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Proportions in the upper lip–lower lip–chin area of the lower face as determined by photogrammetric method

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SUMMARY. **This study is concentrated on the lower face profile, the emphasis being given to the lips and chin area which have been analysed by various proportions. A sample consisted of 110 subjects (52 males and 58 females) with good soft tissue profile, dental class I and Caucasian type. All the records were taken in the natural head position (NHP) and all measurements were performed using the computer and by the same operator. Using the photographs of the facial profile, seven vertical measurements were taken and seven indices used to determine the relationships between measurements of the lower third of the face, lower lip, chin and upper lip. Almost all the vertical profile measurements were greater in males than in females. The only variables with no gender differences were lower (Li–Sto) and upper vermilion heights (Ls–Sto). The largest portion of the lower face was occupied by the chin and the smallest by the lower lip height in both genders. All indices were greater in females except (IND7) representing chin/lower third of the face proportion, which was greater in males. Some acknowledged aesthetic guidelines must be followed when determining orthodontic plan for optimal aesthetics. The proportional relationships found in our sample are a valuable contribution and might serve as a template for vertical facial analysis of the lower face in this patient population.**

Keywords: **lower face proportions, facial analysis, soft tissue profile, photographs**

INTRODUCTION

The lower third of the face from the base of the nose to the soft tissue menton plays an important role in orthodontic diagnosis and treatment planning (*Farkas* et al., 1985; *Bergman*, 1999). The differences in the soft tissue profile of the lower third of the face are perceived in the variations of skeletal convexity, soft tissue thickness, protrusion of the lips and position of the lower incisors (*Farkas* et al., 1984; *Bergman*, 1999). Orthodontists and maxillofacial and plastic surgeons, by studying the human face and profile, are constantly searching for guidelines for the reconstruction of facial dysmorphology and the correction of malocclusion (*Neger*, 1959; *Merriefield*, 1966; *Peck* and *Peck*, 1970; *Legan* and *Burstone*, 1980; *Farkas*, 1981; *Arnett* and *Bergman*, 1993a,b; *Brons* et al., 1998).

Correction of malocclusion mainly effects changes in the lower facial third (*Bloom*, 1961) and a treatment which is based on skeletal standards can result in disharmonious facial proportions (*Subtenly*, 1959; *Burstone*, 1959, 1967; *Legan* and *Burstone*, 1980). There has been increased interest in facial aesthetics in the orthodontic literature and the profile assessment has been routinely performed by objective measurements on profile photographs. Clinical assessment of facial proportions is an important element of orthodontic diagnosis and treatment planning (*Karavaka* et al., 2008).

It has been shown previously that facial aesthetics should be assessed in relation to natural head position (NHP) (*Cooke* and *Wei*, 1988; *Cooke*, 1990; *Lundström* and *Lundström*, 1992). The NHP is a standardized orientation of the head with the eyes focused on a distant point at horizontal eye level. *Cooke* (1990) stated that NHP should be the head position of preference for profile evaluation because it reflects the everyday true life appearance of people.

The aim of the study was to report the linear vertical measurements of the lower face (upper and lower lips and chin, length of the upper and lower vermilion) and to demonstrate their relationships to each other. All measurements were taken from the photographs of Croatian graduate and postgraduate students and done by the same operator (S.A.M.).

MATERIAL AND METHODS

Subjects were students from the School of Dentistry, University of Zagreb, Croatia. The sample consisted of 110 subjects, 52 males and 58 females (age range 23–28). The selection of the sample, photographing and measuring procedure have been described elsewhere (*Anic-Milosevic* et al., 2008a,b). Briefly, the criteria for selection included good and balanced soft tissue profile, dental class I occlusion, no history of orthodontic treatment and Caucasian ethnicity. The photographic setup consisted of a tripod

(Soligor, DT-310 Digital Tripod) that held a digital camera (Olympus 3040C). Each subject stood on an indicated line on the floor. Behind the subject stood a vertical measurement scale in millimetres which allowed measurements at life size (1:1). From the scale a plumbline was hung, suspending a 0.5 kg weight, held by a thick black thread to define the vertical plane on the photographs. All the records were taken in NHP, with the lips in repose. The photographic records were analysed with the software for Windows, Microsoft® Visio® 2003, Standard Edition. The millimetre paper was attached to the computer monitor which produced a universal background. Every photograph was reduced to real size, overlaid on the mentioned calibrating gauge and oriented so that the true vertical (TV) line on the photograph was parallel with the vertical line of the computer monitor. The programmes had already been customised with the landmarks which were located on a digitized image to obtain all the measurements by the computer. All photographic records had been scaled to life size and the manual procedures were done by the same operator (S.A.M).

