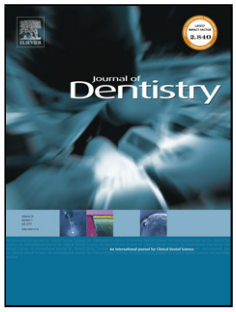

Title: THE INFLUENCE OF VARYING MAXILLARY INCISOR SHAPE ON PERCEIVED SMILE AESTHETICS

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PII: S0300-5712(16)30065-3
DOI: http://dx.doi.org/doi:10.1016/j.jdent.2016.04.004
Reference: JJOD 2606

To appear in: *Journal of Dentistry*

Received date: 25-1-2016
Revised date: 11-4-2016
Accepted date: 14-4-2016

Please cite this article as: Hussain Ahmed, Louca Chris, Leung Albert, Sharma Pranay.THE INFLUENCE OF VARYING MAXILLARY INCISOR SHAPE ON PERCEIVED SMILE AESTHETICS.*Journal of Dentistry* http://dx.doi.org/10.1016/j.jdent.2016.04.004

THE INFLUENCE OF VARYING MAXILLARY INCISOR SHAPE ON PERCEIVED SMILE AESTHETICS

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Keywords:
Maxillary incisors' profile
Smile preferences
Perceived aesthetics

THE INFLUENCE OF VARYING MAXILLARY INCISOR SHAPE ON PERCEIVED SMILE AESTHETICS

ABSTRACT

Objectives
This paper aims to determine the influence of varying the maxillary incisor shape of an individual on perceived smile aesthetics.

Methods
A photograph of a female smile displaying maxillary teeth only was digitally altered to produce five different incisor shapes. They consisted of three basic shapes: square (S), ovoid (O), triangular (T) and two variations, tapered-ovoid (TO) and square-tapering (ST). The images were ranked from the most to the least attractive by 30 dentists, 30 technicians and 30 patients.

Results
The TO maxillary incisor shape was perceived to be the most attractive smile overall (50%), and amongst dentists (70%), technicians (50%) and patients (30%). The O shape maxillary incisors were ranked the second most attractive overall (36.7%) and the most attractive amongst patients (56%). The S shape maxillary incisors were perceived as the least attractive overall (43.3%), and amongst dentists (47%), technicians (50%) and patients (33%).

Conclusions
The tapered-ovoid incisor tooth form for females is preferred to the square form, which corresponds with the findings in the dental literature. However, the results also suggest that there is not one 'ideal' incisor shape and that dental professionals are more critical than patients with respect to the shapes of maxillary incisors. Dental professionals should take the individual variability in patient response into consideration during treatment planning, to produce an aesthetic outcome that is acceptable for the patient.

Clinical significance
As a general rule, the tapered-ovoid tooth form is perceived to be more desirable than the square tooth form. The dental team should therefore keep this finding in mind and liaise with the patients accordingly, in order to help to produce desirable aesthetic clinical outcomes.

1. INTRODUCTION

The maxillary incisors are the most dominant teeth displayed during a smile. According to Phillips[1], the shape of the anterior teeth has a significant influence on smile aesthetics. The crown shape was also ranked the highest from all the various features that contribute to the overall dental attractiveness in a study by Ong et al[2.] Patients are becoming increasingly more conscious of their dental appearance. For many, aesthetic concerns have become one of the main reasons for seeking dental treatment. Treatment that restores function and controls active disease, without delivering optimal aesthetics, is often not perceived by patients to be a complete success.

The morphology of the maxillary anterior teeth is a combination of three basic shapes; ovoid, square and triangular. The unique morphology of teeth allows individuality and diversity. The size and shape of tooth crowns are genetically pre-determined during embryogenesis[3]. As shapes of faces are different from one another, so is the morphology of the teeth.

Tooth shapes are very unique and no two teeth are ever identical. In addition to the three basic shapes, there are six further variations (square-tapering, ovoid-tapering, reverse-tapering, ovoid-square, ovoid-reverse-tapering and square-reverse tapering). This classification was based on the facial outline of crowns and their mesio-distal and gingivo-incisal contours[4].

The shape of the maxillary anterior teeth has been reported in many studies. The most prominent are by Williams[5] and Frush & Fisher[6]. Williams[5] suggested that the shape of the central incisor was the inverted frontal view of the face, a square face merited square teeth and an ovoid face merited ovoid teeth. Although this theory was proposed some time ago, it is still the most common theory for the choice of artificial teeth by dental supply companies, such as Dentsply (York, PA, USA) and their Trubyte® plastic shade guide. Williams[5] and Frush & Fisher[6] both proposed that there are four basic face forms (square, square tapering, tapering and ovoid).

This theory was later invalidated by subsequent studies[7,8] which looked into Williams's geometric theory to find similarity between the face and tooth form. Results concluded that William's theory relating tooth shape to the shape of the face was not necessarily true.

The shape of a tooth requiring restoration can be determined from the adjacent teeth, previous study casts and photographs. If no such records are available, it has been suggested to consider age, sex, and personality[6]. According to this concept, women should be given rounder, softer and more delicate teeth for proper harmony. In

contrast, men are perceived as angular and square, and should be given tooth shapes that harmonise with their appearance.

In another study, it was shown that the ovoid shape was the most prevalent for anterior teeth (47.06%) in a sample of 51 Caucasian individuals[9], whereas 30% of this tooth shape was found in 2000 individuals studied by Ibrahimagic et al[10].

