Dynamic lip to tooth relationship during speech, posed and spontaneous smile using digital videography

Ali S. Al-khafaji, B.D.S. [1]
Nagham M. Al-Mothaffar, B.D.S., M.Sc. [2]

ABSTARCT

Background: The human face is a living mirror held out to the world. Natural, marked, painted or adorned, it has power to attract, charm, captivate or brighten. Therefore the subject of the smile and facial animation, as they relate to communication and expression of emotion, should be of great interest to orthodontists so the aims of this study were to determine the difference of outer commissure width, inter-labial gap, smile index, modified smile index, visible maxillary interdental width, buccal corridor percentage and maximum incisor show among different smile styles (Monalisa, Cuspid and complex) during emotion, posed smile and speech. And to determine the differences of the same variables for each smile style among emotional smile, posed smile and speech.

Materials and methods: The sample consisted of 77 Iraqi adult subjects (18-30) years with skeletal class I occlusion, classified into three categories according to a certain neuromuscular mechanism of smile called smile style, the first group consisted of 34 (24 male, 10 female) subjects with Monalisa smile style, the second consisted of 34 (22 male, 12 female) subjects with Cuspid smile style, the last 9 subjects (5 male, 4 female) were the third group with Complex smile style. Each subject was recorded using digital videographic camera while watching a comical movie to elicit emotional smile, then they asked to say "Chelsea eats cheesecake" to record them during speech. The videographs were imported to the PMB-picture motion browser to capture emotional smile, posed smile and speech frames. Four linear measurements were measured for each frame using AutoCAD program 2011.

Results: The results of this study showed that all the variables changed significantly when the subject change from speech to emotional smile frame in all smile styles. And these changes revealed almost the same behavior when the subject changed from speech to pose or to emotional smile frames.

Conclusion: The result of this study revealed that emotional smile is largely different from posed smile in different aspects which has an effect on decisions related to orthodontic diagnosis and treatment plan.

Keywords: smile style, emotional smile, posed smile, digital videography. (J Bagh Coll Dentistry 2012;24(2):99-103).

INTRODUCTION

Obtaining a beautiful smile is always the main objective of any aesthetic dental treatment. Therefore, it is essential to control the esthetic effects caused by orthodontic treatment, which is only possible by knowing the principles that manage the balance between teeth and soft tissues during smile [1]; as the presence of a malocclusion has a negative impact on facial attractiveness and orthodontic correction of a malocclusion affects overall facial esthetics positively [2]. After all, it is the beauty of the smile that will make the difference between an acceptable or pleasing aesthetic result for any given treatment [3]. Smiles can be either posed or spontaneous [4], the posed, false, or social smile which is voluntarysmile and does not need an emotion to be accomplished. A posed smile is static in the sense that it can be sustained [5]. When posing for a photograph a person uses the social smile in social setting [6]. In treating the smile, the social smile generally represents a repeatable smile [7]. However, the social smile can mature and might not be consistent over time in some patients [8].

The unposed, spontaneous, enjoyment or real smile is involuntary and represents the emotion that persons are experiencing at that moment. Therefore it has many descriptions, such as laughing, cry, knowing or insipid [9]. It is dynamic in the sense that it bursts forth but is not sustained.Emotional backgrounds influence a voluntary posed smile [10], A well-known phenomenon in clinical practice is that patients guard their smiles because of dissatisfaction with them. When asked for a posed smile, they show only what they consciously or subconsciously want to present [11].Another example of interfering emotional factors on the posed smile is feelings of shame by victims of undisclosed childhood sexual abuse. Their social smiles appeared to be considerably less expressive; sospontaneous smiling is a logical focus point in smile diagnostics [12]. This is in line with recommendations of oral surgeons and esthetic dentists [13].Smile style is another soft-tissue determinant of the dynamic display zone. There are three styles: the cuspid smile, the complex smile, and the Mona Lisa smile. An individual's smile style depends on the direction of elevation and depression of the lips and the predominant muscle groups involved. The cuspid or commissure smile is characterized by the action of

