

## IN BRIEF

- Many factors contribute to determine the aesthetics of a smile.
- This study sought to find the opinions of patients, dentists and dental technicians on what constituted the most aesthetically pleasing embrasure space and interproximal contact area.
- An embrasure space arrangement where the size of the embrasures increases progressively distally from the midline was deemed most attractive.

# The influence of varying maxillary incisal edge embrasure space and interproximal contact area dimensions on perceived smile aesthetics

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**Objective** The aim of this study was to determine the influence of incisal edge embrasure space and interproximal contact area dimensions on perceived smile aesthetics. **Design** Cross-sectional study. **Setting** Postgraduate dental teaching hospital. **Methods** A photograph of a smiling female, displaying only the lips and maxillary teeth was digitally altered. First, the proportions of the incisal edge embrasure spaces were modified to produce five different images. Secondly, the lengths of the interproximal contact areas were altered to produce five different images. The two sets of photographs were ranked from 'most attractive' to 'least attractive' by 35 dentists, 35 dental technicians and 35 patients. **Results** An embrasure space arrangement where the size of the embrasures increases progressively distally from the midline was deemed most attractive; absence of embrasure spaces was deemed least attractive. In assessing the interproximal contact areas, all groups assessed an arrangement where the areas between the teeth were equal (and 50% the length of the central incisor) as most attractive, and where the contact areas increased in length progressively distally from the midline as least attractive. There were few statistically significant differences between the groups in these perceptions. **Conclusion** Whilst there is broad agreement in what the participant groups deem to be aesthetic, our findings do not wholly correspond to the 'ideals' that have been previously suggested in the dental literature.

## INTRODUCTION

The aims of modern restorative dentistry include not only the perfect restoration of masticatory function, but also a rehabilitation of aesthetics.<sup>1</sup> In fact, in some cases improved dento-facial appearance is the dominant motivation for treatment, often to a greater extent than improved dental health and function,<sup>2</sup> especially when applied to the anterior dentition.<sup>3</sup> It is therefore important that both clinicians and technicians have an in-depth understanding of the individual components that help to achieve what might be described as the optimal smile aesthetics. This will aid the dental team in

satisfying the aesthetic expectations of the patient in the provision of both direct and indirect restorations.

A review of the literature shows that certain individual components of smile aesthetics have received more attention than others. In particular, very little scientific research is available to support what the ideal maxillary incisal edge embrasure space and inter-proximal contact area dimensions should be.

The pattern of the silhouetting created by the edges and separations between the maxillary anterior teeth against the darker background of the mouth has been reported as helping to define a good-looking smile.<sup>4</sup> It has been suggested that the incisal edge embrasure spaces between the maxillary central incisors, the central incisors and the lateral incisors, and the lateral incisors and the canines should get larger and increase in volume progressively distally.<sup>4,5</sup> This is primarily a function of the anatomy of these teeth, and as a result, the contact point between the teeth moves apically proceeding from the central incisors distally. Failure to provide proper incisal edge embrasure spaces

will make the teeth appear too uniform, and may give the appearance of a more 'senior' dentition.<sup>5</sup>

The interproximal contact area is defined as the zone in which two adjacent teeth appear to meet.<sup>4</sup> There is a distinction between a contact area and a contact point. The contact area is a larger broader region, in comparison to the contact points between the anterior teeth, which are generally much smaller areas (approximately 2 mm × 2 mm), where the teeth actually meet.<sup>4</sup> An aesthetic relationship has been suggested to exist between the anterior teeth, which is referred to as the '50-40-30 rule'. This suggests that the ideal contact area between the two central incisors is 50% of the length of the crowns between the maxillary central and lateral incisor it is 40% the length of the crown of the central incisor, and between the lateral incisor and the canine is 30% the length of the central incisor crown.<sup>4</sup> The size and proportion of the contact area space is obviously linked to the nature of both the incisal edge embrasure spaces and the inter-proximal gingival architecture. No credible literature appears to exist to

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either support or discredit the use of the '50-40-30' rule.

