An orthodontic analysis of the smile dynamics with videography

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ABSTRACT

Background and objectives: Smile is one of the most effective means by which people convey their emotions. The objective of this study was to capture, analyse and measure the parameters through videos clips for studying the dynamics of posed and unposed smile and to measure the parameters through video clips for studying the dynamics of speech.

Methodology: A total of 100 subjects seeking orthodontic treatment with Angle's Class I malocclusion were included in the study. The principal investigator selected the frames for speech and a panel of five members selected the appropriate frames for posed smile and unposed smiles. Frames after videography were used for measurements. Parameters like Maximum incisor exposure, Lower lip to upper incisor, Gingival exposure, Inter-labial gap etc were measured in "mm" for posed and unposed smile frames. Categorical data was compared using McNemar's test. $p < 0.05$ was considered significant.

Results: The median of maximum upper incisor exposure ($p = 2.2e-16$), lower lip to upper incisor ($p = 2.422e-13^A$), inter-labial gap ($p = 2.2e-16^A$), smile width ($p = 5.212e-16^A$) and smile index were significant ($p = 0.0001^A$). There was a significant change from not exposed to exposed gingival exposure over posed smile to unposed smile ($p = 0.0008$). The most posterior maxillary tooth visible in the posed and unposed groups were the second premolars in 57% and 74% patients, respectively. In both the smile groups, 55% of subjects exhibited a consonant smile.

Conclusion: It can be concluded that the information obtained from the current video graphic study can be used as a guideline for the diagnosis and as a part of comprehensive treatment planning.

Introduction

Smile is the most recognized expression used to convey a sense of happiness, compassion, and appreciation among human beings. It may well be the cornerstone of social interaction.¹ The human face is a mirror held out to the world. A beautiful smile enhances self-esteem and improves the quality of life by providing overall health benefits. According to Hulsey, "Smile is one of the most effective means by which people convey their emotions".² Smiles can be either posed or spontaneous.

Buccal corridors, smile arc, incisor protrusion and gingival display have commonly been considered as potential characteristics by various clinical and experimental studies that influence the aesthetic outcome of an orthodontically treated patient.³

Clinicians often consider parameters such as lip function, the anatomy, position of teeth and periodontal visibility as part of a facial aesthetics evaluation.

A smile can be evaluated by taking photographs. It has been found

that one is able to detect posed emotion from motion photography than from still photography.⁴ By the use of videography, smile can be compared in a better way. Videography has minimized the errors when compared to studying one snapshot from the static photography. It also allows to identify a more standardized smile (greatest width).

Videography now permits the clinician to measure dynamic lip-tooth relationships from the frames which are extracted from the video and incorporate that information into the orthodontic problem list and treatment plan.⁵ Digital videography thus facilitates patient observation during rest, conversation and smiling, providing information that cannot be visualized with a static image.⁶

Providing a wider range of images which enables the clinician to choose the best image is the advantage of videography. Observing the patient during normal speech gives the most valuable aesthetic information for planning treatment. And certain consonant sounds may be more reproducible than smiles.⁷

Orthodontic treatment is primarily driven by an objective of

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procuring a beautiful smile.

In this study a patient's smiling photograph was analyzed as a part of the diagnostic process to determine a course of treatment. Questions about the timing of photograph to ponder were: (a) Can the timing make any difference in the smile recorded (few seconds sooner or later)? (b) Whether a different directive be used to obtain a smile producing the same kind of response? (c) Can videography provide a more effective diagnostic impression than photography?

Hence, the aim of the present study was to capture, analyse and measure the parameters through videos clips for studying the dynamics of posed and unposed smile and to measure the parameters through video clips for studying the dynamics of speech.

Materials and methods

This was an observational hospital-based study which consisted of 100 patients of North Karnataka population seeking orthodontic treatment who ranged in the age group of 18–25 years. Ethical clearance from the Institutional Ethical Committee and written informed consent was obtained before the commencement of the study. Subjects with Angle's Class I malocclusion with an over jet ≤ 4 mm, Class I skeletal pattern, age group between 18 and 25 years, patients of either gender, presence of a full complement of permanent teeth and patients who could speak English language were included in the study. Subjects with facial asymmetries and facial deformities, Class II and Class III malocclusions, history of orthodontic treatment, patients who have undergone prosthetic replacement or cosmetic treatment with anterior teeth, patients who have undergone gingivectomy and crown lengthening procedures were excluded from the study.

