

Lip - tooth relationships during smiling and speech: an evaluation of different malocclusion types

Roozbeh Rashed and Farzin Heravi

Department of Orthodontics, School of Dentistry, Mashhad University of Medical Sciences, Mashhad, Iran

Background: Few studies have focused on the impact of malocclusion on lip – tooth relationships during smiling and speech.

Aim: To evaluate the impact of different malocclusions on lip – tooth relationships during smiling and speech, using video images.

Methods: One hundred and three subjects with Class I (N = 31), Class II division 1 (N = 26), Class II division 2 (N = 16) and Class III malocclusions (N = 30) were asked to repeat the same sentence and then smile in front of a video camera. Nine frames were extracted from each subject's video clip: at rest, posed smile, unposed smile and during the pronunciation of the sounds: 'che', 'fa', 'se', 'chee', 'tee' and 'mee'. On each frame, up to 10 parameters describing the lip – tooth relationships were measured.

Results: In all frames, there were no statistically significant differences in the upper central incisor display ratios among the malocclusion groups ($p > 0.05$). The buccal corridor ratio in the posed and unposed smiles did not differ significantly among the malocclusions ($p > 0.05$). The most frequently visible last maxillary tooth was the first premolar in the posed smile, and the second premolar in the unposed smile. In each malocclusion group, the upper central incisor display ratio varied significantly among the nine frames and the buccal corridor ratio during the unposed smile was less than the ratio during the posed smile; although this was only significant in the Class II division 2 subjects. The smile arc was similar in all malocclusions.

Conclusions: In each malocclusion the upper central incisor display ratio varied significantly among the nine frames. In each group, the buccal corridor ratio during the unposed smile was less than that during the posed smile, but only the Class II division 2 group was significantly different. The smile arc did not differ among the malocclusions.

(Aust Orthod J 2010; 26: 153–159)

Received for publication: December 2009

Accepted: June 2010

Roozbeh Rashed: rashedr@mums.ac.ir, roozberashed@yahoo.com

Farzin Heravi: heravif@mums.ac.ir

Introduction

Psychological studies have shown that facial attractiveness affects the way an individual is regarded by others. Infants considered to be unattractive by the general population and their own mothers tend to be perceived more negatively than attractive infants.¹ The attractiveness halo extends from home to school. It can affect teacher – student and student – peer relations and academic attainment.² The benefits of physical attractiveness also extend to the workplace, where attractive individuals tend to fare better than unattractive individuals with regard to perceived job qualifications, hiring decisions and future career success.³ In modern society, a pleasant smile is an

advantage in job interviews, social interactions and even in the selection of a spouse.^{3–5}

An unattractive dental appearance during childhood can lead to teasing by age peers that may result in a profound psychological impact, which may continue into adult life.^{6–8} Both adolescent patients and their parents expect orthodontic treatment to improve oral and dental function, health and aesthetics and to enhance self-confidence and the quality of their social life.^{9,10} Needless to say, the goal of modern orthodontics is to improve the quality of life which, in part, is achieved through the enhancement of the patients' smile and facial appearance. Oral health related quality of life (OHRQoL) has been defined as 'the



Figure 1. Smile Analyzer software. This picture shows five windows for the operators' use, and the patient's personal information, loading the desired image, measuring the desired parameter (here, the width of the right upper central incisor) and the table of measured variables.

absence of negative impacts of oral conditions on social life and a positive sense of dentofacial self-confidence'. Thus, orthodontic treatment should carefully consider the patient's facial appearance and particularly his/her smile. Patients will not be satisfied with the treatment outcome if aesthetics are sacrificed for the sake of a good occlusion, even if all the functional goals are met. Improvement in facial aesthetics is a powerful motivation for seeking treatment.¹¹

Lip – tooth relationships during speech and smiling are important aspects of facial aesthetics. However, few studies have focused on lip – tooth relationships during speech and only one study has considered the impact of malocclusion on these relationships during speech and smiling. Our aim was to evaluate the lip – tooth relations in subjects with different types of malocclusion, using video images taken during smiling and speech.

