DOI: 10.7860/JCDR/2020/43190.13533

Original Article

Dentistry Section

# The Perception of Asymmetries in Occlusal Plane in the Frontal View among Laypeople: An Eye-tracking Study

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## ABSTRACT

**Introduction:** Eye-tracking studies have explored the need for orthodontic treatment and treatment outcomes from a lay perspective as a newer diagnostic tool versus traditional assessments based on static photographs.

**Aim:** To evaluate the visual aesthetic perceptions of laypeople with regard to occlusal plane cant in a frontal smile analysis.

**Materials and Methods:** Images of smiling male and female faces had occlusal plane cant added with Photoshop CC on the magnitudes of 0°, 2°, and 2.5° to the left side on the female face and the male to the right side. To obtain eye-tracking data, two software programs, OGAMA and The Eye Tribe Tracker®, were used together. Thirty male and 30 female laypeople raters were selected from the student population of a university (Pontifícia Universidade Católica do Paraná) and consisted of undergraduate students and not those of dentistry, to visualise ocular movement in the Areas of Interest (AOI). A One-Way Analysis of Variance (ANOVA) was applied to compare one of the independent variables with the dependent variable.

**Results:** Eye-tracking showed that the laypeople identified a triangle shape between the right eye, left eye, and mouth with greater fixation of the eyes. There were statistically significant differences according to the number of fixations at the mouth and menton.

**Conclusion:** Laypeople were not able to perceive the occlusal plane cant located on the right side of the male face or to the left on the female face. However, it is important to do take the laypeople perspective into consideration when making treatment alternatives.

**Keywords:** Asymmetry, Frontal smile, Occlusal cant

## INTRODUCTION

Smile arrangement and composition are crucial components in orthodontics. Perception of beauty is subjective, which makes it difficult to achieve solid goals to guide during orthodontic treatment [1]. Perception of beauty varies from person to person and may be influenced by gender, personal experience and social environment [2].

An attractive smile is a requirement to win elections and advertising uses beautiful smiles to subliminally suggest “look better, feel younger” [3]. The aesthetic acceptability thresholds for aesthetic facial and dental problems should be well defined [4].

The perceptions of laypeople in relation to smiling aesthetics are important to better understand treatment goals from the point of view of the patient. The characteristics of the smile should be highly assessed during orthodontic treatment planning [5].

People are influenced by what they see on television, internet and social networks, and not meeting the standards of beauty can affect confidence and self-esteem. Alhammadi MS et al., found beauty is a key motivational reason for patients seeking dental and orthodontic treatment as they mainly seek an aesthetically pleasing smile similar to the standards presented in society and the media, which correlate a beautiful smile with success [6].

The inclination of the occlusal plane is a characteristic that must be evaluated in any analysis of smile aesthetics. When left side or right side of the teeth present different vertical position it is defined as the rotation up or down in the transverse plane of one side over the other. It can be observed both frontally and obliquely, always when the lips are relaxed but more clearly in the smile [7].

Several devices facilitate the orthodontist to analyse and evaluate asymmetries in the vertical position of the posterior teeth when the patient is in occlusions, such as a wooden tongue depressor or metallic ruller [8].

Eye-tracking studies have explored the need for orthodontic treatment and treatment outcomes from a lay perspective as a newer diagnostic tool versus traditional assessments based on static photographs. Eye-tracking is a method to gauge what people notice and look at, and the data obtained can establish a hierarchy of visual attention [9]. The use of this technology may complement analysis of the psychosocial aspect of aesthetics in facial asymmetry and malocclusion.

Therefore, the objective of the study was to analyse the perception of occlusal plane cant asymmetries in a frontal view by laypeople through eye-tracking.

## MATERIALS AND METHODS

Before starting this qualitative and observational study, approval was granted by the Research Ethics Committee of the University (registry number: 2,235,302). The study was conducted on the University campus between June 2018 and July 2019, and data collection with the selected population was carried out between March and April 2019.

Six (3 male and 3 female) digital images were obtained by one of the researchers with 1.0 m between the subject and the camera, with the use of a Canon camera model T2i, lens EF-S 60 f2.8 Macro USM, and flash Macro Ring Lite MR-14EX II (Canon, Tokyo, Japan). The standard method employed was the following: Models were instructed to sit comfortably in a chair and look at the lens to take a frontal facial photo with the camera in the portrait direction with the head oriented with the Frankfort plane horizontal to the floor and without lateral tilt or rotation [10]. The direction of the focus was in between the eyes, and they were asked to relax all facial expressions.

