
Perception of dental midline deviation and smile attractiveness by eye-tracking and aesthetic ratings

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Aim: To evaluate the perception of smile aesthetics and midline deviation considered by orthodontists (ORT), dentists (DT), patient's-relatives (PR), and laypersons (LP) using an eye-tracking device and survey.

Methods: The study invited the participation of 42 orthodontists, 51 dentists, 50 patient-relatives, and 52 laypersons. A posed smile photograph of a female was chosen as a base image. The dental midline (DML) was digitally moved 1 mm (DML1R, DML1L), 2 mm (DML2R, DML2L), 3 mm (DML3R, DML3L), and 4 mm (DML4R, DML4L) on the base image's right (DMLR) and left (DMLL) segments. Eight modified images were subsequently obtained. The base, modified, and repeated images were randomly arranged and uploaded into the Tobii Pro Lab software program for assessment by the participants. An eye-tracking dataset included first fixation duration (FFD), total fixation duration (TFD), and visit counts (VC). The participants also evaluated the photographs on the survey forms via a Visual Analogue Scale (VAS) and a Likert scale. The intra-group relations and inter-group correlations were evaluated statistically.

Results: The TFD for the DML2R photograph was found to be statistically significant between the assessment groups ($p = 0.026$). While the longest fixation time (0.93 sec) belonged to the orthodontists, it was observed that the patient relatives had the shortest fixation time (0.51 sec). The VAS score for the DML2R image was found to be highest in laypersons ($p < 0.001$). In general, the survey scores of the patient relatives and laypersons were higher.

Conclusion: The fixation time between the participant groups increased when there was a 2 mm deviation. A 2 mm shift in the DML was noticed by all participant groups and was considered unaesthetic.

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Introduction

Smile characteristics require detailed consideration during treatment planning to make an orthodontic result more acceptable.¹⁻³ Smile aesthetics are influenced by oral components which are identified as smile arcs, buccal corridors, the smile line, upper lip curve, smile symmetry, occlusal cant, dental alignment, and gingival morphology.² In order to achieve an ideal cosmetic result, identifiable reference parameters should be considered as aesthetics remains a subjective concept which can vary between individuals and cultures.³ Previous research has reported aesthetic

perception studies using various evaluation scales to assess smile components. The evaluation tools are commonly a visual analogue scale (VAS),⁴⁻¹⁷ or a Likert scale.¹⁸⁻²¹

Technology instruments and computer programs have been developed in order to determine human perceptions and the sites of visual attention. Eye-tracking, as a sensor technology, enables the focus of the eyes to be determined.²² Although these systems are used in medical and para-medical fields, they have also been recently incorporated into orthodontic research.²³⁻²⁷ Using eye tracking, Hickman et al.²³

determined six areas of special facial interest, which included the eyes, ears, nose, mouth, jaw, and sundry areas. Also discovered was that the mouth received less than 10 percent of a viewer's visual attention in well balanced faces of orthodontically treated patients. Richards et al.,²⁴ Johnson et al.²⁵ and Baker et al.²⁶ used eye-tracking technology to determine which area of the face focussed the visual attention of observers when assessing dental and facial attractiveness. Wang et al.²⁷ reported that there was significant deviation in the tracking scan path of pre-treatment patients compared with normal subjects and post-treatment patients. In addition, orthodontic treatment normalised a scan path. Kim et al.²⁸ used eye-tracking to examine visual attention changes affected by facial angles and smiles during an evaluation of facial attractiveness.

Overlapping midlines are an important component of functional occlusion and are used as a clinical guide to create ideal intercuspation. Midline asymmetries play an important role in orthodontic diagnosis and treatment planning. Therefore, the aim of the present study was to evaluate the effects of dental midline (DML) deviations on the perception of smile aesthetics by orthodontists, dentists, patient-relatives, and laypersons using eye-tracking technology and surveys. In addition, it was aimed to determine tolerance ranges that may be applied in dental midline deviations related to orthodontic smile aesthetics.

This study was designed to test the following null hypotheses: (1) Dental midline deviation will have no effect on aesthetic perception, and (2) there will be no differences in aesthetic scores between orthodontists, dentists, lay people, and patient relatives.

Material and methods

The present study was conducted using volunteer participants and undertaken in Necmettin Erbakan University Faculty of Dentistry, Department of Orthodontics. Ethics committee approval was obtained by Necmettin Erbakan University Faculty of Dentistry, in accordance with the decision numbered 2018/06.