Despite the many theories and proportions that have been put forward to determine the ideal arrangement of the anterior teeth in order to achieve the optimal aesthetic outcome,<sup>6-8</sup> opinion suggests that patients' perceptions of optimal aesthetics vary.<sup>9</sup> In order therefore to ensure that any indirect, or indeed direct restorations fabricated for a patient meet with the aesthetic approval of the patient, communication between the patient, dentist and dental technician must be optimised. Success in prosthodontics and aesthetic restorative dentistry is achieved only when both proper function and aesthetics are achieved.<sup>10</sup>

The aim of this study was to determine the influence of incisal edge embrasure space and interproximal contact area dimensions on perceived smile aesthetics.

**METHODS AND MATERIALS**

A photograph of a smiling female face showing a full 'posed' smile was digitally altered using computer software (Adobe® Photoshop® CS2 Software, Adobe Systems Inc, San Jose, California) to produce a standardised image that was almost bilaterally symmetrical and possessed most of the objective dental, soft tissue and gingival criteria of aesthetic principles.

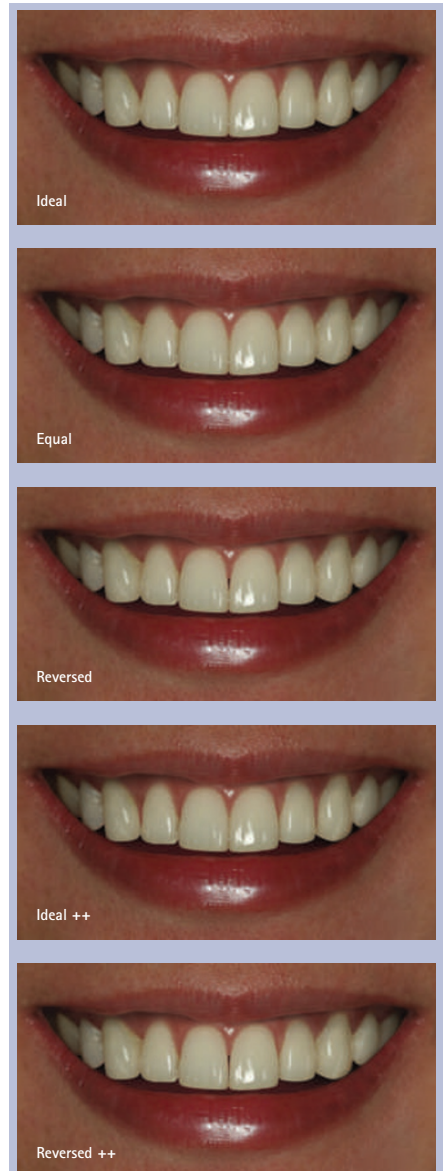
The first variable to be investigated was the individual dimensions of the maxillary incisal edge embrasure spaces, with the master image digitally altered to produce a set of five different images (Fig. 1). In each image, the relative proportions of the incisal embrasure spaces were changed to form a different arrangement.

In the second set of images, the relative ratios of the interproximal contact areas were modified to produce another set of five images (Fig. 2). In each image, the relative ratios of the interproximal contact areas were modified. When digitally altering the photographs, all inter-proximal contact length ratios were based upon the length of the maxillary right central incisor. The length of this tooth was measured using a tool within Photoshop, and divided into a nominal 100 units. The connector lengths of the teeth within this study, that is, the length of the adjacent teeth that appeared to be in contact, were based upon ratios from this measured length. For



**Fig. 1 Embrasure space modification photographs. Ideal** – the embrasure spaces increase in size and volume the further back in the arch that the teeth are positioned; **Equal** – All of the embrasure spaces are an equal, minimal size; **Reversed** – The embrasure space proportions are reversed from 'ideal', with the spaces decreasing in size and volume as you progress distally in the arch; **None** – No embrasure spaces exist between the teeth, giving the appearance of a flattened occlusal plane; **Exaggerated** – The embrasure spaces are all uniformly equal and increased.

example, in the 'Ideal' image, the contact area between the two central incisors is 50 units (ie is 50% the length of the central incisor); between the central incisors and lateral incisors is 40 units (40% the length of the central incisor), and between the lateral incisors and the canines is 30 units (30% the length of the central incisor), giving a 50:40:30 ratio.