The next step involved the selection of one male and one female facial photograph by three orthodontists each with five years of clinical experience.

The inclusion criteria were images considering the symmetry, volume and colour. Exclusion criteria were features that could have a significant impact (e.g., piercings, tattoos, excessive makeup) were avoided [10]. The images were saved in JPEG format at high resolution for use in the eye-tracking software.

The two selected images were edited using Photoshop CS5® software (Adobe®, San Jose, USA). The mandibular arch was maintained intact and simulated images were developed with the occlusal plane cant of 0°, 2°, and 2.5°. To reduce bias, deviations were performed on the left side for female and to the right side for male [11]. A Total of six groups: three for female images: A: 0°; B: 2°; C: 2.5°, and three for male images: D: 0°; E: 2°; F: 2.5°, of different occlusal plane cant [Table/Fig-1a-f].


**[Table/Fig-1]:** Occlusal plane cant. Female to the left side: A: 0°; B: 2°; C: 2.5°. Male to the right side: D: 0°; E: 2°; F: 2.5°.

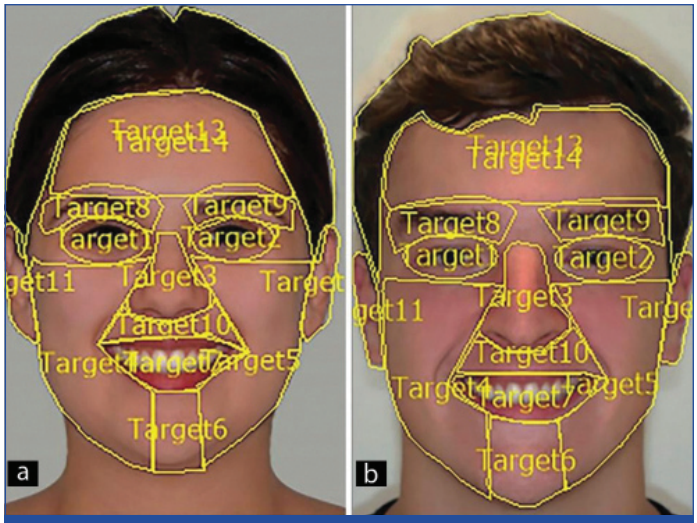
A total of 30 male and 30 female raters were selected randomly from the student population of a university consisting of non-dental undergraduate students aged 18 to 29 years (student age range of the polytechnical school) and without knowledge of the objectives of the study. Raters did not present neurological alterations, did not engage in drug or alcohol use, were not on medications that could interfere in cognitive abilities, had robust vision (glasses were recommended if necessary), and had never participated before in eye-tracking research.

To obtain the results with Open Gaze And Mouse Analyser (OGAMA; Freie Universität, Berlin, 2016) software, the following AOIs were added to the face and teeth: the right and left eyes, right and left eyebrow, nose, mouth, left and right side of the mouth, forehead, right and left cheek, chin, and the right and left ears [Table/Fig-2a,b]. Each image was evaluated for three seconds on a 17-inch P2317H monitor (Dell Inc., Round Rock, USA), upright as recommended by the manufacturer, with raters positioned comfortably at a distance of 60-90 cm for hardware calibration, and the images were arranged randomly with a green slide used in the transition between images, selected because this colour helps avoid eye fatigue [12].

The OGAMA software (Freie Universität, Berlin) was used in conjunction with The The EyeTribe © (Copenhagen, Denmark) hardware to obtain gaze trajectory-tracking data with images for both heatmap and scanpaths, presented in a randomised order. The heatmap provided a colour scale, from light colours (green) to dark colours (red), representing the areas of fixation concentration.

