

## ORIGINAL RESEARCH

# An *in vivo* Study to Evaluate the Correlation between Facial Form, Tooth Form, and Arch Form in Dentulous Subjects

<sup>1</sup>Himanshu Arora, <sup>2</sup>Chethan Hegde, <sup>3</sup>Deeksha Sharma, <sup>4</sup>Bala S Bhat, <sup>5</sup>Sarfaraz Memon, <sup>6</sup>Neeraj Mittal

## ABSTRACT

**Objectives:** Sex-related optimal esthetics is assumed to be achieved only if the face, arch, and tooth forms are in harmony. The need of this study was to evaluate and question the hypothesis that there is correlation among face, tooth, and arch forms.

**Materials and methods:** For the study 120 subjects were selected. Thirty subjects were divided into four facial forms. Arch and tooth forms were analyzed for each subject and correlation between tooth form, face form, and arch form was evaluated. Face form was analyzed using Trubyte tooth indicator; arch form was analyzed using a mathematical formula; and tooth form was analyzed using measurements on maxillary central incisor.

**Results:** The results demonstrated that ovoid tooth, face, and arch forms were most prevalent and no significant correlation was established between face, tooth, and arch form.

**Conclusion:** Although no significant correlation was observed between the face, arch, and tooth forms, but a high level of association was seen between tooth form and arch form. Also ovoid face form and ovoid tooth form were among the highest association forms, albeit statistically insignificant. Hence the importance of pre-extraction records cannot be neglected as they serve as best aid for the selection of artificial teeth and if they are not available these correlations can be used as a side tool for the selection of teeth clubbed with experience and expertise of the clinician and subjective sense of esthetics of both patient and dentist.

**Keywords:** Arch form, Facial form, Ovoid, Square, Square tapering, Tapering, Tooth form.

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## INTRODUCTION

The way, beauty of the face is perceived is dependent to a large extent on the appearance of anterior teeth. The appearance of anterior teeth dictates how attractive a face looks and how pleasing the smile appears.<sup>1</sup> The most challenging part of complete denture esthetics is the appearance of anterior teeth and the way they harmonize with the surrounding structures. The fabrication of complete denture prosthesis with appropriate form, color, and contour of the artificial teeth would not pose a big problem if natural teeth remain, but the selection poses a serious problem when natural teeth are lost and no pre-extraction records are available.<sup>2</sup> Numerous methods have been utilized in the past to help in the selection of artificial teeth to achieve desirable esthetics.<sup>1</sup>

The first theory which gained popularity was the temperamental theory which classified patients according to their temperament and further selecting teeth based on the same. In 1914, "law of harmony" put forth by Williams gained popularity and replaced the temperamental theory and is till date the most commonly followed method for artificial tooth selection. In 1956, Frush and Fisher developed dentogenic concept which discussed about the selection of teeth based on sex, personality, and age of an individual.<sup>3</sup> According to "law of harmony" outline of face when inverted may correspond to the maxillary central incisor, resulting in desirable esthetics. This theory of matching face form with the tooth form has also been popularized by many as geometric theory.<sup>3,4</sup>

Although the geometric theory is the most commonly used method by most prosthodontist, but still the reliability of this method has been questioned by many researchers in the recent past. Generally, the arch form is assessed visually in an arbitrary manner classifying it as square, tapering, and ovoid. Any attempt to classify arch form in this arbitrary manner is subjected to errors. Consistency between face and arch form has been reported in a high percentage of edentulous cases by the use of

<sup>1,3-6</sup>Senior Lecturer, <sup>2</sup>Professor and Head

<sup>1,3,5</sup>Department of Prosthodontics, MP Dental College and Hospital, Vadodara, Gujarat, India

<sup>2</sup>Department of Prosthodontics, AB Shetty Memorial Institute of Dental Sciences, Mangaluru, Karnataka, India

<sup>4</sup>Department of Prosthodontics, Dr DY Patil Dental College and Hospital, Pune, Maharashtra, India

<sup>6</sup>Department of Prosthodontics, JCD Dental College and Hospital, Sirsa, Haryana, India

**Corresponding Author:** Deeksha Sharma, Senior Lecturer Department of Prosthodontics, MP Dental College and Hospital, Vadodara, Gujarat, India, Phone: +918141007846 e-mail: dr.deeksha.sharma@gmail.com

digital photography and software, which is not the most easily accessible method.<sup>2</sup> The square, ovoid, and tapered arch forms have not yet been mathematically defined.<sup>5</sup> In the light of these observations, a mathematical formula was derived to identify arch form that only required subject's maxillary cast to identify arch form.

