Soft Tissue Profiles of 3-5 Year Old Preschool Children

Kerem Dalci * / Serap Cetiner **

Objective: *Identifying the characteristics of soft-tissue profiles in 3-5 year old children.* ***Methods:*** *Children that participated in the study were selected from the 6 major districts of Ankara. In the selected schools, 3-5 year old 1513 children with primary dentition were examined and profile photographs were obtained. Facial convexity angle (FCA) and Total facial convexity angle (TFCA) were measured from profile photographs.* ***Results:*** *The mean values for the total facial convexity (145.9º ±4.2) and facial convexity (165.3º ±4.5) angles were determined. FCA and TFCA were significantly influenced by primary second molar terminal plane relationship.* ***Conclusion****: Finding of this study may be used as clinical references for pediatric dental patients and also, the significant relationship between soft tissue profile and primary occlusion is important for orthodontic diagnosis and treatment of pediatric dental patients.*

Keywords: *Soft Tissue Profile, Preschool Children, Primary Dentition*
J Clin Pediatr Dent 35(3): 339–344, 2011

INTRODUCTION

Soft tissue profile has always been an important clinical tool in the diagnosis and treatment planning of skeletal discrepancies. Both cephalometric radiographs[1] and facial photography[2] have been used to identify and classify soft tissue parameters. However, the use of facial photography for this purpose fell out of favor with introduction of radiographic analyses and Roentgenographic cephalometrics. The recent resurgence of facial photography has been brought about in part due to concerns about radiation and in part by improvements in imaging tools, which have made soft tissue imaging easier and eliminated worries about associated radiation exposure.[3]

The soft tissue profile is affected by a number of variables, including skeletal relationships, dental positions and soft tissue thickness and function.[4] Several studies have used linear and angular measurements obtained from profile photographs to describe soft tissue profiles in children with unilateral cleft lip and palate,[5,6] while other studies have used lateral photographs to assess changes in soft tissue from adolescence to adulthood.[7-10] However, despite numerous studies dealing with soft tissue profiles in adolescents and adults, the literature includes few studies with children under 6 years of age and only one that was conducted with children under age 5.[11]

Identifying the characteristics of soft-tissue profiles in children under 6 years of age could provide useful prognostic and diagnostic criteria. Therefore, this study aimed to describe soft-tissue profile types in children aged 3-5 years; to assess the relationship between the occlusal features of primary dentition and the soft tissue profile; and to determine soft tissue convexity norms for two profile angles in a population of children aged 3-5 years with normal primary occlusion.

MATERIALS AND METHOD

This school-based, cross-sectional study was conducted with children aged 3-5 years attending pre-school in the Turkish capital, Ankara. Located in the Central Anatolia region, Ankara has a population of approximately 4 million. According to the Ministry of National Education (MONE), a total of 2,971 children in Ankara aged 3-5 years attend pre-school, with 22 state-run pre-schools enrolling 2,277 children and 34 private pre-schools enrolling 694 children.

The study utilized a two-stage stratified sampling design. In the first stage, 6 districts in Ankara (Altı ndağ, Keç iö ren, Mamak, Yenimahalle, Sincan, Çankaya) were selected based on housing density, and in the second stage, 1 private and 3 state-run pre-schools were randomly selected from each district, for a total of 24 schools. Permission to conduct the study was granted by the MONE.

The study population consisted of all children aged 3-5 years attending the participating pre-schools and present on the days during which the examinations were conducted. Children's ages were identified from school records. The age range of 3-5 years was selected in order to eliminate children with incomplete primary dentition as well as those with mixed dentition.

* Kerem Dalci, DDS, PhD; Clinical Tutor, Department of Pediatric Dentistry, Faculty of Dentistry, The University of Sydney, New South Wales, Australia.
** Serap Cetiner, Professor, Head of Department, Department of Pediatric Dentistry, Faculty of Dentistry, Near East University, Turkey.

Send all correspondence to: Kerem Dalci, 306/1 Boomerang Pl. Woolloomooloo, 2011, New South Wales, Australia.

Phone: +61402449801
Fax:+61293518336

E-mail: keremdalci75@yahoo.com

According to different authors,[12, 13] the sagittal relationships of the dental arches were described according to the terminal plane relationship of the maxillary and mandibular primary second molars and the relationship of the primary canine teeth. Occlusion was assessed with teeth in the intercuspal position. Teeth were examined under direct light, and both left and right molar and canine occlusions were recorded.

