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Mandibular Molar (M1, M2 and M3) Crown Morphometrical Variations from Prehistoric Human Population to Present-Day Sri Lankans

Variaciones Morfométricas de la Corona de los Molares Mandibulares (M1, M2 y M3) Desde la Población Humana Prehistórica Hasta los Habitantes Actuales de Sri Lanka

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SUMMARY: Teeth serve as invaluable sources of information in forensic and archaeological studies for understanding past human populations. Their morphological and morphometric variations, along with sexual dimorphism, provide insights into evolutionary and population differences. The present research aimed to evaluate the variability and indices of mandibular molar crowns—first (M1), second (M2), and third (M3) molars—among prehistoric humans (dating from approximately 5,000 to 36,000 BCE) and present-day Sri Lankans. The study analyzed mandibular molar teeth from eleven prehistoric adult mandibles (five male and six female) and 80 molar teeth from modern Sri Lankan individuals. Two major crown diameters—bucco-lingual (BL) and mesio-distal (MD)—were measured using a digital vernier caliper accurate to 0.01 mm. Using these dimensions, crown index (CI), crown area (CA), and crown module (CM) were calculated. Results revealed that, among prehistoric males, the right first molar (M1) had the largest BL and MD diameters compared to M2 and M3 teeth, showing a decreasing trend from M1 > M2 > M3 on both sides. Similarly, crown area, crown index, and crown module values were highest for the right M1 molar. Overall, prehistoric male mandibular molars showed greater MD, BL, CA, CI, and CM values than those of modern Sri Lankans. Statistically significant differences ($p < 0.005$) were observed in the right M2 and left M3 molars of prehistoric males compared with present-day individuals. In females, the right M3 molar of prehistoric mandibles also showed significantly higher values ($p < 0.005$) than modern counterparts. These findings indicate a clear reduction in molar crown size and indices from prehistoric to present-day Sri Lankans, suggesting evolutionary or environmental influences on dental morphology across millennia.

KEY WORDS: Mandibular molar teeth; Prehistoric humans; Morphometry; Present- day Sri Lankan population.

INTRODUCTION

Teeth are a valuable source of information for studies on past extinct human populations as their preservation is unique due to its hard tissues such as enamel, dentine, and cementum (Gómez-Robles *et al*., 2015). In physical anthropology, teeth have been examined using a variety of approaches, including the estimation of age at death (Bertrand *et al*., 2019), the use of dental wear and calculus as bioindicators of diet (Cummings *et al*., 2018), cultural changes (Smith-Guzmán *et al*., 2020), dental pathologies (Wasterlain *et al*., 2020), and linear measurements of tooth crowns employed to evaluate sexual dimorphism and morphometrical variations in both extant and extinct human populations (Gómez-Robles *et al*., 2015) and dental variability among present-day humans and extinct humans (Brook *et al*., 2009). The study of molar teeth's size, shape, and structural characteristics is known as molar dental morphometry. Many studies have shown that dental morphology and morphometry are significantly influenced by genetic, environmental, and epigenetic variables (Farzin *et al*., 2020).

In order to comprehend evolutionary relationships, population dynamics, and the diets of ancient humans and other hominins, molar dental morphometric analysis in

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prehistoric contexts entails examining the size, shape, and proportions of teeth, especially molars (Farzin *et al*., 2020). This kind of analysis quantifies and compares dental traits using a variety of techniques to identify trends of variation and divergence throughout time. In order to generate a digital representation of the shape of teeth and enable statistical analysis of shape variations, geometric morphometrics uses landmarks and semi-landmarks on the occlusal surface of teeth.

Molar dental morphometric analysis in prehistoric contexts involves the study of the shape, size, and proportions of teeth, particularly molars, to understand evolutionary relationships, population dynamics, and the diets of ancient humans and other hominins (Gómez-Robles, *et al*., 2015). This type of analysis uses various methods, including geometric morphometrics, to quantify and compare dental features, revealing patterns of variation and divergence over time. Geometric morphometrics utilizes landmarks and semi-landmarks on the occlusal surface of teeth to create a digital representation of their shape, allowing for statistical analysis of shape differences. Classic morphometrics include measurements like cusp areas, angles, and occlusal polygon area are used to compare tooth morphology, particularly between different hominin species and populations. Allometric analyses examine the relationships between different molar sizes and proportions within a population or lineage (Gómez-Robles, *et al*., 2015).

Most studies of the tooth crown size variability of molar teeth are based on the measurement of the mesiodistal (MD) and bucco-lingual (BL) diameters (Ciorpac-Petraru *et al*., 2020; Yoo *et al*., 2016), although other alternative measurements have been reported (Hillson *et al*., 2005). Due to their sexual dimorphism and resistance to postmortem alteration process, teeth, by crown dimensions, are essential in assessing human evolutionary affinities, population variations when other skeletal parameters are not reliable (Ciorpac-Petraru *et al*., 2020). Although odontometric research was carried out in dental remains found in extinct human populations, those that lived in different prehistoric time durations in Sri Lanka, there are no reported studies to determine the variations of molar crown morphometry among prehistoric extinct humans and present-day Sri Lankans.