**Fig. 2 Interproximal contact area modification photographs. Ideal** – The inter-proximal contact areas were arranged in a 50:40:30 ratio; **Equal** – The inter-proximal contact areas were arranged in a 50:50:50 ratio; **Reversed** – The inter-proximal contact areas were arranged in a 30:40:50 ratio; **Ideal++** – The inter-proximal contact areas were arranged in a 50:30:10 ratio; **Reversed++** – The inter-proximal contact areas were arranged in a 10:30:50 ratio

When digitally altering the photographs for both variables under investigation, care was taken to ensure that only the aspect of the image under investigation was altered. Photographs were professionally printed on photographic paper (7 × 5 inch) with a matte finish. Each photograph was ascribed by an exclusive symbol on its posterior surface as a code for identification when

collecting the results, and patients were asked to ignore any identifiable marks on the images.

One hundred and five participants – 35 adult patients attending for prosthodontic treatment (20 female, 15 male), 35 dentists (12 female, 23 male) and 35 dental technicians (13 female and 22 male) – were recruited into the study. Each participant was interviewed separately and consented to participate. All participants took part voluntarily and were unpaid. Ethical approval was obtained from the joint University College London (UCL)/ University College London Hospitals (UCLH) Committee on the Ethics of Human Research (Committee A).

Participants were asked to rank each of the sets of photos, from the image they deemed to be ‘most attractive’ to the image they found to be ‘least attractive’. Participants examined the photographs under similar lighting conditions and were given as much time as they required to rank-order the images. Participants were allowed to handle and move the images until they had arrived at their final decision as to their order of preference. In order to assess ‘intra-observer’ reliability, each participant was asked to repeat the ranking exercise after a period of 10 minutes.

Data were analysed using SPSS software for Windows (version 14.0; SPSS Inc, Chicago, Illinois, USA). To test if there was any significant difference between the overall perceptions of the three groups of participants, Chi-squared tests for independent samples were carried out. The critical level of significance was set at  $p$ -value  $\leq 0.05$ . To assess the reliability of participants in their ability to arrange the images in the same order at the second ranking, agreement was measured using Cohen’s Kappa. (Kappa reflects the proportion of agreement after chance agreement is removed from consideration).

## RESULTS

### Effect of modifying the incisal edge embrasure spaces on perceived smile aesthetics

Combining the collected data for all three participant groups reveals the order of attractiveness for the five modifications to the incisal edge embrasure spaces (Fig. 3). Participants considered the ‘ideal’

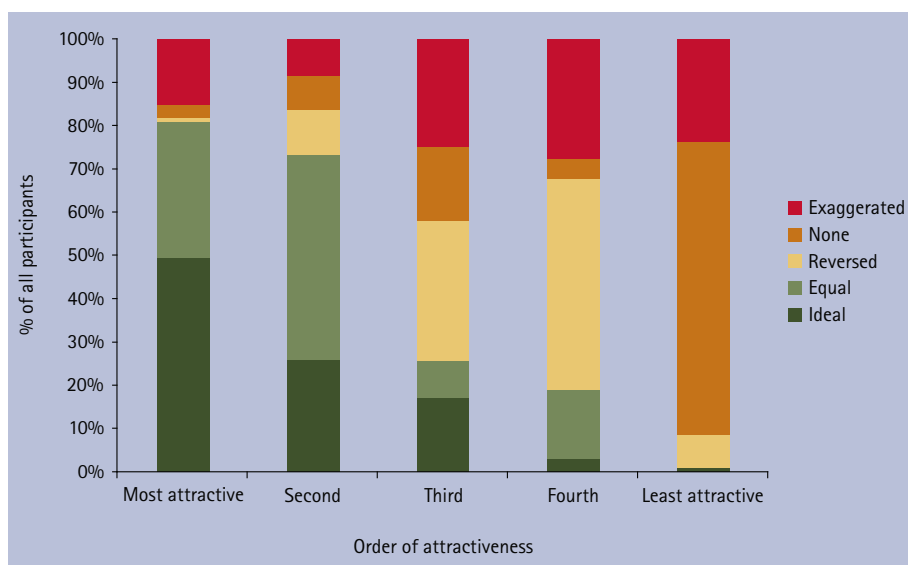


Fig. 3 Order of attractiveness for incisal edge embrasure spaces – summary of all groups combined