Lateral profile photographs were taken with children seated upright in a chair. Children were asked to look at the reflection of their pupils in a mirror positioned at their eye level. Photographs were taken using a Sony DSC T33 (Tokyo, Japan) under natural light and with a camera-to-subject distance of 1 meter. Images were transferred to a computer using Photoshop® 7.0 (Adobe® Systems Inc., Minnesota, United States), and 4 soft tissue landmarks were marked, as follows: Soft tissue Glabella (Gl'): most prominent or anterior point of the forehead; Pronasale (Pr): most prominent or anterior projection point of the nose; Subnasale (Sn): junction of the columella and the upper cutaneous lip; Soft tissue Pogonion (Pog'): most anterior point of the soft tissue chin (Figure 1a). Using these anatomical landmarks, the following angular measurements were obtained:

Facial Convexity Angle (FCA) (Gl'SnPog'): the acute angle formed by Gl', Sn and Pog'[11,14] (Figure 1b); and Total Facial Convexity Angle (TFCA) (Gl'PrPog'): the acute angle formed by Gl', Pr and Pog'[11,14] (Figure 1c). All soft tissue reference points in this study were marked on digital photographs according to the definitions of Chaconas and Bartroff.[22]

Lateral images were accepted as satisfactory if they complied with the following photographic criteria: All defined landmarks are visible; The sagittal view includes the area anterior to the ear and extends vertically from the soft tissue chin to the glabella and tragion; The opposite pupil, eyebrow and eyelashes are not visible; One philtral column is visible; The lips are lightly touching; There are no cast shadows, and all facial features are visible.[15]

All photographs were taken by the same observer (KD), who also marked the soft tissue anatomical landmarks on the photographs and performed the angular measurements. Intra-observer agreement was assessed by having the observer repeat this procedure with 150 children after a 2-week interval. Kappa values calculated for FCA (0.957) and TFCA (0.950) indicated reliability between the first and second round of evaluations.

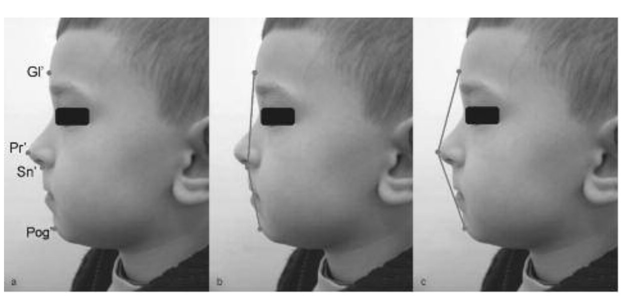


Figure 1. a. Landmarks; **b**. Angle of Facial Convexity (Gl'SnPog'); **c.** Angle of Total Facial Convexity (Gl'PrPog')

Kappa coefficients were also calculated to assess the reliability of lateral photographs by randomly selecting 25 children, repeating the above procedure using a cephalostat, and then comparing the angular measurements recorded from the photographs taken with and without a cephalostat. A Kappa score of 0.978 indicated reliability between photographs taken with and without a cephalostat.

Statistical Analysis

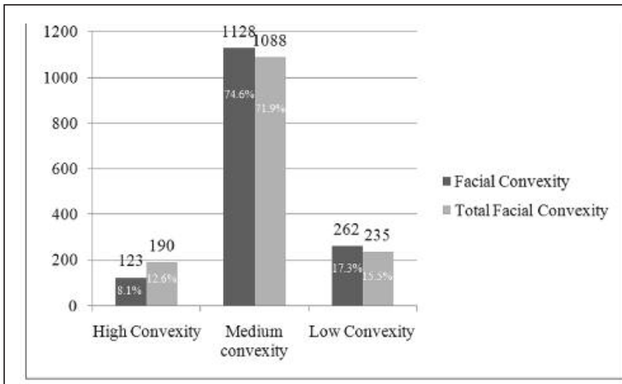
Chi-square tests were used to compare soft tissue profile characteristics by sex and age group, with a value of $p<0.05$ considered significant. Mean values of soft tissue profile angles were compared using one-way ANOVA.

RESULTS

Soft tissue profile evaluations were conducted on 1,513 children (male: 814, female: 699). The mean age of participants was 4.21±0.7 years, and the total numbers of children ages 3, 4 and 5 years were 355, 483 and 675, respectively.

