International Journal of Archaeology
2025, Vol. 13, No. 2, pp. 171-177
https://doi.org/10.11648/j.ija.20251302.14

Research Article

Single Root Molars- Prevalence in Modern Population and Its Relation to Dental Evolution

Sherman Maayan, Maatuk Avraham, Ben-Shitrit Librush Michal, Hershkovitz Fanny, Zilberman Uri*

Pediatric Dental Unit, Barzilai Medical University Center, Ashkelon, Israel

Abstract

Background and Aim: Anatomic variation in root morphology of permanent molars that have been reported pertain to the presence of additional roots, canals or fused roots and C-shaped canals. The occurrence of a single root in molars (SRM) is rare. The aim of the study was to determine the prevalence of single root molar in a large sample of Israeli population and to correlate the crown size of SRM to dental evolution of *HS*. *Methods:* 2425 panoramic radiographs of modern healthy patients were examined on a light table and the prevalence of SRM was determined. The crown width (MD) of the mandibular second molars of normal two rooted molars, single root molars and homologue two-rooted molars were measured using a digital caliber on a light table. The results of the crown width were compared to anthropological populations (Early *HSS* and Neanderthals) and archeological population from excavations in Israel from 3000 BC to 13-19 century AC. *Results:* The prevalence of single root molars in the modern population was 6.13%. No significant differences were found between males and females. In the upper jaw single root molar was found in both first and second molars while in the lower jaw only second molars showed SRM. In both the Neanderthal and Early *HSS* groups 1 case with single root molars were found. No single root molars were found in the archeological groups from Israel excavations (3000 years BC till 19th century AC). The size of the crown was relatively stable during evolution but during the modern period the MD size of the crown was significantly reduced. The crowns of the molars with single root showed significant reduction in comparison to two-rooted molars and even to homologues molars with two roots and the differences were significant statistically (P value<0.01). The homologue two-rooted second molars showed results between the normal population and single root molars. *Discussion:* This is the first analysis of the prevalence of single root molar in a large population of Israel. The results showed that the crown size is decreasing during the modern period and this reduction is increasing in single root molars, implicating that an on-going reduction in tooth size is happening, probably due to reduction of jaw size and the major changes in food processing and mastication forces.

Keywords

Single Root Molars, Dental Evolution, Crown Size, Inter-apices Distance, Neanderthals, Early *Homo sapiens sapiens*

*Corresponding author: uriz@bmc.gov.il (Zilberman Uri)

Received: 5 October 2025; **Accepted:** 20 October 2025; **Published:** 26 November 2025

1. Introduction

Variations in root morphology occurs during tooth development is due to alterations in the function of Hertwig's epithelial root sheath (HERS). HERS is derived from the cervical loop of the enamel organ, derived from ectoderm tissue, and is thought to be responsible for root number, shape and length [1]. The HERS extends apically, interacting with the mesenchyme cells of the developing canal structures, and differentiating into odontoblasts and cementoblasts responsible for dentin and cementum production [2]. Inter-radicular processes, finger like protrusions are released from the HERS and are responsible for the formation of multiple secondary foramina, which in turn forms multiple tooth roots [3]. Disturbances in the formation of the HERS and the inter-radicular processes results in abnormalities in root number and shape [4]. The relation of root number and number of canals in modern population showed that root number is dependent on canal number and this relationship becomes more variable as canal number increase [5]. The ratio of canal number to root number is an important indicator of variation in dental phenotypes [6]. During hominin dental evolution root length and dental tissue volume proportion in mandibular molars were related to different occlusal loading regime in Neanderthals compared with both recent and Pleistocene *Homo sapiens* [6].

Today, description of the number of roots and root canal anatomy in molars is performed mainly for endodontic reasons. A thorough knowledge of root canal anatomy is necessary to achieve appropriate cleaning and shaping of the root canal system and ensure success of endodontic treatment [7]. In a multi-center cross-sectional study with meta-analysis of root morphology of maxillary permanent first molars, prevalence of single-root molar was 0.16%, and four-rooted configuration was 0.28%, while in second molar the prevalence of single-root molar was 2.56% and prevalence of four-rooted molar was 0.83% [8]. Single root molars (SRM) cases were described as astounding occurrence in deciduous molars [9-12], and as rare cases or occurrence in permanent molars [13-15].