---

(1) M.Sc. student, dep. of Orthodontics, college of dentistry, university of Baghdad
(2) Professor, dep. of Orthodontics, college of dentistry, university of Baghdad

all the elevators of the upper lip, raising it like a window shade to expose the teeth and gingival scaffold. The complex or full-denture smile is characterized by the action of the elevators of the upper lip and the depressors of the lower lip acting simultaneously, raising the upper lip like a window shade and lowering the lower lip like a window. The Mona Lisa smile is characterized by the action of the zygomaticus major muscles, drawing the outer commissures outward and upward, followed by a gradual elevation of the upper lip. Patients with complex smiles tend to display more teeth and gingiva than patients with Mona Lisa smiles [14].

MATERIALS AND METHODS

The sample of the study composed of 77 Iraqi adult subjects in an age group of 18-30 years with skeletal class I occlusion.The sample was classified into three groups according to smile style as the following:Monalisa group composed of 34 subjects (24 male and 10 female), Complex group composed of 9 subjects (5 male and 4 female), Cuspid group composed of 34 subjects (22 male and 12 female).This classification was done depending on the direction of elevationand depression of the lips and the predominant muscle groups involved.The video recordings for each group were made in a setup consisting of a chair with a digital video camera and television set (laptop connected to the screen). The television screen was placed at eye level. When the visual axis will be horizontal, the subjects will keep their heads mainly in a natural head position[15]. The video camera was adjusted to the subject's mouth level at a 55-cm distance and continuously registering the face as shown in figure 1.

Figure 1: Standardization of the videogragh

To prompt emotional smiling, the subjects watched television fragments of practical jokes downloaded from the website of videos "you tube" the funniest Iraqi practical jokes. The subjects will be unaware of the exact aim of the study. While watching the television, the subjects wear glasses with a clipped-on reference standard to enable calibration in a digital measurement program. In this way, a maximum emotional smile (emotional smile frame) will be recorded with minimal intrusion of the subject [16].By using the same technique for obtaining natural head position in emotional smile capture, the subject was asked to read a sentence appeared on the screen made by a power point slide, this sentence was "Chelsea eats cheesecake" to capture him\her saying the syllable "chee" (speech frame)**.** The subject was asked to relax, and then smile to capture the posed smile (posed smile frame)**.**Firstly, the videographs were imported to the PMB- picture motion browser. This software enables the operator to save a movie as an image sequence and then export roughly 24 frames per second. Each frame could be saved identical in size and resolution [17].To extract frame from video recording of speech, a video converter computer software was used to split the second in which the subject saying the syllable "chee" in the word "cheesecake" into 30 frames or more in persons who pronounced the word very fast.In addition to high quality video recording mode (HQ MODE) the photos (frames) extracted from the video clips were treated with another software which was the "photozoom pro 3" to improve image quality while zooming in AutoCAD program 2011. Finally, smile frame was imported to the AutoCAD program. Magnification correction was done in reference to the glasses with the attached ruler, so that the real measurements were obtained. After that, landmarks were identified and measurements were determined (Figure 2).

Figure 2: Linear measurements during emotional smile

RESULTS

The sample is classified into three groups, each group captured in three frames: speech, posed and emotional smile frames.Comparison among different smile styles for each frame is done first, to compare among different smile style during emotional smile,analysis of variance (ANOVA test) was performed to identify the presence of significant differences for the measured variables. As shown below (Table 1) there was a significant difference in all the variables measured except for outer commissure width.

Table 1: ANOVA test for emotional smile among different smile style.

Variable	F	p-value	Sig
OCW	0.320	0.727	Ns
ILG	12.45	.000	***
SI	13.90	.000	***
MSI	12.47	.000	***
VIW	21.66	.000	***
BCP	30.89	.000	***
MIS	3.657	0.03	**

The LSD test (Table 2) was used to detect statistically significant difference between every two groups for the significant different variable found in ANOVA test (Table 1), Interlabial gap (ILG) and modified smile index (MSI) were significantly higher in Cuspid group when compared with Monalisa and Complex groups, while smile index (SI), visible intermaxillary width (VIW) and buccal corridor percentage (BCP) was significantly higher in Monalisa and Complex groups than in Cuspid group.

