" chromosome in males or "X" chromosome in females. The "Y" chromosome in males causes more dentin production compared to females, whereas "X" chromosome in females cause more enamel production (Alvesolo, 1997; Varrela 1988). In addition to such differences caused by sexual base, alterations in number of "X" and "Y" chromosomes would be related with teeth anomalies, such as, supernumery in teeth number, taurodontism, amelogenesis imperfecta, dentinogenesis imperfecta, and supernumery in root number. Moreover, hereditary anomalies that arise due to chromosomal defects could also explain such disorders. Apart from all such cases, genes producing three rooted teeth may be evolved from the duplication of gene producing two rooted teeth as in the case of hemoglobin producing genes have evolved from myoglobin producing genes by duplication.

Migrating human populations bring their biological properties with them, which are dispersed according to frequency, population size, spreading time, or isolation. Such features including number of roots show variability, especially according to population size or spreading time. Homogenic 3RM1 prevalence in Dilkaya Middle Age population should be a least adapted feature. Although, the 1.05% 3RM1 gene frequencies were affected by the sporadic immigration waves of Asian populations, genetic drift of 3RM1 in the Dilkaya population was probably not this high. Specimens seen in Middle Age Dilkaya population are important samples demonstrating the introduction of 3RM1 feature by a migration wave from Asia to west with pioneer groups to Turkey. There exists no study in the literature about the root number of deciduous teeth -attributable to the insufficiency of materials both from clinical studies and archeological excavations. High mortality rates of infants and children within the Middle Age Dilkaya population increased the number of deciduous teeth. Observed 2.41 % of 3rm1 frequency is remarkable for Middle Age.

The number and shape of the human teeth root has a complex structure that exceeds genetic or simple environmental explanations. Limited knowledge or studies based on assumptions further hinder consensus. Inter and intra population relationships, geographic alterations, and microevolution are important factors to include in assessing biological relationships between populations. It can be reasoned that data from future studies with the help of mathematical modeling and ontogenic knowledge will lead to a more developed understanding of this anomaly and its implications.

REFERENCES

Al-Nahzan, S. (1999) Incidence of Four Canals in Root- Canal-Treated Mandibular First Molars in a Saudi Arabian Sub-Population. *Int. Endod. J.*, No 32:49-52.

Alvesolo, L. (1997) Sex Chromosomes and Human Growth-A Dental Approach. *Hum Genet.*, No 101, 1- 5.

Barker, B.C.W., Parson, K.C., Mills, P.R., and Williams, G.L. (1974) Anatomy of root canals III. Permanent mandibular molars. *Australian Dental Journal*, No 19, 408–13.

Bass,W.M. (1987) *Human Osteology,A Laboratary and Field manual*, Third Edition, Special Publication No.2 of the Missouri Archaeological Society.

Belli, O. and Konyar, E. (2003) *Doğu Anadolu Bölgesinde Erken Demir Çağı Kale ve Nekropolleri*, Arkeoloji ve Sanat Yayınları, Page:1-144.

Burns, K.R. (1999) *Forensic Anthropology Training Manual*. New Jersey: Prentice Hall, 1-282.

Bolk, L. (1915) Bemerkungen uber Wurzelvariationen ammensch-lichen unteren molaren. *Zeitscrift für Morphologie Anthropologie,* No 17, 605–10.

Campbell, T.D. (1925) *Dentition and the palate of the Australian aboriginal*. Keith Sheridan Foundation, Adelaide publication 1.

Curzon, M.E.J. (1973) Three-rooted mandibular permanent molars in English Caucasians. *Journal of Dental Research,* No 52, 181.

Curzon, M.E.J. (1974) Miscegenation and the prevalence of three-rooted mandibular first molars in the Baffin Eskimo. *Community Dentistry and Oral Epidemiology,* vol. 2, No 2, 130–131.

Curzon, M.E.J. and Curzon J.A. (1971) Three-rooted mandibular molars in the Keewatin Eskimo. *Journal of Canadian Dental Association*, No 37, 71-72.