Sample size was calculated by using formula which is $n = \frac{(Z_{1-\beta} + Z_{1-\alpha/2})^2}{d^2}$, Where $d = \frac{\text{mean of difference}}{\text{standard deviation of difference}}$ = Effect size, where effect size (0.283) with 80% power and 5% significant level, and it has been found that the minimum sample size required for the study was 100 matched pairs and $Z_{1-\alpha/2}^2 = 1.96$ for 5% significance level and $Z_{1-\beta} = 0.84$ for 80% power.⁸ Thus, the sample size was set at 100.

The video recordings were carried out with facilities such as adjustable chairs and lights. For adequate lighting, five light sources were used to focus on the subject's lower third of the face. The subjects were instructed to sit on an adjustable chair, hold their head in natural position, relax and look forward as if they were looking at their own eyes in a mirror. For the standardization of video images, a sticker of 1-cm scale was placed on the subject's chin. A CANON 1200 D DSLR camera with 90 mm macro lens (SLR Model XXX- 9413) was used and mode dial was set to the movie setting to capture the videos. The camera was mounted on a tripod and positioned at a fixed distance of one-foot five-inches between the patient's face and the camera lens and the camera was aimed at subject's mouth.

All the subjects were instructed to say, "Chelsea eats cheesecake at Chesapeake," relax for a few seconds after saying the phrase and then to smile. When the speech segment ended, the patients were asked to smile as though they were posing for a photograph, showing his or her teeth. Following which, jokes were narrated to the subjects, until a full spontaneous smile was recorded. The length of each video was approximately 15 s.

The most challenging part of smile analysis studies is recording of social and spontaneous smile, as not all patients readily exhibit the required type of smile for the study. But it was observed in the current study that patients exhibited social and spontaneous smile more readily through video recording. Videography is an easier smile recording method over static photography as it records the maximum smile of subjects who are generally hesitant to smile.

Since video clip provides multiple images when processed, the image which exhibits the best smile can be selected unlike static photography wherein a single image is taken. Hence it was easier to record the maximum smile in this study.

The video clip was then transferred to a Dell laptop and uploaded to a Windows Movie Maker Version 2012 (Build April 16, 3528.0331) software. This software extracted 25 frames from the video clip every second using its inbuilt features.

The principal investigator selected the frames for speech. A panel of five members selected the appropriate frame for posed smile and unposed smile. The panel consisted of two Orthodontists, one Prosthodontist and two Post-graduate students because of their knowledge and experience regarding assessing and correcting the smile. The panellists judged the frames and selected one frame for posed smile, one frame for unposed smile and two frames for the speech. The panel were informed to select only one optimal frame from each of the two categories (posed and unposed smile categories) and the panellists were blinded. The principal investigator selected the two frames for speech, one representing the maximal upper incisal exposure and the other frame representing the maximum lower incisal exposure during speech.

After obtaining the optimal frames, they were saved as JPEG files. Each JPEG file was opened in Adobe Photoshop Cs5 Extended, Version 12.0 $\times$ 32 and the ruler function was chosen and set to millimetre. The sticker measurement which was 10 mm was customized to the millimetre ruler of Photoshop and then the measurements were made. This standardized the frames and with the help of a ruler tool, the measurements were carried out (Fig. 2).

The following parameters (Fig. 1) were assessed and measured in "mm" for posed and unposed smile frames:

Maximum incisor exposure: The distance between the lower edge of the upper lip and the incisal edge of the maxillary right central incisor, measures the vertical display of the maxillary central incisors during smiling.

Lower lip to upper incisor: Vertical distance from the incisal edge of the maxillary right central incisor to the deepest midline point on the superior margin of the lower lip.

Gingival exposure: It is the distance between the lower edge of the upper lip and the gingival margin of the maxillary right central incisor, measures the gingival exposure during smile.

Inter-labial gap: Distance between the most inferior portion of the tubercle of the upper lip and the deepest midline point on the superior margin of the lower lip.

Smile width: Distance from the right outer commissure to the left outer commissure.

Smile index: Ratio of smile width divided by inter-labial gap.

Buccal corridor width: Horizontal distance from the most lateral aspect of the most posterior visible tooth to the inner commissure.