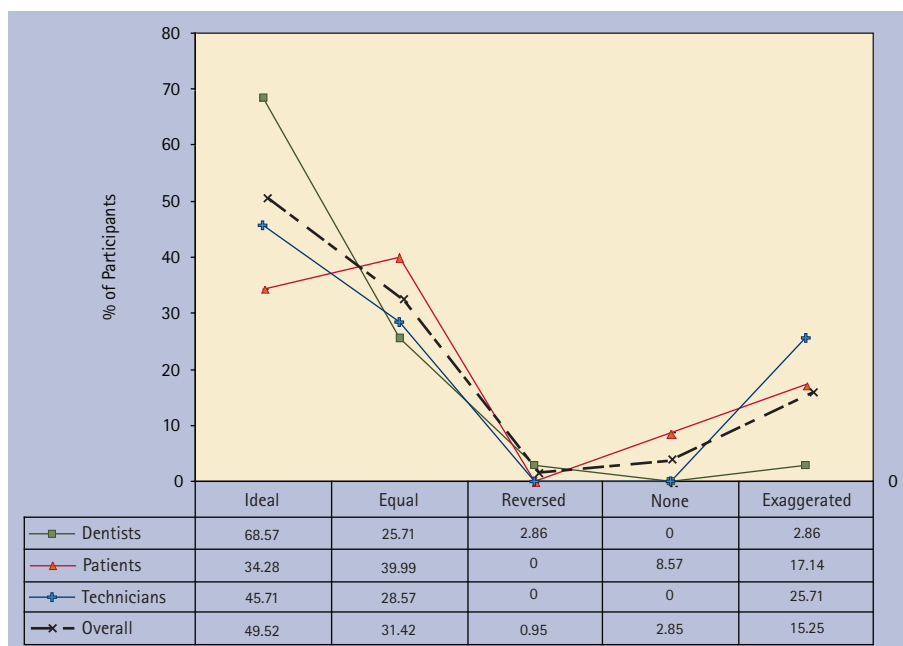


Fig. 4 Perception of ‘most attractive’ smile following changes to the incisal edge embrasure spaces

or ‘minimal’ embrasure spaces to be most attractive (49.5% and 33% of participants respectively). The presence of no embrasure spaces was deemed to be the least attractive arrangement by 67.6% of participants, whilst 27.6% least preferred the ‘exaggerated’ arrangement.

When examining the preferences of the three groups as to the ‘most attractive’ embrasure arrangement (Fig. 4), dentists demonstrated a strong preference for the ‘ideal’ arrangement, with almost twice as many dentists (68.57%) preferring this arrangement, compared to patients (34.28%). Slightly more patients preferred

the ‘equal’ (39.99%) arrangement to the ‘ideal’ (34.28%). Analysis revealed a statistically significant difference perception between the groups when viewed globally ( $p = 0.012$ ). No significant difference existed in perception between patients and technicians ( $p = 0.231$ ). However, there was a statistically significant difference between dentists and technicians ( $p = 0.029$ ) and dentists and patients ( $p = 0.021$ ).

In examining the preferences of the three groups as to the ‘least attractive’ embrasure arrangement (Fig. 5), the majority of dentists selected the ‘none’ arrangement (82.86%), as did the majority

of technicians (71.42%). However, only approximately half of patients considered this arrangement to be the least attractive (48.57%). The ‘exaggerated’ arrangement was the second most commonly reported least attractive modification (23.8% of the combined score).

Statistical analysis revealed no significant differences in perception between the groups ( $p = 0.078$ ) when assessing which embrasure arrangement they least liked.