On photographs of the facial profile, six landmarks were determined and seven vertical profile measurements were taken in the area of the lower face as shown in Fig. 1.

Seven indices were used to determine the relationships between vertical profile measurements in the lower face. The relationship between measurements was expressed as a ratio (index) in which the smaller measurement was expressed as a percentage of the larger. The indices used in the present investigation were: IND1 − upper vermilion height/upper lip height; IND2 − lower vermilion height/lower lip height; IND3 − upper vermilion height/lower vermilion height; IND4 − upper lip height/height of the lower face; IND5 − lower lip height/height (lower third of the face); IND6 − lower lip height/chin height; IND7 − chin height/height (lower third of the face).

To compare males with females, a Student *t*-test was used. The correlation coefficient was calculated to demonstrate the degree of dependence of the measurement composing the index. The coefficient was positive if both measurements increased and negative if the increase in one measurement was accompanied by a decrease in other. The reproducibility of the method was tested using Dahlberg's (1940) formula. The error was calculated from the equation $ME = \sqrt{d^2/2n}$ where d is the difference between duplicated measurements and n is the number of replications. To determine the difference between two measurements made at least two months apart, 20 randomly selected records were redigitized. All the respective values for the linear measurements were ranged between 0.36 and 0.49 mm (*Anic-Milosevic* et al., 2008a,b).

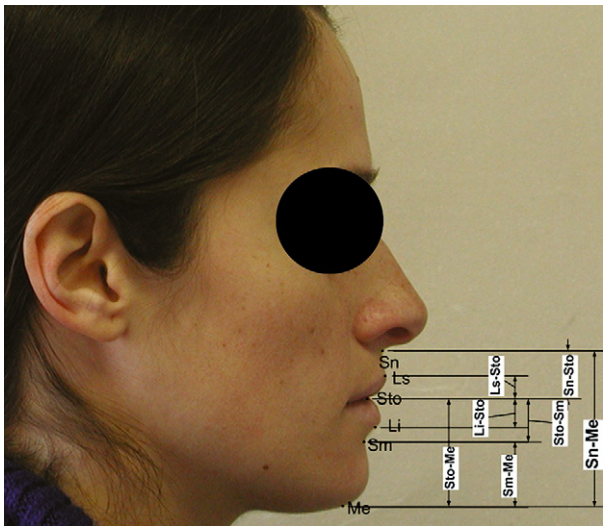

Fig. 1 − Vertical profile measurements of the lower face. The following six landmarks used in the study are: subnasale (Sn) − the point where the upper lip joins the columella; labrale superior (Ls) − the point that indicates the mucocutaneous limit of the upper lip; stomion (Sto) − the point where upper lip contacts the lower lip; labrale inferior (Li) − the point that indicates the mucocutaneous limit of the lower lip; supramentale (Sm) − the deepest point of the inferior sublabial concavity and menton (Me) − the most inferior point of the outline of the chin (Fig. 1). The following seven vertical linear measurements (parallel to TV) include: Sn−Me − height of the lower face; Sn−Sto − upper lip height; Sto−Sm − lower lip height; Ls−Sto − upper vermilion height; Li−Sto − lower vermilion height and Sm−Me − chin height.

RESULTS

All seven vertical profile measurements are reported in Table 1. Almost all the measurements, as expected, were significantly greater in males than in females: height of the lower face (Sn−Me); upper lip height (Sn−Sto); height of the lower third of the face (Sto−Me); chin length (Sm−Me) ($p < 0.001$) and lower lip height (Sto−Sm) ($p = 0.001$). Cumulative percentiles of the above mentioned variables are shown in Figs. 2−5. The only variables with no gender differences were lower (Li−Sto) and upper vermilion heights (Ls−Sto).

Percentage of the contribution of the vertical upper lip length, vertical chin length and vertical lower lip length to the lower face height is shown in Fig. 6.

Relationships between the vertical measurements of the lower face, the upper and lower lips and the chin and the results of the *t*-test in relation to gender are shown in Table 2. Significant differences between males and females were found in IND1 ($p < 0.001$), IND5 ($p = 0.031$), IND6 ($p = 0.035$) and IND7. All those indices were greater in females except IND7 ($p = 0.037$) representing chin/lower third of the face, which was greater in males than in females.

The lower third of the face was divided into three segments (Sn−Sto, Sm−Me and Sto−Sm) and the largest portion of the lower face was occupied by the chin and the smallest by the lower lip height in both genders (Fig. 6).

