Original Article

Dynamics of a smile in different age groups

Patil Chetan[a]; Pradeep Tandon[b]; Gulshan K. Singh[c]; Amit Nagar[d]; Veerendra Prasad[e]; Vinay K. Chugh[f]

ABSTRACT

Objective: To evaluate smile in different age groups and to detect gender differences in smile.

Materials and Methods: Digital videographic records of 241 randomly selected subjects were obtained for smile analysis. The subjects were divided into four groups by age (15–20 years, 21–30 years, 31–40 years, and 41–50 years). Each group was further subdivided by gender. After 41 subjects were excluded, the smile dimensions of 200 subjects were analyzed by two-way multivariate analysis of variance (MANOVA) with Duncan's multiple range post hoc test.

Results: All dynamic measurements (change in upper lip length, upper lip thickness, commissure height, and intercommissural width from rest to smile) decreased with age in both males and females. Changes in upper lip length and commissure height on smiling were greater in males as compared with females of the same age groups. Changes in intercommissural width on smiling were greater in females as compared with males in all age groups.

Conclusion: Smile changes with increase in age, and the changes differ between males and females. Females had a wider smile as compared with males of similar age groups. (*Angle Orthod.* 2013;83:90–96.)

KEY WORDS: Smile; Digital video; Age; Gender

INTRODUCTION

The most common reason for seeking orthodontic treatment is to improve dentofacial esthetics. It is now accepted that modern orthodontic treatment requires a shift away from Angle's paradigm of achieving ideal occlusion to the more esthetically focused soft tissue paradigm that is based on the patient's overall benefit.[1,2] Ideal occlusion should certainly remain the primary functional goal of orthodontists, but the esthetic outcome is also critical for patient satisfaction.

When developing the appropriate diagnosis and treatment plan for a patient, the hard and soft tissues are usually analyzed in three dimensions: sagittal, vertical, and transverse. Recently, time has been recognized as the fourth dimension.[1,2] With time, people undergo many skeletal and soft tissue cellular changes that dramatically affect the overlying soft tissue envelope, the related muscles, and their functions.[3,4]

The literature demonstrates that with age, the lips become less elastic and less mobile.[5,6] Further, oral structures such as teeth and periodontium change with age. These changes affect the smile. Appropriate knowledge of smile changes with age can help orthodontists obtain long-lasting and esthetically appealing treatment results. Also, there are indications that there are differences in facial movements between the genders in adulthood.[7] Modern psychological research indicates that men and women possess different smile behavior.[8]

Although there is much conjecture about ''smile design'' and treatment for smile esthetics, sound

[a] Resident, Department of Orthodontics and Dentofacial Orthopaedics, Faculty of Dental Sciences, CSM Medical University, Lucknow, UP, India.

[b] Professor and Head, Department of Orthodontics and Dentofacial Orthopaedics, Faculty of Dental Sciences, CSM Medical University, Lucknow, UP, India.

[c] Professor, Department of Orthodontics and Dentofacial Orthopaedics, Faculty of Dental Sciences, CSM Medical University, Lucknow, UP, India.

[d] Associate Professor, Department of Orthodontics and Dentofacial Orthopaedics, Faculty of Dental Sciences, CSM Medical University, Lucknow, UP, India.

[e] Assistant Professor, Post-Graduate Department of Plastic Surgery, CSM Medical University, Lucknow, UP, India.

[f] Assistant Professor, Department of Orthodontics and Dentofacial Orthopaedics, Faculty of Dental Sciences, CSM Medical University, Lucknow, UP, India.

Corresponding author: Dr Patil Chetan, Department of Orthodontics and Dentofacial Orthopaedics, Faculty of Dental Sciences, CSM Medical University, Chowk, Lucknow, UP, India 226003
(e-mail: drchetpat85@yahoo.co.in).

Accepted: May 2012. Submitted: April 2012.
Published Online: August 13, 2012

scientific data are actually quite sparse, and most of the results were not statistically tested. Until now, there has been limited quantitative information comparing age differences in smile. Geld[9] and Desai et al.[10] have recently studied the age-related changes in smile videographically. However, gender differences in age-related changes in smile are yet unclear. Because of a lack of information concerning gender and age differences, a cross-sectional study was performed to determine the tendencies and patterns between the groups of different ages and whether gender played a role in these tendencies.