The prehistory of Sri Lanka spans the Palaeolithic, Mesolithic, and early Iron Ages and begins around 125,000 YBP (years before the present) and may extend up to 500,000 YBP (Deraniyagala, 1988). Despite the fact that the prehistoric human bones discovered in Sri Lanka are approximately 40,000 years old, the skeletal remains from 34,000 years and later are more complete and have better fossilization, which provides stronger evidence and more support for in-depth study.

According to Kennedy *et al.* (1987), the best and most complete hum an skeletal record sequence in South Asia may have been found in the prehistoric human skeleton remains that were excavated from Sri Lanka. Human dental remains among the skeletal remains have been discovered at prehistoric sites located in several climate zones of Sri Lanka (Kennedy *et al*., 1987; Deraniyagala, 1988) Belilena-Kithulgala (12,000 BP and 2700 BP), Belilena-Athula (27,000 BP-3,000 BP), Batadombalena - Kuruwita (31,000 BP, 28,500 BP, and 16,000 BP), Bellanbandi Palassa (6,500 BP), Alu Lena (10,500 BP), Miniatheliya (3,600 BP), Pellemalala (3,000 BP), and other prehistoric sites are among them (Kennedy *et al*., 1987; Deraniyagala, 1988; Kanthilatha, *et al*., 2012; Chandimal *et al*., 2019).

Bellanbandi Palassa, known as an open-air prehistoric site, is located in wet climate zone in the Rathnapura district of the Sabaragamuwa province in Sri Lanka. Numerous human skeletal remains, including 13 burials, were discovered at the site. The term "Balangoda Man," which refers to the prehistoric people that lived in Sri Lanka, may be studied largely from these skeletal remains (Deraniyagala, 1988; Kanthilatha, *et al*., 2012). The ancient shell midden site known as Pallemalala is located in the Hambantota district of the southern province, which is in the dry climate zone of the Sri Lanka. While doing archaeological research, the Postgraduate Institute of Archaeology at the University of Kelaniya discovered these Mesolithic bones. The remains, which included 233 distinguishable human bones, were examined and revealed evidence of at least seven individuals (Ranaweera & Adikari, 2022). A prehistoric cave site called Belilena Kithulgala is situated in the wet zone of the Kegalle district in the Sabaragamuwa province. The location contains the ten skeleton remains. Kennedy *et al.* (1987), claim that the oldest human remains found in Belilena date back to the archeological layer that is 16,000 years old. Batadombalena Kuruwita, a well-known ancient cave site, is located in the Rathnapura district of Sabaragamuwa province, which is the wet zone of the country 1981, skeleton fragments of adults and children were found during excavations at Batadombalena. These remains are believed to represent the Balangoda Man, an extinct hominid species that lived only in Sri Lanka (Kennedy *et al*., 1987). In the intermediate zone of Potana, Sigiriya, an ancient cave site in the Matale district of the Central province, two full human skeletons and one incomplete skeleton belonging to a single individual have been identified (Chandimal *et al*., 2019).

Several morphological and morphometrical studies have been conducted to determine the crown dimensions and indices of morphological variations of dental remains excavated from these prehistoric sites Batadombalena, Belilena, Bellanbandi Palassa, Pellamalala, Potana by Kennedy *et al*. (1987), Deraniyagala (1988), Kanthilatha *et al*. (2012), Rannaweera & Adikiari (2022) and Chandimal *et al*. (2019), respectively. However, the morphometry of mandibular molar morphometry of prehistoric skeletal remains in Sri Lanka have been studied, and there were no any comparative studies done to determine similarities and variations among extinct populations that lived in different prehistoric sites in Sri Lankans. Morphometry of molar dental remains of ancient humans and modern molar dental morphometries have been extensively compared as well the dental variability between ethnic groups globally (Brook *et al*., 2009; Gómez-Robles *et al*., 2015). However, there is no reported evidence to determine the mandibular molar dental morphometrical variations between prehistory and present-day Sri Lankans to determine the population affinities based on molar dental morphometry. Thus, the objective of this study was to compare the molar crown morphometry and indices of the prehistoric mandibular molar dental remains discovered at prehistoric sites of Batadombalena, Belilena, Bellanbandi Palassa, Pellamalala, and Potana Sri Lanka antiquity ranged from 5,000 to 36,000 BC) with present-day Sri Lankan with reference to first, second and third molar teeth.

MATERIAL AND METHOD

Adult molar teeth (M1, M2 and M3) of 80 dry human mandibles of present-day Sri Lankan were taken to the study. The sex and the age at death of selected mandibles were recorded by observing the data base in the department and sex and age were further confirmed by following the morphological sexual dimorphism and dental attritions over the molar teeth described in in Bass (2005).