Material and methods

Subjects and video recording

The experimental sample consisted of 37 male and 66 female subjects who presented for orthodontic treatment. The mean ages of the male and female subjects were 19.0 ± 6.7 years and 18.1 ± 4.9 years, respectively. Of the 103 subjects, 31 had a Class I malocclusion, 26 a Class II division 1 malocclusion, 16 a Class II division 2 malocclusion and 30 a Class III malocclusion.

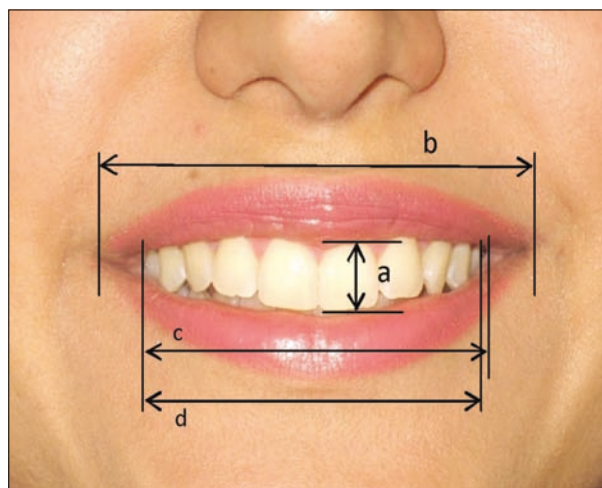


Figure 2. (a) Maximum upper central incisor display. (b) Outer commissure width (smile width). (c) Inner commissure width. (d) Visible maxillary dentition width.

The study was explained to each participant and/or his/her parent or guardian and all agreed to participate in the study. The subjects were seated facing a mirror positioned two metres in front of them. To obtain the natural head position (NHP), each subject was asked to pitch his/her head up and down until a position of balance was obtained and to look at the reflections of their eyes in the mirror.

Video images were captured by means of a video camera recorder (Sony Video Camera Recorder, Model CCD-TR311E, Sony Corporation, Japan) mounted on a tripod 1.5 metres in front of each subject, and aimed at the mouth. Each subject was then asked to repeat a sentence which included words containing the sounds: 'che', 'fa', 'se', 'chee', 'tee' and 'mee'. The subject was then asked to smile voluntarily (posed smile) and spontaneously (unposed smile), while the movements of the lips were recorded. After calculating the magnification of the recorded images, a vernier caliper was used to measure the width of an upper central incisor.

The captured images were then downloaded to a personal computer. Using the Windows Movie Maker software (Windows XP Professional, Microsoft Corporation, USA), nine frames were extracted from each video clip: the subject at rest, during the posed smile, during the unposed smile and during pronunciation of the sounds: 'che', 'fa', 'se', 'chee', 'tee' and 'mee'.

Measurements were made using a software programme designed by the author and called 'Smile

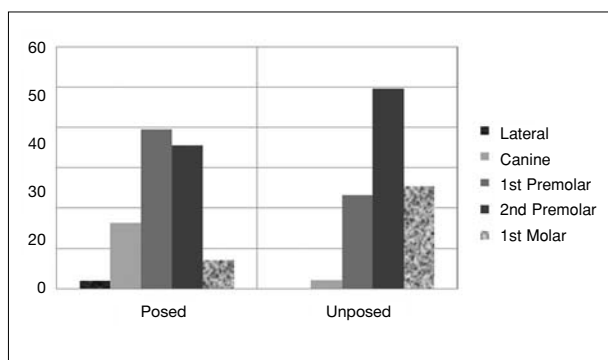


Figure 3. Frequency distribution of the last visible maxillary tooth during posed and unposed smiles.

Analyzer' (Figure 1). In this software, all measurements were saved in the integrated database, and could be transferred to other Windows-based software, such as Microsoft Excel or SPSS.

Measured parameters

For each subject, the height and width of an upper central incisor was measured on a frame that showed all of the central incisor crown, and the height-to-width ratio calculated (Figure 2). The following measurements were taken from a representative frame with the subject at rest:

1. Maximum upper central incisor display and the upper central incisor display ratio. These are the percentage and ratio of the crown height on the frame.
2. Gingival display of the upper central incisor. The amount of gingival tissue displayed above the long axis of the incisor, in millimetres.
3. Interlabial gap.
4. Philtrum height.
5. Left and right commissure heights. The distances between the outer commissures and a horizontal line passing through the subnasal point.