The aim of this research was: A. To analyze the prevalence of permanent single root molars in a large population from Israel and to evaluate the relation of single root molars in the mandible with crown width in comparison to multiple rooted molars and to homologues molars and, B. To compare the crown width and distance between apices of multiple rooted mandibular molars in the modern population with archeological populations from Israel (3000 years BC-1900 years AC) and to archaic hominins (*Homo sapiens sapiens* and Neanderthals).

2. Materials and Methods

2.1. Populations Examined

Modern Israelis- 2643 panoramic X-rays of healthy young adolescents (age >16 years) performed during regular dental treatment were examined by the same person on a light table. Only cases with all first and second molars and with full formation of the apices were included. 218 cases were excluded due to missing molars. A total of 2425 cases were included in the research.

Archeological population from Israel: X-rays of 174 mandibles were examined (from the ancient to the modern): 9 cases from Kisufim (3000 years BC), 6 cases from Jabel Kakir (2000 years BC), 8 cases from Sasa and Beit Marsin (1600 years BC), 25 cases from Achziv (600-800 years BC), 70 cases from Wadi Dalia (200 years BC), 6 cases from Hirbet madras (100 AC) and 50 cases from Dor (1300-1900 AC).

Early hominin populations: X-rays of 18 mandibles of Early *Homo sapiens sapiens* (Abri Pataud, Bruniquel la Faye, Bruniquel les Forges, Fontechevaide, Haua Fteah, Lachaud, Laugerie Basse, La Madaleine, La Pique, Le Marin AIII, Le Placard, Le Roc de Sers 75113, Les Rois, Miesslingtal 22034, Parpalo, Roc de Cave, Saint Germain la Riviere, Qafze 4) and 11 mandibles of *Homo sapiens neanderthalensis* (Archi, Bruniquel la Faye 24, Ehrinsdorf, Krapina C, Krapina D, La Chaise 13, Malarnaud, Mieslingtal 22034, Montgaudier, Petit Puymoyen 1, Petit Puymoyen 2) were examined. The X-rays of archeological and archaic population were from the collection of Prof. Patricia Smith, Lab Bioanthropology and ancient DNA, Hebrew University, Jerusalem. All X-rays of the archaic populations were performed by the same examiner. The radiographs were taken by applying the film parallel to the major axes of the teeth, the parallel film technique. The focus-film distance was 23 cm. The amount of radiation was consistent with obtaining the sharpest photographic image possible. Only radiographs without overlapping of adjacent teeth and with full overlapping of buccal and lingual cusps were used [16].

2.2. Methods

The first and second maxillary and mandibular molars of the modern, archeological and archaic population were examined by residents (SM, MA, SLM) during specialization in pediatric dentistry and specialized pediatric dentists (HF, ZU) from the Pediatric dental clinic, Barzilai Medical University Center, Ashkelon, to determine the presence of single root molar. On the mandibular molars from all periods the crown maximal mesio-distal width and the distance between the root apices in two rooted molars with fully developed apices were measured on a light table using a digital caliber by calibrated residents in pediatric dentistry (SM, MA, SLM) (Figure 1). The crown width and the distances between apices were compared between all populations.

In cases with single root molars only the crown width was measured. The crown width of single root molars were compared to the results for all populations and to the results of homologue teeth in the same mandible, and the distances between apices of two-rooted molars were compared between all populations and to homologue teeth of single root molars.

Figure 1. Measurement of crown width and inter-apices distance.

2.3. Statistical Analysis

We conducted all statistical analyses using R version 4.1.0 (2021-05). Tooth width and apex distances across different archeological and archaic periods were summarized as means and standard deviations, while the number of observations in each period, and the number of individuals with a single-root molar, were summarized as counts and percentages.