In this study, mandibular molar teeth available in eleven dry adult prehistoric mandibles—five male and six female—that were dated between 5,000 and 36,000 BCE were included into the study. The study comprised mandibular molar teeth available in five mandibles found at Bellan-bandi Palassa ((6,500 – 10,000 BP), two mandibles found from the prehistoric site Batadombalena, Kuruwita (36,000 BP), one mandible found in prehistoric site Belilena Kithulgala (16.000 – 30,000BP). two mandibles from prehistoric site Potana (6,000 BP) and mandibular dental remains belonging to several fragmented mandibles found in Shell midden prehistoric site Pallamalala,

The predetermined sex of each prehistoric mandible was once again confirmed by comparing the morphological characteristics of the mandibles included in the study with published standard sex-determining morphological traits of male and female mandibles, such as the mandibular angle, gonion morphology, and chin shape, as described in Bass (2005).

Mandibular molar teeth were selected for measurement only if they were morphologically usual, not noticeably affected by attrition, caries, or resto ration, and were fully erupted to the occlusal plane. Two maximum crown diameters of BL and MD were taken using a digital vernier caliper recorded to the nearest 0.01 millimeter. The MD diameter was taken as the maximum width of the tooth crown in the mesio-distal plane while BL diameter was taken as the widest point of the tooth crown in the bucco-lingual plane, perpendicular to the MD (Bass, 2005) (Fig. 1). The crown index (CI) (CI = BL diameter x 100/MD diameter), the crown area (CA) (CA = BL diameter x MD diameter) and crown module (CM) (CM = MD Diameter + BL Diameter) / 2) were used to characterize the overall crown size (Bass, 2005).

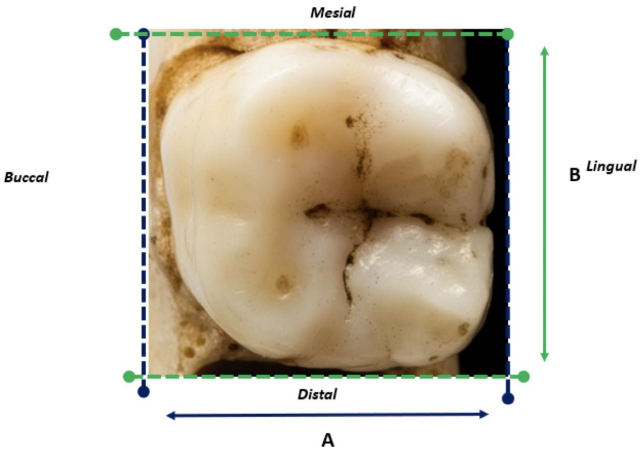

Fig. 1. Anatomical landmarks of BL diameter and MD diameter. A. Buccal lingual (BL) diameter; B. Mesial distal (MD) diameter

A single observer carried out all measurements, each measurement was taken three times of each molar tooth, and the mean values were taken for analysis. The measurements and indices of each molar tooth of prehistoric population were compared with the corresponding measurements and indices of the present-day Sri Lankans according to sex, by using SPSS 23.0 version. Means were calculated and the comparisons were done using the independent samples t-test.

RESULTS

Adult molar teeth (M1, M2 and M3) of 37 female dry mandibles and 43 male mandibles were identified in the collection of 80 dry human mandibles of present-day Sri Lankan following the sex determining characteristics described in Bass (2005). The sex of prehistoric mandibles was confirmed by following the same procedure described in Bass (2005). Five male and six female prehistoric mandibles were identified (Fig. 2). The teeth were analyzed separately according to sex. The mean standard deviations of each tooth of each sex for each side of the body were statically analyzed by using SPSS version 23.0. Comparison of the measurements and indices of Molar 1, Molar2, and Molar3 were done in ancient and modern teeth separately using One-way Anova test.

The BL diameter and MD diameter of right first molar (M1) of male prehistoric population is larger compared to M2 and M3 molar teeth and mean BL diameter is reduced from M1> M2 > M3 among male prehistoric mandibular molar teeth (Table I). Same pattern of reduction of MD diameter in left mandibular molar teeth (M1>M2>M3) was identified in the prehistoric male as well. The crown area/crown index/ crown module of right first molar (M1) is larger compared to M2 and M3 molar teeth of left and right side of the prehistoric man

Table I. Comparison of measurements and indices of the male right and left mandibular molar teeth of prehistoric population.