### Effect of modifying the interproximal contact areas on perceived smile aesthetics

Combining the collected data for all three participant groups reveals the order of attractiveness for the five modifications to the interproximal contact spaces (Fig. 6). Results show that ‘equal’ or ‘ideal’ contact spaces are considered to be most attractive by 38.1% and 32.4% of participants respectively. The ‘reverse++’ arrangement, which is associated with a large inter-dental black triangle between the maxillary central incisors, was deemed to be the least attractive arrangement by 54.3% of participants, whilst 17.1% found the ‘ideal++’ arrangement least attractive.

When examining the preferences of the three groups as to the ‘most attractive’ contact area arrangement (Fig. 7), the ‘equal’ (38.08%) and ‘ideal’ (32.26%) arrangements are perceived by almost equal proportions of participants as the most attractive. Overall and in each of the three groups examined, the ‘equal’ arrangement was deemed to be more attractive by marginally more participants than the ‘ideal’ arrangement. No statistically significant difference was found between the perceptions of groups ( $p = 0.253$ ).

In comparing the contact area arrangement deemed ‘least attractive’ by the groups (Fig. 8), 54.3% of participants deemed the ‘reversed++’ arrangement as least attractive. More dentists perceived this arrangement as being least attractive (62.86%) than did the technicians (51.43%) or patients (48.57%). The remaining perceptions of least attractive contact area arrangement were fairly evenly distributed amongst the other four images. Again, no statistically significant difference in perception between the groups was found ( $p = 0.505$ ).

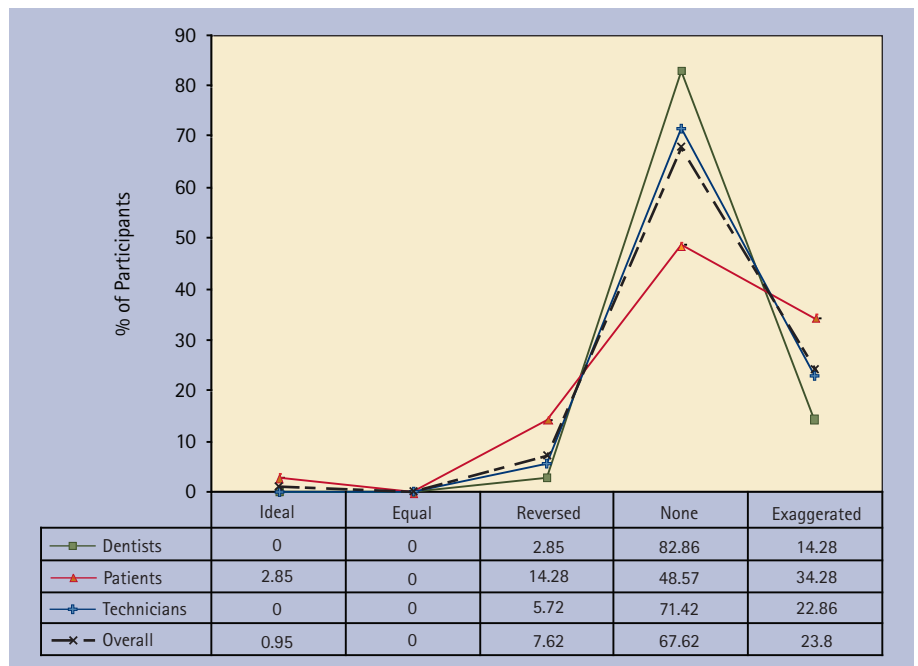


Fig. 5 Perception of ‘least attractive’ smile following changes to the incisal edge embrasure spaces

