

# Estimation of Crown Length, Root Length and Golden Divine Ratio in Extracted Permanent Maxillary and Mandibular Central Incisors: An In-vitro Study

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## ABSTRACT

**Introduction:** Human teeth serve many crucial functions, and aesthetics is one of these. Aesthetics and beauty are often correlated with the Golden Divine Ratio (GDR), a unique proportion hypothesised to exist in individuals or things with a harmonious appearance.

**Aim:** To estimate the crown length, root length, and GDR in extracted human permanent maxillary and mandibular Central Incisors (CI) in the population of Tamil ethnicity from South India.

**Materials and Methods:** This in-vitro cross-sectional study was conducted in the Department of Oral Pathology and Microbiology at Saveetha Dental College and Hospitals, Chennai, Tamil Nadu, India, from January 2023 to October 2023. The study included a total of 90 extracted human teeth from the Institutional tooth repository, out of which 27 were upper permanent CIs and the

remaining 63 were mandibular CIs. Crown length and root length were measured using digital vernier calipers, and golden ratios were derived. Statistical Package for Social Sciences (SPSS) software version 26.0. was used for descriptive analysis and deriving means and standard deviation.

**Results:** The average crown length, root length, and total length of upper CIs were  $8.06 \pm 0.09$  mm,  $13.01 \pm 1.47$  mm, and  $21.06 \pm 2.36$  mm, respectively. For the remaining 63 extracted permanent mandibular CIs, the mean crown length, root length, and total length were  $7.85 \pm 0.66$  mm,  $12.6 \pm 0.97$  mm, and  $20.45 \pm 1.49$  mm, respectively. The Root-to-Crown (R/C) ratio and Total Length to Root Length (T/R) ratio approximated 1.618 for both sets of teeth.

**Conclusion:** The crown length of maxillary and mandibular CIs from the Tamil population followed the golden ratio in the present study.

**Keywords:** Golden ratio, Mandibular forensic, Morphology, Teeth, Tooth measurement

## INTRODUCTION

The averageness, youthfulness, gender dimorphism, and symmetry of the face are the most important factors depicting the physical appearance of any individual. Among these, facial asymmetry has been associated with the GDR [1]. The GDR is not a newly described concept and was initially acknowledged centuries ago by Greek philosophers. This ratio (1.618) has been described ubiquitously in the universe, whether in flowers, seashells, human faces, or the harmony of music [2,3]. Similarly, achieving aesthetics in dentistry is an essential component in addition to functional rehabilitation. A previous study assessed the golden ratio in a limited sample size comprising human extracted teeth pertaining to crown length and root length, and the authors concluded that human teeth are divided at the cemento-enamel into two parts in the golden ratio [4]. Additionally, Sarode SC et al., in their study on fabricated maxillary and mandibular casts, found the golden ratio in the transverse ridges of the premolars and oblique ridges of the maxillary molars [5].

Carving is an important part of undergraduate and postgraduate dental training; however, the values and dimensions of teeth being followed date back to the 1940s, and no updates are available since then. Furthermore, a marked variation is noted in tooth size, shape, enamel thickness, tooth mass, and the number of roots and canals [6,7]. Thus, the same values are not necessarily applicable to the global population. It has been reported that in comparison with Europeans, Africans have thicker enamel and larger teeth with thicker enamel [6,8,9]. There is limited data on the estimation of tooth dimensions in the Indian population [4,10-15]. In a previous study, Deepak V et al., comparatively analysed four different populations which included Iranians, Hindus, Muslims, and Christians, and estimated mesiodistal and buccolingual tooth crown dimensions. It was found that the Christian sample displayed the

maximum tooth dimensions while Iranians displayed the statistically smallest buccolingual and mesiodistal dimensions of the crown [10]. In other previous available studies on the Indian population, the measurements of human incisors were done using stone casts or direct facial measurements [11-15], and Anand R et al., estimated the dimensions and golden ratio in extracted teeth [4]; however, there is a scarcity of data from Tamil Nadu [11]. Hence, the present study was conducted to estimate crown length, root length, and GDR in extracted human maxillary and mandibular CIs in the population of Tamil ethnicity from South India.

## MATERIALS AND METHODS

This in-vitro cross-sectional study was conducted in the Department of Oral Pathology, Microbiology, and Oral Biology (SDC Vivarium) at a tertiary healthcare centre, Saveetha Dental College and Hospitals, Chennai, Tamil Nadu, India, from January 2023 to October 2023. Prior ethical clearance was obtained from the Institutional Human Ethical Clearance Committee (IHEC/SDC/UG-2068/23/OPATH/033).