We compared mean tooth crown width and apex distances for the 1st and 2nd mandibular molar teeth between different modern, archeological and archaic periods using a one-way ANOVA test to assess overall differences. We also conducted Bonferroni post-hoc tests to determine pairwise differences between specific periods while controlling for multiple comparisons.

Additionally, we compared the tooth crown width in the modern population between two-rooted molars, single root molars and the homologue molars of single roots teeth, using one-way ANOVA. We also compared the apex distances between normal teeth and homologue teeth of single root molars, using independent samples t-test.

3. Results

In the modern population, single root molars were found in 162 out of 2425 cases, a prevalence of 6.68%. Out of the 162 cases with single root molars, 71 cases showed only one molar with single root (43,83%), 58 cases showed 2 molars with single root (35.8%), 18 cases with three single root molars (11.11%), 14 cases with 4 single root molars (8.64%) and one case with 5 single root molars (0.62%) (Figure 2). In the modern population, 94 cases of single root molars were in the maxilla (58.02%), 27 cases with in the mandible (16.67%) and 41 cases with single root molars in both jaws (25.31%). 99 of the cases were of females (61%) and 63 cases of males (39%).

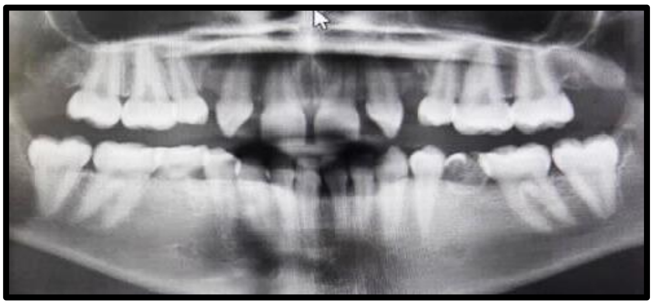

Figure 2. The case with five single root molars. Note: Missing four second premolars and two upper lateral incisors.

Figure 3. Neanderthal case with SRM, 1st molar- Mountgaudier.

Figure 4. Early HSS with SRM- 2nd molar- Le Placard.

In the archeological populations no single root molars were found. In the archaic populations one case with single root was found in the Neanderthals group, Mountgaudier (Figure 3), and one in the early *HSS*, Le Placard (Figure 4).

Crown width and distance between apices in two rooted molars were measured in 437 first mandibular molars and 489 second mandibular molars across 10 periods. Most first molar measurements were from the Modern period (223 cases, 51.3%), followed by 200 B.C (70 cases, 16.0%), 1300-1900 A.C (46 cases, 10.5%), 600-800 B.C (25 cases, 5.7%), Early HSS (29 cases, 6.6%), Neanderthal (16 cases, 3.7%), 1600 B.C (8 cases, 1.8%), 3,000 B.C (7 cases, 1.6%), 2,000 B.C (6 cases, 1.4%), and 100 A.C (6 cases, 1.4%). For the second mandibular molar, the highest numbers of measurements were also from the Modern period (306 cases, 62.6%), followed by 200 B.C. (61 cases, 12.5%), 1300-1900 A.C. (50 cases, 10.2%), 600-800 B.C. (25 cases, 5.1%), and Early HSS (18 cases, 3.7%). Smaller proportions were observed in 3,000 B.C. (9 cases, 1.8%), Neanderthals (8 cases, 1.6%), 2,000 B.C. (5 cases, 1.0%), 1600 B.C. (3 cases, 0.6%), and 100 A.C. (4 cases, 0.8%).

3.1. First Mandibular Molar- Crown Width and Inter-Apices Distance

Crown width significantly declined over time (Table 1, $p < 0.001$). Neanderthals had a mean width of 11.80 ± 0.83 mm, similar to Early HS (11.67 ± 0.78 mm). Bronze Age populations showed larger crowns (12.74 ± 0.47 mm in 1600 B.C.), while the Iron Age and Classical periods had relatively stable values (12.22–12.55 mm). The decline became evident in the late medieval period (12.18 ±0.66 mm) and continued into the Modern period, where the smallest crown width dimensions were recorded (10.24 ± 0.85 mm).