There is very little evidence in the literature showing the importance of arch form in tooth selection and very few researches have been carried out to compare the importance of face as well as arch form in artificial tooth selection.

Thus, this study was planned with the following objectives in mind:

- To determine prevalence of varying tooth form and arch form in 120 dentulous subjects having ovoid, square, tapering, and square tapering face form.
- To determine whether any correlation between tooth form, facial form, and arch form exist.
- To verify the reliability of the method for measuring the arch form that can be used as a diagnostic tool in prosthodontic and orthodontic practices.

## MATERIALS AND METHODS

A total of 120 subjects were selected from the student population and from the subjects reporting to the outpatient department of prosthodontics at a dental institute in India.

The subjects were randomly selected and rejected based on the following inclusion and exclusion criteria.

### INCLUSION CRITERIA

- Subjects with full complement of teeth
- No history of orthodontic treatment
- Subjects should be above the age of 21 years (facial growth would be essentially complete)
- No history of congenital facial abnormality and facial surgery.

### Exclusion Criteria

- Severely attrited or compromised upper anterior teeth
- Subjects with fixed or removable prosthesis
- Generalized decay or periodontal pathology
- Severely malaligned upper anterior teeth.

After selection of the subjects the study was carried out in the following sequential manner.

### Identification of Facial Form

The facial form was analyzed first and subjects were categorized into ovoid, square, tapering, and square tapering using Trubyte tooth indicator (Dentsply International, 570 West college Avenue, York, PA 17405-0872 1-880-786-0085 Distributed by Dentsply Canada) (Fig. 1). Thirty subjects were selected in each category.



Fig. 1: Armamentarium

### Classification of Face Form with Face Form Indicator

The following procedures were used to classify the face forms:

The subjects were made to stand upright with head firmly positioned against the wall with the subject looking straight. The head was kept in a stable position and any movement was avoided to cause errors while recording the facial outline. The Trubyte indicator was then centered on the face with the midline of the indicator coinciding with the midline of the face. For the purpose of classifying the face forms, three reference points were used,  $A_1A_2$ ,  $B_1B_2$ , and  $C_1C_2$ , on either side of the face to represent the greatest width of the face of forehead, zygomatic arch, and the angle of mandible respectively.

*Reference point  $A_1A_2$ :* These points represented the greatest width of the forehead at the upper third of the face.

*Reference point  $B_1B_2$ :* These points extended across the middle third of the face and represented the greatest width of the face at the most prominent part of the zygoma.

*Reference point  $C_1C_2$ :* These points extended between the greatest width at the angle of the mandible to give the greatest width of the lower third of the face.

In this manner, six reference points  $A_1A_2$ ,  $B_1B_2$ ,  $C_1C_2$  were marked with an erasable marking point.

*Square face form:* When  $A_1, B_1, C_1$  and  $A_2, B_2, C_2$  were situated on the same side of the vertical line, on either side of the face, it was designated as square face form. All the reference points had the same width (Fig. 2).

*Tapering face form:* When there is a progressive reduction in the width from  $A_1A_2$  to  $B_1B_2$  and  $C_1C_2$  it was designated as tapering face form.  $A_1A_2$  had the greatest width, while  $C_1C_2$  had the narrowest width (Fig. 3).

*Ovoid face form:* When reference points  $B_1B_2$  had greater width than  $A_1A_2$  and  $C_1C_2$ , it was designated as ovoid face form (Fig. 4).