MATERIALS AND METHODS

Participants

The present study was conducted on 241 subjects randomly selected from the students, residents, staff, faculty, and parents/guardians of patients at the CSM Medical University, Lucknow, to evaluate smile in different age groups. Videographic records of these 241 subjects, who willingly consented to participate in the study, were taken to study the perioral zone at rest and on smiling. Of these, 27 subjects were excluded because of various videographic errors, and 14 subjects were further excluded because of the following reasons: visible periodontal disease (7), restorative work (4), excessive attrition (2), and gross facial asymmetry (1). Thus, the final sample consisted of 200 subjects.

Subjects of 15 to 50 years of age willing to volunteer in the study were included. Exclusion criteria were gross facial asymmetry, missing tooth visible on smiling or prosthodontic/restorative work on tooth/teeth visible on smiling, visible periodontal disease, caries, excessive dental attrition, lip irregularities, or history of lip surgery. The subjects were divided into four age groups, namely, group 1 (15–19 years), group 2 (20–29 years), group 3 (30–39 years), and group 4 (40–50 years), with each group containing 25 males and 25 females.

The research protocol was approved by the Ethics Committee of CSM Medical University, Lucknow, UP, India.

Smile Recording and Measurements

The subjects were explained that this was a study on smile involving a 5- to 10-second video clip of a small part of the face. An informed consent was obtained from each subject who agreed to participate in the study voluntarily.

The videographic equipment for recording was based on the guidelines established by previous studies.[1,11] A video camera (Samsung SMX-K44SP) was set on the tripod 3 feet from the subject. The subjects were seated on the adjustable stool and instructed to hold the head in natural head position by looking straight into a mirror hung on the wall at eye level. An effort was also made to keep the interpupillary line parallel to the horizontal ruler. The relaxed lip position was achieved by asking the subject to lick the lips and then swallow. Then, the subjects were instructed to say "Subject number __" and then smile. Recording began 1 second before the subject started speaking and ended after the smile.

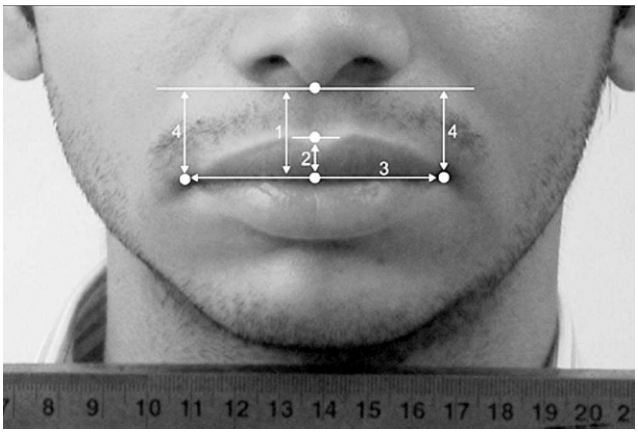

Figure 1. Linear measurements made on rest position photograph. (1) Upper lip length. (2) Upper lip thickness. (3) Outer intercommissural width. (4) Commissural height.

The video clip, thus obtained, was transferred to a computer and converted into sequential images (30 images/s) with a video-editing software program (Adobe Premiere, version 6.0, Adobe, San Jose, Calif) to observe the dynamics of smile frame by frame. Each frame was then analyzed, and finally two frames were selected for the study. The first frame represented the subjects' lips at rest or relaxed lip position, and the second frame represented the subjects' natural unstrained posed smile. The widest commissure-to-commissure posed smile frame was selected as one of 10 or more frames showing an identical smile. Thus, the selected smile image represented a sustained and hence repeatable smile position.

Each frame was opened in Adobe Photoshop 6.0 (Adobe Systems, San Jose, Calif) and adjusted by using the millimeter ruler in the frame. Calibration of the software was done in accordance with the previous study of Desai et al.[10]

The linear measurements were made on rest and the smile photograph as shown in Figures 1 and 2 and Table 1. Using the linear measurements, four dynamic measurements were obtained. To avoid anatomical variation due to physical size differences between the individuals, the dynamic measurements were expressed as a percentage change from the corresponding distance in the rest position.