Curzon, M.E.J. (1974) Three-rooted mandibular first permanent molars in Greenland Eskimo skulls. *Arctic*, vol. 27, No. 2, 150-153.

Çilingiroğlu, A. (1993) *Van Dilkaya Höyüğü Kazıları Kapanış*. XIV Kazı Sonuçları Toplantısı I, Page, 469-489.

De Souza-Freitas, J.A., Lopes, E.S., and Casati-Alvares, L. (1971) Anatomic variation of lower permanent molars in two ethnic groups. *Oral Surgery, Oral Medicine and Oral Pathology,* No 31, 274–278.

De Deus, Q.D. (1960) *Topografia da cavidade pulpar. Contribuição ao seu estudo*. Doctorate thesis, Belo Horizonte, Universidade de Minas Gerais.

Donnison F.S.V. (1970) *Burma*. London, UK, Ernest Benn Limited, 32–4.

Drennan M.R. (1929) The dentition of the Bushmen tribe. *Annals of South African Museum,* No 24, 61–87.

Drusini, A.G., and Swindler, D. R. (2009) Frequency and variation of three-rooted lower first permanent molars in precontact Easter Islanders and in Pre-Conquest Peruvians. *Dental Anthropology,* vol. 22, No 2,1-6.

Fabian H. (1928) Spezielle Anatomie des Gebisses. Leipzig: Werner Klinkhardt.

Fabra-Campos, H. (2007) Three canals in the mesial root of mandibular first permanent molars: a clinical study. *International Endodontic Journal,* vol. 22, No 1, 39 – 43

Ferraz, J.A.B. and Pecora, J.D. (1992) Three-rooted mandibular molars in patients of Mongolian, Caucasion and Negro origin. *Brazilian Dental Journal*, No 3, 113-117.

Grag A.K., Tewari, R.K, Kımar, A., Hasmi, S., Agrawal, N., Mishra, S.K. (2010) Prevalence of Three-rooted Mandibular Permanent First Molars among the Indian Population. *Journal of Endodontics,* vol. 36, No 8, 1302-1306.

Gulabivala K, Aung T.H., Alavi A., and Ng Y-L. (2001) Root and canal morphology of Burmese mandibular molars. *International Endodontic Journal*, No 34, 359–370.

Güleç, E. (1986) Van-Dilkaya Iskeletlerinin Paleoantropolojik Incelenmesi. Kültür Bakanlığı Anıtlar ve Müzeler Genel Müdürlüğü, IV. Araştırma Sonuçları Toplantısı, 369-380.

Güleç, E. (1989) Paleoanthropological structure of Van / Dilkaya dwellers: B.C. First Millenium-A.D. First Millenium. *Humanbiologia Budapestinensis*, No 19, 47-52.

Hjelmman, G. (1929) Morphologische Beobachtungen an den Zähnen der Finnen. *Acta Society of Medicine Fenn Duodecim,* No 11, 1–136.

Hochstetter, R.L. (1975) Incidence of trifurcated mandibular first permanent molars in the population of Guam. *Journal of Dental Research,* No 54, 1097.

Irish , J.D. (2005) Population continuity versus discontinuity revisited: dental affinities among Late Paleolithic through Christian era Nubians. *American Journal of Physical Anthropology*, No 128, 520-35

Jayasinghe, R.D. and Lun Li, T.K., (2007) Three-rooted first permanent mandibular molars in a Hong Kong Chinese population: a computed tomographic study, *Hong Kong Dental Journal*, No 4:90-3

Jones, A.W. (1980) The incidence of the three-rooted lower first permanent molar in Malay people. *Singapore Dental Journal,* No 5, 15–17.

Laband, F. (1941) Two years' dental school work in British North Borneo; relation of diet to dental caries among natives. *Journal of the American Dental Association*, No 28, 992–998.