Volunteer participants' rights were protected and informed consent was obtained. The study comprised participants from four different occupational groups, including 52 laypersons (LP), 50 patient-relatives (PR), 51 dentists (DT), and 42 orthodontists (ORT). In all, 102 females and 93 males were involved for

a total of 195 volunteer participants (VP). VP consisted of individuals who did not use medication and were without neurological disorders and eye defects. Attention was paid to the absence of false eyelashes and make-up around the eyes. Also, gender distribution and the educational level of the VP were balanced in the study groups. The age range of the VP was subdivided into four groups identified as a 20–30 age range, 30–40 age range, 40–50 age range, and over 50 years.

A frontal posed smile photograph of a female was captured using a Nikon D60 (Tokyo, Japan) camera. The image was cropped to include only the mouth and teeth which produced a base image (DML0). Care was taken not to deteriorate image quality. On this image, the DML, determined by the maxillary central incisors relative to the facial midline measured from cupid's bow in the centre of the philtrum, was evaluated. The DML was adjusted 1, 2, 3, and 4 mm towards the right and left sides using the Adobe Photoshop CC 2014 (San Jose, California) software, and eight modified smile images were created from the base photograph (Figure 1).

The study datasets were obtained from the eye-tracking device and surveys.

Receiving eye-tracking records

Tobii X2-60 technology (60 Hz [60/s], Tobii Technology, Stockholm, Sweden) was used to obtain the eye records of the VP. The eight modified smile images, one base image and two repeated modified images (total of 11 images) were randomly arranged and uploaded to the Tobii Pro Lab software program installed on a Monster Abra A5 V13.2.1 15.6" computer. When the program was run, it was ensured that the detection of both eyes of the VP were entirely on the screen (Figure 2A). During the recording of eye movement, attention was directed to ensure that there was little ambient light and that daylight did not shine directly into the eyes of the VP. The program software was calibrated for each participant's eyes at the beginning of monitoring before each record (Figure 2B). Each image was shown for 4 sec following which a white blank screen with a randomly placed "+" close to the screen frame was displayed for 1 sec. The VP were advised that they should look at "+" after each image. In this way, the participant's eyes were focused out of the photo area

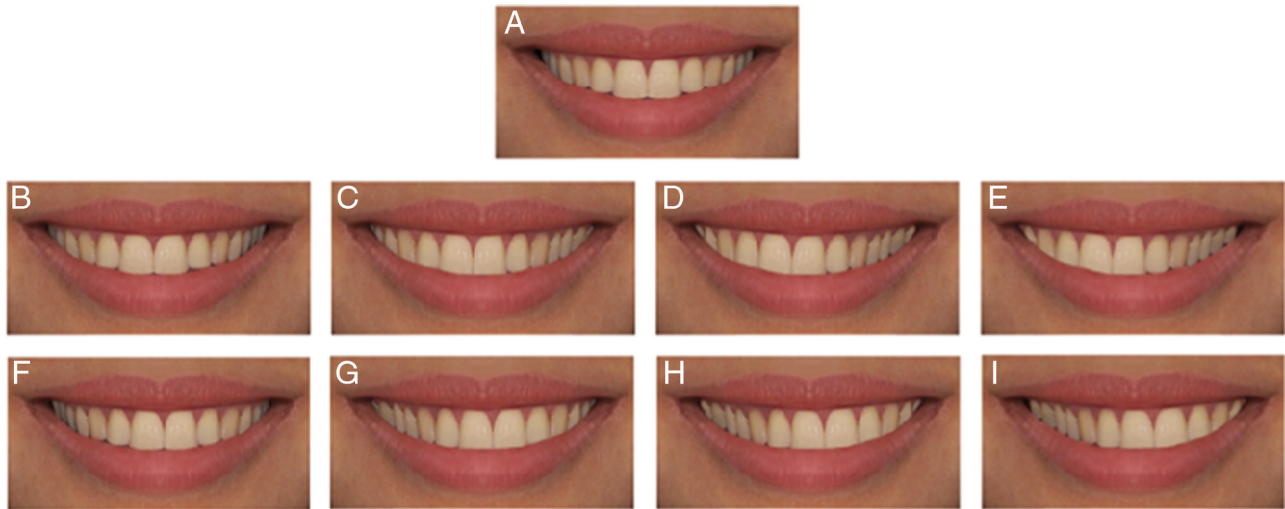


Figure 1. The study photograph and eight modified smile photographs. The dental midline was shifted to the left and right segments gradually. A. Dental Midline In Place (DML0). B. Shifted Dental Midline 1 mm Right (DML1R). C. Shifted Dental Midline 2 mm Right (DML2R). D. Shifted Dental Midline 3 mm Right (DML3R). E. Shifted Dental Midline 4 mm Right (DML4R). F. Shifted Dental Midline 1 mm Left (DML1L). G. Shifted Dental Midline 2 mm Left (DML2L). H. Shifted Dental Midline 3 mm Left (DML3L). I. Shifted Dental Midline 4 mm Left (DML4L).