Measurements of width/length ratios of normal clinical crowns represent the most stable reference point for aesthetics. For example, the height-to-width ratio of the central incisor should range from 0.75 to 0.8, a value less than 0.6 creates a long narrow tooth, and a value beyond this ratio results in a short wide tooth[11,12].

As defined by the golden proportion, a ratio of 1 is given to the lateral incisor with regard to mesio-distal width. The central incisors will then have a 1.616 ratio and the canines will have a 0.618 ratio when compared with the lateral incisors. Studies have shown that clinically the Golden proportion is not always apparent and variations are often evident. In one study, measurements of plaster casts of natural teeth revealed that only 17% conformed to the Golden proportion and can cause narrowing of the lateral incisors when applied[13].

In a previous similar study where the contribution of tooth shape to the aesthetic smile was evaluated, orthodontists preferred round and square-round incisors in women whereas general dentists preferred square-round incisors. Lay people in the study did not discriminate between incisor shapes for women but unlike the orthodontist group, they preferred square-round and square-square incisor shapes for men[14].

Dental appearance was also assessed using a questionnaire completed by dentists, technicians and patients. The images of smiles varied in tooth size, tooth form, tooth colour, smile line and the presence of a diastema. The triangular tooth form for both male and female images was the least popular, whereas the oval form for the female image and the rectangular form for the male image were the most popular[15].

Brisman[16] compared dentists' and patients' perceptions of attractiveness. Photographs of three shapes – square ovoid, ovoid and tapered ovoid were presented to 293 subjects. Ovoid was found to be the first choice in three of the four groups.

It is therefore clear that some individual components of smile aesthetics have received more attention than others. There has been research on the influence of tooth shape on smile aesthetics which focused on the incisal edge morphology of maxillary incisors. There have been few studies that have focused on the influence of the geometric shape of incisor teeth.

The aim of this paper was to determine the influence of varying maxillary incisor shape on perceived dental aesthetics amongst dentists, dental technicians and patients.

2. MATERIALS AND METHODS

A photograph of a female smile displaying only maxillary teeth, was digitally altered using an iPad Smile Guide Touch application and Adobe Photoshop (Creative Cloud, San Jose, CA, USA) to produce five different incisor shapes. They consisted of three basic shapes, square (S), ovoid (O), triangular (T) and two variations namely, tapered-ovoid (TO) and square-tapering (ST). This follows similar approaches reported by Cooper et al.[17], Foulger et al.[18] and Bukhary et al.[19]

2.1 Final images used for this study

Fig 1. Image for square incisors (S)

Fig 2. Image for ovoid incisors (O)

Fig 3. Image for triangular incisors (T)

Fig 4. Image for square tapering incisors (ST)

Fig 5. Image for tapered ovoid incisors (TO)

(The colour coded reference for the above tooth shapes used in Figures 6-9 are as follows:

1. Square incisors (S)
2. Ovoid incisors (O)
3. Triangular incisors (T)
4. Square tapering incisors (ST)
5. Tapered-ovoid incisors (TO))

The square shape (Fig.1) was digitally manipulated to produce mesio- and disto-incisal angles that approximate to a right angle. They typically have a long proximal contact area, the longest of the three basic morphologies and a straight incisal outline. The mesial and distal proximal surfaces are parallel to each other and perpendicular to the incisal edge.

The square shape was also manipulated to produce characteristics typical of an ovoid tooth shape (Fig. 2), having rounded incisal edges, proximal contact areas in the middle of the proximal outline and curved mesial and distal proximal outlines.

The triangular shape (Fig. 3) had the sharpest incisal angles of the three morphologies. The contact areas were near the incisal edge within the proximal outline. It had a straight outline with a prominent convergence from incisal to cervical aspects with a V-shaped cervical line.

The tapering ovoid shape (Fig. 4) had rounded incisal edges. The lines following the proximal surfaces converged to meet at a point near the root apex. In contrast, the square tapering shape (Fig. 5) had similar incisal angles and proximal surfaces to the

square shape, however the lines following the proximal surfaces converged to meet at a point near the root apex.

The numbers of confounding variables in the images were reduced by only including the maxillary teeth and eliminating other parts of the face, lips or lower teeth.

The height-to-width ratios of the maxillary central incisor were kept consistent within the 78-82% range proposed in the dental literature[12,17,20,21]. 0.8-0.81 was chosen as the center-stage of the images[12,21,22] to eliminate this confounding variable, so that the perception of attractiveness would only be influenced by the variation of tooth shape.

The square image was used as a baseline, which was then digitally manipulated using Photoshop® to produce the different tooth shapes. The overall size of the images were standardised to 10.7cm x 3.8cm, in order to accommodate the five images onto one A4 sized gloss finished photographic paper.

The requisite research ethics approval was applied for and granted. Ninety participants aged 25 years or older were recruited into this study, including 30 patients, 30 general dental practitioners and 30 dental technicians.

The images were ranked in order of attractiveness (1 for the most attractive and 5 for the least attractive) by 30 dentists (15 male, 15 female), 30 technicians (24 male, 6 female) and 30 patients (12 male, 18 female). The colour temperature (background lighting) was standardised to a white fluorescent light for the entire study.

In order to elicit qualitative responses, the study participants were additionally asked to express why and how they made their choices.