Table 2: LSD for emotional smile frame among different smile style

Var.	SMILE STYLE		P	SIG
ILG	Monalisa	Cuspid	.000	***
	Monalisa	Complex	.635	NS
	Cuspid	Complex	.009	*
SI	Monalisa	Cuspid	.000	***
	Monalisa	Complex	.846	NS
	Cuspid	Complex	.003	**
MSI	Monalisa	Cuspid	.000	***
	Monalisa	Complex	.894	NS
	Cuspid	Complex	.002	**
VIW	Monalisa	Cuspid	.000	***
	Monalisa	Complex	.465	NS
	Cuspid	Complex	.000	***
BCP	Monalisa	Cuspid	.000	***
	Monalisa	Complex	.946	NS
	Cuspid	Complex	.000	***
MIS	Monalisa	Cuspid	.052	NS
	Monalisa	Complex	.273	NS
	Cuspid	Complex	.020	*

Finally maximum incisor show (MIS) was only significantly higher in Cuspid group than Complex group, but insignificantly higher in Monalisa than Complex group.

The same method is used to compare among different smile styles in speech and posed smile frames. Comparison among different frames for each smile style is also done by ANOVA test for Monalisa group in different frames (emotional, posed, and speech frame) as revealed in Table 3.

Table 3: ANOVA test for Monalisa group in different frames

Variable	F	p-value	Sig
OCW	20.94	.000	***
ILG	45.87	.000	***
SI	11.88	.000	***
MSI	12.65	.000	***
VIW	80.08	.000	***
BCP	32.68	.000	***
MIS	30.89	.000	***

The LSD test revealed that all variables shows significant difference between every two frames except for smile index (SI) and modified smile index (MSI) between posed smile and speech which were insignificantly differ from each other. Again the same statistical analysis is used to compare the other smile styles (Cuspid and Complex) in different frames.

DISCUSSION

The age of the sample ranged from 18 to 30 years because adolescents undergo a maturational sequence in learning how to smile [18] and on the other hand all dynamic measurements of the smile decrease with age especially after ages 30 to 39 years [19]. In addition in this study, there was no need to differentiate between genders [16]. Firstly, Emotional smile in each smile style:the Interlabial gap (ILG) was significantly higher in Cuspid group than Monalisa and Complex groups, this increase may be due to the dominance of the levatorlabiisuperioris musclein Cuspid group exposing more attached gingivae above the maxillary anterior teeth than the other groups and thus increasing Interlabial gap this comes in agreement with the explanation of Phillips in 1999.The same reason mentioned above was responsible for significant increase in modified smile index (MSI) and decreased smile index (SI) for Cuspid group over the other groups because they depend on Interlabial gap (ILG). This come in agreement with Ackerman and Ackerman (2002); Sarver and Ackerman (2003b) who found

any increase in interlabial gap leads to decrease in smile index and any increase in outer commissure width leads to increase smile index.

For visible maxillary interdental width (VIW) of Complex group showed statistical significant increase from Cuspid and statistical non-significant increase from Monalisa groups, this may be due to the fact that in Complex group the shape of the lips are typically illustrated as two parallel chevrons, the levators of the upper lip, the levators of the corners of the mouth, and the depressors of the lower lip contract simultaneously, showing all the upper and lower teeth concurrently showing more area of upper teeth than the other groups, this comes in line with the conclusion Phillips 1999.For buccal corridor percentage (BCP) the same explanation can be given to significant increase of Complex group compared with Cuspid group because buccal corridor percentage (BCP) depends on visible maxillary interdental width (VIW).Finally the Cuspid group showed significant increase in maximum incisor show (MIS) than Complex group, also may be due to that the vertical distance between upper left central incisor incisal edge and upper lip margin increased, this comes in agreement with the findings of Phillips in 1999[20], who reported that the maximum incisor show increased in Cuspid group.