## STATISTICAL ANALYSIS

An ANOVA was utilised to compare one of the independent variables with the dependent variable, indicating a significant difference. Once the occlusal plane cant of 0°, 2°, and 2.5° presented a standard




**[Table/Fig-2]:** Areas of interest (AOI).

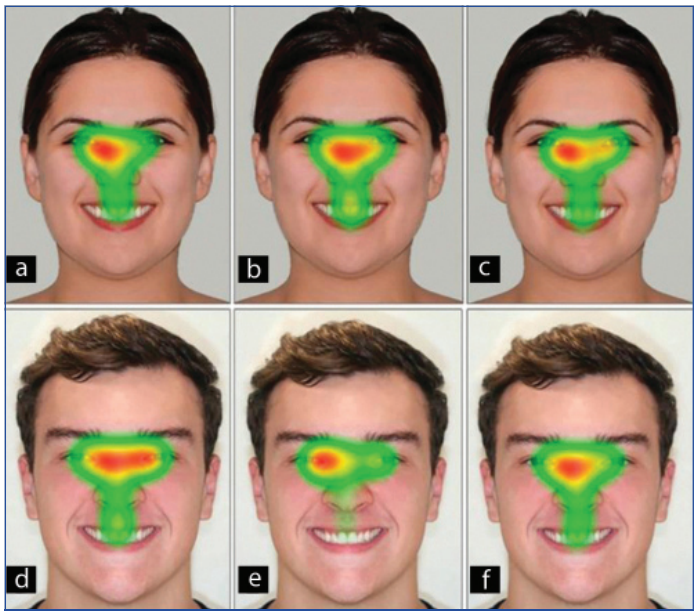
deviation of 0 and did not have a normal distribution, comparison between groups for the four variables (dependent and independent) was performed. The statistical test selected for the present study was the parametric test ANOVA, or if the N in one of the six groups (male and female with 0º, 2º, and 2.5º) was too small, the non-parametric test of Kruskal-Wallis was applied.

All results of the number of fixations recorded from the eye-tracking were exported to Microsoft Excel and then to the Statistical Package for the Social Sciences (SPSS) software version 25.0 (IBM Corp., Armonk, USA). Statistical analyses were performed using SPSS at the 5% level of significance. The dependent variable was the number of fixations in the AOIs (eyes, mouth, and menton), and the independent variables were the occlusal plane cant in both sexes.

## RESULTS

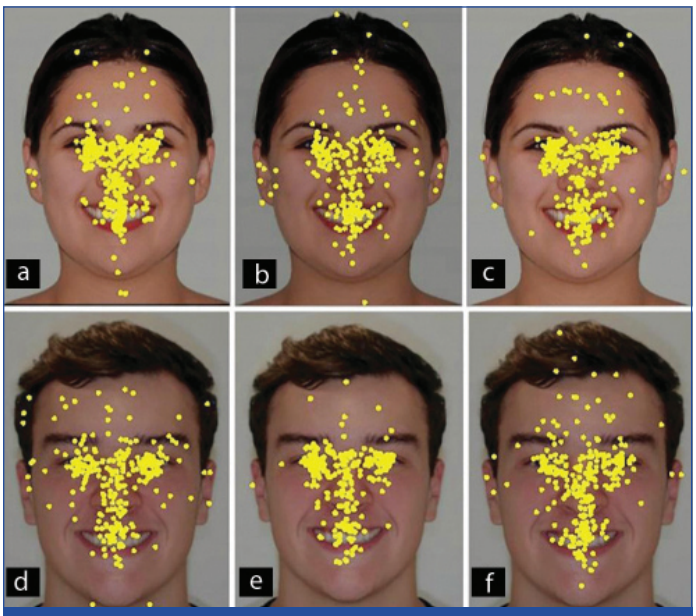
The mean age of the observers was 21.6 years. Degrees of the females were compared against degrees of the male.

According to the results obtained from the heatmap, it was verified that the highest density of fixation occurred in the eye and mouth regions. In the male image, when the occlusal plane was canted 2°, it was shown that the raters did not observe the deviation. By grouping, the results of the female and male heatmap results, homogeneous findings could be deduced. Even if there is statistical significance, this does not mean that the raters perceived those differences. Statistical analysis was applied to compare different magnitudes of the occlusal plane cant [Table/Fig-3a-f].




**[Table/Fig-3]:** Heatmap of the occlusal plane cant to the left side (female). A: 0°; B: 2°; C: 2.5°, and to the right side (male). D: 0°; E: 2°; F: 2.5°.

The raters were not able to perceive the occlusal plane located on the right side either in the male image or female image (left side). The results of the scanpath on the female [Table/Fig-4a-c] and male images [Table/Fig-4d-f] showed that the scanpath was strongly concentrated on both eyes and the mouth, forming a triangle between the right eye, left eye, and mouth.




**[Table/Fig-4]:** Scanpath of the occlusal plane cant to the left side (female). A: 0°; B: 2°; C: 2.5°, and to the right side (male). D: 0°; E: 2°; F: 2.5°.

