Orthodontists’ and laypeople’s perception of smile height aesthetics in relation to varying degrees of transverse cant of anterior teeth

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Aims: To determine the effect of varying the transverse cant of the anterior teeth on orthodontists’ and laypeople’s perceptions of smile aesthetics, and the influence that smile height has on this perception.

Materials and methods: A 20-year-old Chinese female with an aesthetic smile and normal occlusion was chosen and agreed to participate. Digital pictures of her posed smile were taken and manipulated to create three smile height variations: low, medium, or high. Each variation was further manipulated to create varying degrees of transverse anterior tooth cant. Fifty-six laypeople and 40 orthodontists participated as raters of the dental and facial impact of the altered smile images.

Results: The orthodontists more commonly and precisely identified the transverse cants of the anterior teeth and the detracting influence on smile aesthetics compared with laypersons. The orthodontists accepted a lesser range of anterior transverse cant. Increased smile heights enhanced the capability of all raters to detect a transverse cant and reduced the acceptable cant range. In addition, an increased smile height worsened the detracting effects of the transverse anterior cant in all raters’ perceptions of smile aesthetics. An increased display of teeth and angulation of an anterior cant increased the ability of raters in both groups to detect differences.

Conclusion: Transverse cants of anterior teeth can affect orthodontists’ and laypeople’s perceptions of smile aesthetics. Smile height and incisor display were significant factors that affected the orthodontist’s and layperson’s perceptions of smile aesthetics, and suggested that a description of the detracting effect of an anterior transverse cant should also consider smile height.

Clinical relevance: A transverse occlusal cant is an important aesthetic factor used by clinicians during orthodontic diagnosis and review. It is important to appreciate that there is a difference in perception between orthodontic professionals and patients (laypeople). The extent of this perceptual difference and influencing factors could help the clinician set more appropriate treatment goals.

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Introduction
Achieving a harmonious soft-to-hard-tissue relationship between the dentofacial complex and improving smile aesthetics are essential goals of orthodontic treatment. Recently, there has been a move towards greater awareness of the importance of anterior tooth display in orthodontic diagnosis and treatment.1-3 Clinical examinations of dental arch form, arch width and symmetry may not be sufficient to describe the position of the anterior teeth relative to the soft tissues of the face and could be enhanced by information related to tooth display in the three planes of space and the anterior arc of the dentition.

A posed smile is a repeatable pattern that may be used to evaluate an improvement in smile aesthetics as a result of treatment.2-4 A posed smile takes into account parameters such as dental arch form, buccal corridor, occlusal cant, midline deviation, incisal

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position, lip thickness and gingival architecture.\textsuperscript{5-14} Of the various parameters that affect smile aesthetics, a transverse anterior cant is considered overwhelmingly displeasing as a cant can change either maxillary anterior tooth display or the curvature of the anterior arc of the dentition.\textsuperscript{15-17}

Previous studies have demonstrated that dental professionals and lay observers can identify smile characteristics that enhance or detract from anterior aesthetics.\textsuperscript{18,19} Using a method previously reported to study the perception of an anterior transverse cant,\textsuperscript{4} the present study was designed to investigate the influence that a transverse cant of the anterior teeth might have on smile aesthetics as perceived by orthodontists and laypeople. An additional aim was to determine how smile height (low, medium, or high) influenced this perception in the two groups.

The following five hypotheses were tested:

1. The smile height would affect the perception of an occlusal cant.
2. A transverse anterior cant would affect the perceptions of smile aesthetics for professionals and laypeople to varying degrees.
3. Orthodontists would be more perceptive than laypeople in detecting smaller degrees of transverse occlusal cant.
4. Orthodontists would have a smaller acceptable range of transverse anterior cant than laypeople.
5. Orthodontists would be more likely to consider an anterior transverse cant as a detracting aspect of smile aesthetics.

Materials and methods

The research was approved by the institutional review board of Sichuan University, China.