Most posterior maxillary tooth visible: Most distal maxillary tooth visible on smiling.

Smile arc: The curvature of the maxillary incisal edges and canines relative to the curvature of the lower lip on smile.

Two parameters measured in speech frames were

Maximum upper incisor exposure: Maximum upper incisal display during the pronunciation of syllable 'chee'.

Maximum lower incisor exposure: Maximum display of lower incisor during speech.

Statistical analysis

Data was analyzed using R software version 3.6.1 and Excel. Categorical variables are given in the form of frequency table. Continuous variables are given in mean $\pm$ sd form. Paired t-test/Wilcoxon sign rank test was used to study the different parameters between posed and unposed smile. Categorical data were compared using McNemar test/Graphical representation.

Results

A total of 100 subjects were enrolled in the study consisting of 75 females and 25 males.

Fig. 1. Representing video recording set up and smile parameters (A to L).

Using Friedman test, we observed that the median of Maximum upper incisal exposure significantly different for at least any 2 groups (p -value). Using pairwise Wilcoxon signed rank test with Bonferroni adjustment, we observed that median of maximal upper incisal exposure is significantly different between 3 groups (PS vs S:0.0006; PS Vs US:2e-16; S Vs US:6.3e-07). Using paired t -test, we observed that, mean vertical distance from Lower lip to upper incisor is significantly less in posed than unposed ie; the measurement of vertical distance from lower lip to upper incisor is increased from posed smile to Unposed smile. Also, the mean of inter labial gap as well as Smile width is significantly less in posed smile i. e; inter labial gap and smile width is increased from posed to unposed smile. But, using paired t -test, we observed that the mean of smile index is significantly more in posed smile i. e; the smile index is decreased from

posed to unposed smile. Using paired t -test, we observe that the mean of right-side Buccal corridor width is not significantly different between 2 groups while mean of left Buccal corridor length is significantly less in posed smile (Table 1).

The mean of MLIE in speech group is 4.40 ± 1.58 .

Using McNemar test, there was a significant difference from not exposed to exposed gingival exposure over posed smile to unposed smile (Table no 2).

The most posterior maxillary tooth visible in the posed and unposed groups were the second premolars in 57% and 74% patients respectively (Table no 3).

In both the smile groups, 55% of subjects exhibited consonant smile (Table no 4).

Fig. 2. Steps involved in processing of recorded video (M to Q).

Discussion

The records needed for contemporary smile visualization and quantification can be divided into 2 groups: static and dynamic. The reliability of static photographs for evaluating the smile has been questioned, and digital videography has been advocated for use in capturing the dynamic nature of facial animation with special emphasis on the smile and speech. Hence in this study, digital videography rather than static photography was considered for analysing smile and speech. Age group of 18–25 was considered in this study as complete maturity is attained by males and females by 18 years of age; hence, lower limit was kept at 18 years. Also, with age there is a decrease in the resting tonus and elasticity as well as the activity and function of muscles involved in retracting and elevating the corners of mouth while smiling. This is usually noticed from 29 years of age. So, the upper limit was considered up to 25 years. Different phonetic tests seem to be best indicated for maximal horizontal and

vertical display, namely ‘ee’ for the horizontal display, and respectively ‘chee’ for the vertical display. Hence the chee segment of the video was selected as the best frame for assessing and measuring the maximal upper incisal and lower incisal exposure.

In a study by Ackerman and Landis, they observed maximum incisal exposure during posed smile was 6.47 ± 1.56 and during speech (‘cheese’ segment) was 5.77 ± 1.79 . The difference in maximum incisal display compared to other studies could be due to the subjective perception difference while selecting the posed smile frame. Buccal corridor ratio was higher in the posed smile group in the current study. A significant positive correlation was observed between Inter labial gap at rest and posed smile.⁹ In the present study it was found that the mean of left Buccal corridor length was significantly less in posed smile while the mean of right-side Buccal corridor width was insignificant. Also, the mean of inter-labial gap was significantly less in the posed smile.

Parekh et al. conducted a study on Class I subjects and found that the

Table 1
Variables for posed, unposed smile and speech.