**Inclusion criteria:** A total of 90 extracted human teeth were included, comprising 27 permanent maxillary CIs and 63 extracted human permanent mandibular CIs.

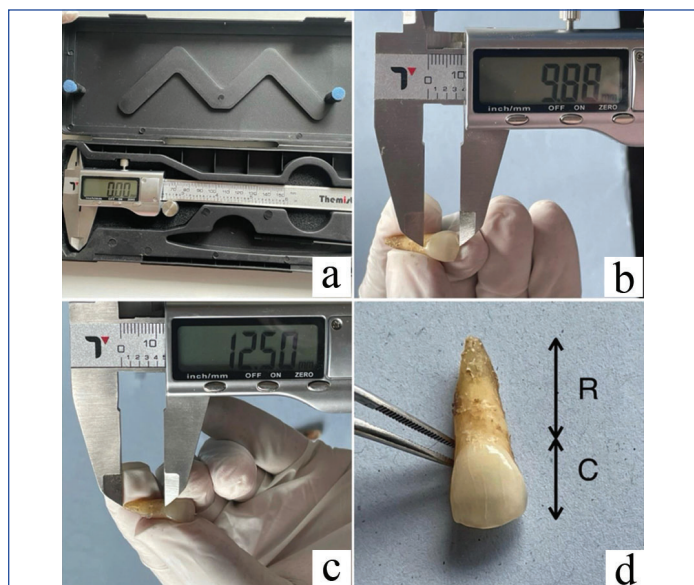
**Exclusion criteria:** Teeth showing attrition/erosion, fractured roots or crowns, coronal/radicular caries, and unusual anatomical variations like dilacerated roots or teeth exhibiting hypercementosis were not included.

## Study Procedure

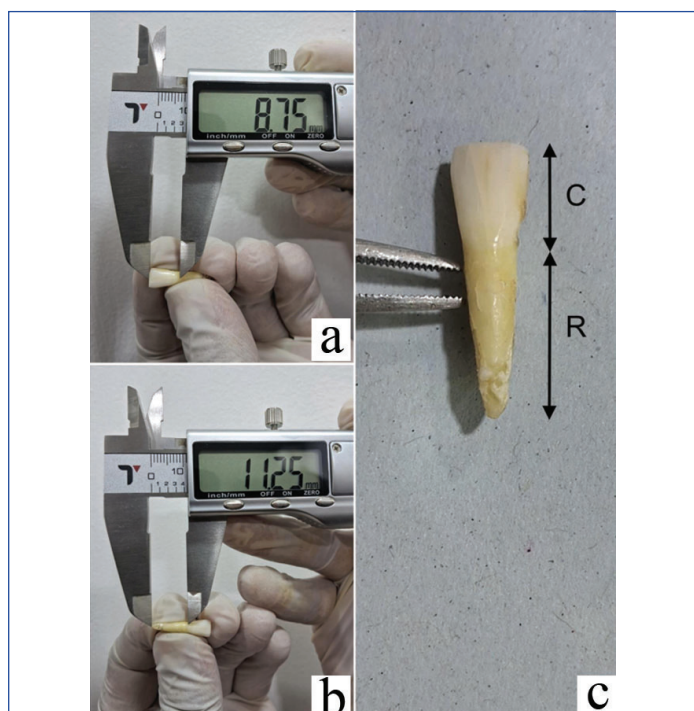
All 90 included teeth were manually cleaned, and the debris was removed. Subsequently, these teeth were submerged in a 5.25% sodium hypochlorite solution.

**Estimation of crown and root length:** To measure the lengths of the roots and crown, digital vernier calipers with a minimum count of 0.01 inch/0.02 mm were used (Themisto TH-M61 digital vernier caliper, 0-150 mm/6 inch, India) [Table/Fig-1a]. For estimating the crown length, the facial aspects of the included teeth were measured from the center of the incisal edges of both upper and lower extracted human teeth to the deepest portion of the Cementoenamel Junction (CEJ). Similarly, the length of the roots was estimated from the deepest point in the CEJ to the radicular apex [Table/Fig-1b,c].

**Estimation of Golden Divine Ratio (GDR):** The golden ratio was calculated as previously described [3]. Using digital vernier calipers, the measurements of the crown and root lengths were recorded first. Two ratios were then calculated: i) the ratio of root length (R) to crown length (C), recorded as R/C; and ii) the ratio of total tooth length (T) to root length (R), recorded as T/R [Table/Fig-1d] and [Table/Fig-2]. These ratios were then correlated to approximate the GDR as follows:  $R+C:R=R:C=\Phi$  (1.618).