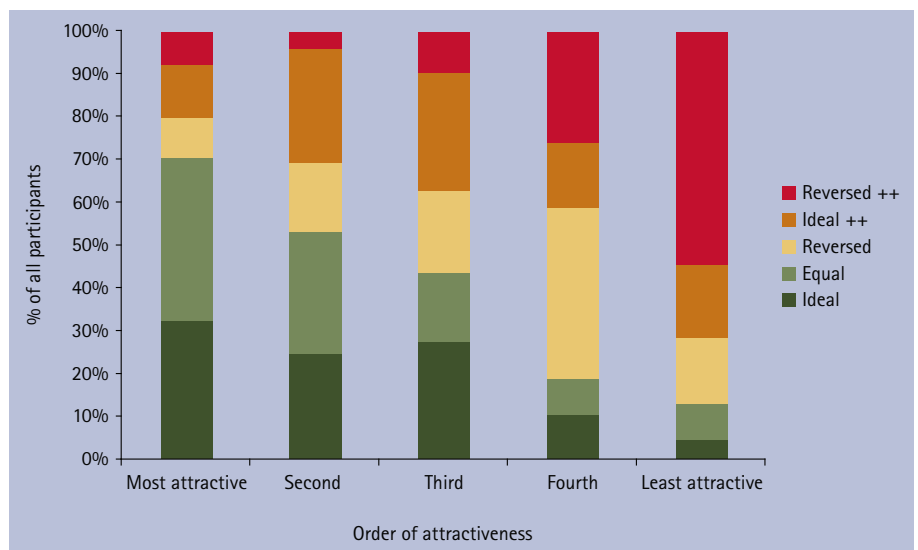


Fig. 6 Order of attractiveness for interproximal contacts spaces – summary of all groups combined

### Assessment of reliability

To assess the reliability of participants in their ability to arrange the images in the same order at the second ranking, agreement was measured using Cohen’s Kappa. Results from all groups, when re-ranking both sets of images, demonstrated a slightly higher level of reliability when individuals assessed the incisal edge embrasure spaces images (Fig. 1), Kappa Score = 0.430, compared to those obtained for the contact area images (Fig. 2), Kappa Score = 0.350. These scores represent ‘Reasonable’ and ‘Moderate’ levels of agreement respectively, and no

discernable difference existed between the levels of reliability when comparing the participant groups.

### DISCUSSION

Previous studies investigating smile aesthetics have gathered the opinions of members of the dental profession, principally orthodontists and dental surgeons, along with laypersons. Few have sought to obtain the opinions of dental technicians,<sup>11</sup> who are integral to the process of providing a successful outcome if fixed or removable prosthodontic restorations are provided.

No evidence-based information is available regarding individuals' preferences for the arrangement of the incisal edge embrasure spaces or interproximal contact area dimensions instead the literature contains only a few professional opinions.<sup>4</sup> Therefore the views of dentists, technicians and patients were targeted, to see if they were in agreement, or held broadly different views as to the most attractive arrangements.

Previous studies investigating opinions of attractiveness with regard to smile aesthetics have varied greatly in the manner in which the image is presented. Some authors have used full-face images,<sup>12,13</sup> in which the mouth region is only a small component of the total area of the image. In these cases, other components of facial appearance may distract the viewer from the variable being examined, and therefore skew results. Indeed, it has been suggested that non-dental professionals more readily discern differences in smile aesthetics when presented with images that show only the oral region.<sup>14</sup>

Approaches involving close-up images, showing only the oral region, have also differed. Images showing only the arrangement of the teeth and gingivae without the surrounding lip curtain have been used<sup>15-17</sup> when assessing aspects of smile aesthetics, but in doing so, may alter the opinion of the assessor. This can be overcome by using images of the teeth and gingivae surrounded by the lips, thereby presenting an image that will let the assessor more easily assess the overall smile aesthetic.<sup>9,17</sup>

Similar studies have predominantly used a Visual Analogue Scale (VAS) to measure an individual's preferences.<sup>1,9,17</sup> However, VAS are highly subjective and the scales are of most use when looking at change within individuals, and are of less value for comparing across a group of individuals.<sup>18</sup> In addition, the use of a VAS allows participants to demonstrate no preference, thereby adopting a neutral position, rather than placing a series of images in any particular order. The aim of this study was to ascertain an order of preference that would allow us to determine the most and least attractive options. For these reasons, it was decided that it would be most appropriate to use a rank ordering of assessments in this study, to allow comparison within and between individual participants.