In order to determine consistency, the participants were then asked to repeat the study after an interval of 60 minutes. Previous studies used a wash out period of 10 minutes[17,23]. However, this was increased in this study to prevent the results being influenced by the effects of memory. Cohen's kappa values were calculated to test the reliability of participants in their ability to rank the images in the same order of attractiveness.

The data was tabulated on a spreadsheet, which was then transferred to SPSS software (version 22: SPSS Inc, Chicago, Illinois, USA) for data analysis. The level of significance was set at 5%. Pearson's chi-squared was used to compare the most and least attractive tooth shape overall and between the three cohorts. The effect of potential confounding factors (such as gender & age) on the most and least attractive tooth shape, was evaluated using Logistic regression.

3. RESULTS

Combining the collected data for all three groups revealed that the image TO recorded the most number of observations (50% of participants) and contributed the greatest amount to the chi-squared (0.47). This demonstrates that there was a statistically significant preference overall for image TO, as the most attractive tooth shape. Image O was ranked as the second most attractive tooth shape (36.7%) (Fig. 6). There was a statistically significant difference in ranking of the 5 images as the most attractive tooth shape overall ($p<0.001$).

Participants considered image S to be the least attractive image (41% of participants) and contributed the greatest amount to the chi-squared (0.55). This demonstrated that there was a statistically significant ($p<0.001$) preference overall for image S to be the least attractive tooth shape (Fig. 6).

3.1. The most attractive image between the three groups

Dentists ranked TO as the most attractive image (70%) and O as the second most attractive image (50%) (Fig.10). Technicians also ranked TO as the most attractive image (50%) and O as the second most attractive image (27%) (Fig.8). However, patients ranked O as the most attractive image (56%) and TO as the second most attractive image (20%) (Fig.9).

There was a statistically significant difference in the ranking of image TO as the most attractive tooth shape between dentists, technicians and patients ($\chi^2 = 9.600$, $p < 0.01$). There was most similarity in the ranking by dentists, with more dentists (70%) demonstrating a strong preference for image TO as the most attractive tooth shape. In contrast, patients found image O as the most attractive tooth shape (56%).

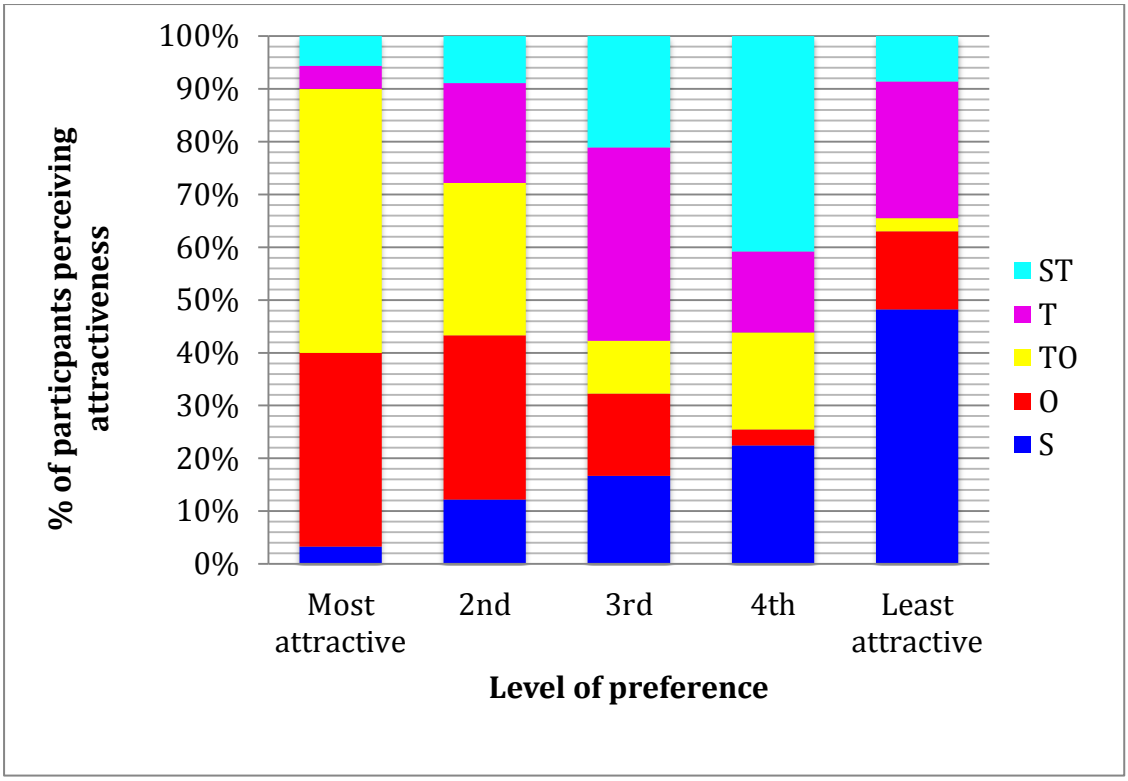


Fig. 6: Perceived overall order of attractiveness for tooth shape for all participants (S= square, O= ovoid, TO= tapered-ovoid, T= triangular, ST= square taper)

