

Upper anterior tooth dimensions in a young-adult Indian population in the UK: implications for aesthetic dentistry

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In brief

Suggests that successful outcomes in aesthetic dentistry depend to a large degree on knowledge of tooth dimensions, relationships and proportions.

Reports variations in tooth dimensions, relationships and proportions in a sample of young adults of Indian origin.

Confirms that approaches to smile design which assume average values for tooth dimensions, formulaic relationships in dental parameters and right/left symmetry may result in unnatural smiles.

Introduction Knowledge of tooth dimensions and relationships and ethnic variations in these parameters are important in the planning and provision of aesthetic dentistry. **Aim** The aim of the present study was to investigate the dimensions and relationships of the upper anterior teeth in young adults of Indian origin, living in an urban location in the UK, and to compare the data obtained with data pertaining to other ethnic groups. **Materials and methods** This was a qualitative, non-experimental, cross sectional descriptive study with ethical approval. The dependent variables were tooth dimensions and relationships. The independent variable was gender. Fifty male and 50 female young adult Indians were recruited to the study, according to predetermined criteria. Upper and lower, full arch impressions were obtained for each of the 100 participants. Stone cast were obtained from these impressions. The width and length of each upper anterior tooth included in the casts were measured using precision callipers. Anterior arch length was determined using a flexible measuring tape. All measurements were repeated at least three times to obtain consistent values. The error of the method was investigated by means of repeat measurements. The data obtained was analysed, and compared with existing data on tooth dimensions and used to investigate the presence of Golden Proportion relationships. **Results** The measurements obtained had a normal distribution. Statistical analysis revealed significant differences in the overall data for left and right canine width and length ($P < 0.05$). No such differences were noted in respect of the upper central and lateral incisors. Also, significant differences ($P < 0.05$) were found to exist between male and female subjects in respect of the width of all anterior tooth types, except for the upper right lateral incisor. There were significant differences in the length of the upper left central incisor and upper right and left canines between male and female subjects ($P < 0.05$). Significant differences (< 0.05) were found in the width to length ratios between right and left canines. No such differences were observed for incisors. There was an absence of Golden Proportion relationships. **Conclusion** Within the limitations of the present study, it is concluded that it is inappropriate to adopt a formulaic, left/right symmetrical approach to smile design in the provision of aesthetic dentistry for young adults of Indian origin.

Introduction

Facial attractiveness is known to correlate with extraversion, self-confidence and self-esteem,¹⁻³ affording perceived benefits in social interactions.^{4,5} For many patients seeking

dental treatment, aesthetic issues are their primary concern.⁶ Although the aesthetics of the upper anterior teeth are largely determined by the colour, shape, size and proportions,⁷ subjective assessments of dental attractiveness vary according to culture and ethnicity.⁸

Historically, the understanding, assessment and management of dental attractiveness tended to be based more on complete denture considerations and guidelines than the application of knowledge of the morphology, dimensions and relationships of natural teeth.⁹ More recently, average value data on, in particular, the width and length of teeth have been recommended as a key aid to smile design, with little, if any consideration of reported variations

within and between patients of different sex and race. Acceptance, and the application of average value data only in aesthetic dentistry is akin to the Greeks believing that all beauty had some mathematic basis, notably the Golden Ratio (ϕ) 1:1.618, widely used by natural scientists and artists for many centuries.¹⁰

In dentistry, the Golden Ratio, more commonly referred to as the Golden Proportion, has been promoted to determine, among other relationships, the gradation in the apparent width of teeth included in the smile.¹¹ According to Levin,¹² when the Golden Proportion is applied: 'The width of the maxillary lateral incisor should be 62% of the width of the maxillary central incisor, and

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the width of the canine should be 62% of the lateral incisor when viewed in a frontal plane.² It remains possible to this day to purchase Golden Proportion gauges for dental purpose.