Analysis of the descriptive statistics and results of the ANOVA test comparing the rotation of the occlusal plane in both genders against the number of fixations on AOIs are presented in [Table/Fig-5], thereby demonstrating statistically significant differences according to the number of fixations at the mouth and menton ($p<0.05$).

The number of fixations on the AOI of the mouth presented statistically significant differences in relation to the occlusal plane cant on the magnitude of group with 2.5°of the male image when compared to the group with 2.5° female image ($p<0.05$). It means that the group of females presented with a higher number of fixations when compared to the group of males. For the 0º and 2º occlusal plane cant did not presented significant difference ($p>0.05$).

The number of fixations on the AOI of the menton features statistically significant differences in relation to the occlusal plane cant when the image of the group with 0° female was compared to the group of 2.5º female ($p<0.05$). The occlusal plane cant presented statistically significant differences when the image of the group 0° female was compared to the group of 2º male.($p<0.05$) [Table/Fig-5].

The number of fixations on the AOI of the eyes did not present statistically significant differences for any magnitude of the occlusal plane ($p>0.05$).

## DISCUSSION

Photographs are the most common way of diagnosing rotation in the occlusal plane and is an important resource of study for smile aesthetics. Rotation of the occlusal plane canting usually is a complex treatment because can cause additional asymmetry during orthodontic treatment and uncertain stability of treatment [8,13].

The objective of this study was to evaluate smile aesthetics of the occlusal plane cant via tracking by laypeople. In the current study, experts including prosthetists, periodontists and orthodontists could have been included because they are more directly linked to aesthetic rehabilitation, but only laypeople were requested to assess the images. Laypeople do not have any specific technical knowledge about the arrangement and disposition of the smile and are the most important group because their opinion is imperative for evaluating the ever changing aesthetic patterns [5].

The occlusal plane of 2° was evaluated as aesthetically acceptable and was not perceived by orthodontists, general dentists, and laypersons [7]. Indeed, Kokich VO et al., concluded that laypersons were unable to detect this kind of asymmetry until it reached a 4º inclination [14].

These findings indicate that laypeople and general practitioners consider the occlusal plane cant more acceptable than orthodontists, denoting that the category of observer affected the way smile aesthetics is perceived when a rotation of the occlusal plane is presented. On the contrary, Padwa BL et al., suggested that the differences in detection of the occlusal plane angulation depended on the degree of rotation and not based on the experience of the observers in analysing smile [15]. In the current study, according to the heatmap and scanpath (qualitative results), laypeople were not able to observe differences in any of the canting of the occlusal plane between 0º and 2.5º, even when the quantitative results exhibited statistically significant differences. The differences were prominent on the magnitude of 0º when compared to the magnitude of 2.5º for the female and 2º for the male as well as for the magnitude of 2.5º between sexes, although the results show that the higher the magnitude, the smaller number of fixations. In considering qualitative analysis, the present authors can confirm that the raters were not able to perceive the occlusal plane cant.

Skilled orthodontists, paediatric dentists, and laypeople perceive certain dental aesthetic discrepancies at various levels of deviation, which helps out the dental professional to plan various treatments. Padwa BL et al., concluded that untrained lay observers detected 90% of the occlusal cant above 4° and trained observers could detect 98% of facial photographs with the occlusal plane cant [15].

In this study, the lay population did not have any dental or medical training. For this reason, before each test, the profession of the observers was asked. Perception of beauty varies from person to person and may be influenced by gender, personal experience, and social environment. These components may influence the opinion between aesthetic of laypeople and general dentists or orthodontist [16-18]. In general, dentists give a higher attractiveness score than orthodontists and layperson usually are the most generous [19].