Lau, E.G., Mohandas T.K., Shapiro, L. J., Slavkin, H.C., and Snead, M.L. (1989) Human and mouse amelogenin gene loci are on the sex chromosomes. *Genomics*, No 4: 162-168.

Leigh, R. W. (1929) *Dental Morphology and Pathology of Prehistoric Guam*. Memoirs of the Bernice P. Bishop Museum, 1 I, no 3.

Loh, H.S. (1991) Mongoloid features of the permanent mandibular second molar in Singaporean Chinese. *Aust. Dent. J.*, vol. 36, No 6, 442-444

Lovell, N. C. and Scott Haddow, S. (2006) Nonmetric analysis of the permanent dentition of Bronze Age Tell Leilan, Syria. *International Journal of Dental Anthropology* 9,1-7.

Luciane, F., Da, C.R., and Manoel, D.S.N. (1996) External and Internal Anatomy of Mandibular Molars, *Brazilian Dental Journal*, vol. 7, No 1, 33-40.

Lukacs, J. R. (1983) Dental anthropology and the origins of two Iron Age populations from northern Pakistan. *Homo*, vol. 34, No 1, 1-15.

Lukacs, J.R. (1988) Dental morphology and odontometrics of early agriculturalists from neolithic Mehrgarh, Pakistan. In *Teeth Revisited, Memoires du Museum d'Histoire Naturelle (Paris),* D.E. Russell, J.P. Santoro, and D. Sigogneau-Russell (eds), Serie 53:287-305

Matshes, E.W, Juurlink, B., Sher, B., Mohamed, A., and Juurlink, B. (2005) *Human Osteology and Skeletal Radiology: An Atlas and Guide.* University of Saskatchewan, Saskatoon-Canada, Florida-USA.

Merbs, C. F. (1969) Quoted as personal communication in ref. 3.

Ming-Gene, T., Chi-Cheng, T., Ming-Jia, J., Lie C., Yu-Fang, C., San-Yue, C., and Hui-Wen, C. (2007) Prevalence of three-rooted mandibular first molars among Taiwanese individuals. *J Endodontics,* No 33, 1163-1166.

Ming G.T., Jeng F.L., Pei W.D., San Y.C., Jui T.H., Heng L.H. (2010) Prevalence of Three-rooted Primary Mandibular First Molars in Taiwan. *J. Formos. Med. Assoc*. vol., 109, No 1, 69-74.

Nelson, C. (1938) The Teeth of the Indians of Pecos Pueblo. *Am. J. Phys. Anthrop*., No 23, 261- 293.

Özbek, M. (2007) *Dişlerle Zamanda Yolculuk*. Hacettepe Üniversitesi Yayınları, Ankara.

Özer, İ. (1999) *Dilkaya (Van) Populasyonunun Diskriminant Fonksiyon Analizi ve Anadolu Toplulukları Arasındaki Yeri.* Ankara Üniversitesi S.B.E. Yayınlanmamış Doktora Tezi, Ankara.

Pedersen, P.O. (1949) The East Greenland Eskimo dentition. Numerical Variations and Anatomy. Copenhagen: C. A. Retzels Forlag *Meddelelser Om Gronland,* 142, 141.

Peiris, R., Pitakotuwage, N. ,Takahashi, N., Ohzeki, S., Nakayama, M., Sakurai, S., Igarashi, Y., Matsuno, M., Sasaki, K., Satake,T., Kanazawa, E. (2009) Mandibular permanent second molar with four roots and root canals: a case report. *Odontology,* No 97:51–53.

Pucci, F.M. and Reig, R. (1944) Conductos Radiculares. Barreiro y Ramos, Montevideo, vol 1.

Rashid, A.M. and Suliman A.A. (2006) Incidence of third root in mandibular permanent first molar: An endodontic challenge. *Al–Rafidain Dent J*. vol., 6, No 2, 194-198.

Reichart, P.A. and Metah, D. (1981) Three-rooted permanent mandibular first molars in the Thai. *Community Dentistry and Oral Epidemiology,* vol., 9, 191–192.