Fig. 2: Square face form

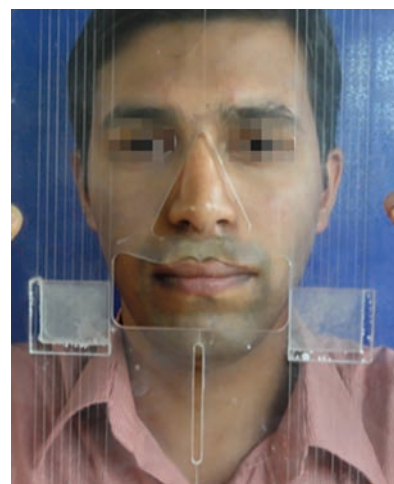


Fig. 3: Tapering face form



Fig. 4: Ovoid face form



Fig. 5: Square tapering face form

*Square tapering face form:* When reference points  $A_1A_2$  and  $B_1B_2$  had same width and there was reduction in width at points  $C_1C_2$ , it was designated as square tapering face form (Fig. 5).

After dividing subjects into four groups based on their face form, arch form and tooth form of each subject were analyzed.

For recording of arch form and tooth form, maxillary impression of each subject was made with the help of irreversible hydrocolloid (Zelgan Plus; Dentsply India) and the cast was poured with the help of type 3 dental stone (Kalabhai Dental Stone). The resultant maxillary cast was used to identify arch and tooth forms of each subject.

### Identification of Arch Form

Arch form was determined by a mathematical formula that compares arch form to an ideal parabola.

In the mathematical method the obtained cast was placed with incisal edges and occlusal surfaces contacting the graph paper. After stabilizing the cast the outermost points of contact of midpoint between the central incisors,

tip of canines were marked on a graph paper using a fine marking pen. The midpoint between central incisors was designated as V. The markings of tip of canines were designated as  $C_1$  and  $C_2$ . These reference points were joined to get the arch form.  $C_1$  and  $C_2$  were connected and a perpendicular was dropped from V to meet  $C_1$  and  $C_2$  (Figs 6A and B).

The values obtained were used to obtain arch form in the following manner:

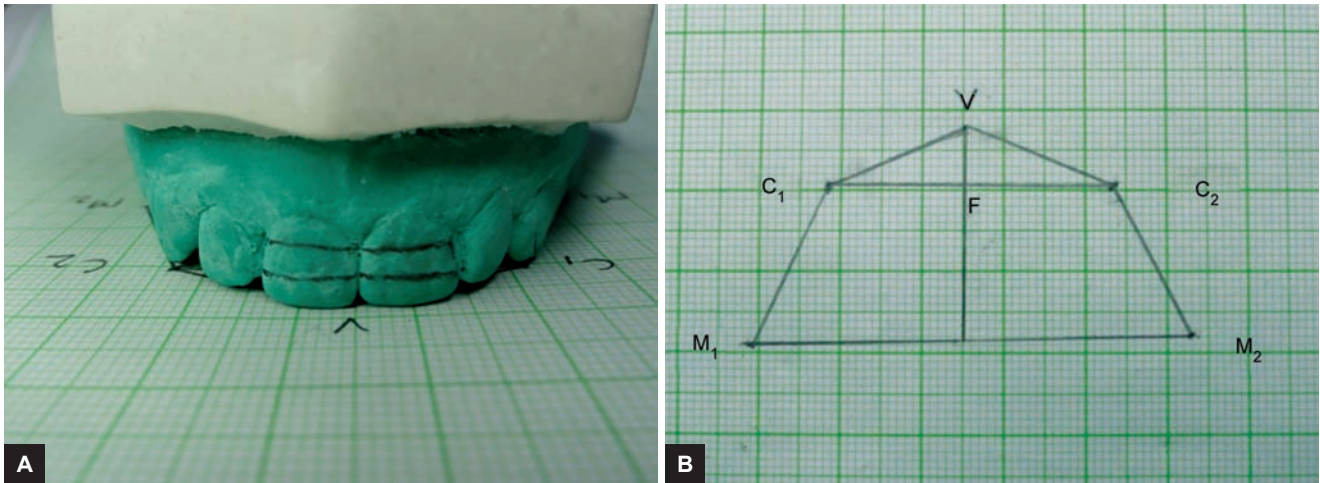
$$R = C_1C_2 / VF$$

If the calculated value of R was less than 3.5 cm, it was designated as tapering arch form; if the calculated value of R was between 3.5 and 4 cm, it was designated as square arch form; and if the calculated value of R was greater than 4 cm, it was designated as ovoid arch form.