Other theories based on formulaic relationships between average values for the dimensions of anterior maxillary teeth and associated parameters have included: Preston Proportion,¹³ Golden Percentage,¹⁴ Recurring Aesthetic Dental Proportion¹⁵ and the Gauge Proportion.¹⁶

Traditionally, there has been a tendency to assume, possibly through lack of evidence, that average tooth dimension values, as detailed in texts on tooth morphology, can be successfully applied in the management of all patients, except for patients with micro- and macrodontia. There is new, growing evidence, however, that such stereotyping is flawed, as the dimensions of teeth may be found to vary to greater or lesser extents within and between male and female patients and different ethnic groups,¹⁷ greatly adding to the complexity of aesthetic dentistry, especially when practised in multicultural communities.

Aim

The aim of the present study was to investigate anterior tooth dimensions, proportions and relationships in a sample of 18–35-year-old patients of Indian origin living in an urban location in the UK and to compare the data obtained with existing data.

Ethical approval

Ethical approval for the study was granted by the Biomedical Science, Dentistry, Medicine and Natural and Mathematical Sciences Research Ethics Subcommittee (BDM RESC) of Kings College London (BDM/14/15–62).

The study was conducted in strict accordance with the requirements of BDM RESC and the Declaration of Helsinki (2013).

Study design

The study was a qualitative, non-experimental, cross-sectional descriptive investigation. The dependant variables were tooth dimensions and relationships. Gender was an independent variable.

Study setting

The study was conducted in the principal author's dental practice in Ashford Dental Practice 8 New Rents, Ashford, Kent TN23 1JJ UK.

Study criteria

The inclusion criteria for the study were as follows

- People of Indian origin, 18–35 years of age, living in the UK with both parents being of Indian lineage
- Intact upper and lower anterior dental arches, free of imbrications and crowding
- Absence of restorations or replaced teeth in the anterior teeth
- No evidence of pathological tooth wear or interproximal stripping having been carried out on the anterior teeth.

The exclusion criteria comprised:

- Established periodontal disease, including recession
- Anterior diastema
- History of allergy to alginate impression material and/or impression tray adhesive
- History of difficulties in having upper and/or lower full arch alginate impressions recorded.

Study participants

One hundred patients with a male to female ratio of 1:1 were recruited from 116 volunteers (56 males and 60 females) –16 volunteers having been excluded, principally for failing to satisfy the study criteria.

Materials and methods

Impressions

After obtaining consent, upper and lower alginate impressions, extending to at least the first permanent molars, were recorded using high definition alginate impression material (DE Healthcare Products, Holland) in stock impression trays (Codent Trays, Henry Schein, UK). The impressions were washed under running tap water for at least 30s, disinfected (EuroSept Max, Henry Schein, UK) per manufacturer's directions, and inspected for defects.

Impressions considered to be satisfactory were wrapped in damp gauze, numbered using unique patient numbers for the study, bagged and sent to the laboratory.

The impressions were cast in dental stone within half an hour of being removed from the mouth. After 24 hours, the casts were trimmed, air dry, numbered as per the impressions, wrapped in tissue paper and bubble wrap, placed in cardboard boxes and returned for measurement.

Any cast found to contain defects of the anterior teeth were rejected and arrangements made to repeat the impressions.

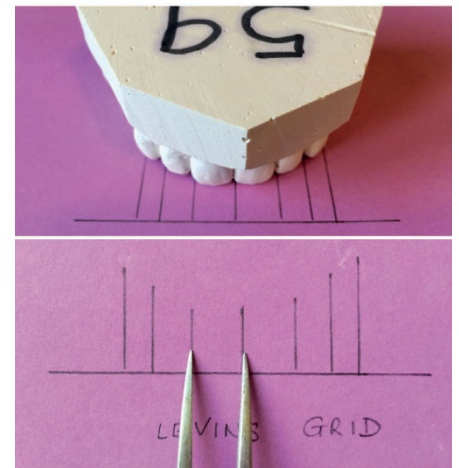


Fig. 1 Levin's grid¹²

Measurements

The length (lowest point on the incisal edge to the most cervical extension of the labial surface of the anatomical crown [mm] perpendicular to the occlusal plane) and width (greatest mesio-distal, labial surface dimension [mm] at the level of the contact areas parallel to the occlusal plane) of the six maxillary anterior teeth included in each set of casts were measured using precision callipers. Each measurement was repeated at least three times, or until a consistent value was obtained. Measurement was limited to ten casts at a time to limit fatigue errors. After two weeks, a random sample of one in every ten casts was selected for repeat measurements to determine the error of the method.