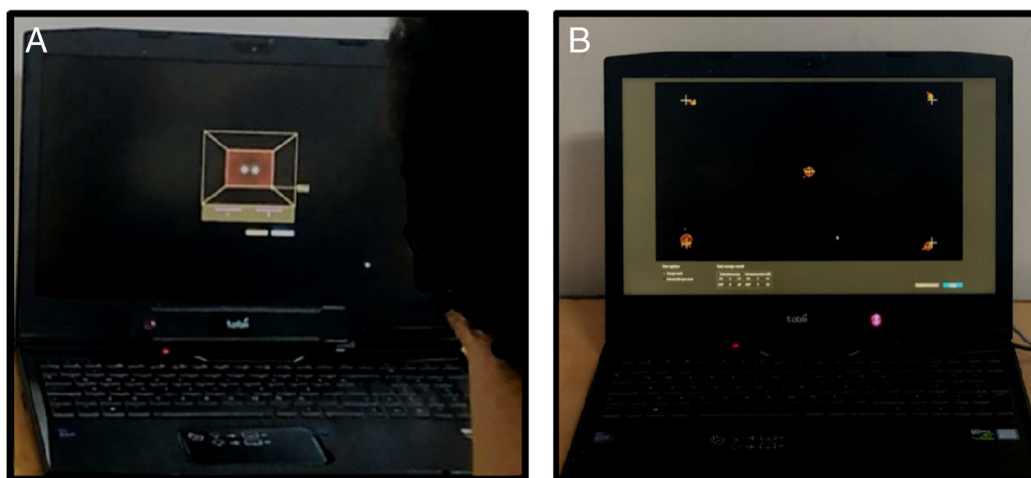


Figure 2. A. The detection of the VP eyes. B. The calibration of the VP eyes.

to be monitored before observing the next image, thus overcoming fixed staring. The eye-tracking device was placed at the bottom of the computer screen such that the distance between the VP and the device did not exceed 65 cm. Areas of interest (AOI) were identified separately for the base and each of the modified smile images. The DMLT area of interest on teeth and DMLP area of interest on the philtrum were determined on the base image. “Total Fixation Duration” (TFD), “First Fixation Duration” (FFD), and “Visit Count” (VC) measurements were selected from the metrics dataset and defined as:

Total fixation duration (TFD): the duration of the participant’s fixation on the selected AOI.

First fixation duration (FFD): the initial fixation time indicates the time taken for the VP to look at a specific AOI from the onset of stimulation.

Visit count (VC): is the number of times the volunteer visited/looked at the selected AOI.

Receiving survey records

After the eye-tracking data were obtained, the participants were briefed and asked to complete relevant survey forms. A total of 11 images with eight modified smile photographs, one study photograph and two repeating photographs were randomly listed, and the survey forms were created by adding VAS and

Likert scales for each photograph. The survey forms were printed in colour. The VAS consisted of a ruler with values between 0 and 10. In addition, a five-point Likert scale was preferred with “very ugly”, “ugly”, “undecided (neutral)”, “beautiful”, and “very beautiful” as choices (Figure 3). VP were asked to evaluate each image from an aesthetic point of view, to mark the most suitable option and place a mark on the ruler.

Statistical analysis

The survey and eye-tracking device data obtained from VP were evaluated using SPSS 20.0 (IB Inc., Chicago, IL, USA) program. The type I error value was taken as 5 per cent, and a $p < 0.05$ was considered statistically significant. The intraclass correlation coefficients (ICC) were determined. For the two groups, the Mann–Whitney *U* test was applied, and the Kruskal–Wallis test was used for multiple groups.

Results

The ICC was 0.814 for eye-tracking data, 0.805 for the VAS, and 0.760 for the Likert scale. The TFD value for the DML2R photograph was statistically

significant ($p = 0.026$). The longest focusing time (0.93 sec) belonged to the orthodontists, while the patient-relatives were observed to have the shortest focusing time (0.51 sec). There was a statistically significant difference between the VC for the DML1L photograph. The VC of the dentists was higher than for the other groups ($p = 0.014$) (Table I). Survey assessments for the DML are presented in Table II.