	Right M1	Right M2	Right M3	P-Value
MD	10.48 ± 0.35	10.30 ± 0.52	9.68	P=0.286
BL	10.49 ± 0.74	10.46 ± 0.71	10.55	P=0.985
Area	109.99 ± 9.44	108.91 ± 10.49	102.12	P=0.770
Index	100.30 ± 7.24	97.76 ± 7.15	91.75	P=0.544
Module	10.48 ± 0.44	10.43 ± 0.50	10.11	P=0.773
	Left M1	Left M2	Left M3	P-Value
MD	11.66 ± 1.76	10.28 ± 0.12	11.27	P=0.461
BL	10.91 ± 1.93	10.03 ± 1.17	11.37	P=0.530
Area	128.97 ± 41.80	103.10 ± 11.61	128.13	P=0.413
Index	107.06 ± 2.74	103.64 ± 12.70	99.12	P=0.935
Module	11.28 ± 1.84	10.15 ± 0.56	11.32	P=0.411

The BL diameter and MD diameter of right first molar (M1) of prehistoric female is larger than that of M2 and M3 molar teeth and MD diameter is reduced from M1> M2 > M3 among female prehistoric mandibular molar teeth (Table II). The crown area/crown index/crown module of right first molar (M1) is larger compared to M2 and M3 molar teeth of right side of the prehistoric female.

Table II. Comparison of measurements and indices of the right and left female molar teeth in prehistoric population.

	Right M1	Right M2	Right M3	P-Value
MD	11.07±0.27	10.53±0.35	10.15±0.21	P=0.534
BL	10.27±0.34	10.42±0.07	9.31±0.57	P=0.468
Area	113.70±5.14	109.73±4.42	94.60±7.92	P=0.532
Index	107.85±3.94	101.04±2.70	109.21±4.44	P=0.325
Modul	10.67±0.24	10.47±0.21	9.73±0.39	P=0.536
	Left M1	Left M2	Left M3	P-Value
MD	10.75±0.30	9.89	11.96	P=0.238
BL	9.69±0.78	9.72	9.84	P=0.985
Area	98.65±14.91	96.13	117.68	P=0.553
Index	104.68±3.27	101.74	121.54	P=0.037
Modul	9.91±0.76	9.80	10.9	P=0.554

The BL diameter and MD diameter of right first molar (M1) of present-day male Sri Lankan is larger compared to M2 and M3 molar teeth and BL diameter is reduced significantly from M1> M2 > M3 among present-day mandibular molar teeth (Table I). Same pattern of reduction of BL and MD diameter in left mandibular molar teeth (M1>M2>M3) was identified in the present-day male Sri Lankans as well. The crown area/crown index/crown module of right first molar (M1) is larger compared to M2 and M3 molar teeth of left and

Fig. 2. Prehistoric Mandibles found in Sri Lanka. A. Potana, Sigiriya; B. Bellanbandi Palassa; C. Bellanbandi Palassa

right side of the male present-day Sri Lankans and crown area//crown module reduces significantly from M1>M2>M3 in present-day male mandibular molar teeth of both right and left side (Table III).

The BL diameter and MD diameter of right first molar (M1) of present-day female Sri Lankan is larger compared to M2 and M3 molar teeth and BL diameter is reduced significantly from M1> M2 > M3 among present-day mandibular molar teeth (Table IV). Same pattern of reduction of BL and MD diameter in left mandibular molar teeth (M1>M2>M3) was identified in the present-day male Sri Lankans as well. The crown area/crown index/crown module of right first molar (M1) is larger compared to M2 and M3 molar teeth of left and right side of the male present-day Sri Lankans and crown area//crown module reduces significantly from M1>M2>M3 in present-day male mandibular molar teeth of both right and left side.

Comparison of measurements and indices of the male right mandibular molar teeth (M1, M2 and M3) of ancient teeth and present-day Sri Lankan teeth were separately done. When the mean measurements of MD, BL, crown area, crown index and crown module of male prehistoric right molar teeth (M1, M2, M3), are compared with present-day male Sri Lankans respective teeth, the mean of MD, BL, crown area, crown index and crown module of male prehistoric mandibular M1, M2 and M3 teeth is larger than that of the present-day Sri Lankans. The mean values of each studied parameter of M2 molar tooth of prehistoric mandible is significantly (<0.005) higher than that of present-day Sri Lankans except for crown module. (Table V).

When the mean measurements of MD, BL, crown area, crown index and crown module of male prehistoric left molar teeth (M1, M2, M3) are compared with present-day Sri Lankans respective teeth, the mean of MD, BL, crown area, crown index and crown module of prehistoric mandibular M1, M2 and M3 teeth is larger than that of the present-day Sri Lankans. The mean values of each studied parameter of M3 molar tooth of prehistoric mandible is significantly (<0.005) higher than that of present-day Sri Lankans except for crown module. (Table V).

Table III. Comparison of measurements and indices of the male right and left molar teeth in present-day Sri Lankans.

	Right M1	Right M2	Right M3	P-Value
MD	10.43 ± 0.43	9.49 ± 0.51	9.03±1.08	P=0.017
BL	10.35 ± 0.56	9.40 ± 0.56	9.39 ± 0.35	P=0.004
Area	108.06 ± 7.81	89.47 ± 9.98	87.61 ± 10.71	P=0.002
Index	99.30 ± 6.37	99.05 ± 2.30	98.98 ± 8.82	P=0.994
Module	10.39 ± 0.37	9.44 ± 0.52	9.77 ± 0.55	P=0.002
	Left M1	Left M2	Left M3	P-Value
MD	11.15 ± 0.44	10.27 ± 0.58	8.98 ± 0.35	P=0.000
BL	10.77 ± 0.50	9.69 ± 0.41	9.47 ± 0.30	P=0.000
Area	120.32 ± 9.35	99.56 ± 6.62	85.03 ± 2.83	P=0.000
Index	96.68 ± 3.71	94.62 ± 7.05	105.65 ± 6.72	P=0.137
Module	10.96 ± 0.42	9.98 ± 0.33	9.22 ± 0.15	P=0.000

Table IV. Comparison of measurements and indices of female right and left molar teeth in present-day molar teeth.