| Variables | Mean grade (±SD) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Degrees female | | | Degrees male | | | |
| | 0 | 2 | 2.5 | 0 | 2 | 2.5 | p-value |
| Number of fixation at mouth | 1.53 (±0.810)$^{ABC}$ | 1.72 (±0.849)$^{ABC}$ | 1.93 (±1.016)$^{AB}$ | 1.30 (±0.465)$^{ABC}$ | 1.30 (±0.470)$^{ABC}$ | 1.30 (±0.637)$^{AC}$ | 0.020* |
| Number of fixation at menton | 2.00 (±0.00)$^{A}$ | 1.67 (±0.577)$^{AB}$ | 1.00 (±0.00)$^{B}$ | 1.50 (±0.707)$^{AB}$ | 1.00 (±0.000)$^{B}$ | 1.20 (±0.447)$^{AB}$ | 0.048* |
| Number of fixation at right eye | 1.65 (±0.978)$^{A}$ | 1.35 (±0.587)$^{A}$ | 1.44 (±0.847)$^{A}$ | 1.41 (±0.733)$^{A}$ | 1.61 (±0.728)$^{A}$ | 1.47 (±0.776)$^{A}$ | 0.729 |
| Number of fixations at left eye | 1.74 (±0.984)$^{A}$ | 1.40 (±0.707)$^{A}$ | 1.71 (±0.938)$^{A}$ | 1.48 (±0.712)$^{A}$ | 1.58 (±0.683)$^{A}$ | 1.26 (±0.514)$^{A}$ | 0.166 |

**[Table/Fig-5]:** Comparison of the occlusal plane cant with number of fixations.
*Statistically significant at $\alpha$=0.05, ANOVA test results
Superscript letters, values with the same letters in the superscript among observers, do not differ significantly ($p>0.05$)

Kaya B and Uyar R, assessed quantitatively the influence of the occlusal plane together with maxillary gingival exposure surrounding the perception of smile attractiveness during the spontaneous smile evaluated [19]. This study also analysed quantitatively the presence of the occlusal plane cant in male and female models according to the ocular fixations of the raters through the heatmap, and results indicate that they were not able to perceive the occlusal plane cant.

Occlusal deviations within the 0° to 3° range were observed by Ferrario VF et al., in normal and healthy patients, with normal masticatory function within this range [20]. The occlusal plane cant was not perceptible and occlusal inclination of this magnitude has no detrimental effects on postoperative results. Heimansohn HC, suggested that normal individuals have a natural inclination to the occlusal plane and that altering this inclination by restoring the dentition and placement of prostheses may contribute to the development of temporomandibular joint dysfunction [21]. Therefore, awareness of the presence of moderate levels of rotations of the occlusal plane is still important in dentistry. The goal of this study was to compare the rotation of the occlusal plane cant, analysed in a frontal view to determine which rotation is considered perceptible according to the category of observer.

The assessment of the interaction between the amount of rotation of the occlusal plane and amount of gingival exposure could be further developed as well to differentiate the observers between the sexes and associate the visual analogue scale with quantitative evaluation.

For Farret MM, wrong vertical position of the teeth represent a great complexity in orthodontic treatment of adult patients and these as symmetries are usually treated in a limited way or with limitations in terms of the final result [22]. During moderate to severe deviations, it is fundamental to perform a correct diagnosis in order to plan the positioning of the skeletal anchorage device to correct the asymmetry.

### Limitation(s)

The hardware has an accuracy of 85% to obtain the eye-tracking data. According to this, the Ogama may not acquire a totally faithful data, however, the scanpaths demonstrated that the eye-tracking tests are highly effective to evaluate the rotation of the occlusal plane cant.

## CONCLUSION(S)

Laypeople were not able to perceive the occlusal plane cant located on the right side of the male face or to the left on the female face. However, it is important to take the laypeople perspective into consideration when making treatment alternatives.

### Acknowledgement

The present authors thank all participants in this study and Daniel Damin da Silva for his help with the technical aspects of figures.