Apex distance also significantly decreased ($p < 0.001$, Table 1). The Modern period had the shortest apex distance (5.22 ± 1.35 mm), while earlier populations exhibited larger distances (e.g., 6.72 ± 1.42 mm in 1300-1900 A.C., 6.29 ± 1.64 mm in 3000 B.C.). Neanderthals had the smallest apex distance among prehistoric groups (4.81 ± 1.22 mm), while Early HSS measured 5.71 ± 1.10 mm.

Table 1. *Summary Statistics of Crown Width and Distance Between Apices –1st mandibular molar. Note the significant difference between the modern population and the archeological and anthropological populations (P < 0.001).*

Period	Sample Size	Mean Tooth Width	SD Tooth Width	Median Tooth Width	IQR Tooth Width	Mean Apex Distance	SD Apex Distance	Median Apex Distance	IQR Apex Distance
Modern	223	10.24	0.85	10.23	8.13 - 12.7	5.22	1.35	5.07	1.8 - 9.32
1300-1900 A.C	46	12.18	0.66	12.00	11 - 13.8	6.72	1.42	6.70	3.9 - 9.5
100 AC	6	12.55	0.62	12.75	11.5 - 13.1	5.17	0.80	5.10	4 - 6.5
200 BC	70	12.19	0.51	12.20	11 - 13.7	5.83	1.35	6.00	1.5 - 8.9
600-800 BC	25	12.22	0.70	12.20	9.6 - 13.4	6.54	1.48	6.70	3.5 - 11
1600 BC	8	12.74	0.47	12.85	12 - 13.3	6.53	0.84	6.50	5.2 - 8
2,000 BC	6	12.35	0.67	12.45	11.5 - 13.2	5.83	1.13	5.75	4 - 7
3,000 BC	7	12.17	0.58	12.00	11.2 - 13	6.29	1.64	6.00	3.7 - 8.8
Neanderthal	16	11.80	0.82	11.25	10.2 - 13	4.81	1.22	4.65	3.1 - 7.3
Early HSS	29	11.67	0.78	11.20	9 - 12.8	5.71	1.10	5.80	3.3 - 7.2

3.2. Second Mandibular Molar- Crown Width and Apex Distance

Crown width significantly declined over historical periods ($p < 0.001$, Table 2). Neanderthals had a mean width of 12.50 ± 0.82 mm, the largest crowns, while Early HSS measured 11.41 ± 0.51 mm. Bronze Age values were relatively high (12.48 ± 0.41 mm in 2000 B.C.), comparable to the Neanderthals, followed by stable measurements in the Iron Age and Classical periods (11.82–12.30 mm). A gradual decline was observed from the late medieval period (11.69 ± 0.73 mm) to the Modern period (9.99 ± 0.89 mm).

Apex distance significantly decreased ($p < 0.001$, Figure 2), showing a consistent reduction over time. Neanderthals measured 4.08 ± 1.91 mm, Early HSS 3.42 ± 1.41 mm, and Bronze Age populations around 5.00 mm. The Modern period had the shortest mean apex distance (2.70 ± 2.09 mm).

***Table 2.** Summary Statistics of Crown Width and Distance Between Apices – 2nd mandibular molar. Note the significant difference between the modern population and the archeological and anthropological populations (P< 0.001).*

Period	Sample Size	Mean Tooth Width	SD Tooth Width	Median Tooth Width	IQR Tooth Width	Mean Apex Distance	SD Apex Distance	Median Apex Distance	IQR Apex Distance
Modern	306	9.99	0.89	9.89	7.74 - 12.04	2.70	2.09	2.82	0 - 8.93
1300-1900 A.C	50	11.69	0.73	11.95	10 - 12.8	4.81	1.60	5.00	0 - 7.8
100 AC	4	12.30	0.08	12.30	12.2 - 12.4	4.62	0.57	4.65	4 - 5.2
200 BC	61	12.02	0.58	12.00	10.9 - 13.5	3.84	1.38	3.50	1.7 - 7.3
600-800 BC	25	11.82	0.50	12.00	10.9 - 12.5	4.96	1.18	5.00	2.3 - 7.5
1600 BC	3	12.07	0.81	12.20	11.2 - 12.8	5.03	1.45	5.00	3.6 - 6.5
2,000 BC	5	12.48	0.41	12.50	12.1 - 13.1	5.00	1.58	5.00	3 - 7
3,000 BC	9	11.90	0.78	12.10	10 - 12.7	3.86	1.69	3.40	1.8 - 7
Neanderthal	8	12.50	0.82	11.05	9 - 13	4.08	1.91	4.55	0 - 6
Early HSS	18	11.41	0.81	11.00	9.6 - 12.5	3.42	1.41	3.65	0 - 5.4