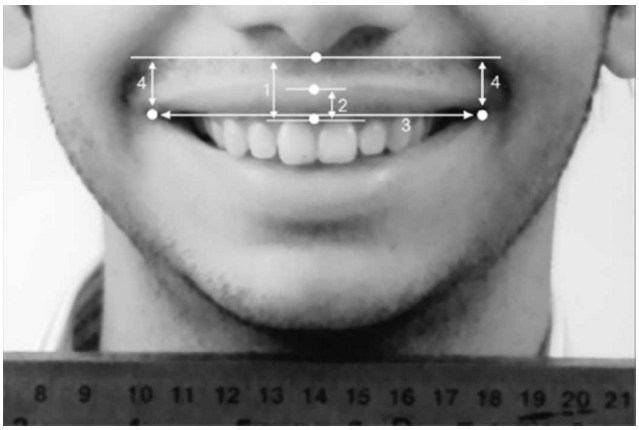

Figure 2. Linear measurements made on smile photograph. (1) Upper lip length. (2) Upper lip thickness. (3) Outer intercommissural width. (4) Commissural height.

Data were summarized as mean ± SD. Groups were compared by two-factor (age groups and sex) analysis of variance (ANOVA) using general linear models. If the ANOVA showed statistical significance, the Duncan multiple range post hoc test was done after ascertaining the homogeneity of variance by Levene's test to determine which groups were significant from the others.

RESULTS

The results are shown in Tables 2 through 7. The upper lip length, intercommissural width, and commissural height in rest photographs showed that these parameters increase with age in both males and females (Table 2).

From group 2 onward, the upper lip thickness decreased significantly in both males and females (Tables 2 and 3).

The upper lip length, upper lip thickness, intercommissural width, and commissural height in rest photographs between the four age groups (within males and within females) were significantly higher ($P > .05$) in group 4 as compared with group 1 (Table 3).

The upper lip length on smiling of males in group 2 ($P < .05$), group 3 ($P < .05$), and group 4 ($P < .001$) were found to be significantly higher as compared with females (Table 4).

The upper lip length on smiling of males of group 4 was found to be significantly higher when compared with group 1 ($P < .05$), group 2 ($P < .001$), and group 3 ($P < .01$), respectively. Further, the upper lip length on smiling of males of group 3 was found to be significantly ($P < .05$) higher as compared with group 1. However, in females, the upper lip length on smiling of group 3 and group 4 was found to be significantly ($P < .05$) higher as compared with group 1 (Table 5).

The change in upper lip length from rest to smile in all age groups between males and females was nonsignificant ($P > .05$; Table 6).

The change in intercommissural width from rest to smile in females was significantly higher ($P < .05$) as compared with males in all of the age groups except group 1 (Table 6).

The mean change in upper lip length from rest to smile between the four age groups (within males and females) decreased significantly ($P < .05$) in group 4 males as compared with group 1, while in females, the change in upper lip length was nonsignificant ($P > .05$; Table 7).

In both males and females, the change in intercommissural width from rest to smile decreased significantly ($P < .001$) in group 3 and group 4 as compared with group 1 or group 2. The change in intercommissural width of both males and females also decreased significantly ($P < .05$) in group 4 as compared with group 3 (Table 7).

The change in commissure height from rest to smile decreased significantly in group 4 as compared with group 1 ($P < .001$), group 2 ($P < .05$), and in group 3 as compared with group 1 ($P < .05$), while in females, the difference was nonsignificant ($P > .05$) among the groups (Table 7).

DISCUSSION

The smile plays an important part in orthodontic diagnosis and treatment planning. This has been recognized since the beginning of the specialty, and in the current esthetically oriented society, it seems to play a central part in self-perception and social image. The selection of the two frames used in this study was based on the reproducibility of the two expressions. Several studies[12–14] have concluded that the rest

Table 1. Measurements Used in the Study

Measurement	Description
1. Upper lip length	Distance measured between subnasale and stomion superius
2. Upper lip thickness	Distance measured between labrale superius and stomion superius
3. Outer intercommissural width	Distance measured between right and left outer commissure
4. Commissural height	Distance measured from the horizontal line passing through subnasale to outer commissure (if right and left commissures were not at the same levels, average of the two measurements was used)

Table 2. Descriptive Statistics and Significance of Mean Differences of Rest Position Measurements Between Males and Females by Duncan Multiple Range Post Hoc Test