### Identification of Tooth Form

For recording the tooth forms, the maxillary central incisor was taken as an ideal tooth form and certain measurements were made in order to arrive at square, tapering, ovoid, and square tapering tooth form in the following manner:





Figs 6A and B: Arch form identification

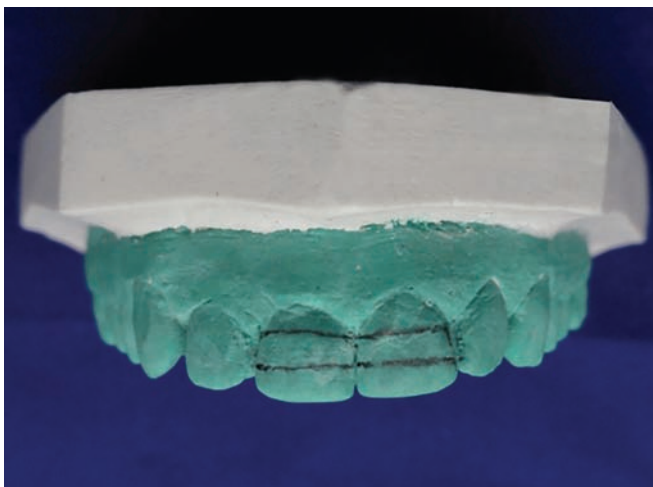


Fig. 7: Identification of tooth form

The labial surface of maxillary central incisor was divided into cervical, middle, and incisal one third (Fig. 7). The width of labial surface was recorded at three reference points:

- Width at cervical one third
- Width at contact point
- Width at incisal edge
- When the widths at the cervical one third, at contact point, and at incisal edge were equal, the tooth was designated as square tooth form.
- When the width at contact point exceeded the width at cervical one third and incisal edge, the tooth was designated as ovoid tooth form.
- When the width sequentially reduced from incisal edge to contact point to the cervical one third, it was designated as tapering tooth form.
- When the width at incisal edge and contact point was the same and reduced then at cervical one third, it was designated as square tapering tooth form.

After obtaining face form, arch form, and tooth form of each subject, the data obtained were subjected

to statistical analysis to determine whether correlation existed between these forms.

The test used to ascertain the correlation between face, tooth, and arch forms was chi-square test.

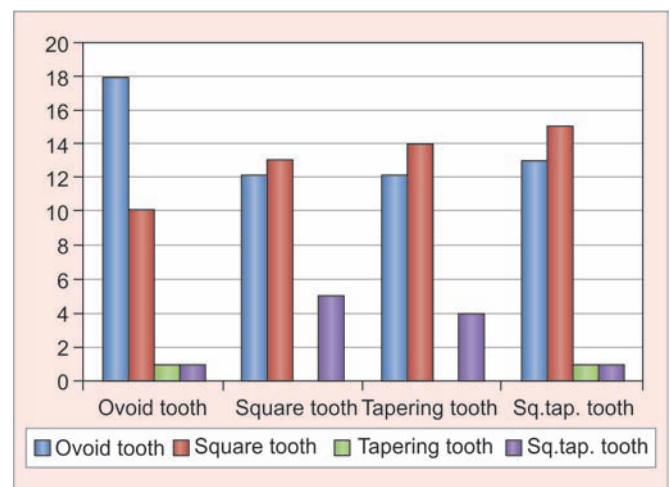
## RESULTS

A total of 120 subjects were selected for the study and they were grouped into four facial forms (ovoid, square, tapering, and square tapering) and 30 subjects were selected in each category.