## REFERENCES

[1] Ackerman MB, Ackerman JL. Smile analysis and design in the digital era. J Clin Orthod. 2002;36(4):221-36.
[2] Abu Alhaija ES, Al-Shamsi NO, Al-Khateeb S. Perceptions of Jordanian laypersons and dental professionals to altered smile aesthetics. Eur J Orthod. 2011;33(4):450-56.
[3] Ackerman JL, Ackerman MB, Brensinger CM, Landis JR. A morphometric analysis of the posed smile. Clin Orthod Res. 1998;1(1):02-11.
[4] Parekh SM, Fields HW, Beck M, Rosenstiel S. Attractiveness of variations in the smile arc and buccal corridor space as judged by orthodontists and laymen. Angle Orthod. 2006;76(4):557-63.
[5] Parrini S, Rossini G, Castroflorio T, Fortini A, Deregibus A, Debernardi C. Laypeople's perceptions of frontal smile esthetics: A systematic review. Am J Orthod Dentofacial Orthop. 2016;150(5):740-50.
[6] Alhammadi MS, Halboub E, Al-Mashraqi AA, Al-Homoud M, Wafi S, Zakari A, et al. Perception of facial, dental, and smile esthetics by dental students. J Esthet Restor Dent. 2018;30(5):415-26.
[7] Olivares A, Vicente A, Jacobo C, Molina SM, Rodriguez A, Bravo LA. Canting of the occlusal plane: perceptions of dental professionals and laypersons. Med Oral Patol Oral Cir Bucal. 2013;18(3):e516-20.
[8] Jeon YJ, Kim YH, Son WS, Hans MG. Correction of a canted occlusal plane with miniscrews in a patient with facial asymmetry. Am J Orthod Dentofacial Orthop. 2006;130(2):244-52.
[9] Richards MR, Fields HW, Jr., Beck FM, Firestone AR, Walther DB, Rosenstiel S, et al. Contribution of malocclusion and female facial attractiveness to smile esthetics evaluated by eye-tracking. Am J Orthod Dentofacial Orthop. 2015;147(4):472-82.
[10] Leandro de Oliveira W, Saga AY, Ignacio SA, Rodrigues Justino EJ, Tanaka OM. Comparative study between different groups of esthetic component of the Index of Orthodontic Treatment Need and eye-tracking. Am J Orthod Dentofacial Orthop. 2019;156(1):67-74.
[11] Jarosz KF, Bosio JA, Bloomstein R, Jiang SS, Vakharia NS, Cangialosi TJ. Perceptions of chin asymmetries among dental professionals and laypersons. Am J Orthod Dentofacial Orthop. 2018;154(2):201-12.
[12] Trevisan C, Pithon MM, Meira TM, Miyoshi CS, Saga AY, Tanaka OM. The visual perception and attractiveness of maxillary central incisor abrasion as evaluated via eye-tracking. European Journal of General Dentistry. 2019;8:07-12.
[13] Kang YG, Nam JH, Park YG. Use of rhythmic wire system with miniscrews to correct occlusal-plane canting. Am J Orthod Dentofacial Orthop. 2010;137(4):540-47.
[14] Kokich VO, Kokich VG, Kiyak HA. Perceptions of dental professionals and laypersons to altered dental esthetics: asymmetric and symmetric situations. Am J Orthod Dentofacial Orthop. 2006;130(2):141-51.
[15] Padwa BL, Kaiser MO, Kaban LB. Occlusal cant in the frontal plane as a reflection of facial asymmetry. J Oral Maxillofac Surg. 1997;55(8):811-16; discussion 817.
[16] Albino JE, Tedesco LA, Conny DJ. Patient perceptions of dental-facial esthetics: shared concerns in orthodontics and prosthodontics. J Prosthet Dent. 1984;52(1):09-13.
[17] Pinho S, Ciriaco C, Faber J, Lenza MA. Impact of dental asymmetries on the perception of smile esthetics. Am J Orthod Dentofacial Orthop. 2007;132(6):748-53.
[18] Roden-Johnson D, Gallerano R, English J. The effects of buccal corridor spaces and arch form on smile esthetics. Am J Orthod Dentofacial Orthop. 2005;127(3):343-50.
[19] Kaya B, Uyar R. The impact of occlusal plane cant along with gingival display on smile attractiveness. Orthod Craniofac Res. 2016;19(2):93-101.
[20] Ferrario VF, Sforza C, Miani A, Tartaglia G. Craniofacial morphometry by photographic evaluations. Am J Orthod Dentofacial Orthop. 1993;103(4):327-37.
[21] Heimansohn HC. The Heimansohn plane a new occlusal lateral plane. Dent Dig. 1968;74(8):345-46.
[22] Farret MM. Occlusal plane canting: A treatment alternative using skeletal anchorage. Dental Press J Orthod. 2019;24(1):88-105.

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**PLAGIARISM CHECKING METHODS:** [Jain H et al.]
- Plagiarism X-checker: Nov 19, 2019
- Manual Googling: Jan 20, 2020
- iThenticate Software: Jan 30, 2020 (11%)

**ETYMOLOGY:** Author Origin

**AUTHOR DECLARATION:**
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. Yes

Date of Submission: **Nov 09, 2019**
Date of Peer Review: **Dec 06, 2019**
Date of Acceptance: **Jan 30, 2020**
Date of Publishing: **Feb 01, 2020**