In other research of a similar nature, a number of different approaches have been used in an attempt to test the reliability of the participants. Often used is the 'test-re-test' approach, where the participant repeats the same test on two separate occasions and the degree of agreement is determined. Issues may arise with this method however if insufficient time elapses between the two assessments, as if the re-test occurs too soon after the original test, the results obtained may be influenced by the effects of memory. In using the 'test-re-test' approach with a 10-minute interval between the initial ranking of the images and the repeat ranking, our results demonstrated 'reasonable' or 'moderate' Kappa Agreement scores. This might suggest that participant memory did not play a significant role in determining the outcome of the repeat ranking. The Kappa scores obtained probably reflect the subtlety of the differences that the participants were asked to assess.

Several studies have demonstrated that differences exist in the preferences of dental professionals and lay people<sup>14,15,17</sup> with regard to aspects of the smile aesthetics. Our findings differ from these observations, in that only the perception of the 'most attractive' incisal edge embrasure space arrangement showed statistically significant differences when comparing the study groups ( $p = 0.012$ ). These results would suggest that dentists, dental technicians and patients hold broadly similar preferences with regard to these aspects of embrasure space and interproximal contact area aesthetics.

When the opinions of all participants were viewed collectively, an arrangement where the embrasure spaces get larger and increase in volume progressively distally from the midline, as proposed by Morley & Eubank,<sup>4</sup> was deemed to be 'most attractive' by almost half of those questioned. An arrangement where no embrasure spaces were evident between the teeth, resulting in an incisal plane with a flattened, uniform appearance, was deemed 'least attractive' by two-thirds of all participants questioned. Minor variations in preference existed between the groups, as displayed in Figures 4 and 5, highlighting the need for communication between all parties involved in restorative treatment to ensure that the result of any indirect restorations provided meet with the approval of the patient.

Results as to which interproximal contact area arrangement was deemed to be 'most attractive' show no statistically significant difference between the groups ( $p = 0.253$ ), with all groups selecting the 'equal' interproximal contact space arrangement, (where the contact areas between the central incisors, the central and lateral incisors and the lateral incisors and the canine are all 50% the length of the maxillary central incisor) as the 'most attractive' (38.1%). This is in contrast to the 50:40:30 ratio proposed by Morley & Eubank.<sup>4</sup> Conversely, an interproximal contact area arrangement resulting in the presence of a 'black triangle' was deemed 'least attractive' by 54.6% of all participants, with no statistically significant difference in the opinions of the different groups studied ( $p = 0.505$ ).

During fixed prosthodontic work, the contact areas represent the connector space between units, which allows the linking of adjacent restorations together. Any increase in the length and hence dimensions of the connector area may contribute significantly to the strength and rigidity of any prosthesis. Care must however be taken to ensure that any increase in contact area length is not to the detriment of gingival health, and does not impede an individual's ability to clean and maintain a prosthesis. In addition, an increase in the length of the interproximal contact space may allow the clinician to help camouflage a lack of interdental soft tissue, minimising or avoiding the occurrence of a 'black triangle', which has been shown to be deemed unattractive by all participants.

In summary, our results demonstrate that whilst there is broad agreement amongst the groups in terms of what constitutes optimal aesthetics, differences exist and unless communication is effective, individual pre-conceptions may compromise the patient's acceptance of the end result.

## CONCLUSIONS

Within the stated limitations of our study, we are able to draw the following conclusions:

- An incisal embrasure space arrangement where the embrasure spaces increase in size and volume progressively distally from the central incisors is the most popular, followed by an arrangement where

the embrasure spaces are minimal and equal in size

- The absence of embrasure spaces is ranked as the least attractive arrangement
- The 'equal' (50:50:50) interproximal contact area arrangement is deemed the most attractive, marginally more so than the 'ideal' (50:40:30) arrangement proposed by Morley & Eubank<sup>4</sup>
- The 'reversed++' (10:30:50) interproximal contact area arrangement (which results in a 'black triangle' between the maxillary central incisors) is ranked as least attractive by all groups studied
- Overall the perceptions of all groups are broadly similar with regard to the aspects of smile aesthetics evaluated in this study.

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