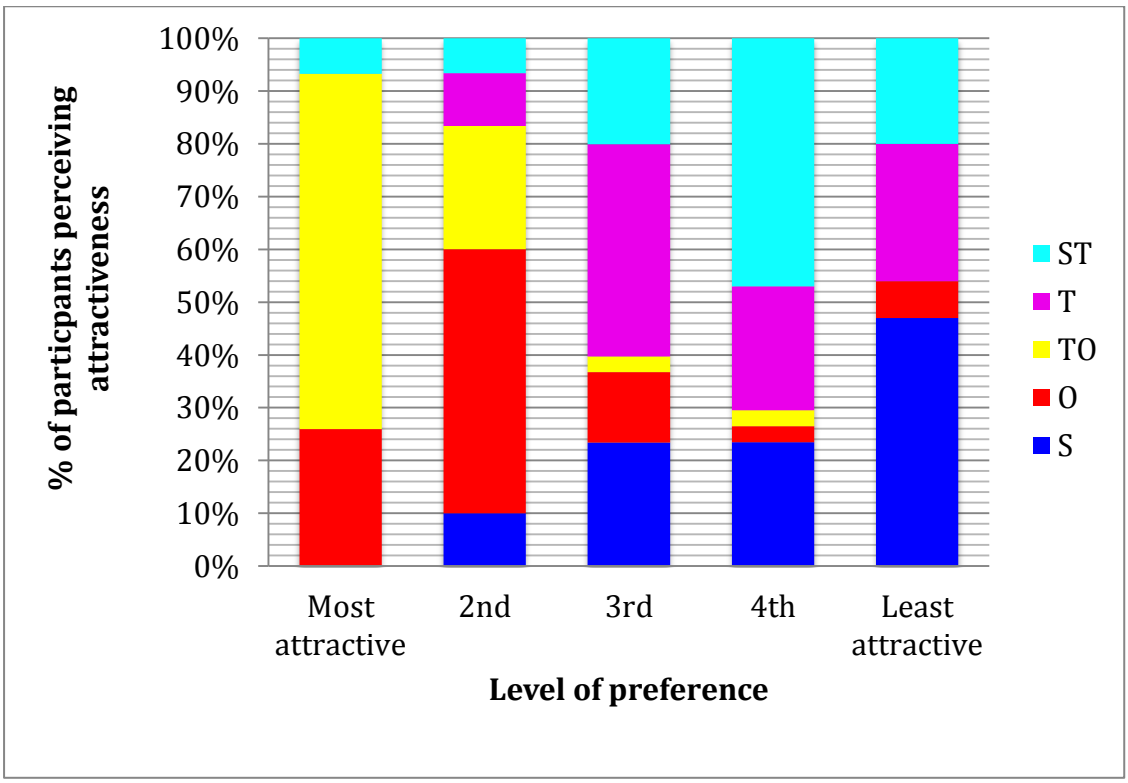


Fig. 7: Dentist participants' perceived order of attractiveness of tooth shape (S= square, O= ovoid, TO= tapered-ovoid, T= triangular, ST= square taper)

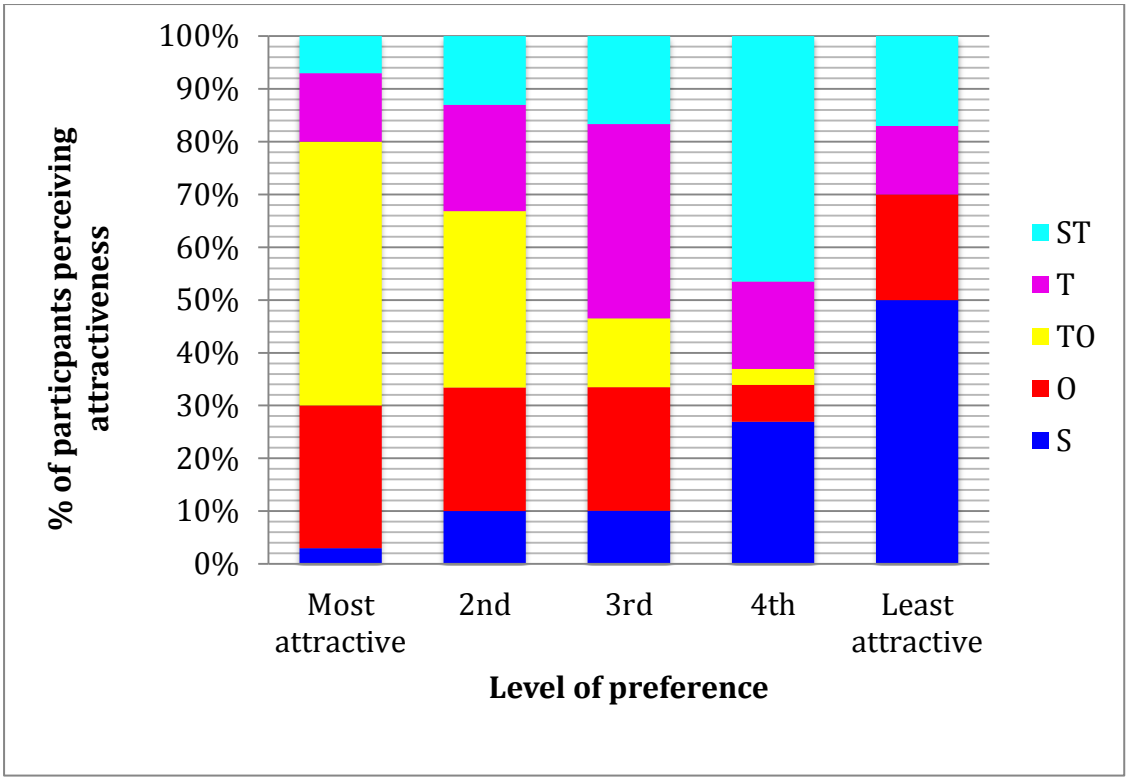


Fig 8. Technician participants' perceived order of attractiveness of tooth shape (S= square, O= ovoid, TO= tapered-ovoid, T= triangular, ST= square taper)