Linear Measurements in Rest Position Photographs, mm	Groups	Sex		
		Male	Female	
		Mean ± SD	Mean ± SD	*P* Value
Upper lip length	Group 1	20.64 ± 2.33	19.12 ± 1.81	.008**
	Group 2	21.32 ± 1.97	19.84 ± 1.46	.010*
	Group 3	21.60 ± 2.20	20.24 ± 1.45	.018*
	Group 4	22.96 ± 1.99	20.36 ± 1.38	<.001***
Upper lip thickness	Group 1	7.64 ± 1.04	7.64 ± 0.76	1.000
	Group 2	8.28 ± 1.67	8.16 ± 1.07	.744
	Group 3	7.68 ± 1.75	7.72 ± 1.37	.913
	Group 4	6.56 ± 1.50	6.48 ± 0.82	.827
Outer intercommissural width	Group 1	50.04 ± 2.59	49.64 ± 3.08	.673
	Group 2	52.44 ± 4.35	50.08 ± 3.49	.021**
	Group 3	52.28 ± 3.03	51.32 ± 3.06	.311
	Group 4	53.72 ± 3.86	52.52 ± 3.02	.206
Commissural height	Group 1	21.04 ± 2.82	20.52 ± 2.54	.534
	Group 2	22.32 ± 2.01	20.96 ± 2.82	.112
	Group 3	22.40 ± 2.81	21.44 ± 2.53	.248
	Group 4	23.36 ± 3.53	22.60 ± 2.74	.329

* $P = .05$; ** $P = .01$; *** $P = .001$.

position of the lips and posed smile are the reproducible expressions.

An important aspect to consider when evaluating smile is the effect of age on smile. Based on clinical experience, the prosthetic literature demonstrates that with age, the elasticity of the lips decreases. As a result of this, older people have been reported to show less of the maxillary and more of the mandibular teeth during smiling.[5] Dong et al.[6] and Dickens et al.[15] measured changes in the smile as an effect of age. Both studies reported a decrease of maxillary incisor display during smiling.

Another important aspect to consider is gender differences in smile. Otta[8] found that older individuals in general and men in particular smile less frequently and less intensely. Females smile more expansively than males do. Frush and Fisher[16] stated that the qualities of femininity and masculinity are important factors in the interpretation of smile. Rigsbee et al.[17] studied changes in orofacial soft tissue after the movement from repose to smiling and found that women exhibited a greater degree of facial animation than men did. Peck et al.[18] confirmed the smile line dimorphism between males and females and stated that at maximum smile, the upper lip line relative to the gingival margin of maxillary central incisors was positioned 1.5 mm more superiorly in females than in males. However, the literature on assessment of smile in different age groups as related to gender differences has not yet been extensively studied.

The upper lip length at rest increased with age in both sexes from 16 years to 55 years. An increase in resting upper lip length could be attributed to the loss of resting muscle tone, increased flaccidity, and redundancy with age. Upper lip length on smiling was found to increase significantly in males, whereas the increase was evident only in older age groups in females. The increase in upper lip length on smiling with age can be either because of an increase in lip length at rest or a decreased lip elevation during smiling as result of muscular atrophy (decreased muscle mass leading to muscle weakness) seen with age.

Table 3. Comparisons of Rest Position Measurements Between the Four Age Groups Within Males and Within Females (Duncan Multiple Range Post Hoc Test)

Comparison	Upper Lip Length		Upper Lip Thickness		Outer Intercommissural Width		Commissural Height	
	Male	Female	Male	Female	Male	Female	Male	Female
Group 1 vs group 2	.195	.170	.130	.200	.022*	.665	.121	.572
Group 1 vs group 3	.083	.042*	.919	.839	.029*	.107	.112	.288
Group 1 vs group 4	<.001***	.029*	.003**	.003**	<.001***	.007**	.017*	.019*
Group 2 vs group 3	.594	.446	.138	.230	.866	.191	.918	.566
Group 2 vs group 4	.003**	.354	<.001***	<.001***	.205	.019*	.229	.065
Group 3 vs group 4	.010*	.819	.004**	.002**	.169	.254	.248	.178

* $P = .05$; ** $P = .01$; *** $P = .001$.