**[Table/Fig-1]:** a) Showing Themisto TH-M61 digital vernier calliper used for measurements of dimension; b) Showing estimation of crown length from incisal edge to CEJ for maxillary central incisors; c) Showing estimation of root length from CEJ to root apex; and d) Depicting estimation of measurement for Golden ratio derivation.



**[Table/Fig-2]:** Showing estimation of crown length, root length and GDR for mandibular incisors.

### STATISTICAL ANALYSIS

The measurements of crown and root lengths of upper and lower permanent CIs, estimated using vernier calipers, were recorded in a Microsoft Excel spreadsheet (2021). Mean and standard deviation values of crown length, root length, total tooth length, total length to root length ratio, and root length to crown length ratio were analysed using SPSS software version 26.0 (Released 2019; IBM Corp., Armonk, New York, United States).

### RESULTS

Total 27 extracted permanent maxillary CIs were included in the study. The average crown length, root length, and total length were  $8.06\pm 0.09$  mm, (Range: 6.3-9.5),  $13.01\pm 1.47$  mm; (Range: 10-15.5), and  $21.06\pm 2.36$  mm; (Range: 16.3-24.5), respectively. For the remaining 63 extracted permanent mandibular CIs, the mean crown length, root length, and total length were  $7.85\pm 0.66$  (Range: 6.5-9.5),  $12.6\pm 0.97$  (Range: 10-14.5), and  $20.45\pm 1.49$  (in mm; Range: 17-23.4), respectively [Table/Fig-3]. Interestingly, the R/C ratio and T/R ratio satisfied the GDR with minimal deviation. The R/C ratio for maxillary CIs was  $1.61\pm 0.057$ , while it approximated  $1.606\pm 0.102$  for its antagonist tooth, mandibular CIs. The T/R ratio for upper permanent and lower permanent CIs was  $1.62\pm 0.023$  and  $1.625\pm 0.043$ , respectively [Table/Fig-3].

Parameters	CL (Mean±SD) mm	RL (Mean±SD) mm	TL (Mean±SD) mm	R/C	T/R
Maxillary CI (n=27)	$8.06\pm 0.09$ Range: 6.3-9.5	$13.01\pm 1.47$ Range: 10-15.5	$21.06\pm 2.36$ Range: 16.3-24.5	$1.61\pm 0.057$	$1.62\pm 0.023$
Mandibular CI (n=63)	$7.85\pm 0.66$ Range: 6.5-9.5	$12.6\pm 0.97$ Range: 10-14.5	$20.45\pm 1.49$ Range: 17-23.4	$1.606\pm 0.102$	$1.625\pm 0.043$

**[Table/Fig-3]:** Mean crown length, root length, total length mean R/C ratio and mean tooth-root ratio for maxillary and mandibular Central Incisors (CI). CI: central incisor; SD: standard deviation; CL: crown length; RL: Root length; TL: Total length; R/C: Root to crown ratio; T/R: Total length to root length ratio

### DISCUSSION

The Golden Divine Ratio (GDR) is ubiquitously demonstrated by any object or person, including Deoxyribonucleic Acid (DNA), to optimise function and structure. It is hypothesised to relate to anything aesthetically pleasing to human eyes [3,4]. This ratio is not only studied in nature but has also been correlated with facial proportions, measurements, and aesthetics [1,2,16]. Previous studies have estimated this ratio in human teeth, revealing that human teeth follow the divine ratio at the CEJ. The aforementioned study involved the analysis of ten teeth from each class, ranging from incisors to molars [3]. In this preliminary study, authors selected maxillary permanent central and lateral incisors from individuals of Tamil ethnicity, along with their antagonist teeth, the mandibular central incisors, from our tooth repository, SDC Vivarium, managed by oral biology. The study aimed to assess the cervicoapical dimensions of the central incisors, a measure not updated for decades, and to estimate the Golden Ratio.

The comparative measurements of central incisors from the Indian population has been presented in [Table/Fig-4] [4,11-15]. The crown length of the maxillary permanent central incisor has been set at 10.5 mm (for carving purposes), with a root length of 13.0 mm [17]. Generally, the crown length, from the incisal edge to the deepest part of the CEJ, ranges from 10 to 11 mm, with roots typically being 2-3 mm longer. In cohort of Tamil population, authors observed an average crown length of 8.06 mm, approximately 2 mm shorter than the standard, while the average root length fell within the reported range (13.01 mm; 10-15.5 mm) in contrast to previous studies [11-15]. Despite differences in crown length, the maxillary central incisors displayed the Golden Ratio for the R/C ( $1.61\pm 0.057$ ) and T/R ( $1.62\pm 0.023$ ), aligning with a study sample from western