There was no statistically significant difference between the genders in the evaluation of DML images by the eye-tracking device. There was no statistically significant difference between the genders in the results of the survey evaluation of DML images. In the second evaluation of the DML3R photograph, only the VAS score was found to be significantly higher in male VP compared with female VP ($p = 0.019$).

No statistically significant difference was found between the age groups for the recorded focusing periods of the DML. There was a statistically significant difference in the VAS and Likert scores in some of the DML photographs in comparison with the age groups. The VAS ($p = 0.011$, $p = 0.014$) and Likert ($p = 0.006$, $p = 0.003$) scores for the DML3R and

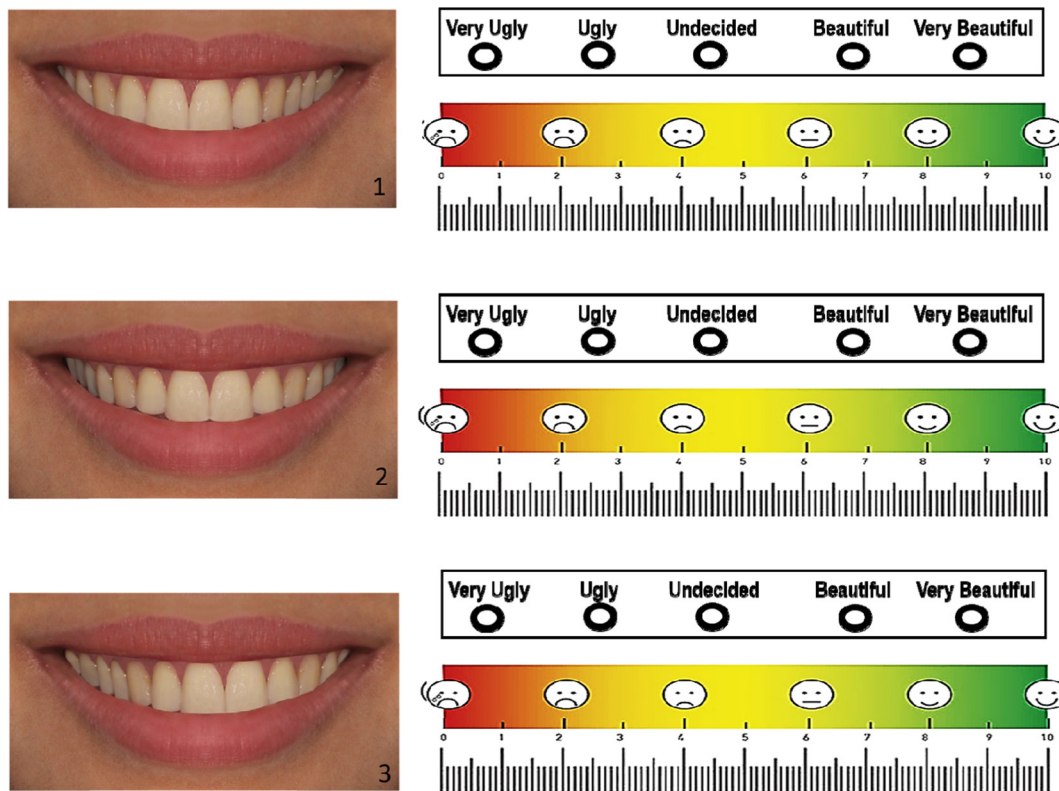


Figure 3. An example of the survey form.

Table 1. Fixation values based on occupational groups.