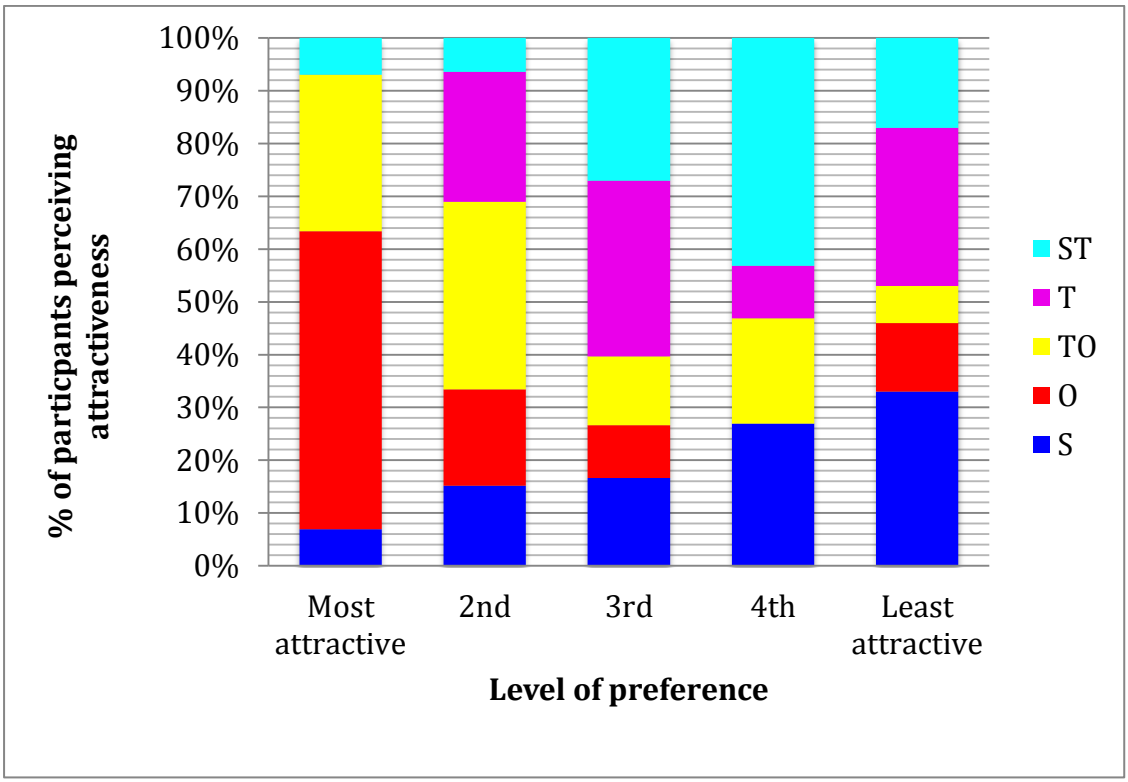


Fig 9: Patient participants' perceived order of attractiveness of tooth shape (S= square, O= ovoid, TO= tapered-ovoid, T= triangular, ST= square taper)

Regarding the most attractive tooth shape based on gender, there was no statistical difference in the ranking of image TO as the most attractive tooth shape amongst males and females ($p > 0.01$).

Regarding the influence of potential confounding factors on the most attractive image (TO), logistic regression was used to check for potential confounding factors, such as gender and age, when the most attractive image (TO) was compared to the other images. There was no significant evidence to suggest that age and gender contributed as confounding factors ($p = 0.542$ and $p = 0.064$).

When age and gender were controlled, the group comparing patients with dentists ($p = 0.001$) and patients with technicians ($p = 0.036$) showed significant differences. The group differences remained significant despite controlling age and gender. Therefore these variables did not influence the differences observed in the perception of tooth shape attractiveness between dentists, technicians and patients.