In addition to the first three parameters measured on the 'at rest' frame, the following parameters were measured on representative frames of the posed and unposed smiles (Figures 2 and 4):

1. Smile width or outer commissure width, as delineated by the outermost confluences of the vermilion borders of the lips at the corners of the mouth,¹² and the smile index, that is, the smile width divided by the smile height (interlabial gap).¹³

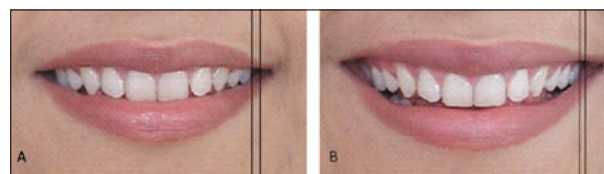


Figure 4. (a) Posed smile. (b) Unposed smile. In an unposed smile, despite the greater smile width, because the lips are stretched more, a larger part of the modiolus becomes visible and the inner commissures get more distinct and closer to each other. Thus, the buccal corridor ratio during an unposed smile is less than that of a posed smile.

2. Inner commissure width (the inner commissure is formed by the mucosa overlying the buccinator muscle where it inserts with the orbicularis oris muscle fibres at the modiolus).¹²

3. Visible maxillary dentition width, which is the distance between most lateral left and right points of the maxillary dentition during smiling.¹³

4. Left and right buccal corridors, measured from the inner commissure to the last visible maxillary tooth. This measurement was divided by the visible maxillary dentition width. The result was a ratio of the maxillary teeth while smiling, minus the buccal corridor. For example, 0.92 means that the maxillary dentition occupied 92 per cent of the inner inter-commissure width. Therefore, the buccal corridor would then occupy 8 per cent (100 minus 92 per cent) of the smile.¹⁴

5. Smile arc, which may be in one of three forms: consonant (i.e. parallel), flat or reverse.¹⁵

6. Most posterior maxillary tooth visible. In case of a discrepancy between the two sides, the most posterior tooth was entered.¹⁴

For the frames in which the subject was speaking the following were measured:

1. Maximum upper central incisor display and the upper central incisor display ratio.
2. Gingival display of the upper central incisor.
3. Interlabial gap.

Statistical analysis

Statistical analyses were performed with SPSS 15.0 for Windows (SPSS Inc., Chicago, IL, USA). One-

Table I. Comparisons of the buccal corridor ratios.

	Class I Mean (SD)	Class II div 1 Mean (SD)	Class II div2 Mean (SD)	Class III Mean (SD)	<i>p</i> *
Posed smile	0.13 (0.06)	0.14 (0.07)	0.18 (0.07)	0.14 (0.08)	0.14
Unposed smile	0.12 (0.06)	0.13 (0.08)	0.14 (0.06)	0.13 (0.07)	0.68
<i>p</i> †	0.27	0.77	0.04	0.50	

* One-way ANOVA

† Paired *t* test, significant value in bold**Table II.** Frequency distributions of the smile arc during posed and unposed smiles.

		Unposed smile arc				Total	
		Non definable	Consonant	Flat	Reverse		
Posed smile arc	Non definable	Number	4.0	6.0	5.0	2.0	17.0
		% of total	4.4	6.6	5.5	2.2	18.7
	Consonant	Number	0.0	24.0	8.0	0.0	32.0
		% of total	0.0	26.4	8.8	0.0	35.2
	Flat	Number	0.0	3.0	23.0	3.0	29.0
		% of total	0.0	3.3	25.3	3.3	31.9
	Reverse	Number	0.0	0.0	2.0	11.0	13.0
		% of total	0.0	0.0	2.2	12.1	14.3
	Total	Number	4.0	33.0	38.0	16.0	91.0
		% of total	4.4	36.3	41.8	17.6	100.0

Contingency coefficient: .716, *p* < 0.001

way ANOVA and paired-*t* tests were used to analyse the parametric data and the nonparametric tests: the Friedman, Wilcoxon, Mann-Whitney and Kruskal-Wallis were used to analyse the quantitative data. The qualitative data were analysed with the chi-squared test. A significance level of 0.05 was used for all tests.