3.3. Single-root Molars Analysis

Among the 429 second-molar measurements from the Modern period, 84 individuals (16.3%) had a single-root molar. A significant reduction in crown width was observed across modern groups (two rooted molars> homologous molars of single root molars > single root molars) ($p < 0.001$, Table 3, Figure 3): 10.2 ±0.82 mm in the modern two rooted group, 9.58 ±0.80 mm in the homologue group, and 9.36 ± 0.78 mm in the single root molar group.

A significant reduction in inter-apices distance was also observed between the modern two rooted molars and homologue group of single root molars ($p < 0.001$, Table 3), with mean distances of 3.69 ±1.53 mm and 1.90 ±1.09 mm, respectively.

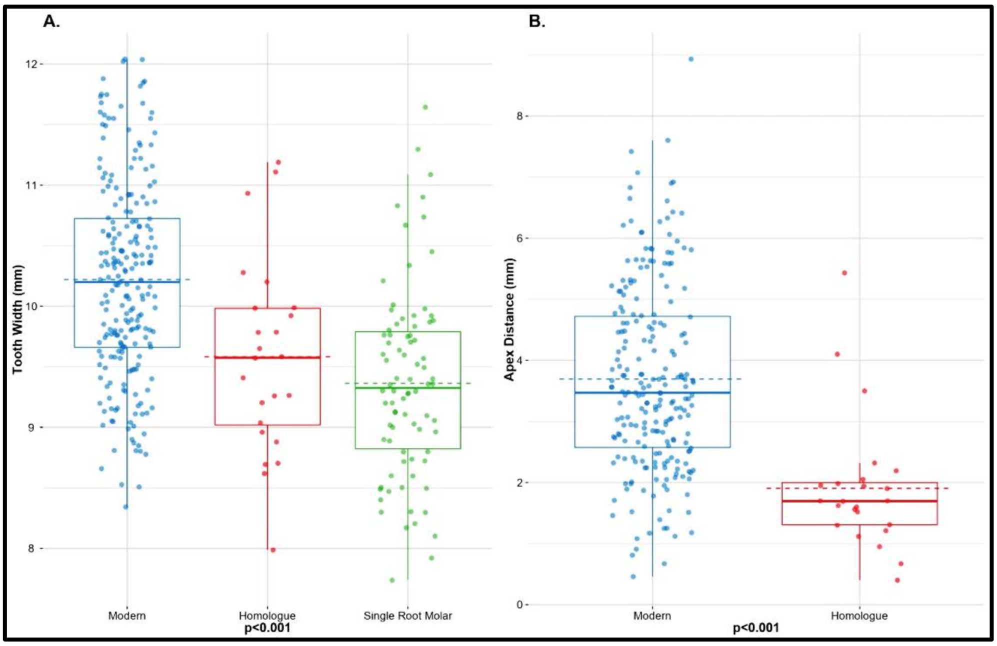

***Figure 5.** A. Mandibular second molars crown width in modern two rooted teeth in comparison with single root molars and homologue teeth of single root molars. B. Inter apices distances between two rooted molars and homologue teeth of single root molars cases. Note the P value between groups (0.001).*

***Table 3.** Comparison of Tooth Width and Apex Distance between Modern, Homologue teeth of single root molars and Single Root Second Mandibular Molar. The differences are significant statistically (P<0.001).*