Digitally-manipulated images were used to eliminate possible confounding factors that can be present in clinical pictures of patients with a genuine occlusal cant. Digitally manipulated images have been widely used and provide consistency of manipulation.\textsuperscript{20}

A 20-year-old female who had received professional smile training was chosen due to: (1) an aesthetic smile close to the textbook ideal;\textsuperscript{21} (2) a normal occlusion, straight profile and symmetrical face; (3) aligned, intact and natural maxillary incisors without restorations or colour disharmony. A full-face image was taken using a digital camera (Canon digital, A610, Tokyo, Japan) with the subject’s head held in a naturally relaxed position with coinciding facial and dental midlines to allow the observer to determine an interpupillary line.\textsuperscript{22}

Several posed frontal smile images were captured, and one image was identified as the original ideal smile by clinical consensus (Figure 1b).

One hundred people including 50 men and 50 women were involved in the smile evaluation study over the following six months. The participant inclusion
criteria were: (1) orthodontists from the orthodontic department, West China School of Stomatology, Sichuan University, engaged in the profession for more than three years; (2) laypeople of non-medical college students without prior knowledge of orthodontics. Exclusion criteria consisted of: (1) orthodontists involved in related research; and (2) laypeople with a medical education background or involvement in related research.

The original posed image was manipulated using software (Adobe Photoshop 9.0, CA, USA) to produce three pictures of differing smile heights that correspondingly affected the vertical display of the maxillary anterior teeth (Figure 1).23 The smile levels were defined as (1) a low smile (less than 75% exposure of maxillary anterior teeth); (2) a medium smile (75%–100% exposure of maxillary anterior teeth); and (3) a high smile (full crowns and gingival exposure of maxillary anterior teeth).

Varying degrees of transverse occlusal cant were subsequently created for the three smile heights. Zero inclination was defined as parallelism of the lateral incisal gingival line to the upper lip margin. Using a line connecting the most gingival point of the upper lateral incisors as the centre, the dentition from a parallel position to the upper lip margin was rotated in one-degree increments from zero to five degrees in both clockwise and counterclockwise directions. The canted planes were recorded as +1° to +5° when rotated clockwise and −1° to −5° when rotated counterclockwise. Ten pictures with anterior transverse cants were therefore generated (Figures 1–3) in each of the three smile height groups. This resulted in a total of 33 pictures (including three neutral with different smile heights).

The 33 pictures of varying degrees of cant and smile heights were randomly displayed on a screen, with a 5 second interval between each image. The raters were placed 60–80 cm from the screen and each was asked whether the maxillary anterior teeth had a transverse cant. If the answer was no, the value was recorded as 0; if the answer was yes, raters were then asked whether the transverse cant had a negative effect on smile aesthetics. If the answer was yes, the raters were asked to grade the detracting effects on the smile. A visualised aesthetics scale from 1 to 10 was used, in which 1 represented the least detracting effect and 10 represented the most detracting effect. The scores were kept to one decimal place. Fifteen orthodontists (from a total of 40) and 21 laypeople (from a total of 56) were chosen randomly from the raters to repeat the grading two weeks later to check scoring reliability.

**Statistical analysis**

Chi-square (χ2) tests were used to compare the ability of orthodontists and laypeople to detect the varying levels of transverse anterior cant. Chi-square tests were
also used to compare the three smile heights between orthodontists and laypeople and, additionally, to assess the detracting effects of the transverse occlusal cant on smile aesthetics. Finally, the Chi-squared test was used to determine the influence of the different smile heights on the capability of orthodontists and laypeople to detect transverse cants of the anterior teeth.

The independent sample t-test was used to analyse the scores graded by orthodontists and laypeople on the detracting effects of the transverse cants of the anterior teeth on smile aesthetics. The Kappa statistic was used to check the reliability of the research. The independent sample t-test and linear regression were used to test the influence of gender and age of the raters on the evaluations. The level of significance for all statistical tests was set at 0.05. All statistical tests were performed using the Statistical Package for the Social Sciences (SPSS) software program for Windows, version 13.0 (IL, USA).

Results

Of the original 100 participants, 96 (40 professionals and 56 laypeople) completed the investigation. The 40 professionals were either full-time orthodontic teaching staff or orthodontic residents recruited from the Department of Orthodontics, West China College of Stomatology, Sichuan University, China. The remaining 56 raters were laypeople with no orthodontic experience drawn from two local student colleges whose disciplines were not related to dentistry. The Kappa values that assessed the reliability of the identification of a transverse anterior cant were high for the evaluations carried out by the orthodontists (0.79) and laypeople (0.91). The gender or age of raters had no significant effects on the smile aesthetic assessments (p > 0.05).