Author and Year	Place of the study	Samples used	Sample size	Parameters analysed	Maxillary Central Incisors (CI)	Mandibular Central Incisors (CI)
Sridhar K et al., 2011 [11]	Chennai, Tamil Nadu	Dental casts	100 casts	Cervico-incisal heights	Males: 10.73±0.67 Females: 10.07±1.10	Males: 8.26±0.65 Females: 8.88±1.11
Raghavendra N et al., 2014 [12]	Bengaluru, Karnataka	Direct facial measurements	100 subjects	Clinical crown length	11.6 (median 10.5)	ND
Anand R et al., 2017 [4]	Pune, Maharashtra	Extracted human teeth	10 maxillary CI 10 mandibular CI	R/C T/R	R/C: 1.627±0.043 T/R: 1.609±0.016	R/C: 1.628±0.022 T/R: 1.61±0.008
Shetty TB et al., 2017 [13]	Indian population in UK	Dental casts	100 casts	Length of crown	Males Right: 9.74±1.39 Left: 9.98±1.34 Females Right: 9.36±0.88 Left: 9.28±1.34	ND
Pillai JP et al., 2016 [14]	Ahmedabad, Gujarat	Plaster models	100 casts	Gingivoincinal length of crown	Right: 9.49±1.13 mm Left: 9.6±0.49 mm	ND
Dave BH et al., 2023 [15]	Ahmedabad, Gujarat	Plaster models	68 casts	Length of crown	Right: 9.788±1.046 mm Left: 9.823±0.946 mm	ND
Present study	Chennai, Tamil Nadu	Extracted human teeth	27 maxillary CI 63 mandibular CI	Length of crown Length of root Total length R/C T/R	8.06±0.09 mm 13.01±1.47 mm 21.06±2.36 mm 1.61±0.057 1.62±0.023	7.85±0.66 mm 12.6±0.97 mm 20.45±1.49 mm 1.606±0.102 1.625±0.043

**[Table/Fig-4]:** Tabulation of the comparative measurements of Central Incisors (CI) from population of Indian origin (parameters relevant for comparison are only shown) [4,11-15].

CI: Central incisor; R/C- Root to crown ratio; T/R: Total length to root length ratio; ND: Not done

India [3]. Although present study had a small sample size due to a lower extraction rate of maxillary central incisors, significant findings were observed. Firstly, the crown length in population is smaller than reported, and secondly, the permanent central incisors follow the Golden Ratio. Given that traumatic injuries often impact the anterior teeth and lower lips, the baseline data from present study could inform treatment decisions involving crowns, implants, or restoration [18,19]. However, a limitation lies in the lack of determination of the sex of the included teeth, necessitating future studies.

In relation to lower incisors, we were able to include a comparatively larger sample size of 63 extracted teeth. Typically, the length of the crown, measured from the incisal edge to the deepest part of the CEJ, is set at 9.5 mm, with a root length of 12 mm for mandibular permanent central incisors [17]. In comparison to maxillary centrals, mandibular incisors exhibited a shorter crown length but a similar root length as previously reported. Interestingly, despite the smaller size in the Tamil ethnicity, the golden ratio was maintained, with a ratio of 1.606 for R/C and approximately 1.625 for T/R. While it is widely accepted that the golden ratio is associated with aesthetics and functionality, Preston JD, based on a study of 58 dental casts, argued that maxillary anterior teeth do not adhere to the golden ratio and suggested that the characteristics of this ratio are unrealistic [20]. Other authors have taken a different approach, deviating from the divine ratio [21]. More recently, Agou SH et al., determined a width proportion of 77% for the lateral incisor to the central incisor, instead of the golden proportion of 62% for 'the most attractive smile', further challenging the concept of the Golden Ratio [22].

Although the results were derived from a smaller sample size, current study findings still provide baseline data for future studies. The dimensions of teeth currently being followed are outdated and require updating based on ethnicity and geography.

### Limitation(s)

There were a few limitations to the present study; the primary one being that the number of maxillary central incisors included in the study was comparatively low in comparison to the lower incisors, due to the rarity of upper central incisor extractions unless strictly necessary. Secondly, vernier calipers were used for morphometric analysis, which could introduce additional confounding factors due to the curved root morphologies and instrumental errors. Furthermore, sex-wise segregation was not performed, which could have further diluted the number of included teeth.

## CONCLUSION(S)

The crown lengths of maxillary and mandibular central incisors from a cohort in South India were examined. Interestingly, the root lengths were comparable; nonetheless, all teeth followed the Golden Ratio. These values can be utilised for prosthetic and endodontic treatment planning, as well as serve as baseline data for odontometry in forensic science. Further studies with larger sample sizes are needed to update the literature.

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