Upper anterior arch length (from the distal contact of one canine, across the labial surfaces of the anterior teeth to the distal contact of the contralateral canine) was measured (mm) using a flexible measuring tape.¹⁸

Golden Proportion

Each upper maxillary cast was placed on a blank piece of paper and the apparent width of the anterior teeth, as seen in a frontal view, marked, creating a Levin's grid.¹² The elements of the grids were measured (mm) at least three times to obtain consistent values, using engineer dividers and a ruler (Fig. 1).

Statistical analysis

The data collected were collated and analysed using SPSS v20 software. Paired sample t-tests were performed to compare left and right mean values obtained for the male and female participants. Also, independent sample t-tests were performed to determine if there were gender differences in the width, length and width to

Table 1 The mean (mm), standard deviation, 95% confidence interval (95% CI), width and length of the upper anterior teeth according to gender

Upper anterior teeth												
	13		12		11		21		22		23	
Gender	Width	Length	Width	Length	Width	Length	Width	Length	Width	Length	Width	Length
Male (M)	8.16 (0.55)	9.58 (1.67)	7.42 (0.63)	8.40 (1.20)	8.93 (0.78)	9.74 (1.39)	8.93 (0.78)	9.98 (1.34)	7.45 (0.45)	8.45 (1.10)	8.02 (0.56)	9.81 (1.70)
N	50	50	50	50	50	50	50	50	50	50	50	50
95% CI	0.33 (0.12– 0.54)	0.68 (0.14– 1.21)	0.23 (0.005– 0.46)	0.09 (-0.32– 0.151)	0.28 (0.01– 0.56)	0.38 (-0.01– 0.56)	0.33 (0.12– 0.53)	0.70 (0.24– 1.16)	0.31 (0.11– 0.51)	0.11 (-0.26– 0.50)	0.25 (0.04– 0.46)	0.82 (0.27– 1.37)
Female (F)	7.82 (0.56)	8.89 (0.89)	7.18 (0.55)	8.30 (0.90)	8.64 (0.59)	9.36 (0.88)	9.03 (0.57)	9.28 (1.34)	7.14 (0.52)	8.34 (0.79)	7.77 (0.47)	8.98 (0.93)
P-value M vs F	0.002*	0.01*	0.05	0.64	0.04*	0.10	0.002*	0.003*	0.002*	0.54	0.01*	0.004*

*Significant gender difference at level $P < 0.05$

length ratio for each tooth type. The level of statistical significance was set at $P < 0.05$.

Results

The mean age of the female subjects was 28.04 years of age, SD 4.53 years, while that of the male subjects was 30.18 years of age, SD 3.16 years. There was no significant difference in the mean age according to gender ($P > 0.05$).

As shown in Table 1, significant differences existed in mean width values between the male and female participants, except for the upper right lateral incisor ($P = 0.05$). There were also significant gender differences in length for the central incisor and canine tooth, but not the lateral incisors (left $P = 0.54$, right $P = 0.64$).

When the male and female mean width and length were combined and tabulated according to side (Table 2) there was a significant left/right difference in the canine dimensions – width and length ($P < 0.03$). The central and lateral incisors showed no such difference.

Arch length

The male participants had a greater mean anterior arch length (49.05mm, SD 3.21) than the female participants (47.33, SD 2.89). This difference was statistically significant ($P < 0.05$).

As with the measurements of tooth width and length, the error of the method was small (< 0.56 mm) and considered to have no significant influence on the findings.