Comparison of the ability to identify transverse cants of anterior teeth

The ability of the orthodontists and laypeople to detect transverse cants of anterior teeth was different as orthodontists were able to detect smaller degrees of anterior transverse cant (Table 1). Significant differences between orthodontists and laypeople were found in angulations ±2°, ±3°, ±4°, and −5° in the low-smile group; −1°, −2°, and ±3° in the medium-smile group; and ±1° and ±2° in the high-smile group. The differences in capability to detect the occlusal cants between the two groups reduced when exposure of teeth and the angle of transverse anterior cant increased.
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Comparison between three smile heights among orthodontists and laypeople

Orthodontists’ and laypeople’s ability to detect transverse anterior cants was enhanced by an increase in smile height (Table II). The varying smile heights affected the orthodontic participants’ ability only in the groups with a smaller cant angulation (±1˚ to ±2˚) (p < 0.05). However, the laypeople’s ability to detect cant angulations of +1˚, +2˚, ±3˚, ±4˚, and ±5˚ (p < 0.05) was affected by smile height.

Comparison of grading transverse anterior cants on a 10 point scale between orthodontists and laypeople

Using the visualised aesthetics scale, the orthodontists graded the detracting effects of transverse anterior cants higher (p < 0.05) than laypeople in most of the angulated groups (except ±1˚ and −2˚ for the low smile). This suggested that orthodontists were more likely to interpret a transverse anterior tooth cant as a detracting influence on smile aesthetics (Table III).

The grading by orthodontists and laypeople of the detracting aesthetic effects was also influenced by smile height (Table III). As the smile height increased, higher scores were assigned (p < 0.05) for the same angulation.

Table I. Three smile heights affecting the ability to detect various degrees of transverse cants of anterior teeth while grouped separately as orthodontists and laypeople.

| Raters | Degree° | % | Lower smile | Medium smile | High smile | χ² | p |
|--------|---------|---|-------------|--------------|------------|----|---|
|        |         |   |            |              |            |    |   |
|        | -5      |  40 (100.0) |  40 (100.0) |  40 (100.0) | - | - |
|        | -4      |  39 (97.5) |  40 (100.0) |  40 (100.0) | 2.017 | .365 |
|        | -3      |  35 (87.5) |  38 (95.0) |  40 (100.0) | 5.984 | .056 |
|        | -2      |  32 (80.0) |  35 (87.5) |  39 (97.5) | 5.765 | .049* |
|        | -1      |  13 (32.5) |  27 (67.5) |  32 (80.0) | 20.208 | .000* |
|        |  0      |  5 (12.5) |  6 (15.0) |  4 (10.0) | 4.57 | .796 |
|        |  1      |  9 (22.5) |  12 (30.0) |  23 (57.5) | 11.699 | .003* |
|        |  2      | 22 (55.0) |  31 (77.5) |  36 (90.0) | 13.135 | .001* |
|        |  3      | 36 (90.0) |  36 (90.0) |  39 (97.5) | 2.162 | .339 |
|        |  4      | 39 (97.5) |  40 (100.0) |  40 (100.0) | 4.068 | .131 |
|        |  5      | 38 (95.0) |  40 (100.0) |  40 (100.0) | 4.068 | .131 |
| Laypeople |         |   |            |              |            |    |   |
|        | -5      |  47 (83.9) |  54 (96.4) |  56 (100.0) | 13.035 | .000* |
|        | -4      |  38 (67.9) |  54 (96.4) |  56 (100.0) | 38.262 | .000* |
|        | -3      |  28 (50.0) |  44 (78.6) |  54 (96.4) | 32.762 | .000* |
|        | -2      |  31 (55.4) |  34 (60.7) |  38 (67.9) | 1.857 | .395 |
|        | -1      |  12 (21.4) |  19 (33.9) |  24 (42.9) | 5.893 | .053 |
|        |  0      |  7 (12.5) |  10 (17.9) |  7 (12.5) | 875 | .646 |
|        |  1      |  7 (12.5) |  11 (19.6) |  18 (32.1) | 6.576 | .037 |
|        |  2      | 17 (30.4) |  31 (55.4) |  41 (73.2) | 23.105 | .000* |
|        |  3      | 30 (53.6) |  40 (71.4) |  52 (92.9) | 21.793 | .000* |
|        |  4      | 43 (76.8) |  53 (94.6) |  56 (100.0) | 19.204 | .000* |
|        |  5      | 46 (82.1) |  56 (100.0) |  56 (100.0) | 21.266 | .001* |