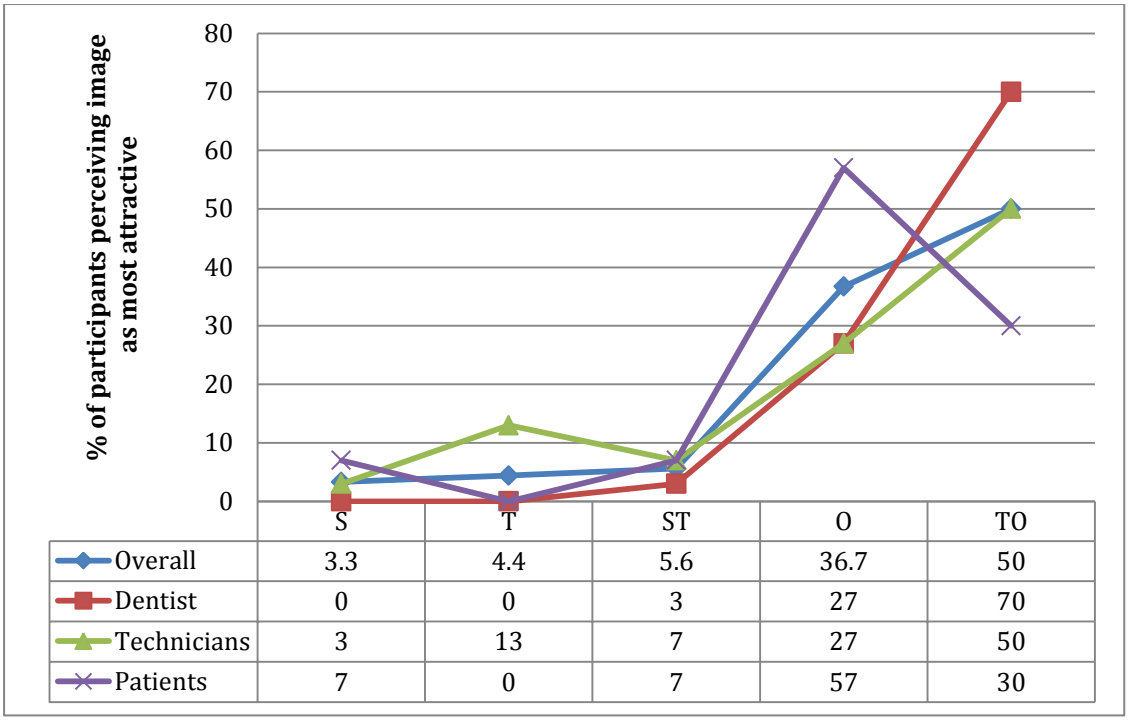
3.2. The least attractive image between the three groups

There was no difference in ranking of image S as the least attractive tooth shape amongst dentists, dental technicians and patients ($p = 0.387$).

In relation to the least attractive tooth shape based on gender, there was no significant difference in ranking of image S as the least attractive tooth shape amongst males and females ($p = 0.966$).

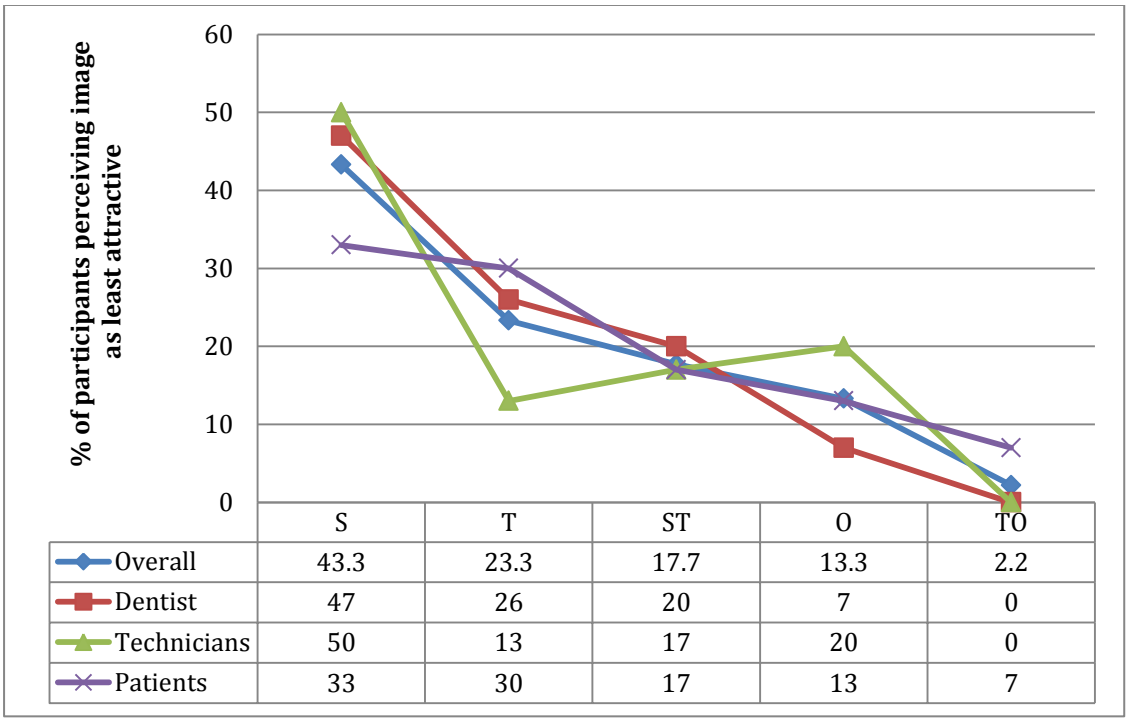
In relation to the influence of potential confounding factors on the least attractive image (S), logistic regression was used to check for potential confounding factors, when the least attractive image (S) was ranked compared to the other images ranked as least attractive. There was no significant evidence to suggest that age and gender contributed as confounding factors ($p = 0.117$ and $p = 0.606$).

When age and gender factors were controlled, the group comparing patients with dentist ($p = 0.135$) and group comparing patients and technicians ($p = 0.080$) showed no significant influence..