Golden Proportion

The data obtained from the Levin grids revealed differences in apparent 'smile zone' tooth width ratios within and between the male and female subjects and in the overall, combined data. The mean apparent width ratio of the central incisor to lateral incisor was 1.21, SD 0.09 compared to the ideal 1.618, while the lateral incisor to canine ratio was 0.92, SD 0.08 compared to the ideal of 0.618.

Discussion

The Indian people, about one-sixth of the global population, are one of the world's oldest civilisations. It has a unique blend of cultures, religions, beliefs and ideas.¹⁹ Given numbers, wide geographic distribution and representation across all sectors of society, Indian people show great diversity, including diversity in, among other features, stature and form. Indian people in countries such as the UK have tended to remain relatively homogeneous, but are beginning to show more heterogeneity, with increasing numbers of mixed marriages and resultant families. Dental attractiveness is of growing importance among at least younger members of the UK Indian community, in common with younger members of the population at large.

Mean values

The mean values for the various parameters investigated in the present study were not

found to be significantly different ($P > 0.05$) from those in the related study by Beyou and Wilson²⁰ which investigated young Zimbabweans. There were, however, some significant differences when comparisons were made with the values reported by Sterrett et al.²¹ who investigated a sample of Caucasians – highly significant difference in the width of all upper anterior tooth types ($P < 0.001$); no differences in lengths, except for the female lateral incisor ($P < 0.05$), but significant differences in overall tooth width: length ratios for canines ($P < 0.004$).

These findings indicate that while intact teeth of the same type and typical appearance in male and female patients and patients of different ethnicity may be found to share similar features, it cannot be assumed that they share the same dimensions. Thus, smile design, especially when treating patients in a multicultural community, cannot be approached with a 'building brick' type mentality. Small variations in the size of teeth, while maintaining the 'visual balance' of the smile, may be one of the keys to achieving a truly natural appearance in aesthetic dental procedures.

Gender variation

Gender variations in tooth dimensions have been noted in most races, with teeth in males being typically larger than those in females.^{17,21–26} The findings of the present study reveal sexual dimorphism in favour of

Table 2 The mean (mm) width and length (pooled) of the upper anterior teeth according to side (left/right)

		Mean (SD)		Paired t test		
		Right	Left	t	df	P-value
Width (mm)	Central incisor	8.79 (0.70)	8.87 (0.54)	-1.67	99	0.09
	Lateral incisor	7.30 (0.60)	7.30 (0.51)	0.08	99	0.93
	Canine	7.99 (0.55)	7.90 (0.53)	2.09	99	0.03*
Length (mm)	Central incisor	9.55 (1.18)	9.63 (1.19)	-1.05	99	0.29
	Lateral incisor	8.35 (1.06)	8.39 (0.96)	-0.55	99	0.57
	Canine	9.24 (1.37)	9.40 (1.42)	-2.10	99	0.03*

*Statistically significant, level $P < 0.05$ **Table 3** Paired t-test of combined width to length ratios comparing right and left teeth

		Mean (SD)		Paired t test		
		Right	Left	t	df	P-value
Width/length ratio	Central incisor	0.91 (0.14)	0.92 (0.12)	0.499	99	0.61(NS)
	Lateral incisor	0.87 (0.14)	0.86 (0.13)	-0.489	99	0.62(NS)
	Canine	0.86 (0.17)	0.84 (0.18)	-2.93	99	0.004*

*P Statistically significant level $P < 0.05$

men, notably for the mesio-distal width of the upper anterior teeth, except for the upper right lateral incisor. In addition, the findings indicate sexual dimorphism in crown length in favour of men for upper canines and upper left lateral incisors. There was no significant gender difference in length for upper right central and lateral incisors. These findings lend further support to the view that men tend to have larger teeth than women, and that variations in tooth dimensions exist within and between men and women.²⁰