*p < 0.05
| Smile height | Tilting* | Orthodontists | Laypeople | $\chi^2$ | $p$ |
|--------------|---------|---------------|-----------|---------|-----|
|              | detraction | % | detraction | % |        |   |
| Lower smile  |         |     |           |     |       |   |
| -5           | 37      | 92.5 | 42        | 75.0 | 4.904 | .027* |
| -4           | 34      | 85.0 | 30        | 53.6 | 10.371| .002* |
| -3           | 24      | 60.0 | 15        | 26.8 | 10.672| .002* |
| -2           | 17      | 42.5 | 17        | 30.4 | 1.504 | .220 |
| -1           | 2       | 5.0  | 7         | 12.5 | 1.545 | .214 |
| 0            | 3       | 7.5  | 3         | 5.4  | .183  | .669 |
| 1            | 2       | 5.0  | 3         | 5.4  | .006  | .938 |
| 2            | 15      | 37.5 | 10        | 17.9 | 4.674 | .036* |
| 3            | 21      | 52.5 | 25        | 44.6 | .577  | .447 |
| 4            | 31      | 77.5 | 30        | 53.6 | 5.767 | .019* |
| 5            | 34      | 85.0 | 36        | 64.3 | 5.070 | .024* |
| Medium smile |         |     |           |     |       |   |
| -5           | 40      | 100.0| 51        | 91.1 | 3.768 | .052 |
| -4           | 38      | 95.0 | 54        | 96.4 | .119  | .730 |
| -3           | 29      | 72.5 | 31        | 55.4 | 2.926 | .087 |
| -2           | 24      | 60.0 | 20        | 35.7 | 5.543 | .019* |
| -1           | 13      | 32.5 | 10        | 17.9 | 2.746 | .097 |
| 0            | 4       | 10.0 | 6         | 10.7 | .013  | .910 |
| 1            | 4       | 10.0 | 5         | 8.9  | .032  | .859 |
| 2            | 22      | 55.0 | 18        | 32.1 | 5.016 | .025* |
| 3            | 26      | 65.0 | 33        | 58.9 | .363  | .547 |
| 4            | 38      | 95.0 | 49        | 87.5 | 1.545 | .214 |
| 5            | 40      | 100.0| 54        | 96.4 | 1.459 | .509 |
| High smile   |         |     |           |     |       |   |
| -5           | 40      | 100.0| 56        | 100.0| -      | -   |
| -4           | 39      | 97.5 | 56        | 100.0| 1.415 | .234 |
| -3           | 38      | 95.0 | 46        | 82.1 | 3.527 | .060 |
| -2           | 35      | 87.5 | 26        | 46.4 | 16.990| .000*|
| -1           | 26      | 65.0 | 10        | 17.9 | 22.126| .000*|
| 0            | 4       | 10.0 | 4         | 7.1  | .249  | .618 |
| 1            | 19      | 47.5 | 9         | 16.1 | 11.156| .001*|
| 2            | 30      | 75.0 | 26        | 46.4 | 7.837 | .005*|
| 3            | 38      | 95.0 | 45        | 80.4 | 4.237 | .039*|
| 4            | 38      | 95.0 | 55        | 98.2 | .796  | .372 |
| 5            | 39      | 97.5 | 56        | 100.0| 1.415 | .234 |

* $p < 0.05$

**Discussion**

A consonant smile exists when the curvature of the maxillary incisal edges parallels the curvature of the upper border of the lower lip. An occlusal cant is considered a displeasing smile characteristic in which the transverse cant of the anterior teeth changes either the tooth display or the curvature of the smile arc. An occlusal cant is visible when a person smiles but is not perceived on intra-oral images or study casts as the relationship of the anterior arc of the dentition to facial hard and soft tissues is not shown. Using aeronautical items as a supplementary diagnostic system (pitch, roll and yaw), an occlusal cant is described as the roll of the anterior arc and the pitch of the posterior arc. The hypothesis of the present study was that (1) the transverse cant of the anterior teeth affected the perceptions of smile aesthetics for professionals and laypeople to different degrees, and (2) the smile height affected the perception of the occlusal cant.