The overall mean FCA value was 165.3º ±4.5 (min: 149.3º , max: 179.3º), and the overall mean TFCA value was 145.9º ±4.2 (min: 131.7º , max: 159.7º). FCA and TFCA were classified as low [FCA>169.8º (165.3º +4.5); TFCA>150.1º (145.9º +4.2)], medium (FCA=165.3º ±4.5; TFCA=145.9º ±4.2), and high convexity [FCA<160.8º (165.3º -4.5); TFCA<141.7º (145.9º -4.2)]. High convexity FCA was observed in 8.1% of all children, medium convexity in 74.6% and low convexity in 17.3%. High convexity TFCA was observed in 12.6% of all children, medium convexity in 71.9% and low convexity in 15.5% (Graph 1).

Facial convexity was found to increase with age (i.e. FCA decreased) (Table 1). High convexity was more prevalent among five-year-olds (19.3%) than among three-year-olds (15.5%). Medium convexity was also more prevalent among five-year-olds (74.2%) than among three-year-olds (71.3%). Conversely, low convexity was more prevalent among three-year-olds (13.2%) than among five-year-olds (6.5%). Differences between age groups were statistically significant.



Graph 1. Distribution of Facial Convexity and Total Facial Convexity types.

No statistically significant differences were observed in the distribution of facial convexity by sex (p>0.05) (Table 2). Medium convexity FCA was the most common type in both boys (73.8%) and girls (75.4%).

Total facial convexity was also found to increase with age (i.e. TFCA decreased) (Table 3). High convexity was more prevalent among five-year-olds (16.6%) than three-year-olds (14.1%), whereas low convexity was more prevalent among three-year-olds (18.6%) than five-year-olds (10.5%). Differences between age groups were statistically significant.

No statistically significant differences were observed in the distribution of total facial convexity by sex (p>0.05) (Table 2). Medium convexity was the most common type in both boys (70.9%) and girls (73.1%).

FCA and TFCA mean, minimum and maximum values and standard deviations by sex are given in Table 4. The mean FCA was 165.3º ±4.5 in boys and 165.3º ±4.4 in girls, and the mean TFCA was 145.9º ±4.1 in boys and 145.8º ±4.3 in girls. These differences were not statistically significant.

FCA and TFCA mean, minimum and maximum values and standard deviations by age are given in Table 5. The mean FCA values for children ages 3, 4 and 5 were 164.7º , 165.5 º and 165.5º respectively, and the mean TFCA values for children ages 3, 4 and 5 were 145.2º , 146.2º and 146.0º respectively. The differences in mean values by age group were significant for both FCA (p<0.05) and TFCA (p<0.01).

FCA and TFCA mean, minimum and maximum values and standard deviations by primary molar terminal plane relationship are given in Table 6.

The prevalence of total facial convexity by terminal plane relationship is given in Table 7. The prevalence of high convexity profiles as measured by FCA was significantly higher (p<0.001) among children with distal terminal plane relationships (18.5%) when compared to children with mesial step (1.1%) and flush terminal plane relationships (8.7%), whereas the prevalence of low convexity profiles was significantly lower (p<0.05) among children with distal termi-

Table 1. Distribution of facial convexity by age group.

Facial Convexity	Age 3 (%)	Age 4 (%)	Age 5 (%)	3-4 Years	4-5 Years	3-5 Years
High Convexity	15.5	17.2	19.3	ns	*	*
Medium Convexity	71.3	73.2	74.2	ns	ns	*
Low Convexity	13.2	9.6	6.5	***	ns	***

*p<0.05, **p<0.01, *** p<0.001.

Table 2. Distribution of facial convexity by sex.

	Facial Convexity			Total Facial Convexity		
	Boys (%)	Girls (%)	p	Boys (%)	Girls (%)	p
High Convexity	7.9	8.4	ns	13.6	11.3	ns
Medium Convexity	73.8	75.4	ns	70.9	73.1	ns
Low Convexity	18.3	16.2	ns	15.5	15.6	ns

*p<0.05, **p<0.01, *** p<0.001.

Table 3. Distribution of total facial convexity by age group.

Total Facial Convexity	Age 3 (%)	Age 4 (%)	Age 5 (%)	3-4 Years	4-5 Years	3-5 Years
High Convexity	14.1	15.1	16.6	ns	ns	*
Medium Convexity	67.3	73.9	72.9	*	ns	*
Low Convexity	18.6	11.0	10.5	*	ns	*

*p<0.05, **p<0.01, *** p<0.001.