	Right M1	Right M2	Right M3	P-Value
MD	11.00±0.19	10.77±0.28	9.75±0.78	P=0.452
BL	10.19±1.29	10.02±0.02	9.46±0.29	P=0.482
Area	112.23±15.51	107.96±3.20	92.39±10.32	P=0.597
Index	95.32±12.97	93.02±2.24	97.16±4.77	P=0.054
Module	10.59±0.71	10.39±0.15	9.60±0.54	P=0.580
	Left M1	Left M2	Left M3	P-Value
MD	10.71±0.58	9.77±0.19	9.21±0.12	P=0.668
BL	10.46±0.36	9.65±0.29	9.35±0.10	P=0.383
Area	109.23±8.79	96.40±4.78	86.18±2.09	P=0.558
Index	100.26±1.02	100.85±1.06	101.44±0.32	P=0.980
Module	10.44±0.42	9.81±0.24	9.2±0.112	P=0.545

When the mean measurements of MD, BL, crown area, crown index and crown module of prehistoric molar teeth (M1, M2, M3) are compared with present-day Sri Lankans respective teeth, the mean of MD, BL, crown area, crown index and crown module of prehistoric mandibular M1, M2 and M3 teeth is larger than that of the present-day Sri Lankans (Table VI).

The same mean value reduction pattern for MD, and BL diameters, crown area, crown index and crown module of left (M1>M3>M3) molar teeth in prehistoric mandibles and present-day Sri Lankans mandibles were found as right side teeth. The mean values of each studied parameter of left M3 molar tooth of prehistoric mandible is significantly (<0.005) higher than that of present-day Sri Lankans (Table VI).

Table V. Teeth dimensions (BL & MD diameter) crown area, crown index and crown module of male mandibular teeth of prehistoric and present-day Sri Lankans.

Tooth	Measurement	Mean Present-day Sri Lankans	Mean Prehistoric populations	P value
Right M1	MD (mm)	10.43 ± 0.43	10.48 ± 0.35	0.842
	BL (mm)	10.35 ± 0.56	10.49 ± 0.74	0.686
	Area	108.06 ± 7.81	109.99 ± 9.44	0.673
	Index	99.30 ± 6.37	100.30 ± 7.24	0.782
	Module	10.39 ± 0.37	10.48 ± 0.44	0.675
Right M2	MD (mm)	9.49 ± 0.51	10.30 ± 0.52	**0.020**
	BL (mm)	9.40 ± 0.56	10.56 ± 0.71	**0.007**
	Area	89.47 ± 9.98	108.91 ± 10.49	**0.006**
	Index	99.05 ± 2.30	97.76 ± 7.15	0.638
	Module	9.44 ± 0.52	10.43 ± 0.50	**0.007**
Right M3	MD (mm)	9.03±1.08	9.68	0.617
	BL (mm)	9.69 ± 0.35	10.55	0.073
	Area	95.61 ± 10.71	102.12	0.598
	Index	98.98 ± 8.82	91.75	0.482
	Module	9.77 ± 0.55	10.11	0.592
Left M1	MD (mm)	11.15 ± 0.44	11.66 ± 1.76	0.419
	BL (mm)	10.77 ± 0.50	10.91 ± 1.93	0.840
	Area	120.32 ± 9.35	128.97 ± 41.80	0.542
	Index	96.68 ± 3.71	107.06 ± 2.74	**0.007**
	Module	10.96 ± 0.42	11.28 ± 1.84	0.609
Left M2	MD (mm)	10.27 ± 0.58	10.28 ± 0.12	0.986
	BL (mm)	9.69 ± 0.41	10.03 ± 1.17	0.520
	Area	99.56 ± 6.62	103.10 ± 11.61	0.540
	Index	94.62 ± 7.05	103.64 ± 12.70	0.171
	Module	9.98 ± 0.33	10.15 ± 0.56	0.544
Left M3	MD (mm)	8.98 ± 0.35	11.27	**0.030**
	BL (mm)	9.47 ± 0.30	11.37	**0.032**
	Area	85.03 ± 2.83	128.13	**0.006**
	Index	105.65 ± 6.72	99.12	0.489
	Module	9.22 ± 0.15	11.32	**0.007**

Table VI. Teeth dimensions (BL & MD diameter) crown area, crown index ad crown module of female mandibular teeth of prehistoric and present-day Sri Lankans.