Table 4. Descriptive Statistics and Significance of Mean Differences of Smile Measurements Between Males and Females by Duncan Multiple Range Post Hoc Test

Linear Measurements in Smile Photographs , mm	Group	Sex		*P* Value
		Male	Female	
		Mean ± SD	Mean ± SD	
Upper lip length	Group 1	16.32 ± 2.36	15.28 ± 2.13	.067
	Group 2	17.12 ± 1.79	15.64 ± 1.66	.012*
	Group 3	17.76 ± 2.11	16.60 ± 1.85	.040*
	Group 4	19.36 ± 1.47	16.52 ± 1.71	<.001***
Upper lip thickness	Group 1	5.88 ± 1.13	6.20 ± 0.91	.397
	Group 2	6.12 ± 1.51	6.24 ± 1.16	.752
	Group 3	5.72 ± 1.40	5.64 ± 1.32	.821
	Group 4	5.60 ± 1.41	5.44 ± 1.00	.650
Outer intercommissural width	Group 1	66.76 ± 4.70	66.04 ± 3.71	.551
	Group 2	67.84 ± 5.12	68.40 ± 3.50	.654
	Group 3	66.48 ± 3.87	67.60 ± 3.88	.322
	Group 4	64.32 ± 5.04	65.68 ± 3.35	.663
Commissural height	Group 1	13.96 ± 3.40	14.40 ± 2.06	.625
	Group 2	15.28 ± 2.99	14.88 ± 2.83	.656
	Group 3	16.80 ± 3.16	16.36 ± 4.22	.625
	Group 4	18.16 ± 3.84	17.24 ± 2.35	.306

* $P = .05$; *** $P = .001$.

From group 2 forward, the upper lip thickness decreased significantly in both males and females, which is in accordance with empirical observations of thinner lips with age (Tables 2 and 3).

The outer intercommissural width at rest increased by 3.68 mm in males and 2.88 mm in females from 20 to 50 years of age. These observations are in agreement with those noted by Desai et al.,[10] who observed a significant increase in resting intercommissural width (2.71 mm) with age. The mean values for all age groups were greater for males as compared with females; however, there were no significant gender differences within the groups except for the 20–29 years age group. Outer commissural width on smiling showed that it was higher in females as compared with males of the same age group. This finding is in accordance with the study of Otta[8] on smile behavior, in which he noted that females smile more expansively than males do.

The commissural height at rest gradually increased with age in both sexes. Dickens et al.[15] found an increase in commissural height by 1.3 mm in males and by 1.1 mm in females from 16 to greater than 40 years. The mean values for all age groups were greater for males as compared with females; however, there were no significant gender differences within the groups. The commissural height on smiling increased significantly with age in both sexes. The reason for increase in intercommissural width and commissure height with age could be due to the sagging at the corners of the mouth reported as a result of an increase in resting muscle length with age (levator anguli oris, zygomaticus minor, and zygomaticus major).[9,19,20]

These results were consistent with the idea that activity and function of the muscles involved in smile decrease with age. Loss of skin elasticity and volume can also contribute to increased wrinkles at the corners of the lip, making it difficult to identify the commissures.

The various parameters discussed above reflected the change in either the resting or dynamic state of perioral musculature with age. However, of greater

Table 5. Comparisons of Smile Measurements Between the Four Age Groups Within Males and Within Females (Duncan Multiple Range Post Hoc Test)

Comparison	Upper Lip Length		Upper Lip Thickness		Outer Intercommissural Width		Commissural Height	
	Male	Female	Male	Female	Male	Female	Male	Female
Group 1 vs group 2	.179	.504	.910	1.000	.222	.256	.184	.594
Group 1 vs group 3	.015*	.027*	.162	.133	.514	.157	.014*	.045*
Group 1 vs group 4	<.001***	.034	.063	.049*	.537	.379	<.001***	<.001***
Group 2 vs group 3	.235	.104	.141	.141	.364	.162	.111	.121
Group 2 vs group 4	<.001***	.123	.052	.052	.014*	.041*	<.001***	<.001***
Group 3 vs group 4	.003**	.882	.597	.598	.543	.295	.154	.360

* $P = .05$; ** $P = .01$; *** $P = .001$.