Table 4. Mean, minimum and maximum values and standard deviations of facial convexity and total facial convexity by age group.

	Mean	sd	Minimum	Maximum
Facial Convexity Angle (Boys)	165.3º	±4.5	149.3º	179.3º
Facial Convexity Angle (Girls)	165.3º	±4.4	152.8º	179.2º
Total Facial Convexity Angl (Boys)	145.9º	±4.1	133.5º	157.4º
Total Facial Convexity Angle (Girls)	145.8º	±4.3	131.7º	159.7º

Table 5. Mean facial convexity and total facial convexity values by age group.

	Facial Convexity Angle	Total Facial Convexity Angle
3 Year Old	164.7º	145.2º
4 Year Old	165.5º	146.2º
5 Year Old	165.5º	146.0º

Table 6. Mean, minimum and maximum values and standard deviations of facial convexity and total facial convexity by primary second molar occlusion.

Type Of Terminal Plane Relationship	Profile Angle	Mean	sd	Minimum	Maximum
Mesial Step	Facial Convexity Angle	165.6º	±4.2	157.9º	178.5º
	Total Facial Convexity Angle	146.3º	±3.7	136.8º	159.7º
Flush Terminal	Facial Convexity Angle	165.5º	±4.4	149.3º	179.3º
	Total Facial Convexity Angle	145.9º	±4.3	131.7º	158.1º
Distal Step	Facial Convexity Angle	163.2º	±4.6	153.5º	175.5º
	Total Facial Convexity Angle	144.1º	±4.2	135.4º	156.5º

nal plane relationships (13.8%) when compared to children with mesial step (17.9%) and flush terminal plane relationships (17.6%).

The prevalence of total facial convexity by terminal plane relationship is given in Table 7. The prevalence of high convexity profiles as measured by TFCA was significantly higher (p<0.001) among children with distal terminal plane relationships (25.8%) when compared to children with mesial step (7.9%) and flush terminal plane relationships (12.2%). In addition, the prevalence of low convexity profiles was significantly lower (p<0.05) among children with distal step relationships (13.3%) when compared to children with mesial step relationships (9.7%).

In order to assess normal values for FCA and TFCA in children ages 3 to 5 years, FCA and TFCA means and standard deviations were extrapolated from the data obtained for children with "normal" dental occlusions. Normal primary occlusion was classified according to the criteria described by Banker et al.,[16] i.e. a mesial step or flush terminal plane relationship; a Class I primary canine relationship; and incisor and primate spaces in both jaws. A total of 628 children from among the study population met the criteria for normal primary occlusion. Among these children, mean value of FCA was 165.4º ±4.5 (min: 149.3º , max: 179.2º) and TFCA was 145.6º ±4.3 (min: 131.7º , max: 158.1º).

FCA and TFCA mean, minimum and maximum values and standard deviations of 3, 4 and 5 year-old children with normal primary dental occlusion are given in Table 8.

DISCUSSION

Profile analysis is considered a vital diagnostic technique to be mastered not just by orthodontists, but by all practitioners providing primary dental care to patients.[17] In general, soft tissue analysis relies on angular, linear, or planar measurements, or a combination of the three.[14] Methods such as anthropometry,[18] photometric analysis[15] and cephalometry[19] have been used to analyze facial features from both frontal and lateral views of the face. More recently, 3D soft tissue laser scanners (eg. 3dMD) and software (eg. Dolphin)[20,21] have been developed to provide 3-dimensional soft-tissue analysis. Although images taken with a 3dMD camera would have provided more comprehensive views of the face and would have permitted more calculations, existing resources did not permit the use of this expensive technology for an epidemiological study of this size.

Angular photometric analyses require no reference planes, and angular measurements are not affected by photographic enlargement.[15] Moreover, the method is considered to be much easier for children to cope with when compared to cephalometrics.