Molar	Measurement	Mean Present-day Sri Lankans	Mean Prehistoric populations	P value
Right M1	MD (mm)	11.00±0.19	11.07±0.27	0.736
	BL (mm)	10.19±1.29	10.27±0.34	0.926
	Area	112.23±15.51	113.70±5.14	0.884
	Index	95.32±12.97	107.85±3.94	0.185
	Module	10.59±0.71	10.67±0.24	0.875
Right M2	MD (mm)	10.53±0.05	10.53±0.35	1.000
	BL (mm)	10.02±0.02	10.42±0.07	**0.018**
	Area	107.96±3.20	109.73±4.42	0.693
	Index	93.02±2.24	101.04±2.70	0.084
	Module	10.39±0.15	10.47±0.21	0.719
Right M3	MD (mm)	9.75±0.78	10.15±0.21	0.559
	BL (mm)	9.46±0.29	9.72	0.605
	Area	92.39±10.32	94.60±7.92	0.833
	Index	97.16±4.77	109.21±4.44	0.121
	Module	9.60±0.54	9.73±0.39	0.817
Left M1	MD (mm)	10.71±0.58	10.75±0.30	0.929
	BL (mm)	10.20	10.20±0.42	1.000
	Area	109.23±8.79	98.65±14.91	0.421
	Index	100.26±1.02	104.68±3.27	0.151
	Module	10.44±0.42	9.91±0.76	0.427
Left M2	MD (mm)	9.77±0.19	9.89	0.709
	BL (mm)	9.65±0.29	9.72	0.070
	Area	96.40±4.78	96.13	0.970
	Index	100.85±1.06	101.74	0.620
	Module	9.81±0.24	9.80	0.973
Left M3	MD (mm)	9.21±0.12	11.96	**0.003**
	BL (mm)	9.35±0.10	9.84	0.050
	Area	86.18±2.09	117.68	**0.006**
	Index	101.44±0.32	121.54	**0.000**
	Module	9.2±0.112	10.9	**0.006**

DISCUSSION

This study explores the dental morphometrical variations of permanent molar crown diameters (MD/BL) crown area, crown index and crown module in prehistoric human populations those lived in Sri Lanka (around 5,000-36,000 BCE) and the present-day Si Lankans. In this research, the molar teeth M1, M2 and M3 have been subjected to linear measurements of tooth crown ((MD), and (BL)), along with three indexes (crown area, crown index and crown module).

The study of the morphometry of the mandibular molar teeth is utmost important in identifying evolutionary changes as well as sexual dimorphisms (Brace *et al*., 1987). The results of the present study show that the BL diameter and MD diameter of right first molar (M1) of male prehistoric population is larger compared to M2 and M3 molar teeth and mean BL diameter is reduced from M1> M2 > M3 among male prehistoric mandibular molar teeth (Table III). Same pattern of reduction of MD diameter in left mandibular molar teeth (M1>M2>M3) was identified in the prehistoric male as well. The crown area/crown index/crown module of right first molar (M1) is larger compared to M2 and M3 molar teeth of left and right side of the prehistoric man (Table I).

The BL diameter and MD diameter of right first molar (M1) of prehistoric female is larger than that of M2 and M3 molar teeth and MD diameter is reduced from M1> M2 > M3 among female prehistoric mandibular molar teeth (Table II). The crown area/crown index/crown module of right first molar (M1) is larger compared to M2 and M3 molar teeth of right side of the prehistoric female.

This result revealed that crown size decreased gradually from the first to the third molar teeth, and the mesiodistal crown width was larger than the buccolingual crown width for all molar teeth examined beside the sex.

In the literature it was reported that the second molars were the largest among the molars in the early hominins who lived in Africa, with some of the earliest potential hominins like Sahelanthropus and Orrorin dating back 6-7 million years ago, followed by Ardipithecus (5.8-4.4 million years ago), and then the Australopithecines (4 million to 2.5 million years ago). (Kurniawan et al., 2022). The results of this study are in contrast with the literature statement and this study results show that the crown area is higher in M1 than that of M2 for both sexes. As this study employed prehistoric extinct human in Sri Lanka represented by around 5,000 to 36,000 BCE mandibular dental remains. Therefore, tooth size of prehistoric extinct population in Sri Lanka may not radically different from the present-day hominids.

The second molar teeth of early hominid are larger among other molars which may be due to their dietary demands, and molar functions. Early hominins consumed tough, fibrous, and abrasive foods, like raw meat and hard plants, which required significant chewing power and strong teeth. The second molar, being located further back in the jaw, was subjected to the highest chewing forces as the food was crushed and ground. Its large size and thick enamel provided the necessary structural integrity to withstand the mechanical stress of these diets (Arenas *et al.*, 2015).