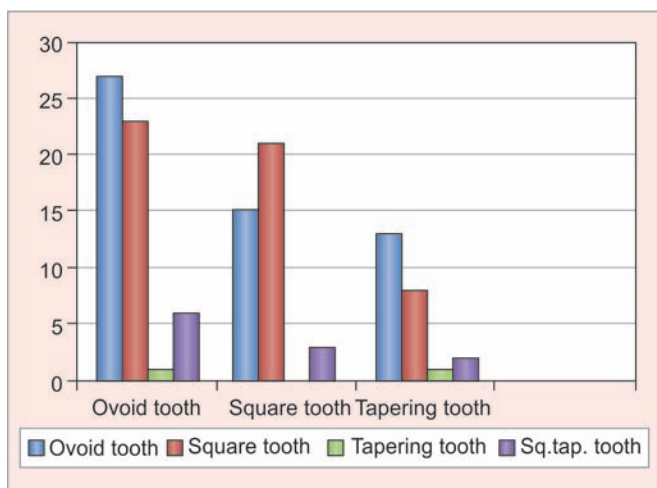
Out of all 120 subjects evaluated, 55 demonstrated ovoid tooth form, 52 demonstrated square tooth form, 2 demonstrated tapering tooth form, and 11 subjects demonstrated square tapering tooth form.

Out of all 120 subjects evaluated, 57 demonstrated ovoid arch form, 39 demonstrated square arch form, and 24 demonstrated tapering arch form.

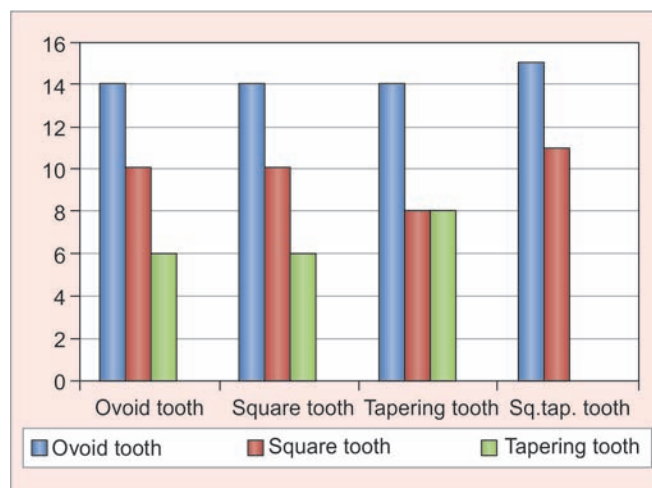
The frequency distribution of varying tooth form in varying face form, varying tooth form in varying arch form, and varying arch form in varying face form are depicted in Graphs 1 to 3 respectively.



Graph 1: Frequency distribution of varying tooth form in varying face form



**Graph 2:** Frequency distribution of varying tooth form in varying arch form



**Graph 3:** Frequency distribution of varying arch form in varying face form

**Table 1:** Comparison between face and tooth form

Category	Frequency	Percentage	p-value
Similar	32	26.66	0.489
Dissimilar	88	73.33	

**Table 2:** Comparison between arch and tooth forms

Category	Frequency	Percentage	p-value
Similar	49	44.95	0.735
Dissimilar	60	55.045	

**Table 3:** Comparison between arch and face form

Category	Frequency	Percentage	p-value
Similar	32	35.55	0.931
Dissimilar	58	64.44	

The comparison between facial, tooth, and arch forms was categorized into two groups: Similar and Dissimilar (Tables 1 to 3) and the results were statistically analyzed using chi-square test.

**DISCUSSION**

Although one of the most important aspect to achieve best esthetics in complete denture prosthesis is selection of artificial teeth, it is often the most neglected phase of prosthodontics. Most of the dentists rely upon the dental laboratory technician to do the same for them. No universally accepted method for the selection of anterior teeth has yet been established, so dentists seek guidance from a variety of techniques using their clinical experience and esthetic sense to attain what is hoped will be an acceptable result.

Long time ago, Leon Williams had categorized all the people to have the three basic face forms which were matching to the same, but smaller and inverse central maxillary incisor’s forms. Although being one of the oldest methods, it is still the most preferred method, but the validity of this method has been questioned in the past.