DML (sn)	Dentist	Ortodontist	Patient relatives	layperson	<i>p</i>
	M ± SD				
<i>DMLT (n = 131)</i>					
TFD	1.74 ± 0.98	1.73 ± 1.01	1.74 ± 0.98	1.41 ± 0.5	0.611
FFD	1.3 ± 1.2	1.12 ± 1.08	1.13 ± 1.09	1.54 ± 1.44	0.870
VC	0.61	0.49	0.46	0.41	0.640
<i>DMLP (n = 56)</i>					
TFD	0.47 ± 0.33	0.30 ± 0.16	0.76 ± 0.64	0.46 ± 0.48	0.026*
FFD	1.38 ± 1.17	0.85 ± 0.45	1 ± 1.18	1.11 ± 1.19	0.621
VC	1	1	1	1	0.322
<i>DML1R (n = 70)</i>					
TFD	0.53 ± 0.51	0.52 ± 0.6	0.33 ± 0.25	0.44 ± 0.54	0.483
FFD	1.34 ± 0.9	1.2 ± 1.08	1.4 ± 1.14	1.57 ± 1.4	0.935
VC	1	1	1	1	0.404
<i>DML1L (n = 80)</i>					
TFD	0.52 ± 0.44	0.5 ± 0.39	0.45 ± 0.35	0.31 ± 0.2	0.450
FFD	1.4 ± 1.22	1.91 ± 1.17	1.46 ± 1.28	1.38 ± 1.29	0.415
VC	1.5	1	1	1	0.014*
<i>DML2R (n = 157)</i>					
TFD	0.84 ± 0.8	0.93 ± 0.71	0.51 ± 0.42	0.66 ± 0.55	0.026*
FFD	0.89 ± 0.92	0.85 ± 0.81	1.13 ± 1.03	1.12 ± 1.04	0.496
VC	2	2	1.5	1	0.085
<i>DML2L (n = 141)</i>					
TFD	0.75 ± 0.61	0.85 ± 0.73	0.68 ± 0.6	0.61 ± 0.52	0.378
FFD	1.17 ± 1	1.04 ± 1.12	1.29 ± 1.23	1.48 ± 1.25	0.530
VC	1	2	2	1	0.638
<i>DML3R (n = 149)</i>					
TFD	0.85 ± 0.62	0.73 ± 0.75	0.77 ± 0.58	0.73 ± 0.64	0.311
FFD	0.93 ± 1.08	1.16 ± 1.15	0.86 ± 1.09	1.08 ± 1.09	0.297
VC	2	1	1	1	0.090
<i>DML3L (n = 151)</i>					
TFD	0.83 ± 0.64	0.82 ± 0.61	0.61 ± 0.64	0.59 ± 0.46	0.072
FFD	1.04 ± 1.01	0.95 ± 1.16	1.19 ± 1.14	1.48 ± 1.21	0.214
VC	2	2	1.5	2	0.080
<i>DML4R (n = 171)</i>					
TFD	0.97 ± 0.65	0.98 ± 0.71	0.77 ± 0.5	0.73 ± 0.62	0.135
FFD	0.59 ± 0.83	0.71 ± 0.9	0.93 ± 1.07	0.89 ± 1.06	0.269
VC	3	2	2	2	0.148
<i>DML4L (n = 177)</i>					
TFD	0.85 ± 0.57	1.04 ± 0.66	0.89 ± 0.65	0.85 ± 0.58	0.445
FFD	0.67 ± 0.76	0.59 ± 0.73	0.88 ± 0.89	0.71 ± 0.94	0.294
VC	2	2	2	2	0.768

M: mean, n: the number of observers, p: significant, SD: standard deviation. **p* < 0.05, ***p* < 0.01, ****p* < 0.001.

Table II. VAS and Likert scale scores according to occupational groups.

DML	M ± SD				p
	Dentist	Ortodontist	Patient relatives	layperson	
DML0-VAS	8.41 ± 1.22	8.48 ± 1.19	8.84 ± 1.31	8.44 ± 1.45	0.204
DML1R-VAS	6.71 ± 2.2	6.5 ± 1.81	7.86 ± 1.69	7.31 ± 1.64	0.002**
DML1L-VAS	7.31 ± 1.96	7.52 ± 1.89	8.66 ± 1.57	8.56 ± 1.65	<0.001***
DML2R-VAS	4.96 ± 2.23	4.45 ± 2.36	6.96 ± 2.26	7.33 ± 2.37	<0.001***
DML2L-VAS	3.65 ± 2.31	3.76 ± 1.75	5.36 ± 2.48	5.38 ± 2.59	<0.001***
DML2L-VAS2	3.45 ± 2.26	3.4 ± 2.12	5.1 ± 2.89	4.96 ± 2.58	0.001***
DML3R-VAS	2.78 ± 2.34	3.26 ± 1.99	4.72 ± 2.66	4.71 ± 2.7	<0.001***
DML3R-VAS2	2.18 ± 2.09	2.48 ± 1.93	3.76 ± 2.72	3.88 ± 2.39	<0.001***
DML3L-VAS	3.55 ± 2.31	3.24 ± 2.12	4.94 ± 2.92	5.67 ± 2.6	<0.001***
DML4R-VAS	1.55 ± 1.98	1.69 ± 1.76	3.1 ± 2.51	3.17 ± 2.32	<0.001***
DML4L-VAS	2.25 ± 2.11	2.31 ± 1.69	3.72 ± 2.62	3.54 ± 2.5	0.003**
DML0-Likert	3.27 ± 0.49	3.38 ± 0.54	3.5 ± 0.54	3.25 ± 0.59	0.085
DML1R-Likert	2.55 ± 0.92	2.6 ± 0.77	2.94 ± 0.62	2.75 ± 0.71	0.063
DML1L-Likert	2.84 ± 0.86	2.9 ± 0.93	3.42 ± 0.64	3.35 ± 0.71	<0.001***
DML2R-Likert	1.86 ± 0.89	1.74 ± 0.96	2.76 ± 0.96	2.85 ± 0.96	<0.001***
DML2L-Likert	1.33 ± 0.91	1.26 ± 0.66	2.18 ± 0.94	2.19 ± 0.97	<0.001***
DML2L-Likert2	1.2 ± 0.85	1.21 ± 0.78	1.94 ± 1.2	2.06 ± 1.04	<0.001***
DML3R-Likert	0.92 ± 0.91	1.07 ± 0.68	1.88 ± 1.06	1.88 ± 1.1	<0.001***
DML3R-Likert2	0.8 ± 0.72	0.76 ± 0.66	1.46 ± 1.11	1.56 ± 0.94	<0.001***
DML3L-Likert	1.27 ± 0.96	1.14 ± 0.81	2.08 ± 1.16	2.19 ± 1.01	<0.001***
DML4R-Likert	0.55 ± 0.76	0.4 ± 0.54	1.2 ± 0.99	1.33 ± 0.92	<0.001***
DML4L-Likert	0.76 ± 0.86	0.76 ± 0.53	1.52 ± 0.97	1.37 ± 0.97	0.001***