Petraru *et al*. (2022) reported that the crown dimensions of the M2 molar crown variability in archaeological human populations from Prehistory (Chalcolithic and Bronze Age, ~ 5000-1150 BCE) and Middle Ages (13th-17th centuries) discovered in sites from North Eastern Romania. The mean MD and BL diameter of M2 molar teeth (BL = 9.42 mm in females and 9.72 mm in males; MD = 10.10 mm in females and 10.43 mm in males) is smaller than that of extinct prehistoric humans in Sri Lanka in the current study (Right MD 10.30 ± 0.52 in male, Right BL 10.56 ± 0.71 in male, Left MD 10.28 ± 0.12 in male, Left BL 10.03 ± 1.17 in male, Right MD 10.53±0.35 in female, Right BL10.42±0.07 in female)

When the mean measurements of MD, BL, crown area, crown index and crown module of male prehistoric right molar teeth (M1, M2, M3) are compared with present-day male Sri Lankans respective teeth, the mean of MD, BL, crown area, crown index and crown module of male prehistoric mandibular M1, M2 and M3 teeth is larger than that of the present-day Sri Lankans. The mean values of each studied parameter of right M2 molar tooth and left M3 of prehistoric male mandible is significantly (<0.005) higher than that of present-day Sri Lankans except for crown index (Table V).

When the mean measurements of MD, BL, crown area, crown index and crown module of female prehistoric left and right molar teeth (M1, M2, M3) are compared with present-day Sri Lankans respective teeth, the mean of MD, BL, crown area, crown index and crown module of prehistoric mandibular M1, M2 and M3 teeth is larger than that of the present-day Sri Lankans. The mean values of each studied parameter of right M3 molar tooth of female prehistoric mandible is significantly (<0.005) higher than that of present-day Sri Lankans (Table VI).

Several comparative studies on metrical and morphological studies on molar teeth around the globe revealed that tooth dimensions reduce from the prehistoric, medieval, and historic to the present-day populations (Brace *et al.*, 1987). In this study it was found that reduction of molar crown dimensions and indices from prehistoric population to present-day Sri Lankans. Same molar crown reduction pattern (BL & MD) of M2 molar was reported by in samples from Mesolithic-Neolithic to Middle Ages from Serbia (Pajevic & Glisic, 2017).

Romanian study shows that the mean of BL and MD diameter of mandibular M2 in prehistory (Chalcolithic and Bronze Age, ~ 5000-1150 BCE) is bit larger than that of mandibular M2 in Middle Ages (13th-17th centuries). It was further reported that there are no any significant differences of mean values of dimensions between two population groups (Petraru *et al*., 2022). Interestingly, same study results show that the BL diameter of the maxillary molar increases from prehistory to the Middle Ages, while the MD diameter values for mandibular molars are higher in the medieval period in comparison with Prehistory. In contrast this study results show that BL, MD diameters and crown index of mandibular right M2 of prehistoric man (Table V) is significantly higher than that of present-day Sri Lankan males and BL diameter of mandibular M2 of prehistoric female is significantly higher than that of present-day Sri Lankan females as well (Table VI).

In contrast to this study, results from a study of Mockers *et al*. (2004), shows that the MD diameter of mandibular teeth of the prehistoric population from Roaix, Southern France, is smaller when compared to its size in modern Caucasian populations. Moreover, the mean value for the MD diameter of prehistoric mandibular M2 molars from prehistoric man in Sri Lanka (left M2- 10.28 ± 0.12mm, Right M2 -10.30 ± 0.52) is higher than the value obtained by Mockers *et al*. (2004), where the prehistoric molars from a population in Roix, France (9.75 mm).

The robustness index, additionally referred to as the crown area (CA), is frequently used to describe the overall size of the crown (Ciorpac-Petraru *et al*., 2020). The M2 molars from Norh East Romania show an increasing CA from the prehistoric period to the medieval one in both mandibular and maxillary molars in females. The same tendency is obtained for the upper M2 molar in males. Similar CA values of medieval maxillary M2 molars in females from Croatia were obtained by Vodanovic *et al*. (2007); interestingly the higher values of CA were found in mandibular male and female molars of prehistoric population in this study in comparison with the data obtained for the dental samples from present-day Sri Lankans.

This paper approached dental measurements and indices in Sri Lankan prehistoric human populations and present-day Sri Lankans in order to assess mandibular M1, M2 and M3 molar crown variability. The results of this study show a greater variability in the prehistoric male and female M1, M2 and M3 teeth compared to present-day Sri Lankans, in mandibular molars (MD and BL variables, crown area, index, module). In the mandibular male right M2 and left M2 teeth, significant statistical differences were obtained between the prehistoric and present-day Sri Lankans (MD & BL variable and CA and robustness variable).

Prehistoric human molars were generally larger and more robust than those of modern humans, reflecting diets that required heavy chewing of tough foods. The prehistoric population that lived in different location of the country, tended to consume course diet such as processed or unprocessed animal flesh, yams, seeds like kekune seeds and Homo species showed a gradual reduction in tooth size.

