Aesthetic evaluation of the labiolingual position of maxillary lateral incisors by orthodontists and laypersons

Xue Jiang
West China Hospital of Stomatology, Sichuan University, Chengdu, China.
Zhiwei Cao
Sichuan University West China College of Stomatology
Yang Yao
Department of Implantology, West China Hospital of Stomatology, State Key Laboratory of Oral Diseases & National Clinical Research Ceter for Oral Diseases, Sichuan University, Chengdu, China
Zhihe Zhao
Department of Orthodontics, West China Hospital of Stomatology,State Key Laboratory of Oral Diseases & National Clinical Research Center for Oral Diseases, Sichuan University, Chengdu,China
Wen Liao (liaowenssw@126.com)
West China Hosipital of Stomatology, Sichuan University, China https://orcid.org/0000-0002-5737-9731

Research article

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Abstract

Backgrounds

The maxillary anterior teeth play a crucial role in smile aesthetics. As for maxillary lateral incisors, most studies concentrated on its size, incisor edge level, inclination, et al. However, the aesthetic effect of lateral incisor movement in spatial position has not been studied yet. Therefore, the purpose of this study was to explore the influence of labiolingual position of maxillary lateral incisors on the aesthetic perception of orthodontists and laypersons and different gender groups.

Methods

A photograph of a male's smile was selected. iOrtho7.0 software (Time Angel, Wuxi, China) was used to edit the three dimensional (3D) dental models. By referring to the 3D models, the photograph was digitally processed to create seven images with different labiolingual positions of the maxillary lateral incisors in 0.5 mm increments (+ indicates labial movement and -indicates lingual movement). Eighty-six orthodontists and one hundred sixty-one laypersons were asked to evaluate images using a visual analog scale. Data were analyzed by Student *t*-test and One-way analysis of variance with post hoc test.

Results

There was no significant difference between the perception of males and females ($P > 0.05$). Orthodontists assigned lower scores to all images than laypersons. +1.5 mm was considered as the least attractive smile by orthodontists while + 1.5 mm and − 1.5 mm were regarded as the least attractive ones by laypersons. 0 mm was rated the most attractive by all judges ($P < 0.05$). Between the 0 mm and − 0.5 mm, laypersons observed the difference but orthodontists did not.

Conclusions

The labiolingual position of maxillary lateral incisors does affect the perception of smile esthetics. Although orthodontists gave lower score to each image than laypersons.

Background

At present, the goal of dental treatment is not only to restore normal function, but also to endow patient with certain aesthetics. The concept of beauty is unquantifiable because it is influenced by many factors, such as different cultures and creeds. Many studies have demonstrated that orthodontists and laypersons have different perceptions of smile aesthetics, and proved that orthodontists were more sensitive to notice the deviation from ideal than laypersons [1–3].

The maxillary anterior teeth play a crucial role in smile aesthetics [4]. As for maxillary lateral incisors, most studies concentrated on its size [1], incisor edge level,[5] inclination [6], and replacement of lateral

incisors with canines [7]. However, the aesthetic effect of lateral incisor movement in spatial position has not been studied yet.

Dental crowding is one of the most common dental malocclusion. One of the consequences of dental crowding is the spatial displacement of teeth. Previous studies have simulated the rotational displacement of the maxillary lateral incisors and central incisors due to crowded dentition [8, 9]. Labiolingual movement of maxillary lateral incisors is also a common deformity caused by crowded dentition, which can be easily found in the clinic. However, to date, no aesthetic studies have been reported on labiolingual movement of maxillary lateral incisors.

Therefore, this study was designed to determine the effect of the labial-palatal movement of maxillary lateral incisors on the aesthetic perception of orthodontists and laypersons and the influence of the raters' gender on this perception.