	S	T	ST	O	TO
Overall	3.3	4.4	5.6	36.7	50
Dentist	0	0	3	27	70
Technicians	3	13	7	27	50
Patients	7	0	7	57	30

Fig. 10. The perceived 'most attractive' tooth shape by the entire participants group (S= square, O= ovoid, TO= taper-ovoid, T= triangular, ST= square tape)



	S	T	ST	O	TO
Overall	43.3	23.3	17.7	13.3	2.2
Dentist	47	26	20	7	0
Technicians	50	13	17	20	0
Patients	33	30	17	13	7

Fig. 11. The perceived 'least attractive' tooth shape by the entire participants group (S= square, O= ovoid, TO= taper-ovoid, T= triangular, ST= square tape)

3.3. Level of agreement between first and repeat ranking

The reliability of participants' in their ability to rank the images in the same order of attractiveness at the repeat ranking was determined using Cohen's Kappa (κ)

Dental Technicians scored the highest level of agreement between the first and repeat ranking (κ = 0.94), followed by dentists (κ = 0.90). Landis & Koch[31] suggest both these κ scores indicate good agreement between the initial and repeat rankings. Patients had the least level of agreement (κ = 0.71) but still represented substantial agreement. Overall, all the groups combined had a good level agreement (κ = 0.85).

3.4. Identification of correct variables in the images

The participants were asked if they could specify any differences between the displayed images and if that influenced your choice.

The results showed that 33% of patients were able to detect the correct difference in the images compared to 80% dentists and 73% technicians. Dental professionals were more likely to detect the changes in tooth shapes as compared to both technicians and patients. The difference between the three groups who were able to detect the correct variables between the images was statistically significant ($p < 0.001$).

3.5. The influence on rankings on images for a male subject

The participants were asked if they were told that the displayed images were of a 25 year old male rather than a 25 year old female, whether that would have influenced their ranking order.

The results show that 90% dentists and 83% technicians would have ranked the images differently if the photographs represented that of a 25-year-old male. Interesting, only 23% of patients would have changed their rankings if the image was to be of a male subject. This probably suggests that patients would find similar tooth shape desirability irrespective of whether the subject was to be male or female. The differences between dentists, technicians and patients who would have ranked differently for a male counterpart, was statistically significant ($p < 0.001$).

3.6. Reasons for "attractiveness" ranking

The participants were asked to give reasons for their ranking order of attractiveness. The least attractive image (S), was most commonly described by dentists as "masculine" and by patients "too straight". The most attractive image (TO) was described by dentists as "round, soft looking and youthful"; amongst technicians as "feminine and attractive" and amongst patients as "healthy, natural and attractive".

4. DISCUSSION

In similar studies on smile aesthetics, both Visual Analogue Scale (VAS)[24,25] and ranking orders have been used for measuring perceptions[7,19]. However VAS would have been a very subjective method as it allows participants not to express a preference. Since the aim of this study was to ascertain an order of preference, the ranking order of assessment was deemed more appropriate for meaningful comparison within and between individual participants.

Images using teeth only were used without the associated lips and face, to eliminate confounding variables. This was adopted in order to replicate the clinical scenario, where technicians are normally dealing with models of teeth without the knowledge of facial features, thereby teeth only was the preferred option. Furthermore, if lips were to be included in the image, the full tooth shape would have been obscured, thereby introducing a variable beyond the scope of this study.

It was important to produce very clear images. Although the authors were able to control most variables, it was not possible to eliminate all. For example, the 'black triangle' formation in the triangular tooth form was seen as a distracting feature, which was subsequently removed (Fig.3).

Comparing the initial and repeat ranking, the level of agreement by technicians was the highest ($\kappa = 0.94$), this was followed by the dentist participants ($\kappa = 0.90$). This reflected the fact that technicians would deal with aspects of tooth shape more often than dentists, and therefore were more consistent in choosing the same image. By the same token, it was therefore not unexpected that patient participants had the least level of agreement ($\kappa = 0.71$), but this still represented a substantial level of agreement.

Several studies have demonstrated differences in the perception of attractiveness between professionals and patients. In this study the authors found that patients referred to the ovoid shape as the most attractive tooth shape, whilst dentists and technicians perceived that the tapered ovoid shape was most attractive. Overall, dentists, technicians and patients had similar preferences and their overall rankings demonstrated a good level of agreement ($\kappa = 0.85$).

There was broad agreement between the groups that the tapered-ovoid (TO) shape was perceived as most attractive for females ($p < 0.001$). This was consistent with traditional educational concepts, basing tooth shapes on gender stereotype, in that "Women are thought of as soft, round and delicate and should have rounded teeth, in contrast, men are thought of as angular, square and hard and should have square, more angled teeth"[6].

Ovoid (O) was the most prevalent shape for anterior teeth (47.06%) in a sample of 51 Caucasian individuals[9]. This might explain the fact that patients have a tendency to prefer a tooth shape that closely resembles their own.

It reaffirmed the findings in the literature, that whilst there were minor differences between the ovoid and the tapered-ovoid shape, broadly speaking, the rounder softer looking appearance was preferred by most participants as in the case of the tapered-ovoid teeth[6,14,15,16]

However, in this study, patients generally preferred a rounder looking incisor whilst the professionals preferred a curved, soft shape but with a taper giving a longer and more youthful appearance. One possible explanation between these two groups would be the presence of an inbuilt educational bias. Since compared to patients, dental professionals are trained in tooth morphology and so would cast a critical eye when evaluating the dentition. Practically speaking therefore, it is of paramount importance to fully involve patients in ascertaining their aesthetic wishes and expectations during treatment planning of anterior restorations.

There was also broad agreement amongst all the participants that square (S) shape was perceived as the least attractive ($p < 0.001$) tooth shape. Participants described this shape as "worn", "old" and "masculine". The straight incisal edges and sharp proximal angles have been associated with tooth wear and an aging dentition. Furthermore, these features might match a male person with a square facial shape by giving a more masculine appearance[5]. These findings also supported the dental literature in that the ovoid tooth form for females was preferred to the square/rectangular shape[6,14,15,16].