Results

The mean upper central incisor display ratio or the per cent of the visible crown height was 23 per cent at rest, 78 per cent during the posed smile and 99 per cent during the unposed smile. On average, the highest ratio of incisor display during speech occurred during the pronunciation of 'che' or 'chee' (70 per cent) and the lowest ratio during pronunciation of 'mee' (47 per cent).

Using Tjan et al.'s classification of incisor display during the posed smile, we found 41.7 per cent of the subjects had an average smile, 13.6 per cent had a high smile and 44.7 per cent a low smile.¹⁶ There

were fewer subjects with high smiles in all of the malocclusion groups, although there was no statistically significant difference in the type of smile among the malocclusion groups (*p* = 0.12). When incisor display in the boys and girls were compared, 12.1 per cent of the girls and 16.2 per cent of the boys had a high smile, but the difference was not statistically significant (*p* = 0.76).

There was no statistically significant difference in the upper central incisor display ratio among the malocclusion groups (*p* > 0.05). However, this ratio was significantly different among nine frames taken at rest, during the posed and unposed smiles, and for the frames taken during the speech exercises (*p* < 0.001). When frames of the speech exercises were paired up, the pairs were statistically different (*p* < 0.001), except for the 'che' - 'chee' and 'fa' - 'se' pairs. We found a significant positive correlation between the upper central incisor display ratio during the posed and unposed smiles (Spearman rank correlation:

$r = .59, p < 0.001$). Furthermore, during speech, the highest positive correlation was between 'chee' and 'tee' ($r = .92, p < 0.001$) and the lowest correlation was between 'che' and 'mee' ($r = .69, p < 0.001$). A positive correlation was found between the upper central incisor display ratio during the posed smile and pronunciation of 'chee' (Pearson correlation coefficient: $r = .60, p < 0.001$).

Although the buccal corridor ratio was greater during the posed smile than during the unposed smile, the difference was not statistically significant ($p > 0.05$), except for subjects with a Class II division 2 malocclusion ($p = 0.04$) (Table I). This ratio did not differ significantly among the malocclusion groups ($p > 0.05$).

A significant positive correlation was found between the interlabial gap at rest and incisor display during the posed smile ($r = .41, p < 0.001$). Within each malocclusion group, the smile indices during the posed and unposed smiles also varied significantly ($p < 0.05$). However, neither during the posed nor during the unposed smile was this difference significant among the malocclusions ($p > 0.05$).

Table II depicts a significant contingency in the smile arc type between the posed and unposed smiles (Contingency coefficient: $.716, p < 0.001$). This means that the smile arc was the same among the posed and unposed smiles in about 70 per cent of the subjects.

As shown in Figure 3 during the posed smile, the most frequently visible last maxillary tooth was the first premolar, whereas during the unposed smile it was the second premolar.

Discussion

Undoubtedly, patients expect to have an attractive and pleasing appearance at the end of orthodontic treatment. Important components of an attractive face are an attractive smile and appropriate lip – tooth relationships during speech: both contribute to social interaction. We measured the upper central incisor display ratio and found no gender difference in the type of smile in our Iranian sample. Other investigators have reported higher smile lines in women than in men, selected from non-Iranian groups.^{17–19} We found that the upper central incisor display ratio in young adult Iranians during speech and a smile did not differ significantly among the malocclusions, although we reported that male subjects with Class

III malocclusion displayed less of their upper incisors during speech and smile than subjects with Class I and Class II malocclusions.²⁰ Age-related and ethnic variations in lip – tooth relationships may exist, as white North American adolescents with a Class I skeletal pattern had different lip – tooth relationships between a posed smile and articulation of 'chee'.²¹

A possible explanation for the similarity in the upper incisor display ratio among the malocclusions is that the soft tissues contribute more to incisor display than the underlying skeletal form.²¹ At present, we have no effective method of classifying dynamic movements of the lips that will allow us to investigate differences in lip – tooth relationships.

The upper incisor display ratio differed significantly among the nine frames because each facial animation resulted from different soft tissue movements. During a posed smile, the lip commissures move more superiorly and laterally compared with lip movement during pronunciation of 'chee'.²¹ We found positive correlations between incisor display during the posed smile and during the pronunciation of 'chee' and between pronunciation of 'chee' and 'tee'.