Methods

Acquisition and Processing of Images

Approval was obtained and the participant assigned informed consent. A male volunteer aged 20 was selected, who did not receive any orthodontic or conservative/prosthetic treatment before being included in the study. His smile can be considered highly attractive according to the following principles: symmetry of maxillary central incisors, less than 1.0 mm of gingival display and proper design of smile arc [10, 11]. The volunteer's smile photographs were taken with a Canon EOS 7D under standard conditions and the brightness, contrast. And midline tilt of the photo was adjusted by Adobe Photoshop (CC2018, Adobe Systems, San Jose, California). The upper 2/3 of the face was removed to minimize interference [12]. The volunteer's digital three-dimensional (3D) models of maxillary and mandibular dentitions was obtained by Sirona D3492 (Sirona Dental Systems GmbH, Bensheim, Germany) first, and the software iOrtho7.0 (Time Angel, Wuxi, China) was used to edit the 3D models to change the position of teeth. The original position of maxillary lateral incisors was regarded as control group. In occlusal view, all teeth were aligned in a harmonious archform (Fig. 1). The left lateral incisors were moved to different labiolingual position in the obtained 3D models with iOtho7.0, and then a screenshot of front view of the entire models was taken. Then the screenshots of the digital simulations were used as references to change the left lateral incisors' position in the two-dimensional (2D) photograph which was taken before with Adobe Photoshop. Through this method, the 3D models and the 2D photos of the volunteer's left maxillary lateral incisors moved − 1.5 mm, -1 mm, -0.5 mm, 0, + 0.5 mm, + 1 mm and + 1.5 mm (the minor sign indicates the tooth moves lingually and the plus sign indicates the tooth moves labially, and 0 mm means that the lateral incisor has not moved from a reasonable position relative to the central incisor, that is to say, in the state of 0 mm, a smooth curve of incisors is formed in the occlusal surface.) were obtained. Then a mirror change was made to obtain the right-side image according to the left side, to eliminate the aesthetic interference caused by asymmetry. With this manner, both frontal view (Fig. 2) and occlusal view (Fig. 3) of 3D models' digital simulations and 2D photos (Fig. 4) were obtained. The occlusal view of 3D models'

digital simulations was to clarify how we did the modifications. And the modified 2D photos were used in the questionnaire.

Selection of participants

Pilot study data from 18 participants in each group was calculated in PASS software (version 11.0; NCSS, America) to verify the sample size. Based on the level of significance of 5% (α = 0.05), the sample size was calculated to achieve 80% power. The results indicated that 28 raters in each group were needed.

According to the pilot study result, we invited 93 orthodontists and 245 laypersons, aged between 18 and 50 years, as the participants. Raters were excluded from the study if they could not identify any difference between photos or had difficulty in understanding the questionnaires.

Process of Investigation

SurveyStar (Changsha, China) was used to create questionnaires. Then, the questionnaires were distributed and answered online. Seven 2D photos were presented in random orders. Based on the principle of visual analogue scale (VAS), the participants were asked to slide the slider below the images to score the photos. The rightmost end of the slider represents the most attractive photo, scored 100 points; the leftmost end of the slider scored 0 points, representing the least attractive one. Each photo was displayed only once and could not be rescored.

Reliability

To determine the reliability of the method, two weeks later, 33 participants of each group were randomly asked to assess the same seven images again. The scores for each photo were examined by the intraclass correlation test (95% confidence intervals) [13]. The result of orthodontists was 0.91 and that of laypersons was 0.98, which indicated that the results of each group had good reliability.

Statistical Analysis

All data were recorded in Microsoft Excel (Microsoft Office 2010, Microsoft Corporation, USA) and then analyzed using SPSS (IBM SPSS Statistics for Windows, Version 23.0, Armonk, NY: IBM Corporation, USA). To test the differences in the mean VAS scores between seven images, One-way ANOVA with the Post hoc tests was used. Student-*t* test was used to observe the statistical difference in the scores of each image between male and female and also between the orthodontists and laypersons. The level of significance was determined at 5% level ($P \leq 0.05$).