Facial convexity is generally determined by two different angular measurements: the "Facial Convexity Angle (FCA)", which excludes the nose; and the "Angle of Total Facial Convexity (TFCA)", which includes the nose.[11,22,23] FCA is formed by the intersection of the soft tissue glabella (Gl'), Subnasal (Sn) and soft tissue pogonion (Pog')[14] and provides information about harmony between the middle and lower parts of the face as well as anteroposterior deviations of the upper and lower basal bones.[2] TFCA is formed by the intersection of the soft tissue glabella (Gl'), Pronasal (Pr) and soft tissue pogonion (Pog')[14] and provides information about growth of the nose and its influence on the soft tissue profile.[11,14,22,24] TFCA is usually affected by nasal changes.[25] With the exception of studies by Subtelny[11] and

Table 7. Distribution of convexity type by primary second molar occlusion.

		Primary Second Molar Terminal Plane Relationship			Mesial-Flush	Flush-Distal	Mesial-Distal
		Mesial step	Flush Terminal	Distal step			
Facial Convexity	**High Convexity**	% 1.1	% 8.7	% 18.5	***	***	***
	Medium Convexity	% 81.0	% 73.7	% 67.7	*	ns	**
	Low Convexity	% 17.9	% 17.6	% 13.8	ns	*	*
Total Facial Convexity	**High Convexity**	% 7.9	% 12.2	% 25.8	*	***	***
	Medium Convexity	% 78.8	% 71.0	% 64.5	**	*	**
	Low Convexity	% 13.3	% 16.8	% 9.7	ns	*	*

*p<0.05, **p<0.01, *** p<0.001.

Table 8. Mean, minimum, maximum and standard deviation values of facial convexity and total facial convexity angles among children with normal primary dental occlusion.

Age Group		n	Mean	sd	Minimum	Maximum
Age 3	**FCA**	168	166.0°	±4.4	149.3°	178.1°
	TFCA	168	146.3°	±4.3	131.7°	158.1°
Age 4	**FCA**	199	165.4°	±4.1	153.3°	179.2°
	TFCA	199	145.8°	±4.1	134.6°	157.4°
Age 5	**FCA**	261	164.1°	±4.8	152.7°	176.4°
	TFCA	261	144.5°	±4.7	133.2°	157.0°

Pelton and Elsasser,[23] all cross-sectional and longitudinal studies of soft tissue convexity in the literature have been conducted with adolescents and adults. Collecting information from younger patients would provide a distinct advantage in view of the growing clinical interest in preventive measures and early detection and treatment of malocclusion.

Of the 1,513 children examined in this study, the majority (74.6%) presented medium convexity profiles, followed by low convexity (17.3%) and high convexity profiles (8.1%) when measured by FCA. Similarly, when measured by TFCA, the majority (71.9%) presented medium convexity profiles, followed by low convexity (15.5%) and high convexity profiles (12.6%). Considering that growth and development peaks well after the age of 5 years, it was not surprising that none of the children in this study had concave profiles.

Subtelny,[11] and Chaconas and Bartroff[22] have shown that facial convexity remains relatively stable after the age of 6 years. While the bony profile straightens with age, the growth in soft tissue covering does not follow the same pattern, leading to a differential in the thickness of soft tissue covering various aspects of the underlying hard tissue.[24] This has been attributed to a greater increase in the thickness of the soft tissue covering the maxillary jaw in comparison to that of the mandibular symphysis and forehead area.[11] In contrast to these studies, a longitudinal study by Bishara *et al*[14] showed that facial convexity increases significantly between the ages of 5 and 9, remains relatively stable from age 9 to age 13, and then decreases from age 13 to adulthood.

Our study found facial convexity increased significantly from age 3 to age 5. Not only did the prevalence of high convexity profiles increased significantly ($p<0.05$) with age (from 15.5% among 3-year-olds to 19.3% among 5-year-olds), the prevalence of low convexity decreased significantly ($p<0.001$) with age (from 13.2% among 3-year-olds to 6.5% among 5-year-olds). These results are similar to those of Subtelny,[11] who reported that between the ages of 3 and 6, there is a slight increase in facial convexity caused by changes in skeletal structures.

In the present study, when total facial convexity including the nose was examined, the prevalence of high convexity profiles increased, unsurprisingly, from 14.1% among 3-year-olds to 16.6% among 5-year-olds, whereas the prevalence of low convexity decreased significantly from 18.6% among 3-year-olds to 10.5% among 5-year-olds. In both cases, the differences in profile by age were statistically significant ($p<0.05$). These findings are consistent with those of Subtelny[11] and Pelton and Elsasser[23] and can be explained by the forward growth of the nose with age.[22]

Studies with older subjects have found differences in TFCA between boys and girls.[7,22,26] Darwis *et al* [27] reported that while facial growth may be similar in young boys and girls, differences become more apparent after 9 years of age. In our study, the mean FCA and TFCA values did not vary significantly between boys and girls. This can be explained by the fact that the children in our study were much younger than the typical age at which children experience the growth spurt that enlarges the maxilla and mandible and results in dramatic changes in the facial profile.