Previous investigations of the dimensions of upper anterior teeth have found sexual dimorphism. Calcada and co-workers²⁷ in studying a sample of Portuguese people found significant gender difference in all the principal dimensions of all anterior tooth types, except for the width of the upper left lateral incisor ($P = 0.177$). Gongalves et al.,¹⁸ who investigated the dimensions of anterior teeth in a sample of young Brazilians, found significant gender differences in the width of all anterior tooth types, except the lateral incisor ($P > 0.05$). Condon and co-workers,²⁸ who studied a sample of young Irish people, found significant gender difference in the dimensions of all upper anterior tooth types, except for the lengths of the lateral incisors and left central incisor. In a more recent study of a sample of young Zimbabweans, as indicated

above, Beyuo and Wilson²⁰ observed significant gender differences in the width and length of all upper anterior tooth types, except for the lateral incisors. Taken together these findings provide substantial evidence that teeth in men tend to be bigger, but not uniformly bigger than teeth in women; indeed, the difference in the size of teeth between males and females may be found to show wide variation within and between different samples of populations of different nationalities and ethnic groups. To date, no study on the dimensional parameters of anterior teeth have found any dimension to be significantly smaller in males than in females.

Symmetry

A statistically significant ($P = 0.03$) right/left difference in canine width was a finding in the present study. No other statistically significant right/left differences were observed for the other anterior tooth types ($P > 0.05$).

In an American sample, who had Northern European ancestry, Garn and co-workers²² investigated the mesio-distal width measurements of 297 left and 297 right central incisors and found variations of only 0.03 mm in men and 0.01 mm in women. In contrast, Mavroskousis and Ritchie²⁹ found right/left differences in >90% of cases when they measured the width and length of upper

central incisors in a sample of 70 English dental students. Goncalves and co-workers¹⁸ also found significant left/right differences ($P > 0.05$) in their sample of Brazilians, despite the dimensions of the central incisors being similar. Differences in tooth width between antimeric teeth were prevalent in a study of black South Africans.³⁰ The authors attributed these differences to the high levels of disease and malnutrition in the population studied. In a similar group, a statistically significant antimeric difference ($P = 0.011$) in the width of upper lateral incisors was found in a sample of healthy Zimbabweans investigated by Beyuo and Wilson.²⁰ These findings collectively indicate that left/right antimeric differences in tooth dimensions are common, with the differences varying within and between men and women and different populations of people. Exact size symmetry should not, therefore, be one of the aims of smile design, let alone a feature of computer generated smiles.

Width to length ratios

Tooth width to length ratios are important in smile design and perceptions of dental attractiveness. The typical width to length percentage ratio for the upper central incisor has been reported to be between 66% and 85%.^{2,31-33} In the current study this value was higher: 91%.

While the findings of the present study included a significant left/right difference in the width to length ratios of upper canine teeth ($P = 0.004$), there was no gender difference in the overall ratios data ($P > 0.05$). This is in concordance with previous studies that report tooth dimension ratios.^{20,28,34} Gender differences in the width/length ratio for maxillary canines have been reported previously.^{17,21,26,35} These findings collectively reinforce the view that a decision to change the width or length of an upper canine and, therefore, the width/length ratio of that tooth, may enhance the 'natural look' of a smile. That said, it may well take more than one variation from the application of mean values for tooth parameters to achieve a 'natural look', assuming this is the desired outcome of the treatment, as agreed with the patient at the time of obtaining consent. In obtaining consent, it is considered important to take time to explain proposed variations, including subtle changes in tooth parameters to the patient, many of whom assume, and therefore expect, among other features, bilateral symmetry in the completed smile.

Arch length

Canine to canine anterior arch length measurements in the present study revealed that Indian men have on average longer, and thereby wider dental arches than Indian women. This difference was statistically significant ($P = 0.5$). This agrees with findings in previous studies.^{18,20,37,38} These findings collectively indicate that men, irrespective of ethnicity, tend to have longer, wider dental arches than women. This result is not surprising given that, as concluded above, men tend to have larger teeth than women.