Results

Among the 247 raters aged between 18 and 50, 86 were orthodontists and 161 were laypersons. Among orthodontists, 22(25.58%) were male and 64(74.42%) were female; among the laypersons, 35 (21.74%) were male and 126 (78.26%) were female (Table 1) .Table 2 showed that there was no statistical difference between male and female in scoring of each image based on the VAS score ($P > 0.05$).

Table 1
Characteristics of the participants in each study group.

characteristics	Orthodontists (n = 86)(%)	Laypersons (n = 161)(%)
Sex		
Male	22(25.58)	35(21.74)
Female	64(74.42)	126(78.26)
Age group		
18–25 years	21(24.42)	130(80.75)
26–30 years	23(26.74)	17(10.56)
31–40 years	26(30.23)	11(6.83)
41–50 years	16(18.60)	3(1.86)

Table 2
Comparison of labiolingual position of maxillary lateral incisor between males and females, using student *t* test[a]

	Male(n = 57)	Female(n = 190)	
Image	Mean(SD)	Mean(SD)	*P*-value
A(+ 1.5 mm)	34.61(20.31)	37.33(23.23)	0.427
B(+ 1.0 mm)	48.07(22.22)	47.39(24.00)	0.849
C(+ 0.5 mm)	64.65(23.59)	66.37(21.82)	0.609
D(0 mm)	74.32(17.00)	75.48(18.71)	0.673
E(-0.5 mm)	68.33(19.44)	67.94(20.57)	0.899
F(-1.0 mm)	64.00(20.26)	69.70(21.47)	0.076
G(-1.5 mm)	44.33(20.58)	44.71(23.23)	0.911

[a] SD refers to standard deviation.

Table 3 represented the average scores for each image given by orthodontists and laypersons. From the perspective of orthodontists, image A was considered to be the least attractive smile (a mean score of 31.69) while the most attractive smile was image D (a mean score of 70.74). According to the laypersons, the lowest scores were assigned to image A and image G (mean scores of 39.39 and 46.16, respectively), while the image D was also rated as most attractive (a mean score of 77.60). Apparently, image D was regarded as the most attractive by all evaluators.

Table 3

The score of each image awarded by Orthodontists and Laypersons [a].

	Orthodontists(n = 86)		Laypersons(n = 161)		O x L
Image	Mean(SD)	Results[b]	Mean(SD)	Results[b]	*P*-value[c]
A(+ 1.5 mm)	31.69(21.27)	A	39.39(22.86)	A	0.010*
B(+ 1.0 mm)	42.37(22.39)	B	50.31(23.76)	B	0.011*
C(+ 0.5 mm)	59.79(21.78)	C	69.27(21.79)	C	0.001*
D(0 mm)	70.74(19.67)	D	77.60(17.12)	D	0.005*
E(-0.5 mm)	66.31(21.79)	C,D	68.95(19.43)	C	0.331
F(-1.0 mm)	67.28(20.41)	C,D	68.98(21.79)	C	0.552
G(-1.5 mm)	41.77(23.40)	B	46.16(22.09)	A,B	0.146

[a] SD indicates standard deviation.

[b] Comparison of labiolingual position of maxillary lateral incisor within groups, there was no statistically significant difference between the same letter variables, and one-way ANOVA and post hoc test were used, $^{*}P < 0.05$.

[c] comparison between orthodontists and laypersons, using student *t* test, $^{*}P < 0.05$.

When comparing the preference between the orthodontists and laypersons, the scores of image A, B, C and D exerted significant difference ($P = 0.010$, 0.011, 0.001 and 0.005, respectively), whereas there was no statistical difference in that of image E, F and G. However, it was obvious that the scores awarded by orthodontists to each image were lower than that of laypersons, indicating that the orthodontists were stricter in evaluating smile aesthetics.