Speech in each smile style had a different lip-tooth characteristics, Although the main muscle responsible for the morphological change in lips during saying "cheese" is the orbicularis oris muscle, it may be affected by the specific neuromuscular mechanism of each smile style because the levatorlabiisuperiorus muscle have the medial slip inserted into the orbicularis oris muscle[21]. Also in a study of electromyography (EMG) of human lip muscle done by Blair and Smith [22], they found that even with intramuscular electrodes, the probability of recording from a single muscle of the lip during speech is extremely low. So the interaction of muscle of facial expression during speech could explain why even with speech each smile style have different lip-tooth relationships.The explanations of significant increase or decrease of different variable during speech among different smile styles may resemble those of emotional or posed smile patterns probably because of interfering facial muscle as discussed above.

Monalisa smile style in each frame: Firstly the outer commissure width (OCW) was greater with highly significant level in emotional smile than posed one, this finding supports the conclusion of Van der Geld et al. in 2008[23]who noticed the significant reduction in inter-commissure distance (smile width) of posed smiling compared to emotional smiling.The statistical significant increase of interlabial gap (ILG) of emotional smile over posed one may result from mouth opening and increase in the mandibular anterior tooth display during emotional smile.The statistical significant decrease of interlabial gap (ILG) of speech when compared with posed smile comes in disagreement with Ackerman et al. in 2004 who found insignificant increase of Interlabial gap (ILG) of speech when compared with posed smile.The statistical significant increase of visible maxillary interdental width (VIW) of emotional smile when compared with other frames may be as a result of exposing the 2nd premolar and 1st molar during emotional smiling than during posed smiling.

The result of this study revealed that emotional smile is largely different from posed smile in different aspects which has an effect on decisions related to orthodontic diagnosis and treatment plan.The outer commissure width and visible maxillary interdental width that compose the buccal corridor percentage, as we know the smaller the buccal corridor the greater the esthetic appearance, and in posed smile the buccal corridor is significantly lower than in emotional smile, so the dependence on buccal corridor percentage (BCP) of posed smile can lead to inadequate diagnosis and treatment plan regarding arch width, smile arc and transversal occlusal plane.This comes in agreement with Van der Geld et al., in 2008who stated that as a result of reduced smile width during posed smiling, the buccal corridors can be underestimated and upper arch widening not deemed to be needed during orthodontic or surgical treatment.The maximum incisor show was significantly higher in emotional smile than posed, in another words the lip line height is appeared too low in posed smile particularly in the case of gummy smile patients, who have the muscular ability to raise the upper lip significantly higher than average on smiling emotionally. Again it was the posed smile smaller measurement that may give us the errors in estimation of gummy smile, and subsequently decisions of intrusion of maxillary anterior teeth versus surgical intervention to correct the problem becomes a matter of controversy.

REFERENCES
1. Ritter DE, Gandini JR, Santos Pinto AD, Locks A. Esthetic Influence of Negative Space in the Buccal Corridor during Smiling. Angle Orthod 2006; 76(2):198–203.

2. Rodrigues CD, Magnani R, Machado MS, Oliveira OB. The Perception of Smile Attractiveness. Angle Orthod. 2009; 79:634–9.

3. Camara CA. Aesthetics in Orthodontics: Six horizontal smile lines. Dental Press J Orthod 2010; 15 (1):118-31.

4. Peck S, Peck L. Selected aspects of the art and science of facial esthetics. Semin Orthod 1995; 1(2): 105–26.

5. Hulsey CM. An esthetic evaluation of lip-teeth relationships present in the smile. Am J Orthod. DentofacialOrthop 1970; 57:132–144. [Cited by 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.