Parameters (mm, millimeter)	Posed Smile Mean $\pm$ SD	Unposed smile Mean $\pm$ SD	Speech Mean $\pm$ SD	p-value
Maximum upper incisal exposure	7.07 $\pm$ 1.82	8.86 $\pm$ 1.79	7.76 $\pm$ 1.75	2.2e-16
Lower lip to upper incisor	0.61 $\pm$ 1.07	1.45 $\pm$ 1.42	–	2.422e-13 ^a
Gingival exposure	0.05 $\pm$ 0.31	0.28 $\pm$ 0.77	–	–
Inter-labial gap	8.05 $\pm$ 2.2	10.71 $\pm$ 2.74	–	2.2e-16 ^a
Smile width	62.92 $\pm$ 4.05	66.43 $\pm$ 4.26	–	5.212e-16 ^a
Smile index	8.96 $\pm$ 6.46	6.62 $\pm$ 2.09	–	0.0001 ^a
Buccal corridor width	Right 1.71 $\pm$ 0.87	1.85 $\pm$ 0.89	–	0.1148
	Left 2.04 $\pm$ 0.98	2.34 $\pm$ 1.01	–	0.0003 ^a

^a Indicates one tailed test.**Table 2**
Gingival exposure measurement.

Posed Smile	Unposed Smile		p-value
	Not Exposed	Exposed	
Not Exposed	82	14	0.0008
Exposed	1	3	

*note gingival exposure measurement “>0” is considered as exposed and measurement 0 considered as not exposed.

Table 3
Differences between posed and unposed smile in terms of the most posterior maxillary teeth visible.

Tooth	Posed Smile	Unposed smile
1st PM	42	20
2nd PM	57	74
Canine	1	0

PM: Pre-molar.

Table 4
Consonant and non-consonant smile.

Variable	Posed Smile	Unposed smile
Consonant smile	55	55
Non-Consonant smile	45	45

consonant smile arc was present in 72% and 62% of female and male subjects respectively.¹⁰ According to a study by Schabel et al. (2010), the smile index for posed smile was 5.3 ± 1.6 mm¹¹ In a study by Desai et al. (2009), smile index during widest commissure to commissure smile for the age group of 20–29 years was 6.73 ± 2.09 mm¹² The smile index was less from posed to unposed smile in the current study. According to a study by Ackerman et al. (2004), smile width for posed smile was 49.39 ± 5.28 mm.¹³ In the current study smile width was significantly less in posed smile. In a study by Jacobson et al. lower incisor display was found to be 3.64 ± 1.71 mm in the age group of 20–29 years.¹⁴ Mean upper central incisor display ratio or the percent of the visible crown height was 23% at rest, 78% during the posed smile and 99% during the unposed smile mean. The most posterior tooth visible in unposed smile group was second premolar in majority of patients while in unposed group it was 1st and 2nd premolar with almost equal distribution. This parameter is of importance when rapid maxillary expansion treatment is advocated as rapid maxillary expansion group have significantly fewer posterior

maxillary teeth visible on smile compared to the nonexpanded group. (Maulik et al.).

In the present study a separate frame for measuring the maximum lower incisal display was selected. It has been proposed that orthodontic movement has an extrusive effect on the dentition and also this parameter has seen to increase with age. Hence, mandibular incisor exposure should be routinely studied as a part of diagnosis and treatment planning of orthodontic cases. This observational study thus revealed that the smile parameters varied greatly amongst posed and unposed smile group and hence it is important to consider dynamic smile for diagnosis and treatment planning. Also the display of dentition during speech is an important indicator of aesthetics required to render the best orthodontic treatment.

Although this was a first of its kind study, the study had a few constraints, such as, sex comparison was not studied because of the unequal sample distribution. Similarly, comparison between posed smile, unposed smile and speech was not considered.

Future studies should be conducted on age-related effects on the various parameters of smile analysis. Comparison of the various parameters amongst all malocclusions needs to be carried out. Assessment of smile and speech related parameters in various ethnic backgrounds can be carried out. Quantitative smile analysis using 3D stereophotogrammetry for various malocclusions can also be undertaken by future studies.

Conclusion

Most patients seek orthodontic treatment with a desire to achieve a pleasing smile. The information obtained from the current video graphic study can be used as a guideline for the diagnosis and comprehensive treatment planning in subjects with Angles's Class I malocclusion.

Author's contribution

All the authors have contributed equally in developing the manuscript.

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Declaration of competing interest

No potential conflicts of interest relevant to this article were reported.

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