Discussion

Researches [14, 15] have shown that the anterior teeth play an important role in smile aesthetics. Previous studies of lateral incisors indicated that the width ratio of lateral incisors to central incisors should correspond to the golden ratio [1, 16]. However, many studies later reported that the golden ratio of lateral incisors to central incisors has negligible effect on the smile aesthetics [17]. For example, Bukhary et al.[1] showed that lateral incisors with a width of 67–72% of the central incisors and a length 1.5 mm shorter than central incisors were considered attractive. Pani et al. [18] demonstrated that most people preferred short, broad lateral incisors, and they could tolerate a small mesial inclination of lateral incisors. Brunzel et al. [6] compared different aesthetic changes brought by different teeth inclination and suggested that a slight amount of mesial inclination of both lateral incisors symmetry had a positive effect on an attractive smile.

Studies mentioned above only included the changes of teeth in 2D plane, whereas in orthodontic cases, the inclination and displacement of the teeth in 3D plane were quite common. Schlosser et al. [19] studied different anteroposterior (AP) positions of the maxillary central incisors, showing that people were more tolerant to labial protrusion of the maxillary central incisors than lingual retrusion. Analogously, Cao et al. [20] found that the labial inclination and lingual retrusion of maxillary central incisors were relatively unacceptable. Chirivella et al. [21] studied the labiolingual inclination and anteroposterior position of maxillary incisors in three different facial patterns on profile, showing that different facial pattern led to different aesthetic criterion, but consistent with previous studies, the tolerance of the labiolingual movement of maxillary central incisors was lower than labiolingual inclination.

The Little's Irregularity Index (LII), the sum of the distances between four anterior teeth's anatomic contact points, is an important index used in the previous study of dentition crowding [22]. However, researches argued that the LII index did not have enough repeatability [23, 24], so it could not meet the research requirements. Studies indicated that scanning models had better reliability than LII index [23]. Sirona intraoral scanner was used to obtain the volunteer's digital dentition models and used iOrtho7.0 software to change the position of maxillary lateral incisors in this study. The 2D photos was created based on the visual effect of the 3D models, so that the changes took place in 3D direction were transformed into 2D images. As orthodontists face more cases of 3D malformation of teeth or dentition in clinic, our research methods may provide references for future research. The angle used in taking the photographs should be matched with the angle to view the dental cast in iOrtho7.0 software, which is worth noting in future research. Moreover, we found that when we change the position of lateral incisors, since we fixed the adjacent teeth in the 3D modle, the space between the lateral incisor and its adjacent teeth was magnified on photographs + 1.0 mm and + 1.5 mm, which was somewhat different from the actual situation. In the future study, we will seek a better balance between controlling single variable and simulating actual situation, making the study more valuable.

VAS can be used for the questionnaire analysis of various factors affecting smile aesthetics due to its convenience and repeatability [25]. Some studies asked participants to rank photos in the order of attractiveness to find which photo was the most or the least attractive. [14] And some studies combined ranking orders and VAS scores together and evaluated their consistency [13]. In our study, since the changes were made bidirectionally, it was not difficult to speculate that a large amount of labial or lingual movement would be both considered unacceptable, so ranking the photos was impractical in this study.

Gender may be one of the factors influencing smile aesthetics [18], but some studies [1, 26] have shown that, there was no significant difference between male and female in evaluating the smile aesthetics, which is consistent with our study. Studies have shown that the gender of the subject could also influence the perceived smile aesthetics [27, 28]. In our study, only one photograph of a man's smile was used, and only the part of mouth was retained to minimize the effects of the subject's gender. Therefore, the evaluation of different maxillary lateral incisors' labiolingual position in different genders can be explored in subsequent studies.