Orthodontists and laypeople were able to detect a transverse cant of the anterior teeth, but to varying extents related to the degree of cant and smile height. The professionals were more sensitive to cant...
deviations compared with laypeople, as more transverse cants of anterior teeth were recognised in almost every angulation and smile height group (p < 0.05) (except the most obvious groups: ±5° angulation with high smile) (Table II). In many smile aesthetic studies, investigators identified a difference in the perceptions of aesthetics between orthodontists, general dentists and laypeople.18,26 Laypeople were less able to detect many aspects of smile asymmetries, notably a deviation of dental midlines to excessive gingival display, or increased overbite/overjet. The different perceptions of aesthetics between professionals and laypeople are possibly due to different personal experiences and social environments.8

Both orthodontists and laypeople considered that transverse anterior cants reduced smile aesthetics, but the orthodontists identified the detractions to a greater extent than laypeople. Orthodontists had, approximately, a one degree lower acceptable range of transverse anterior cant than laypeople.
Smile height was a significant factor that modified the effect of the transverse anterior cants by influencing an observer’s ability to detect the cant. The two observer groups had a similar ability to recognize adverse inclined planes more easily when smile height increased \( (p < 0.05) \) (Table III). Taking 75% as an average range, orthodontists could identify a transverse anterior cant of 1° in the high-smile group but only to 3° in the low-smile group. Laypeople could identify a transverse anterior cant of 3° in the high-smile group and 5° in the low-smile group. Furthermore, there were more significant differences in the percentages of detection between the two groups of people in the low-smile group than in the high-smile group (Table III). The results showed that changes in smile height had a greater effect on the ability of laypeople to detect transverse anterior cants than orthodontists.

Variations in smile height also influenced the orthodontists’ and laypeople’s acceptance ranges. As smile height increased, the acceptance range of occlusal cants decreased (Table III). If 50% is considered the standard, the orthodontists’ acceptance ranged from −3° to +3° for low smiles, −2° to +2° for medium smile, and −1° to +1° for high smiles. For laypeople, the acceptance ranges were wider: −4° to +4° for low smiles, −3° to +3° for medium smiles and −2° to +2° for high smiles.

In studies assessing incisal plane inclination, Kokich et al. reported that laypeople did not detect an occlusal cant until it reached 4°. Ker et al. found that the tolerated cant for laypeople ranged from 4° to 6°. Additional studies also revealed that noticeable occlusal cants varied from 2° to 4°. The present study showed that smile height can strongly affect the acceptance ranges in both professionals and laypeople, which indicated that a cant acceptance range should also be described in terms of smile height. The variations in acceptance ranges of variously reported anterior transverse cants might be caused by differences in smile heights presented in clinical occlusal cant images used for rating (a confounding factor) and the possible influences of different cultural contexts.

The scores provided by orthodontists and laypeople who graded the detracting effects of transverse anterior cants on smile aesthetics were also influenced by smile height (Table III). As the smile height increased, the disharmony was greater for the same angulation. The higher the smile and incisal display, the greater the detracting effects \( (p < 0.05) \). On average, the orthodontists disapproved more strongly than laypeople of transverse anterior cants, and the differences were significant in most of the groups \( (p < 0.05) \) (Table III). In the present study, the observers were asked whether the maxillary incisors had a transverse cant. If the answer was yes, the participants were asked about aesthetics. In this way, bias may have been introduced, as the observers were encouraged to look more closely. A greater display of the incisal clinical crown would make a transverse cant more clearly visible relative to the skeletal and soft tissue structures, such as the inter-ocular line and inter-commissure line. Excessive exposure of the anterior gingiva is also a confounding factor that may affect anterior smile aesthetics and make transverse anterior cants less acceptable in the high-smile line groups.

**Conclusions**

Combined with varying smile heights, the effects of transverse cants of anterior teeth on orthodontists’ and laypeople’s perceptions of smile aesthetics were investigated. A transverse anterior cant was a significant factor affecting smile aesthetics. Varying degrees of smile height affected orthodontists’ and laypeople’s perceptions of smile aesthetics and transverse anterior cants. As the smile height increased, both orthodontists and laypeople more easily detected transverse cants but the acceptance of the cant decreased. Orthodontists were less accepting of anterior cants than laypeople.
However, an increased incisal display and transverse anterior cant increased both groups' ability to detect occlusal cants.

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