Group	Sample size	IQR Crown Width	Median Crown Width	SD Crown Width	Mean Crown Width	IQR Apex Distance	Median Apex Distance	SD Apex Distance	Mean Apex Distance
Modern	224	8.34-12.04	10.21	0,82	10.22	0.46-8.93	3.46	1.53	3.69
Homologue	24	7.99-11.19	9.57	0.80	9.58	0.40-5.43	1.69	1.09	1.90
Single Root Molar	82	7.74-11.64	9.32	0.78	9.36				

4. Discussion

In studies of tooth-jaw relations in human populations, crown size and root size or form showed low correlation [17]. In humans the molar teeth withstand the heaviest masticatory loading that may influence root number and distance between apices for better support, but studies showed that crown size does not correlate with root size and number in humans [18, 19]. Variations in root size and distance between apices may arise also from space in the developing jaws. Mandibular first molar is the first to erupt and have no restriction in developing two roots with large distance between apices, as observed in our study where no single root molar was found in the first mandibular molars in the modern population. But there is some correlation between crown mesio-distal width of the crown and the distances between apices in the populations measured. The modern population with the smallest crown size showed also the smallest distance between apices in first molar. In the second molar there may be restriction in the jaw size for root development and in our study single root molars were found only in mandibular second molars in the modern populations, and also the smallest crown width was related to smallest distance between apices. The crown size of the teeth with single root was the smallest in the modern population. More than that, in cases where single root molar was found only in one side of the jaw, the homologue tooth, although with two roots, the crown size showed a reduction in comparison to the mean of crown size in the population- the crown width was between the mean in the population and width in the single root molars. More than that, the distance between apices in the homologue tooth was reduced in comparison to the mean size in modern population, implicating a restriction in jaw size in these cases. The neanderthals showed larger crown width in both first and second molars in comparison to early HSS, but the distances between apices in the first molars were smaller than the distance in HSS. In the second molar the inter-apices distance was larger than the distance in HSS and the crown size very large. These results are probably due to excess masticatory force in the second mandibular molars, indicating a distinct occlusal loading regime [6]. The neanderthals have also very peculiar and specific tooth components in the first permanent and second deciduous molars that differs from early *HSS*, thinner enamel and taurodont pulp due to delayed furcation formation. Both findings are results due to ectodermal derived tissues alteration. Reduced enamel formation is due to early cessation of ameloblast activity and taurodontism is due to delayed HERS invaginations [16, 20]. In the archeological periods from Israel, the largest crown size and distance between apices were measured in the first mandibular teeth. The second molars showed smaller crown sizes compared to the first molars, but the reduction in inter-apices distance in the second molars was very significant, probably due to jaw size restriction in these populations.

This research showed that the major crown size reduction occured in the modern period in Israeli population in comparison with archeological and anthropological populations and probably due to jaw size restriction that affected also the inter apices distance of molars. These findings shows that the occlusal loading regime in modern population differs significantly from archeological and archaic population due to diet changes and reduced masticatory function.

5. Conclusions

There is a gradual reduction od crown width during hominin evolution, mainly during the modern period.

Single root molars is not a novel finding- we found cases with single root molars in Neanderthals and in early *HSS*.

In modern population, there is a reduction of crown width between two-rooted molars, homologues molars of single root molars and single root molars.

This reduction may be due to reduced occlusal forces and restriction of mandibular space for second molar development.

6. Recommendation

More researches are needed with large groups of modern populations from other countries and different continents to understand the evolution of the jaws and crown size, in order to understand the effect of bone restriction and changes in masticatory forces.

Abreviations

SRM	Single Root Molars
HERS	Hertwig's Epithelial Root Sheath
HSS	*Homo sapiens sapiens*
Neanderthals	*Homo sapiens neanderthalensis*

Conflict of Interest

The authors declare no conflicts of interest.

References

[1] Miller N (2013). In: Nanci A (Ed.) *Ten Cate's oral histology*, 8th edition, St Louis, MO: Mosby.