Our study indicated that orthodontists and laypersons both awarded the highest score to the control group (0 mm), and they gave lower scores as the moving distance of maxillary lateral incisors increased. Compared with laypersons, orthodontists had a lower tolerance for lateral incisors moved labially ($P < 0.05$), and also assigned lower scores to the images of lingual movement of maxillary lateral incisors (though there was no significant difference), which indicated that orthodontists had higher aesthetic standards, and orthodontists are more sensitive than laypersons when the lateral incisors were moved labially. For both laypersons and orthodontists, the intolerance of labial movement was generally higher than lingual movement with the same distance. This is in contrast to the study of Cao et al. [20] which reported that the lingual movement and labial inclination of the maxillary central incisors were more unacceptable. The divergence of the conclusions may result from that different labiolingual position of the maxillary central incisors tends to change the position of entire dentition, and the receding dentition could make the smile look less full [19], while people tend to appreciate fuller smile more. But our study was based on the position of the maxillary lateral incisors, which changed position independently with the entire dentition. What's more, front-view picture was used in our research instead of profile, which can also cause difference.

In addition, our study showed that, orthodontist did not tell difference between 0 mm and − 0.5 mm, while laypersons did. This was not in favor of the previous view that orthodontist were more likely to distinguish between subtle changes in dentition [1–3]. Therefore, before orthodontic treatment, communication and discussion between orthodontists and patients is needed to achieve a better therapeutic outcome.

Conclusion

- Labial position of maxillary lateral incisors was more unacceptable to all judges, and they all agreed that the smile with unmoved (0 mm) maxillary lateral incisors was the most attractive.
- Orthodontists were stricter than laypersons with respect to the labial position of maxillary lateral incisors while there was no significant difference between them in the lingual position.
- Gender of raters did not seem to affect the evaluation of different labiolingual position of maxillary lateral incisors.

Abbreviations

LII
Little's Irregularity Index
VAS
visual analogue scale
2D
two-dimensional
3D

three-dimensional

Declarations

Ethics approval and consent to participate

This work has been approved by the ethics committee of Sichuan University West China School of Stomatology (WCHSIRB-D-2019-066) and applicable patient release was obtained.

Consent to publish

Written informed consent for publication was obtained from the volunteer who provided his smile photographs in the questionnaire and article.

Availability of data and materials

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

We declare no potential conflicts of interest with respect to the authorship and publication of this manuscript.

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Author's Contributions

All authors had contributed to this article. XJ and ZC collected data and drafted this paper. WL designed and guided the whole experiment. YY and ZZ revised this paper. All co-authors have read and agreed with the contents of the manuscript.

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Figures

Figure 1

Three-dimensional digital simulation of maxillary dentition (occlusal view).