M: mean, p: significant, SD: standard deviation. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

DML3L photographs were statistically significantly higher in the over 50-year age group. The VAS score ($p = 0.046$) for the DML4R photograph and Likert score ($p = 0.014$) for the DML4L photograph were found to be statistically higher in the over 50-year age group. The VAS value of the DML3R repeated photograph was similarly higher in the oldest group of volunteers.

There was a statistically significant negative correlation between the TFD and Likert score for the DML2L photograph. For the DML3L photograph, there was a statistically significant low and negative correlation between the TFD and Likert score. There was a statistically significant positive correlation between the FFD and VAS and Likert scores for the DML4R photograph ($p = 0.034$, $p = 0.009$). For the DML4L photograph, there was a statistically low and negative

correlation between the TFD and VAS and Likert scores (Table III). The correlations for repeated images are depicted in Table IV.

Discussion

Previous eye-tracking studies have shown that “the eyes” most attract a viewer’s visual attention.^{24,27} Therefore, the base image and modified images contained only the mouth and teeth to avoid a distracting visual focus.

Aesthetic perception varies between people and can be influenced by gender, personal experience, and social environment. There may be differences between the aesthetic perceptions of individuals who have an oral health background and the aesthetic perceptions of individuals who have not.^{4,21}

Table III. The correlation between datasets of eye-tracking, VAS, and Likert scale.

<i>DML0 Rho (p)</i>	VAS	LIKERT
DMLTTFD	0.011 (0.918)	0.018 (0.861)
DMLTFFD	-0.204 (0.047*)	-0.196 (0.056)
DMLP TFD	-0.113 (0.459)	-0.065 (0.670)
VAS		0.804 (<0.001 ***)
<i>DML1R Rho (p)</i>	VAS	LIKERT
DML1R TFD	0.098 (0.417)	0.077 (0.525)
DML1R FFD	0.236 (0.049)	0.272 (0.023)
VAS		0.810 (<0.001 ***)
<i>DML1L Rho (p)</i>	VAS	LIKERT
DML1L TFD	0.038 (0.737)	-0.008 (0.941)
DML1L FFD	-0.056 (0.625)	-0.005 (0.963)
VAS		0.836 (<0.001 ***)
<i>DML2R Rho (p)</i>	VAS	LIKERT
DML2R TFD	-0.134 (0.095)	-0.139 (0.083)
DML2R FFD	0.120 (0.135)	0.095 (0.235)
VAS		0.852 (<0.001 ***)
<i>DML2L Rho (p)</i>	VAS	LIKERT
DML2L TFD	-0.145 (0.086)	-0.183 (0.030)
DML2L FFD	0.017 (0.842)	0.072 (0.399)
VAS		0.861 (<0.001 ***)
<i>DML3R Rho (p)</i>	VAS	LIKERT
DML3R TFD	0.049 (0.552)	0.026 (0.752)
DML3R FFD	0.034 (0.684)	0.041 (0.623)
VAS		0.877 (<0.001 ***)
<i>DML3L Rho (p)</i>	VAS	LIKERT
DML3L TFD	-0.120 (0.143)	-0.187 (0.022*)
DML3L FFD	0.086 (0.296)	0.114 (0.164)
VAS		0.868 (<0.001 ***)
<i>DML4R Rho (p)</i>	VAS	LIKERT
DML4R TFD	-0.111 (0.147)	-0.122 (0.112)
DML4R FFD	0.162 (0.034*)	0.198 (0.009**)
VAS		0.840 (<0.001 ***)
<i>DML4L Rho (p)</i>	VAS	LIKERT
DML4L TFD	-0.225 (0.023*)	-0.266 (0.042*)
DML4L FFD	0.161 (0.232)	0.165 (0.128)
VAS		0.843 (<0.001 ***)