Golden Proportion

Analysis of the data obtained failed to reveal any Golden Proportion relationships. Golden Proportion relationships have been found to be absent in similar studies investigating samples of individuals from different ethnic groups. These groups include Turkish,³⁵ Irish,²⁸ Iranian,³⁹ Hungarians,⁴⁰ Portuguese²⁷ and African²⁰ peoples. These findings indicate that the adoption of a Golden Proportion approach to smile design may not result in a 'natural appearance'. Golden Proportion considerations may, at best, be a guide in aesthetic dentistry procedures.⁴¹ It would be of interest to test the hypothesis that denture teeth, in addition to having identical left/right dimensions, and therefore identical width/length

ratios, follow Golden Proportion relationships. If this hypothesis were to be confirmed, it could help to explain certain limitations in the dental attractiveness of supposedly 'natural look' complete dentures.

Limitations

Despite the careful planning and execution of the present study, it is acknowledged that it suffers certain limitations. Firstly, the study involved a relatively small sample of Indian people living in one location in the UK, all of whom were 18–35 years of age. This sample may not, therefore, be representative of all Indian people living in the UK, let alone elsewhere in the world. In addition, Indian people of the type included in the present study, and despite the study inclusion criteria, may not be a homogenous group; recent studies having revealed evidence of genetic mixture in Indian people, involving two ancestral groups.⁴² Despite these limitations, the findings of the present study are considered to be of relevance to the clinical practice of, in particular, aesthetic dentistry.

Key finding

The key finding – 'take home message' from the present work is that it is inappropriate to adopt a formulaic, symmetrical approach to smile design in the provision of aesthetic dentistry for, at least, young adults of Indian origin. It is suggested that this key finding probably applies to the management of all patients seeking aesthetic dentistry. Subject to this conclusion being ratified by subsequent studies of a similar nature, questions may arise in the future as to the value of computerised smile design systems which assume standardised tooth dimensions and left/right symmetry.

Specific conclusions

Within the limitations of the present study, the following specific conclusions were drawn:

1. Upper anterior teeth of the same type and typical appearance in young adult Indian patients should not be assumed to share the same dimensions and, in turn, dimension ratios
2. Sexual dimorphism was observed in the upper anterior teeth of the people investigated
3. A significant right/left difference was observed in the width/length ratios of the upper canine teeth
4. Upper anterior arch length was found to be significantly greater in the men investigated in the present study

5. No Golden Proportion relationships were observed.

Clinical implications

The findings of the present study indicate that the members of the dental team involved in the provision of restorative care and aesthetic dentistry for young adult patients of Indian origin, specifically dentists and dental technologists, may be guided by widely accepted data on anterior tooth parameters and relationships, but should not seek to slavishly create restored and modified teeth of standard mean dimensions, let alone aim to generate bilateral symmetry, if the desired clinical outcome is a 'natural look'. In addition, Golden Proportion relationships may act as a guide, but should not dictate smile design, as Golden Proportion relationships have not been found to exist in natural dentitions. Therefore, unmodified electronically created smile designs and associated CAD/CAM systems, based on standard mean tooth dimensions, the assumption of left/right symmetry and/or Golden Proportion relationships, cannot be expected to give a 'natural look' clinical outcome in young adult patients of Indian origin. Available data indicates that the present findings and conclusions may be found to be equally applicable for all patients. Furthermore, it is suggested that in finalising a smile design, the wishes of the patient must be taken into account; however, personal preferences which would adversely affect the 'visual balance' and, in turn, the overall attractiveness of the smile should be discouraged. Finalising details of smile design should be a consensus between the patient and clinician. Agreeing an appropriate smile design with a patient wishing to turn the clock back to look the way they did many years ago, seeking to have the same smile as someone else, typically a 'media star', or with preconceived, ill-informed, subjective ideas of what constitutes an 'ideal smile', which at best would look artificial, remains a formidable challenge, possibly ringing a dental dysmorphia 'alarm bell'.⁴³

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