Berksun et al<sup>1</sup> found that there exist no correlation between face form, tooth form, and arch form and

reported that according to them, face and arch forms showed the highest correlation; the least correlation was noticed between tooth and face form. Their study disproved Leon Williams’ hypothesis that had been followed for long time to match tooth form to face form in order to achieve best of esthetics.

Sellen et al<sup>2</sup> also questioned Leon Williams’ hypothesis through their study and reported that highest correspondence was seen between face and arch forms.

Most of the studies that were carried out previously have employed two methods of recording face, tooth, and arch forms. First method involves subjective examination of each form and then trying to find association between them. The disadvantage of this method is that the subjective examination is prone to errors and can provide a misleading data.

The second method was by far the most commonly followed method in which computer<sup>1,6</sup> and software-based analysis of tooth, face, and arch forms was done and then association between these variables was determined. The disadvantages of this method were its high cost, accessibility, and difficulty in learning and using of software, and also being practically not possible in Indian scenario to make every patient undergo a screening procedure for teeth selection and then transferring the same to the laboratory technician.

Therefore, this study adopted the most easiest and convenient method to evaluate facial form by means of Trubyte tooth indicator, which is not prone to errors and provides a better reliability than subjective examination.

The tooth form was analyzed by mathematically dividing tooth into three equal halves and then using the obtained measurements to ascertain tooth form, which provided better reliability than visual method or by superimposition technique (in which face form and tooth form are superimposed on each other for the evaluation of correlation between them)<sup>6</sup>. Hence in this study the errors were reduced by making a cast to evaluate tooth form rather than using the photograph of the subject. As in recent past, even arch form has been used as an aid in tooth selection process.

The most common methods used for arch form determination are visual and computer based.<sup>1</sup> Both the methods have their own drawbacks; none of them have any mathematical background and rely upon subjective analysis, thereby making them prone to error. Hence in this study a mathematical formula devised by Hassan Noroozi and Sunil Datta was utilized, which proved to be more assertive and reliable than other techniques.

Noorzi et al<sup>5</sup> had revisited dental arch form and they came up with a mathematical formula called the BETA FUNCTION to describe a dental arch. They said that square, ovoid, and tapered arch forms have yet not been mathematically defined. A solution to that, they defined based on relative ratios of canine and second molar cross arch widths along with their relative arch depths. When the Width of canine (Wc)/Width of molar (Wm) ratio increases or the Depth of canine (Dc)/Depth of molar (Dm) ratio decreases, the arch becomes squarer. On the contrary when Wc/Wm ratio decreases or Dc/Dm increases, the arch gets more tapered.

Datta<sup>7</sup> devised a new formula for the identification of arch form and the conceptual basis of the same formula was utilized in this study. The basis for this equation is based on four parameters, i.e., depth and width of dental arch at canine and second molar region. In this study only the depth at the canine region and midpoint of central incisor was utilized. In this study fixed values were used to ascertain arch form, but the basis still remained the same, i.e., as the width at the canine region became narrow and the perpendicular dropping from central incisors became long, it was designated as tapering arch and when width at canine region increased and the perpendicular dropping from central incisor became short, it was designated as an ovoid arch form.

The results of the present study revealed the following findings:

In this study out of 120 subjects studied, ovoid face, tooth, and arch forms had highest prevalence and ovoid face had highest association with ovoid tooth form, and ovoid arch form had highest correlation with ovoid tooth form. These results were similar to the results obtained by Brodbelt et al<sup>4</sup> He even states that least number of tooth

form in his study was tapering tooth form. In this study out of all the subjects studied, only two had tapering tooth form which was least. In this study all 30 subjects had tapering face form, but none of them presented with tapering arch or tooth form.

In the present study, the findings of correlation between face form and tooth form, arch form and face form and arch form and tooth form have been categorized into two groups, i.e., Similar and Dissimilar.

The results of the present study indicate that only 26.6% subjects had any similarity between facial form and tooth form. Also they were in agreement with the results of Ufuk et al<sup>1</sup> who also states that correlation observed between tooth and face forms was insignificant.