Table 6. Descriptive Statistics and Significance of Mean Differences of Dynamic Measurements Between Males and Females by Duncan Multiple Range Post Hoc Test

Measurement	Group	Male	Female	*P* Value
		Mean ± SD (%)	Mean ± SD (%)	
Change in upper lip length	Group 1	20.92 ± 6.92	20.07 ± 8.21	.695
	Group 2	19.49 ± 6.98	21.08 ± 7.02	.511
	Group 3	17.45 ± 9.26	17.93 ± 7.69	.825
	Group 4	15.34 ± 6.97	18.76 ± 7.80	.151
Change in upper lip thickness	Group 1	23.12 ± 9.99	18.84 ± 9.21	.183
	Group 2	25.76 ± 12.50	23.46 ± 10.22	.504
	Group 3	24.85 ± 13.26	27.05 ± 9.21	.523
	Group 4	14.24 ± 12.98	15.92 ± 12.59	.600
Change in intercommisural width	Group 1	24.66 ± 6.94	24.75 ± 4.00	.954
	Group 2	22.25 ± 5.86	26.64 ± 5.78	.016*
	Group 3	21.14 ± 6.08	23.98 ± 4.23	.048*
	Group 4	16.27 ± 5.34	20.27 ± 5.47	.012*
Change in commissure height	Group 1	33.91 ± 12.17	29.83 ± 5.14	.217
	Group 2	31.45 ± 12.91	28.83 ± 10.86	.431
	Group 3	25.15 ± 9.14	24.15 ± 16.39	.748
	Group 4	22.55 ± 10.29	23.60 ± 6.79	.736

* $P = .05$.

importance is to appreciate the changes that the perioral musculature undergoes during the process of producing a smile. The change in upper lip length, upper lip thickness, intercommissural width, and commissural height from rest to smile are measures that give an insight into the inherent activity of the facial muscles involved in raising and widening the perioral musculature while smiling.

The change in upper lip length from rest to smile decreased with age. This suggested a decrease in the muscles' ability to raise the upper lip with age. It is important to note that the mean percentage change in upper lip length showed that in males there is 5.58% decrease in the muscles' ability to raise the upper lip with age, whereas in females it decreased by only 1.31%. This implies that as the age advances, the contractility of muscles responsible for lip elevation is affected more in males than in females. However, within each age group, gender-based comparisons revealed that the difference of the mean values of percentage change in upper lip length was nonsignificant. Thus, it can be concluded that the changes in lip elevation, ie, contractility, contributes less than the sagging of the lip in lowering the lip line as age advances.

The change in intercommissural width from rest to smile also decreased with age in both sexes. From the 20–29 years age group onward in males, this was partly due to an increase in resting intercommissure width (1.2 mm) but largely on account of a decrease in the outer intercommissure width on smiling (3.52 mm). These results were concordant with the idea that with age, there is a decrease in both the resting tonus and elasticity as well as the activity and function of muscles involved in retracting and elevating the corners of the mouth while smiling. In females, both the increase in intercommissural width at rest position (by 2.44 mm) and decrease in the outer intercommissure width on smiling (by 2.72 mm) contributed equally in the change in outer commissural width after second decade of life. Thus, females had a greater horizontal percentage change than males did. Otta[8] also found that females smile more expansively and more often than males do. Johnston et al.[12] reported that females reproduced a

Table 7. Comparison of the Dynamic Measurements Between the Four Age Groups Within Males and Within Females (Duncan Multiple Range Post Hoc Test)

Comparison	Change in Upper Lip Length		Change in Upper Lip Thickness		Change in Intercommisural Width		Change in Commissure Height	
	Male	Female	Male	Female	Male	Female	Male	Female
Group 1 vs group 2	.539	.662	.462	.177	.454	.144	.427	.747
Group 1 vs group 3	.166	.375	.616	.023*	.002**	<.001***	.010*	.095
Group 1 vs group 4	.023*	.572	.010*	.364	<.001***	<.001***	<.001***	.073
Group 2 vs group 3	.398	.210	.777	.316	.014*	.010*	.063	.156
Group 2 vs group 4	.087	.349	<.001***	.030*	<.001***	<.001***	.011*	.126
Group 3 vs group 4	.328	.702	.003**	.002**	<.001***	.024*	.455	.860

* $P = .05$; ** $P = .01$; *** $P = .001$.

maximal smile more accurately and postulated that it was due to their more frequent use of such expression. It could thus be that females use the expression more frequently than males and therefore have a wider smile.