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

In order to evaluate the aesthetics of a smile, Kerr et al.²⁹ and Springer et al.³⁰ preferred to conduct their studies using laypersons. However, Kokich et al.,^{6,15} Roden-Johnson et al.,⁵ Olivares et al.⁹ and Al Taki

et al.¹⁰ included orthodontists, dentists, and laypersons in their study groups. The present study included orthodontists, dentists, laypersons, and patient-relatives. As a result of a literature review, it was determined

Table IV. The repeated photographs correlations between datasets of eye-tracking, VAS, and Likert scale.

DML2LRho (<i>p</i>)	VAS	LIKERT	VAS2	LIKERT2
DML2L TFD	-0.145 (0.086)	-0.183 (0.030*)	-0.145 (0.086)	-0.183 (0.073)
DML2L FFD	0.017 (0.842)	0.072 (0.399)	0.017 (0.842)	0.072 (0.399)
VAS		0.861 (<0.001 ***)	0.711 (<0.001 ***)	0.622 (<0.001 ***)
VAS2		0.635 (<0.001 ***)		0.872 (<0.001 ***)
LIKERT2		0.656 (<0.001 ***)		
DML3RRho (<i>p</i>)	VAS	LIKERT	VAS2	LIKERT2
DML3R TFD	0.049 (0.552)	0.026 (0.752)	-0.027 (0.748)	-0.078 (0.347)
DML3R FFD	0.034 (0.684)	0.041 (0.623)	0.083 (0.314)	0.159 (0.053)
VAS		0.877 (<0.001 ***)	0.714 (<0.001 ***)	0.618 (<0.001 ***)
VAS2		0.625 (<0.001 ***)		0.854 (<0.001 ***)
LIKERT2		0.650 (<0.001 ***)		

p* < 0.05, *p* < 0.01, ****p* < 0.001.

that dental studies using eye-tracking devices were mostly performed on full-face photographs^{23–28} and studies assessing smile aesthetics were usually carried out by surveys.^{6–14,30} Therefore, similar to previous studies, data were obtained by conducting VAS and Likert scale evaluations by the help of surveys. In addition to the proven surveys, the present study also included eye-tracking devices in order to provide a simpler and more practical method which paralleled recent technological advances. In the present surveys, images were printed in natural colour which mirrored the studies of Abu Alhaija et al.¹⁹ and Olivares et al.⁹ In order to provide evaluations of the survey studies, Flores-Mir et al.,⁴ Roden-Johnson et al.,⁵ Kokich et al.,⁶ Pinho et al.,⁷ Ioi et al.,⁸ Olivares et al.,⁹ Al Taki et al.,¹⁰ Sriphadungporn and Chamnannidiadha,¹¹ Nomura et al.,¹² Mollabashi et al.¹³ and Cavalcanti et al.¹⁴ preferred to use a VAS. However, Ong et al.,¹⁸ Abu Alhaija et al.,¹⁹ Chotimah et al.²⁰ and Thiruvengkatachari et al.²¹ preferred to use a Likert scale. The present study aimed to evaluate the correlation between the VAS and Likert scales. Therefore, each participant's consistency levels were also determined. It was further aimed to evaluate the level of possible relationship between the eye-tracking data with the VAS and Likert scale. In the present study, the VAS and Likert scores were consistent, and were consistent with the eye-tracking data.

Beyer and Lindauer³¹ reported that the mean threshold for acceptable DML deviation was 2.2 ± 1.5 mm in their study to determine the limit of aesthetic

acceptance when the maxillary DML deviated from the facial midline. In all, 30 general dentists, 30 orthodontists, 30 adolescent patients, and 30 parents (15 men and 15 women in each group) for a total of 120 people served as evaluators. Orthodontists and dentists were less tolerant of midline deviations compared with patients and patient-relatives.