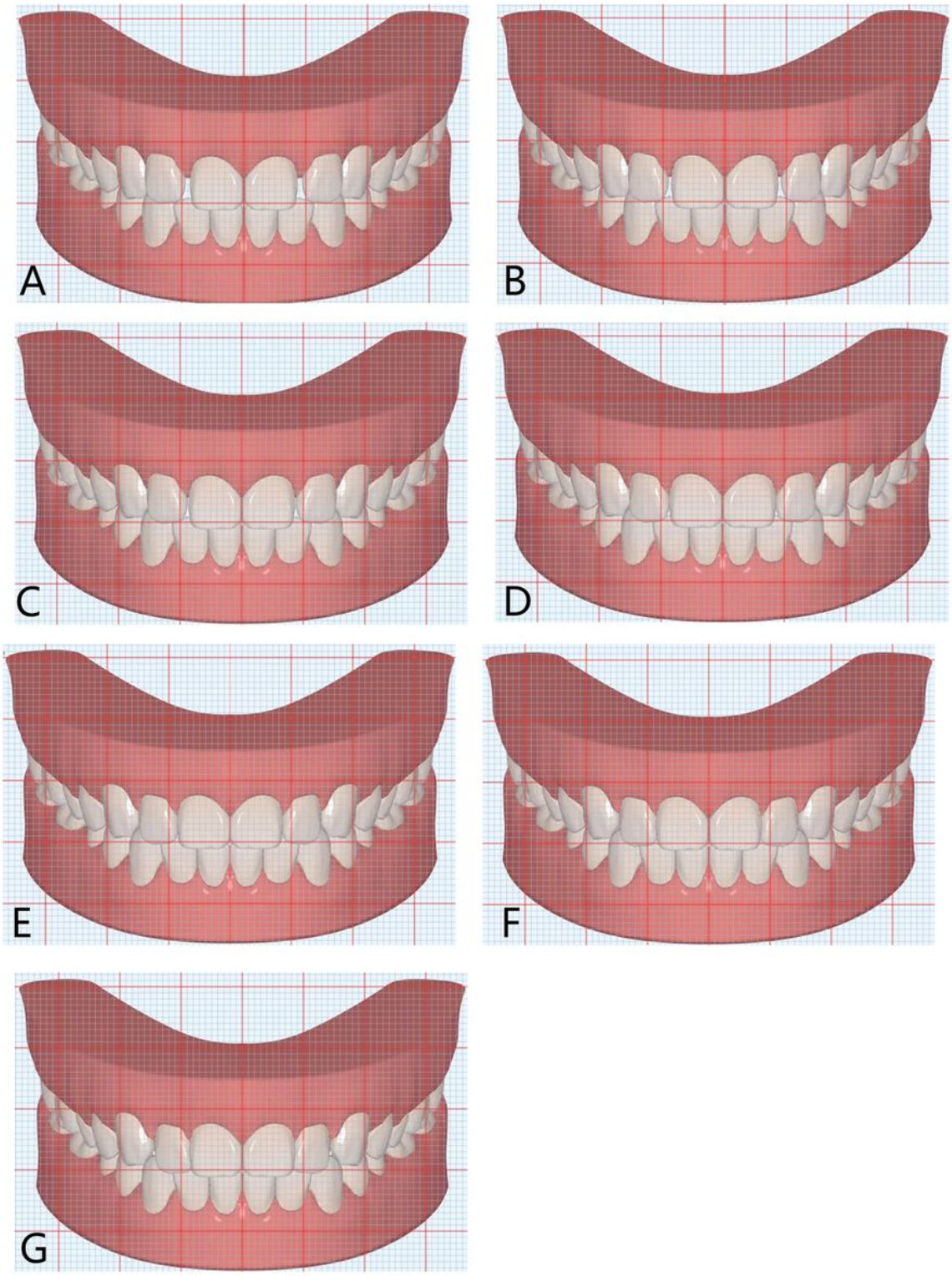

Figure 2

Images of three-dimensional digital simulations were used as references (frontal view). A,+1.5mm,labial movement with 1.5mm.B,+1.0mm,labial movement with 1.0mm. C,+0.5mm, labial movement with 0.5mm.D,0mm,control group.E,-0.5mm, lingual movement with 0.5mm.F,-1.0mm, lingual movement with 1.0mm.G,-1.5mm, lingual movement with 1.5mm.