The change in commissural height from rest to smile also decreased with age in both males (by 11.36%) and females (by 6.23%). However, the mean change in commissural height from rest to smile was higher in males as compared with females. This suggests that males had greater vertical changes as compared with females in initial age groups.

Most orthodontic treatment is during late childhood and early adolescence. Since time has been introduced as the fourth dimension of treatment planning, long-term knowledge of dentofacial changes are paramount for clinical success.[1,2] However, one should be cautious in applying the results of present study in clinical diagnosis and treatment planning, as the major weakness of the present study is that it is based on cross-sectional recordings. In the future, longitudinal data will allow better clarification of the results and give further indications of the individual changes that occur in the different expressions.

CONCLUSIONS

- Smile changes with increase in age and differs between males and females.
- As age advances, the loss of resting muscle tone and increased flaccidity and redundancy contribute more in lowering of the smile height than the decreased muscle's ability to create a smile.
- Males have more vertical movements whereas females have more horizontal movements during smile.

REFERENCES

1. 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.
2. Sarver DM, Ackerman MB. Dynamic smile visualization and quantification: part 2. Smile analysis and treatment strategies. *Am J Orthod Dentofacial Orthop*. 2003;124:116–127.
3. Gonzalez-Ulloa M, Flores ES. Senility of the face—basic study to understand its causes and effects. *Plast Reconstr Surg*. 1965;36:239–246.
4. Lee MM. Physical and structural age changes in human skin. *Anat Rec*. 1957;129:473–493.
5. Shillingburg HT Jr, Hobo S, Whitset LD. *Fundamentals of Fixed Prosthodontics.* 3rd ed. Chicago, Ill: Quintessence; 1957:419–420.
6. Dong JK, Jin TH, Cho HW, Oh SC. The esthetics of the smile: a review of some recent studies. *Int J Prosthodont*. 1999;12:9–19.
7. Weeden JC, Trotman CA, Faraway JJ. Three dimensional analysis of facial movement in normal adults: influence of sex and facial shape. *Angle Orthod*. 2001;71:132–140.
8. Otta E. Sex differences over age groups in self posed smiling photographs. *Psychol Rep*. 1998;83:907–913.
9. Van der Geld P, Oosterveld P, Kuijpers-Jagtman AM. Age-related changes of the dental aesthetic zone at rest and during spontaneous smiling and speech. *Eur J Orthod*. 2008;30:366–373.
10. Desai S, Upadhyay M, Nanda R. Dynamic smile analysis: changes with age. *Am J Orthod Dentofacial Orthop*. 2009; 136:310.e1–310.e10.
11. Ackerman MB, Ackerman JL. Smile analysis and design in the digital era. *J Clin Orthod*. 2002;36:221–236.
12. Johnston DJ, Millett DT, Ayoub AF. Are facial expressions reproducible? *Cleft Palate Craniofac J*. 2003;40:291–296.
13. Miyakawa T, Morinushi T, Yamasaki Y. Reproducibility of a method of analysis of morphological changes in perioral soft tissue in children using video cameras. *J Oral Rehab*. 2006; 33:202–208.
14. Ackerman JL, Ackerman MB, Besinger CM, Landis JR. A morphometric analysis of the posed smile. *Clin Orthod Res*. 1998;1:2–11.
15. Dickens ST, Sarver DM, Proffit WR. Changes in frontal soft tissue dimensions of the lower face by age and gender. *World J Orthod*. 2002;3:313–320.
16. Frush JP, Fisher RD. The dynesthetic interpretation of the dentogenic concept. *J Prosthet* Dent. 1958;8:558–581.
17. Rigsbee OH, Sperry TP, BeGole EA. The influence of facial animation on smile characteristics. *Int J Adult Orthodon Orthognath Surg*. 1988;3:233–239.
18. Peck S, Peck L, Kataja M. The gingival smile line. *Angle Orthod*. 1992;62:91–100.
19. Hulsey CM. An esthetic evaluation of lip-teeth relationships present in the smile. *Am J Orthod*. 1970;57:132–144.
20. Matthews TG. The anatomy of smile. *J Prosthet Dent*. 1978; 39:128–134.