These findings lend support to the belief that sole consideration of the lip – tooth relations in smiling may be misleading. Observing the patient during normal speech gives the most valuable aesthetic information for planning treatment. Tooth display during smiling cannot provide the same information, since the upper lip is raised by three different muscle groups when a person is smiling.²² In addition, certain consonant sounds may be more reproducible than smiles.²³ Consonant sounds are certainly language – specific and, hence, not universal. More research is needed to relate speech sounds to the amount of incisor exposure. In social interactions, people mostly talk to each other rather than just exchanging smiles, thus making the consideration of lip – tooth relationships during speech of prime importance. However, such analysis of the patient's speech is not possible unless dynamic records are obtained before treatment. It is also necessary to define specific words or letters which represent the patient's lip – tooth relationships. This area is fertile ground for further research.

No study has assessed the buccal corridor spaces in different malocclusions. In our study, the buccal corridor ratio both during the posed smile ($p = 0.14$) and

the unposed smile ($p = 0.68$) did not differ significantly among the malocclusions. This may be due to specific soft tissue features in each malocclusion, such as the thickness of the lips, the amount of lip movement, the position and movement of the modiolus.²⁴

An important and interesting observation in this study was that the buccal corridor ratio during an unposed smile was less than that during a posed smile (although this difference was only significant in Class II division 2 subjects). As Ackerman and Ackerman stated, the buccal corridor should be measured from the inner rather than the outer commissures.¹² In an unposed smile, despite the greater smile width, because the lips are stretched more, a larger part of the modiolus becomes visible and the inner commissures become more distinct and closer to each other (Figure 4). Burstone attributed the variability of this space among different types of smiles to the buccinator muscle.²³

We found a positive correlation between the interlabial gap at rest and the upper incisor display ratio during the posed smile. This confirms the notion that the interlabial gap at rest may be a good estimate of incisor display during a smile, underlining the importance of taking the interlabial gap into account during treatment planning.^{13,25,26} We also found that the smile index differed significantly between the posed and unposed smiles, and attribute this to variability of soft tissue movements and different smile widths (i.e. outer commissure width) and smile heights (i.e. interlabial gap). İşiksal and his colleagues reported that the smile index had little impact on smile aesthetics.¹³ In nearly 70 per cent of our subjects, we found the smile arc was the same during the posed and unposed smiles, which suggests that if a consonant smile is present during a posed smile before and/or after treatment then a consonant smile during an unposed smile will be similarly affected.

In agreement with Maulik and Nanda,¹⁴ we found that the most frequently visible last upper teeth were the first and second premolars during the posed and unposed smiles, respectively. It is believed that the muscles of facial expression may account for more than 10,000 visible facial configurations and at least 18 different types of smile.²⁷ We found that the upper central incisor display ratio was significantly different among the nine frames we used, which supports our proposal that dynamic records should be an

integral part of orthodontic diagnosis and treatment planning.^{21,26,28,29}

Conclusions

There was no significant difference in the upper central incisor display ratio among the malocclusion groups.

The buccal corridor ratio during posed and unposed smiles did not differ significantly among the malocclusion groups.

In each malocclusion group, the buccal corridor ratio during an unposed smile was less than that during a posed smile, but only in the Class II division 2 group the difference was significant.

The smile arc did not differ significantly among different malocclusions.

Acknowledgment

This research was supported by a grant from Vice-Chancellor for Research, Mashhad University of Medical Sciences.