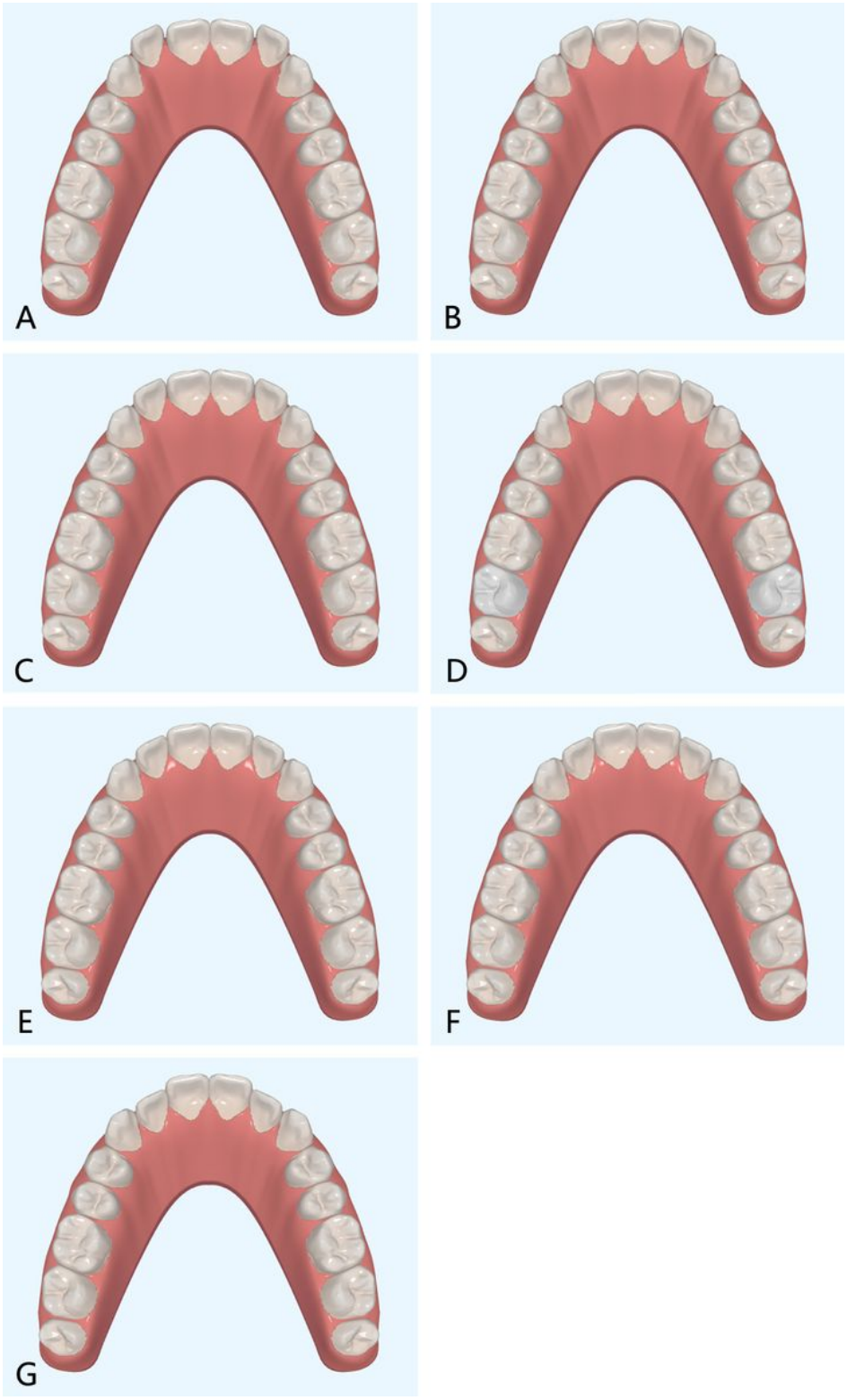

Figure 3

Images of three-dimensional digital simulations were used as references (occlusal view). A,+1.5mm,labial movement with 1.5mm.B,+1.0mm,labial movement with 1.0mm.C,+0.5mm, labial movement with 0.5mm.D,0mm,control group.E,-0.5mm, lingual movement with 0.5mm.F,-1.0mm, lingual movement with 1.0mm.G,-1.5mm, lingual movement with 1.5mm.

Figure 4

The labiolingual position of maxillary lateral incisor was changed in 0.5mm increments. A,+1.5mm,labial movement with 1.5mm.B,+1.0mm,labial movement with 1.0mm.C,+0.5mm, labial movement with 0.5mm.D,0mm,control group.E,-0.5mm, lingual movement with 0.5mm.F,-1.0mm, lingual movement with 1.0mm.G,-1.5mm, lingual movement with 1.5mm.