Rou, J.W., Digu, M.H., Lee, IC., Huang, T.J. and Roan, RT. (1994) Root canal system of mandibular permanent molars in a Chinese population (Abs). *Journal of Endod*. vol., 20, No 4, 208-211.

Scott, G.R. and Turner II, C.G. (1997) *The anthropology of modern human teeth, Dental morphology and its variation in recent human populations*. Cambridge University Press.

Sevin, V. (2005) Urartu Devleti, Doğu Anadolu Demir Çağı. *Arkeoatlas*, No 4, 1-162

Skidmore A.E. and Bjorndal A.M. (1971) Root canal morphology of the human mandibular first molar in Singaporean Chinese. *Oral Surgery, Oral Medicine, Oral Pathology*, vol. 32, No 5, 778-784.

Shaw, J.C.M. (1931) *The teeth, the bony palate and the mandible in Bantu races of South Africa*. London, UK: John Bale, Sons & Danielson

Skidmore, A.E. and Bjorndahl A.M. (1971) Root canal morphology of the human mandibular first molar. *Oral Surgery, Oral Medicine and Oral Pathology* 32, 778–84.

Sperber, G.H. and Moreau, J.L. (1998) Study of the number of roots and canals in Senegalese first permanent mandibular molars. *International Endodontic Journal,* No 31, 112–116.

Sousa-Freitas, J.A, Lopes E.S., and Casati-Alvares L. (1971) Anatomic variations of lower first permanent molar roots in two ethnic groups. *Oral Surg*, No 31, 274-278.

Somogyi-Csizmazia, W. and Simons, A.J. (1971) Three-rooted mandibular first molars in Alberta Indian children. *Canadian Dental Association Journal,* No 37, 105–106.

Taylor, A.E. 1899. Variations in the human tooth-form as met with in isolated teeth. *J. Anat. Physiol.*, No 33:268-272.

Teixeira, L.D. (1963) *Anatomia dentária humana*. Imp Univ Minas Gerais, Belo Horizonte.

Tratman, E.K. (1938) Three-rooted lower molars in man and their racial distribution. *Br. Dent. J.*, No 64, 264-274.

Turner, C.G. II (1990) Major Features of Sundadonty and Sinodonty including suggestions about East Asian microevolution, population history and Late Pleistocene relationships with Australian Aboriginals. *Am. J. Phys. Anthropol*., No 82, 295-317.

Turner, C.G. (1971) Three-rooted mandibular first permanent molars and the question of American Indians' origins. *American Journal of Physical Anthropology,* No 34, 229–242.

Ubelaker, D.H. (1989) *Human skeletal remans: Excavations, analysis, interpretation*. 2nd ed. Manuals on Archeology, Smithsonian Institution, Washington, DC.

Varrela, J. and Alvesolo, L. (1989) Taurodontism in Females with Extra X Chromosomes. *J.Craniofac. Genet. Dev. Biol*., No 9, 129-133.

Vertucci, F.J. (1984) Root canal anatomy of the human permanent teeth. *Oral Surgery, Oral Medicine and Oral Pathology,* No 58, 589–599.

Vertucci, F.J. and Williams, R.G. (1974) Root canal anatomy of the mandibular first molars. *Journal of the N. J. Dental Association*, No 45, 27–28.

Walker, R.T. (1988) Root form and canal anatomy of mandibular first molars in a Southern Chinese population. *Endodontics and Dental Traumatology*, No 4, 19–21.

Walker, R.T. and Quackenbush, L.E. (1985) Three-rooted lower first permanent molars in Hong Kong Chinese. *British Dental Journal* 159, 298–299.

White,T.D.,(2000) Human Osteology. University of California, Berkley, California

Yew, S.C. and Chan, K. (1993) A retrospective study of endodontically treated mandibular first molars in a Chinese population. *Journal of Endodontics,* No 19, 471–473.