6. Sarver D.M. The Face As Determinant of Treatment Choice, In: Frontiers of Dental and Facial Esthetics Craniofacial Growth Series Center for Human Growth and Development. Ann Arbor: University Of Michigan 2001a, 38:19-54.

7. Rigsbee OH, Sperry TP, Begole E. The influence of facial animation on smile characteristics. Int J Adult OrthodOrthognathSurg 1988; 3(1): 233-9.

8. Sarver DM, Ackerman MB. Dynamic smile visualization and quantification: Part 1. Evolution of the concept and dynamic records for smile capture. Am J OrthodDentofacOrthop 2003 a; 124(1): 4-12.

9. Duchenne de Boulogne GM. The Mechanism of human facial expression. Cambridge, United Kingdom: Cambridge Univ. Press 1990, p.167.

10. Otta E, FolladoreAbrosio F, Hoshino R. Reading a smiling face: messages conveyed by various forms of smiling. Percept Mot Skills 1996;82:1111-21. (Cited by: Van der Geld et al. Digital videographic measurement of tooth display and lip position in smiling and speech: Reliability and clinical application. Am J Orthod Dentofacial Orthop 2007 b; 131:301.e1-301.e8.

11. Moskowitz M, Nayyar A. Determinants of dental esthetics: a rationale for smile analysis and treatment. Compend Contin Educ Dent 1995; 16:1164-6. (Cited by: Van der Geld et al. Digital videographic measurement of tooth display and lip position in smiling and speech: Reliability and clinical application. Am J Orthod Dentofacial Orthop 2007 b; 131:301.e1-301.e8).

12. Bonanno GA, Keltner D, Noll JG, Putnam FW, Trickett PK, LeJeune J, et al. When the face reveals what words do not: facial expressions of emotion, smiling, and the willingness to disclose childhood sexual abuse. J Pers Soc Psychol 2002;83:94-110.

13. Allen E, Bell W. Enhancing facial esthetics through gingival surgery. In: Bell WH, editor. Modern practice in orthognathic and reconstructive surgery. Philadelphia: Saunders; 1992. p. 235-51.

14. Ackerman MB, Ackerman JL. Smile analysis and design in the digital era. J Clin Orthod 2002; 36(4): 221-36.

15. Rosetti Y, Tadary B, Pablanc C. Optimal contributions of head and eye positions to spatial accuracy in man tested by visually directed pointing. Exp Brain Res 1994; 97:487-96. (Cited by: Van der Geld et al. Digital videographic measurement of tooth display and lip position in smiling and speech: Reliability and clinical application. Am J Orthod Dentofacial Orthop 2007 b; 131:301.e1-301.e8.

16. Van der Geld P, Oosterveld P, van Waas M A, Kuijpers-Jagtman AM. Digital videographic measurement of tooth display and lip position in smiling and speech: Reliability and clinical application. Am J Orthod Dentofac Orthop 2007 b; 131:301.e1-301.e8.

17. Maulik C, Nanda R. Dynamic smile analysis in young adults. Am J Orthod Dentofac Orthod 2007; 132(3):307-15.

18. Ackerman JL, Ackerman MB, Brensinger CM, Landis JR. A morphometric analysis of posed smile. Clin Orthod Res 1998; 1(2): 2-11.

19. Desai S, Upadhyay M, Nanda R. Dynamic smile analysis: Changes with age. Am J Orthod Dentofac. Orthop 2009; 136(3): 310-1.

20. Philips E. The classification of smile patterns. J Can Dent Assoc 1999; 65(5): 252-4.

21. Ronald P.; Bolognia, Jean L.; Jorizzo, Joseph L. Dermatology: 2-Volume Set. St. Louis: Mosby 2007, pp. 2166.

22. Blair C, Smith A. EMG recording in human lip muscle. Journal of Speech and Hearing Res 1986, Vol.29 256-266 June.

23. Van der Geld P, Oosterveld P, Berge SJ. and Kuijpers A.M. tooth display and lip position during spontaneous and posed smiling in adults. Informa UK Ltd 2008 a; 66: 207-13.