In order to define normal values for soft tissue profiles, children with normal primary occlusions (i.e., physiological incisor spaces, primate spaces, mesial and/or flush terminal plane relationships) were selected from among the study sample (628 children out of 1,513). The mean FCA and TFCA values of these children were found to be 165.4º ±4.5 and 145.6º ±4.3, respectively.

Our study found a strong relationship between soft tissue facial convexity and primary second molar occlusion type, with the mean FCA and TFCA decreasing from 165.6º and 146.3º , respectively, among children with mesial step occlusions to 163.2º and 144.1º , respectively, among those with distal step occlusions. Although medium convexity was the most common type of FCA and TFCA regardless of primary second molar relationship, higher rates of distal-step molar relationships were found among children with high convexity profiles (both FCA and TFCA) when compared to those with medium and low convexity profiles ($p<0.001$), whereas higher rates of mesial-step molar relationships were found among children with low convexity profiles (both FCA and TFCA) when compared to those with high and medium convexity profiles ($p<0.05$). These findings indicate that facial traits have an effect on occlusion, even at very young ages (3-5 years).

In contrast to our study, a study by Fields and Vann[28] that used visual assessment to predict dental and skeletal relationships in preschool children demonstrated that soft tissue alone is not a reliable reference for the assessment of skeletal and dental relationships in young children, probably due to variations in thickness and distribution of the soft tissue drape. The difference between our results and those of Fields and Vann can be attributed to the differences in evaluation methods (visual evaluation vs. photographic measurement) between the two studies.

Studies have shown that facial convexity and total facial convexity differ by race. [29] For example, a longitudinal study by Bishara *et al*[30] that evaluated facial convexity and total facial convexity in American subjects ages 5-25 years found mean FCA and TFCA values of 170.0º ±4.3 and 148.1º ±2.9, respectively, for boys age 5 and of 169.4º ±4.5 and 147.1º ±4.7, respectively, for girls age 5. These values were higher than the values for children age 5 obtained in our study (boys: 165.3º ±4.5 and 145.9º ±4.1, girls: 165.3º ±4.4 and 145.8º ±4.3). These differences in convexity may be attributed to differences in the races of the participants.

CONCLUSIONS

The protocol used in this study is a simple, low-cost and non-invasive method that can be used as a practical diagnostic tool for the evaluation of facial soft tissue, especially with small children and in large epidemiological studies where cephalometric radiographs are not practical.

The significant relationship between primary occlusion and the degree of convexity of the soft tissue profile found in this study is of great importance in the early diagnosis of dento-skeletal discrepancies. Further studies should be conducted that use longitudinal data and include children of different ages.