Prehistoric humans in Sri Lanka consumed a varied diet centered on hunting and gathering, with major components including wild animals like elephants, deer, and wild boar, fish and other aquatic life such as crabs and mollusks, and forest produce like honey, fruits, leaves, and yams (Deraniyagala, 1988). Evidence of their diet comes from archaeological findings of animal bones with cut marks, the consumption of terrestrial and arboreal mollusks, and the absence of cereal harvesting in the dry and wet zones. This is further proved with the archaeological evidence of bones of birds and small mammals, along with signs of consumption that were found at the different prehistoric sites of the country such as Bellanbandi Palassa, Sigiriya Potana, Kithulgala Belilena. Kuruwita batadombalena, Pallamalala etc. providing evidence of their diet. The tougher the consistency of the diet the greater the bite forces required (Kennedy *et al*., 1987). The molar teeth of prehistoric population became larger to facilitate the unprocessed or semi processed food for grinding in the masticatory cycle.

Heavily worn teeth found in different prehistoric sites of the country such as Bellanbandi Palassa, Sigiriya Potana, Kuruwita Belilena, Kuruwita batadombalena, Pallamalala etc. suggest the inclusion of high-grit food plants and unprocessed foods. The absence of silica gloss on artifacts indicates that cereal harvesting was not a

significant part of the diet during this period and no evidence of agriculture. Prehistoric population in Sri Lanka who had a hunting and gathering lifestyle, consuming meat, honey, and forest produce, though their practices were later supplemented by introduction of agriculture. Evidence of sorghum grains from Ravana Ella cave might indicate a rudimentary knowledge of agriculture probably during the Neolithic phase. When the commencement of agricultural life along with animal husbandry in protohistoric and historic period of the country, the hunting and gathering nomadic life style of human slowly disappeared and they tended to process food more for their consumptions. In the course of evolution, the size of mandible & mandibular dentition has showed greater reduction. This may be a result of a progressive softening of the diet. Calcagno & Gibson (1988) maintain that a softer & more cryogenic diet may actively select for smaller teeth. Recent modern population is consuming the softest diet; fine food preparation techniques are used. Food consists of fine particles.

Despite regional and chronological variations, molar tooth sizes in prehistoric people were typically greater than those in medieval and contemporary societies, most likely as a result of a diet high in abrasion. MD and BL diameters were the main focus of measurements, which were usually made using odontometric procedures. Specific results revealed variations in crown shape, overall size, and between sexes and chronological periods.

Tooth size reduction is a significant determinant of the dietary and chronological differences between two populations on the globe. Since there is prehistoric dental evidence from Sri Lanka that goes back to 5000–36,000 BCE, this study finds no substantial drop in the crown morphometry of the prehistoric population compared to present-day Sri Lankans.

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RESUMEN: Los dientes constituyen una fuente invaluable de información en estudios forenses y arqueológicos para la comprensión de las poblaciones humanas del pasado. Sus variaciones morfológicas y morfométricas, junto con el dimorfismo sexual, brindan información sobre las diferencias evolutivas y poblacionales. La presente investigación tuvo como objetivo evaluar la variabilidad y los índices de las coronas de los molares mandibulares —primer (M1), segundo (M2) y tercer (M3) molar— entre humanos prehistóricos (que datan de aproximadamente 5000 a 36000 a. C.) y los habitantes actuales de Sri Lanka. El estudio analizó los molares mandibulares de once mandíbulas adultas prehistóricas (cinco masculinas y seis femeninas) y 80 molares de individuos modernos de Sri Lanka. Se midieron dos diámetros principales de la corona — bucolingual (BL) y mesiodistal (MD)— utilizando un calibrador digital con una precisión de 0,01 mm. Utilizando estas dimensiones, se calcularon el índice de corona (IC), el área de la corona (AC) y el módulo de la corona (MC). Los resultados revelaron que, entre los hombres prehistóricos, el primer molar derecho (M1) tenía los diámetros BL y MD más grandes en comparación con los dientes M2 y M3, mostrando una tendencia decreciente de M1 > M2 > M3 en ambos lados. De manera similar, los valores de área de la corona, índice de corona y módulo de la corona fueron más altos para el molar M1 derecho. En general, los molares mandibulares de hombres prehistóricos mostraron mayores valores de MD, BL, AC, IC y MC que los de los habitantes modernos de Sri Lanka. Se observaron diferencias estadísticamente significativas ($p < 0,005$) en los molares M2 derechos y M3 izquierdos de los hombres prehistóricos en comparación con los individuos actuales. En las mujeres, el tercer molar derecho (M3) de las mandíbulas prehistóricas también mostró valores significativamente más altos ($p < 0,005$) que sus homólogos modernos. Estos hallazgos indican una clara reducción en el tamaño de la corona molar y en los índices desde la época prehistórica hasta la actualidad en Sri Lanka, lo que sugiere influencias evolutivas o ambientales en la morfología dental a lo largo de los milenios.

PALABRAS CLAVE: Molares mandibulares; Humanos prehistóricos; Morfometría; Población actual de Sri Lanka.

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