Kokich et al.¹⁵ performed midline changes by shifting the maxillary tooth segment up to 4 mm to the left of the patient in 1 mm increments. Only the orthodontists were able to identify the maxillary midline line deviating from the ideal. General dentists and laypersons were unable to recognise the midline deviation. It was reported that orthodontists evaluated the smile as aesthetic even if there was a midline deviation of up to 4 mm.¹⁵

Kerr et al.²⁹ shifted the midline to the left by increments of 0.1825 mm to assess harmony between the midline of the maxillary incisors and midline of the face. As a result of their evaluation by laypersons, it was found that a maximum value of 2.9 mm in midline deviation was acceptable, but it was also reported that one-third of participants found the deviation of 4.3 mm acceptable.

Silva et al.,³² as a result of their investigations using people who had no dental training, reported that 1 mm midline deviations were similarly scored on unmodified study images. A 2 mm midline deviation was a considered a threshold value of unacceptability.

Ferreira et al.,¹⁷ in frontal smile images, gradually shifted the dental midline from 0 to 5 mm at 1 mm

intervals to the left. The photographs were cropped in two ways which created six photographs for each of two examining groups. The LCN group included the lips, chin, and two-thirds of the nose, and the L group included the lips only. In the study, 95 laypersons evaluated the images using a VAS. The researchers reported that the midline deviations were noticed by the LCN group participants at 1 mm and by the L group participants at 2 mm.

Springer et al.³⁰ moved the maxillary midline by approximately 0.25 mm increments to the left side in all facial images of a male and a female of average attractiveness. The maximum midline deviation was 6 mm. It was determined that the acceptable limit for maxillary midline deviation from the face was 3.2 mm.

In a study by Williams et al.,³³ smiling photographs of male and female subjects were altered to create three facial type variations (euryprosopic, mesoprosopic, and leptoprosopic) and deviations in the midline ranging from 0.0 to 4.0 mm. In general, the mean threshold value considered to be acceptable in the midline deviation was 2.92 ± 1.10 mm, the threshold value for the male model was 2.80 ± 1.27 mm and the threshold value for the female model was 3.04 ± 0.90 mm.

In the present study, “cupid’s bow” was used to represent the facial midline in accordance with the literature.^{15,29,30,33} Modified photographs were obtained by gradually shifting the DML up to 4 mm in 1 mm increments to the right and left.

As a result of the current evaluation using eye-tracker data, there was a statistically significant difference between the participants in the TFD for the DML2R image ($p = 0.026$). The longest focusing time (0.93 sec) belonged to the orthodontists, while the patient-relatives had the shortest minimum focusing time average (0.51 sec). DML2R-DML2L was most perceived by orthodontists and dentists. However, the deviation was also noticed by patient-relatives and laypersons. DML3R-DML3L was detected by all participating groups. There was a statistically significant difference between the VC for the DML1L photograph. The VC of the dentists was higher than the other groups ($p = 0.014$). For this reason, it was considered that a 1 mm left midline deviation attracted the attention of dentists.

Based on the survey evaluation, patient-relatives and laypersons recorded higher acceptability scores for midline deviations. The 1 mm midline left and right deviations were noticed by dentists and orthodontists,

and were found to be aesthetically acceptable. A 2 mm midline deviation to the left was noticed by all volunteer groups and was not found to be aesthetic. A 2 mm midline deviation to the right was noticed by all groups, except for laypersons, and was not found to be aesthetic. In general, the deviation of the midline to the left was more noticeable and lower values were recorded.

The present results demonstrated that there were differences in perception between the groups. Based on these findings, the null hypothesis was rejected.

There was no statistically significant difference between the genders in the evaluation of the effects of midline deviation on smile aesthetic perception with eye-tracking device data and survey data. However, it was observed that the total fixation times were higher in the female participants. Although it was not statistically significant, females were more sensitive in evaluating midline deviations and provided lower scores.

There was no statistically significant difference between the age groups in the evaluation of the effect of midline deviation on smile aesthetic perception using eye-tracking device data.

In the survey, 3 and 4 mm midline deviations were given higher acceptability scores by participants over 50 years of age.

Conclusions

Eye-tracking data, VAS, and Likert scores were found to be comparable.

Following a 2 mm DML deviation to the right, the focusing time increased between occupational groups. The longest focusing time was identified in the orthodontists, while the shortest focusing time was noted the patient-relatives group.

A 2 mm DML deviation was noticed by all groups, and it was found to be unaesthetic.

The dentist group noted a 1 mm DML deviation to the left, and their VCs also increased.

A 1 mm DML deviation was noticed more by those with professional knowledge compared with those without professional knowledge, but it was accepted as aesthetic.

A DML deviation to the left segment received lower scores in general.

Participants over 50 years of age recorded higher scores and were more tolerant of DML deviation.

DML evaluation did not differ according to gender.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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