Williams<sup>8</sup> had classified face and given the concepts of "law of harmony" and "geometric theory" for the selection of anterior teeth. According to this, he said that face form should correlate with inverted tooth form. Results of the present study show that more than half of the percentages showed dissimilarity in face form to tooth form which do not support the William's Geometric theory stated as above.

Silva et al<sup>9</sup> studied the correlation between the face and tooth shapes in young adult individuals. They stated a predominance of square shape in relation to the taper shape and the ovoid shape. Authors concluded that the "Williams' law of harmony" to select artificial teeth had no efficiency to justify its acceptance. Thus dentist should consider their clinical appearance and critical sense in order to reach a good esthetic result in complete denture. The results of this study are in accordance with the present study. The variation in frequency distribution obtained in both the studies can be attributed to geographic distribution.

Sellen et al<sup>2</sup> had also done computerized study to evaluate these forms and showed 22% correspondence, which is somewhat lower than the present study which can be attributed to the higher sample size evaluated in the present study. Both the studies demonstrate no significant correlation between face and tooth forms.

Berksun et al<sup>1</sup> also carried out their study on computer-based evaluation of gender identification and morphologic classification of tooth face and arch forms. They found that face to arch form (54%) and face to tooth form (51%) correlations were higher than the tooth to arch form correlation, which was 46%.<sup>9</sup> This is somewhat higher than the present study; it may be because of different subjective visual perception and the difference in the method used to record arch and face form.

The results of the present study were in contrast with Pedrosa et al<sup>10</sup> who observed that association between the shapes of the face and maxillary central incisor was significant with greater prevalence with oval shape. A relationship was found between the shape of maxillary



central incisor and pleasant appearance of the images of the smile and smiling faces. They found no relation between the pleasant appearance of the shape of the teeth and gender. The difference in the results can be attributed to the racial difference.

Berksun and Sellen et al<sup>1,2</sup> both have reported highest correlation between arch form and face form, whereas such correlation seems to be nonexistent in the present study. This lower level of correlation obtained in this study can be attributed to nonrandomization sampling followed in this study and the different method used in this study to ascertain face and arch form. This study used Trubyte indicator for facial form and mathematical formula for arch form identification; whereas the other studies have utilized software for both face and arch form identification.

Sellen et al<sup>2</sup> in their study report the highest correlation between arch and face form; but also observe the lowest level of dissimilarity between arch and tooth form, which is same as obtained in the present study.

All the correlations observed in this study between face form, tooth form, and arch form had varying levels of correlation but all these correlations between face, tooth, and arch forms were statistically insignificant, and the results obtained in this study were in accordance with Sellen et al and Semih et al.<sup>1,2</sup> Since no significant correlation was obtained between face, tooth, and arch forms, it should be kept in mind that pre-extraction data play a very vital role in the selection of teeth. In their absence, the selection of teeth in edentulous patients depends on expertise and experience of the clinician and subjective sense of esthetics of both patient and dentist.

## CONCLUSION

Within the limitations of this *in vivo* study, the following conclusions could be drawn:

- The most prevalent tooth form seen was ovoid tooth form, followed by square tooth form and least common tooth form noted was tapering tooth form.
- The most prevalent arch form was ovoid arch form, followed by square arch form and the least common arch form was tapering arch form.
- No significant correlation was noticed between tooth and face forms, but highest form of association was

noticed between ovoid face and ovoid tooth forms. Only 26% subjects demonstrated similar tooth to face form and 74% subjects demonstrated dissimilar tooth to face form.

- No significant correlation was noticed between tooth and arch forms, but the level of association was higher than tooth to face correlation. Only 45% subjects demonstrated similar tooth and arch forms, whereas 55% subjects demonstrated dissimilar tooth form.
- No significant correlation was noticed between face and arch forms, but the association obtained was higher than tooth to face correlation. Only 35.55% subjects demonstrated similar face and arch forms, whereas 64.44% demonstrated dissimilar face and arch forms.

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