Corresponding author

Associate Professor Farzin Heravi
Department of Orthodontics and Dental Research Center
School of Dentistry
Mashhad University of Medical Sciences
Mashhad
Iran
Tel: +98 511 8419814
Fax: +98 511 8423073
Email: heravif@mums.ac.ir

References

1. Langlois JH, Ritter JM, Casey RJ, Sawin DB. Infant attractiveness predicts maternal behaviours and attitudes. *Dev Psychol* 1995;31:466–72.
2. Clifford M, Walster E. The effects of physical attractiveness on teacher expectation. *Sociol Educ* 1973;46:248–58.
3. Hosoda M, Stone-Romero EF, Coats G. The effects of physical attractiveness on job-related outcomes: a meta-analysis of experimental studies. *Personnel Psychol* 2003;56:431–62.
4. Buss DM, Schmitt DP. Sexual strategies theory: an evolutionary perspective on human mating. *Psychol Rev* 1993; 100:204–232.
5. Stevenage SV, McKay Y. Model applicants: the effect of facial appearance on recruitment decisions. *Br J Psychol* 1999;90:221–34.
6. Shaw WC, Meek SC, Jones DS. Nicknames, teasing, harassment and the salience of dental features among school children. *Br J Orthod* 1980;7:75–80.

7. Helm S, Kreiborg S, Solow B. Psychosocial implications of malocclusion: a 15-year follow-up study in 30-year-old Danes. *Am J Orthod* 1985;87:110–118.
8. Kilpeläinen PV, Phillips C, Tulloch JF. Anterior tooth position and motivation for early treatment. *Angle Orthod* 1993;63:171–4.
9. Gosney MB. An investigation into some of the factors influencing the desire for orthodontic treatment. *Br J Orthod* 1986;13:87–94.
10. Cunningham SJ, O'Brien C. Quality of Life and Orthodontics. *Semin Orthod* 2007;13:96–103.
11. Jacobson A. Psychological aspects of dentofacial aesthetics and orthognathic surgery. *Angle Orthod* 1984;54:18–35.
12. Ackerman MB, Ackerman JL. Smile analysis and design in the digital era. *J Clin Orthod* 2002;36:221–36.
13. İşiksal E, Hazar S, Akyalçın S. Smile aesthetics: perception and comparison of treated and untreated smiles. *Am J Orthod Dentofacial Orthop* 2006;129:8–16.
14. Maulik C, Nanda R. Dynamic smile analysis in young adults. *Am J Orthod Dentofacial Orthop* 2007;132:307–15.
15. Sarver DM. The importance of incisor positioning in the esthetic smile: the smile arc. *Am J Orthod Dentofacial Orthop* 2001;120:98–111.
16. Tjan AH, Miller GD, The JG. Some esthetic factors in a smile. *J Prosthet Dent* 1984;51:24–8.
17. Vig RG, Brundo GC. The kinetics of anterior tooth display. *J Prosthet Dent* 1978;39:502–504.
18. Mikami I. An evaluation of the functional lip posture. *Shigaku* 1990;78:339–76.
19. van der Geld PA, van Waas MA. The smile line, a literature search. *Ned Tijdschr Tandheelkd* 2003;110:350–4.
20. Heravi F. Assessment of lip line in different malocclusions with video images. *World J Orthod* 2005;6:50–1.
21. Ackerman MB, Brensinger C, Landis JR. An evaluation of dynamic lip-tooth characteristics during speech and smile in adolescents. *Angle Orthod* 2004;74:43–50.
22. Rubin LR. The anatomy of a smile: Its importance in the treatment of facial paralysis. *Plast Reconstr Surg* 1974;53:384–7.
23. Nanda R, Burstone CJ. JCO Interviews: Part 1 Facial Esthetics. *J Clin Orthod* 2007;41:79–87.
24. Jacobs RM, Brodie AG. The analysis of perioral muscular accommodation in young subjects with malocclusion. *Angle Orthod* 1966;36:325–34.
25. Peck S, Peck L, Kataja M. The gingival smile line. *Angle Orthod* 1992;62:91–100.
26. Frindel F. Sixteen keys for building a youthful smile. *Orthod Fr* 2003;74:83–102.
27. Ekman P, Davidson RJ, Friesen WV. The Duchenne smile: emotional expression and brain physiology II. *J Pers Soc Psychol* 1990;58:342–53.
28. Sarver DM, Ackerman MB. Dynamic smile visualization and quantification: part 1. Evolution of the concept and dynamic records for smile capture. *Am J Orthod Dentofacial Orthop* 2003;124:4–12.
29. Tarantili VV, Halazonetis DJ, Spyropoulos MN. The spontaneous smile in dynamic motion. *Am J Orthod Dentofacial Orthop* 2005;128:8–15.