REFERENCES

1. Holdaway RA. A soft-tissue cephalometric analysis and its use in orthodontic treatment planning. Part I. Am J Orthod, 84: 1–28, 1983.
2. Arnett GW, Bergman RT. Facial keys to orthodontic diagnosis and treatment planning. Part I. Am J Orthod Dentofacial Orthop, 103: 299–312, 1993.
3. Incrapera AK, Kau CH, English JD, McGrory K, Sarver DM. Soft tissue images from cephalograms compared with those from a 3D surface acquisition system. Angle Orthod, 80: 58–64, 2010.
4. Saxby PJ, Freer TJ. Dentoskeletal determinants of soft tissue morphology. Angle Orthod, 55: 147–154, 1985.
5. Zhu NW, Senewiratne S, Pigott RW. Lip posture and mouth width in children with unilateral cleft lip. Br J Plast Surg, 47: 301–305, 1994.
6. Bearn DR, Sandy JR, Shaw WC. Photogrammetric assessment of the soft tissue profile in unilateral cleft lip and palate. Cleft Palate Craniofac J, 39: 597–603, 2002.
7. Dimaggio FR, Ciusa V, Sforza C, Ferrario VF. Photographic soft-tissue profile analysis in children at 6 years of age. Am J Orthod Dentofacial Orthop, 132: 475–480, 2007.
8. Bittner C, Pancherz H. Facial morphology and malocclusions. Am J Orthod Dentofacial Orthop, 97: 308–315, 1990.
9. Ferrario VF, Sforza C, Miani A, Tartaglia G. Craniofacial morphometry by photographic evaluations. Am J Orthod Dentofacial Orthop, 103: 327–337, 1993.
10. Fernandez-Riveiro P, Smyth-Chamosa E, Suarez-Quintanilla D, Suárez-Cunqueiro M. Angular photogrammetric analysis of the soft tissue facial profile. Eur J Orthod, 25: 393–399, 2003.
11. Subtelny JD. A longitudinal study of soft tissue facial structures and their profile characteristics, defined in relation to underlying skeletal structures. Am J Orthod 45: 481–507, 1959.
12. Abu Alhaija ES, Qudeimat MA. Occlusion and tooth/arch dimensions in the primary dentition of preschool Jordanian children. Int J Paediatr Dent, 13: 230–239, 2003.
13. Facal-Garcia M, de N-G, Suarez-Quintanilla D. The diastemas in deciduous dentition: the relationship to the tooth size and the dental arches dimensions. J Clin Pediatr Dent, 26: 65–69, 2001.
14. Bishara SE, Hession TJ, Peterson LC. Longitudinal soft-tissue profile changes: a study of three analyses. Am J Orthod, 88: 209–223, 1985.
15. Park HS, Rhee SC, Kang SR, Lee JH. Harmonized profiloplasty using balanced angular profile analysis. Aesthetic Plast Surg, 28: 89–97, 2004.
16. Banker CA, Berlocher WC, Mueller BH. Primary dental arch characteristics of Mexican-American children. ASDC J Dent Child, 51: 200–222, 1984.
17. Proffit WR, Fields HW, Sarver DM. Orthodontic Diagnosis: The Development of a Problem List. in: Contemporary Orthodontics. 4th ed. St. Louis, Mo: Mosby Elsevier; 167–233, 2007.
18. Budai M, Farkas LG, Tompson B, Katic M, Forrest CR. Relation between anthropometric and cephalometric measurements and proportions of the face of healthy young white adult men and women. J Craniofac Surg, 14: 154–161, 2003.
19. Garner LD. Soft-tissue changes concurrent with orthodontic tooth movement. Am J Orthod, 66: 367–377, 1974.
20. Moss JP, Linney AD, Grindrod SR, Arridge SR, Clifton JS. Tartaglia G. Three-dimensional visualization of the face and skull using computerized tomography and laser scanning techniques. Eur J Orthod, 9: 247–253, 1987.
21. Swennen GR, Mollemans W, Schutyser F. Three-dimensional treatment planning of orthognathic surgery in the era of virtual imaging. J Oral Maxillofac Surg, 67: 2080–2092, 2009.
22. Chaconas SJ, Bartroff JD. Prediction of normal soft tissue facial changes. Angle Orthod, 45: 12–25, 1975.
23. Pelton WJ, Elsasser WA. Studies of dentofacial morphology IV. Profile changes among 6829 white individuals according to age and sex. Angle Orthod, 25: 199–207, 1955.
24. Subtelny JD. The soft tissue profile, growth and treatment changes. Angle Orthod, 31: 105–122, 1961.
25. Foley TF, Duncan PG. Soft tissue profile changes in late adolescent males. Angle Orthod, 67: 373–380, 1997.
26. Hashim HA, AlBarakati SF. Cephalometric soft tissue profile analysis between two different ethnic groups: a comparative study. J Contemp Dent Pract, 4: 60–73, 2003.
27. Darwis WE, Messer LB, Thomas CD. Assessing growth and development of the facial profile. Pediatr Dent, 25: 103–108, 2003.
28. Fields HW, Vann WF, Jr. Prediction of dental and skeletal relationships from facial profiles in preschool children. Pediatr Dent, 1: 7–15, 1979.
29. Miyajima K, McNamara JA, Jr., Kimura T, Murata S, Iizuka T. Craniofacial structure of Japanese and European-American adults with normal occlusions and well-balanced faces. Am J Orthod Dentofacial Orthop, 110: 431–438, 1996.
30. Bishara SE, Jakobsen JR, Hession TJ Treder JE. Soft tissue profile changes from 5 to 45 years of age. Am J Orthod Dentofacial Orthop, 114: 698–706, 1998.