Nearly half the professionals were less tolerant to a tooth with sharp angles compared to a third of patients. Brisman[16] also showed that dentists and patients evaluated the appearance of teeth differently. A third of patients also ranked the triangular shape as the least attractive image. This suggests there was less agreement within the patient group for the least attractive tooth shape compared to professionals. This could also be explained by educational bias.

The second least attractive tooth shape in this study was the triangular (T) shape, which was also the least popular shape in a similar study by Carlsson et al[15]. This could be due to the variation of triangular images used in both studies. The triangular tooth form used by a similar study included the 'black triangle'. This was found to be a confounding factor following the pilot study. To eliminate this variable, this triangular image was closely aligned to the correct morphology as outlined in the literature[27] and the results reported.

In agreement with Brisman[16] and Heravi et al[24], who concluded that "men's and women's esthetic preferences are markedly similar", this study also found there was no difference in rankings of the most or least attractive tooth shape between male and female participants ($p > 0.01$).

Participants differed in their ability to identify the correct variables between the images ($p < 0.001$), with 33% of patients being able to detect the correct difference in the images compared to 80% dentists and 73% technicians. This showed that dental professionals were more likely to be able to identify discrete changes in tooth shape, as compared to patients.

Compared to the dental professional participants, patients were not as particular about the fine details of tooth shape. This was not surprising since dental professionals are trained and would deal more often with different tooth shapes in clinical practice. However, the authors would have expected more technicians to identify the correct differences between the shapes of incisors than dentists, as they would have had more training in tooth morphology. These findings support previous studies Bukhari et al[19], Flores-Mir et al[28], Kokich et al[29].

An overwhelming majority of dental professionals (90% dentists and 83% technicians), indicated that they would have ranked the images differently had these images represented a patient of the opposite sex whereas only 23% of patients would have changed their ranking. This suggested that most patients would find a particular tooth shape similarly attractive in both sexes. Another possible explanation, could be the mean age of the dentists and the technicians in this study was 37, compared to 45 for the patients, and perhaps this mean age difference might account for the different perceptions. For instance, younger subjects in general could be more aesthetically driven and therefore more critical on what would be perceived as attractive.

Interestingly, the participants who ranked the square shape as most attractive did not change their rankings if the image was to represent a subject of the opposite sex. This would suggest that this particular group of participants perceived the square shape as most attractive for all patients. Nonetheless, the overall findings in this study were similar to the dental literature, where it was reported that the ovoid tooth form for females is preferred to the square/rectangular shape[6,14,15,16].

Overall, the perceptions of all groups were broadly similar with regards to the aspects of smile aesthetics when evaluating the qualitative responses in this study. For obvious reasons, patients used a different language when describing dental features such as "healthy and natural" and not as specific as dental professionals.

The results also illustrated that although there was broad agreement amongst all the participants as to what constituted the most favourable appearance aesthetically, there were some minor differences.

There has been contrasting evidence to suggest that perceptions of attractiveness may vary in different parts of the world. Otuyemi et al[32], found no significant differences in the perception of attractiveness with dental aesthetics, between Nigerian and American subjects. Furthermore, Cons et al[33] found that the perception of aesthetics in dentistry in all of the 11 ethnic groups studied, were very similar to that of American dental students. However, Kiyak[34] found that Pacific Asians are more tolerant of spaces between teeth compared to Caucasians. Future studies looking into the influence of varying tooth shape on perceived smile aesthetics in different ethnic groups, may be of interest.

5. CONCLUSION

This study found that tapered-ovoid incisor tooth form was perceived to be aesthetically more pleasing than the square incisors. Although there is not an 'ideal' perceived tooth form, dental professionals are generally more critical than patients as to the desirability of the shapes of maxillary incisors.

Dentists should take into account individual variability when the aesthetic aspects of the treatment are planned for anterior restorations, perhaps using a diagnostic set up and intraoral mock-up to help to explore the patients' perception of attractiveness. This will help to explore and address patient's expectations, and allow for an agreeable outcome prior to the commencement of treatment.

Within the limitations of this study, the following general conclusions can be made:

- The tapered-ovoid maxillary incisor tooth shape was perceived as most attractive for a 25-year-old female.

- The square shaped maxillary incisor tooth shape was perceived as least attractive for a 25-year-old female.

- Dentists, technicians and patients had different aesthetic preferences in respect of the most attractive maxillary incisor tooth shape. Whilst dentists and technicians had strong preference for tapered-ovoid incisors, patients in general preferred ovoid incisors.

- Most dentists and technicians may change their aesthetic preferences for patients of the opposite sex compared only to a minority of patients.

- Apart from adhering to good clinical practice, dentists should take into account individual variability in patients' expectations, in order to produce a realistic aesthetic outcome that would be endorsed by the patient.

ACKNOWLEDGEMENTS

This paper is based on a dissertation by the first author, submitted in partial fulfilment of the requirements for the degree of MSc in Restorative Dental Practice of University College London Eastman Dental Institute.

The authors would like to thank Mr. Robert Blizard, Biostatistics Teaching Fellow, UCL Eastman Dental Institute, for his expert advice on the statistical aspects of this paper.

Conflicts of interest: none

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