[2] Li J, Parada C, Chai Y (2017). Cellular and molecular mechanism of root development. Development, 144: 374-384. https://doi.org/10.1242/dev.137216

[3] Orban BJ, Bhaskar SN (1980). *Orban's Oral histology and embryology*, 9th edition, St. Louis, MO: Mosby.

[4] Luder HU (2015). Malformations of the tooth root in humans. Frontiers in Physiology, 6, 307. http://doi.org/10.3389/fphys.2015.00307

[5] Gellis JJ, Foley RA (2020). Patterns of variation in canal and root number in human post-canine teeth. Journal of Anatomy 241: 896-918. https://doi.org/10.1111/joa.13729

[6] Kupczik K, Hublin JJ (2010). Mandibular molar root morphology in Neanderthals and Late Pleistocene and recent Homo sapiens. *Journal of Human Evolution* 59: 525-541. https://doi.org/10.1016/J.jhevol.2010.05.009

[7] Ingle JI, Bakland LK, Baumgartner JC. *Endodontics*. C Deker ed. Hamilton, Canade, 6th edition 2008.

[8] Martins JNR, Versani MA (2024). Worldwide prevalence of single-rooted with single root canal and four-rooted configurations in maxillary molars: a multi-center cross-sectional study with meta-analysis. *Journal of Endodontics* 50: 1254-1272. https://doi.org/10.1016/j.joen.2024.06.010

[9] Prakash S, Sharma V, Khan W, Saraf BG, Sheoran N, Shaw M (2024). Deciduous mandibular first molar with single root and single canal: an astounding occurrence. *International Journal of clinical Pediatric Dentistry*. 17: 198-201. http://doi.org/10.5005/jp-journals.10005.2743

[10] Haridoss SK, Swaminathan K, Rajendran V, Rajendran B (2014). Single-rooted primary first mandibular molar. *BMJ Case Reports*. http://doi.org/10.1136/bcr.2014.206347

[11] Chaudhari P, Mallikarjuna R, Swadas M, Dave B (2013). Unilateral single-rooted primary mandibular first molar. *BMJ Case Reports*. http://doi.org/10.1136/bcr.2013.2000034

[12] Jevanandan G, Subramanian EMG, Muthu MS (2012). Single-rooted primary first molars. *Indian Journal of Dental Research*. 23: 104-106.

[13] Ujariya U, Bharatiya R, Kohtari A, Shah V, Parikh M, Pandey K, Mehta D, Amin N (2022). A rare occurrence of bilateral single-rooted mandibular first molar. *Case Reports in Dentistry*. http://doi.org/10.1155/2022/1175630

[14] Koul M, Shahi M, Abdullah A, Upadhyay V (2017). A rare case of three single-rooted permanent second molars: A diagnosis with cone beam computed tomography (CBCT). *Journal of Oral Biology and Craniofacial Research*. 7: 137-140. http://doi.org/10.1016/j.jobcr.2017.04.003

[15] Sooriaprakas C, Ballal S, Velmurugan N (2014). Mandibular first molar with a single root and single canal. *Case Reports in Dentistry*. http://doi.org/10.1155/2014/159846

[16] Zilberman U, Smith P (1992). A comparison of tooth structure in Neanderthals and early *Homo sapiens sapiens*: a radiographic study. *Journal of Anatomy* 180: 387-393.

[17] Smith P, Wax Y, Adler R, Silberman U, Heinic G (1986). Post Pleistocene changes in tooth, root and jaw relationships. American Journal of Physical Anthropology. 70: 339-348.

[18] Ledogar JA, Dechow PC, Wang Q et al (2016). Human feeding biomechanics: performance, variation and functional constrain. *Peer J*, http://doi.org/10.7717/peerj.2242

[19] Shields ED (2005). Mandibular premolar and second molar root morphological variation in modern humans: what root number can tell us about morphogenesis. American journal of physical Anthropology, 128: 299-311. https://doi.org/10.1002/ajpa.20110

[20] Zilberman U, Skinner M, Smith P (1992). Tooth components of mandibular deciduous molars of *Homo sapiens sapiens* and *Homo sapiens neanderthalensis*: a radiographic study. American Journal of Physical Anthropology 87: 255-262.