The highest correlations (Table 2) between the measurements were found between upper vermilion height and upper lip height (IND1); lower lip vermilion height and lower lip height (IND2); upper lip height and height of the lower face (IND4); lower lip height and height of the lower third of the face (IND5) and chin height and height of the lower third of the face

Table 1 – Vertical profile measurements in the area of the lower face

Area	Measurement/variable	Gender	*N*	Mean	SD	*t*	*p*
Face	Height of the lower face (Sn–Me)	M F	52 58	71.16 63.47	4.70 3.38	9.919	<0.001
	Height of the lower third of the face (Sto–Me)	M F	52 58	47.60 42.90	3.00 2.48	8.985	<0.001
Upper lip	Upper lip height (Sn–Sto)	M F	52 58	23.55 20.57	2.64 2.01	6.715	<0.001
	Upper vermilion height (Ls–Sto)	M F	52 58	8.39 8.52	1.29 1.35	−0.530	0.597
Lower lip	Lower lip height (Sto–Sm)	M F	52 58	18.92 17.67	2.29 1.73	3.260	0.001
	Lower vermilion height (Li–Sto)	M F	52 58	8.67 8.60	1.62 1.35	0.258	0.797
Chin	Chin height (Sm–Me)	M F	52 58	28.63 25.21	2.22 2.24	8.037	<0.001

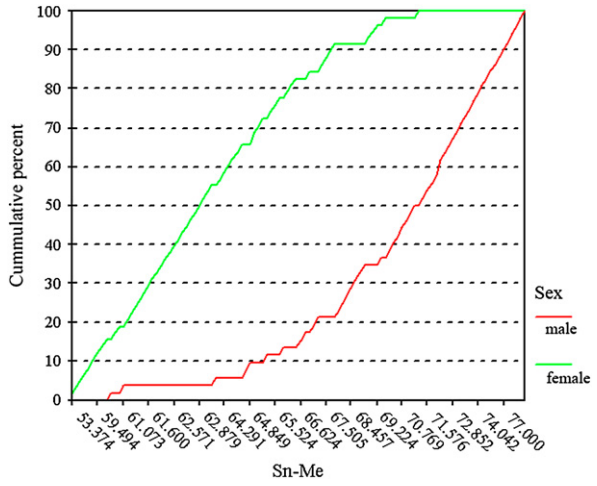

Fig. 2 – Cumulative percentile of the height of the lower face (Sn–Me) regarding gender ($N = 110$).

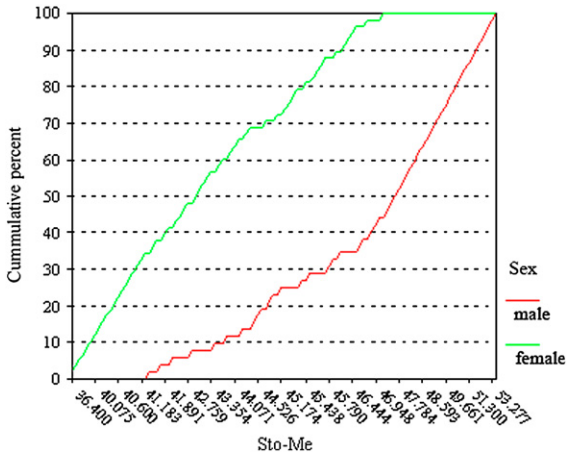

Fig. 3 – Cumulative percentile of the height of the lower third of the face (Sto–Me) regarding gender ($N = 110$).

(IND7). No correlation was observed between the measurement in indices 1–7 in females between upper vermilion height and lower vermilion height (IND3) and lower lip height and chin height in both genders, which was the only negative correlation. All significant correlations were positive.

DISCUSSION

In this investigation seven indices were used to present some relationships within the lower face. Since the main objective was to evaluate the relationships between the lips and the chin, as previously mentioned, one of the main selection criteria included good and balanced soft tissue profile, there is actually no objective basis for the selection based on "good" soft tissue profile. As mentioned in works by several authors (*Arnett* and *Bergman*, 1993a,b), there is a great deal of subjectivity in perceptions of the facial profile. Before making the measurements each photograph of the subject was evaluated and ranked by all three authors and a consensus was reached as to which subject should participate in the study. The criteria were judged on the basis of visual balance of facial parts, and quality parts (i.e., beautiful eyes) were disregarded.

The vermilion height of the upper and lower lip did not show gender differences. This agrees with the findings of *Fernandez-Riveiro* et al. (2002) and *Bishara* et al. (1995). In our investigation, the upper vermilion was smaller than the lower vermilion in both genders and lower lip height was less than the upper lip height, this is also in accordance with the findings of *Farkas* et al. (1984). The upper lip height (Sn–Sto) was larger in males ($p < 0.001$) as per the findings of *Park* and *Burstone* (1986); *Yuen* and *Hiranaka* (1989); *Fernandez-Riveiro* et al. (2002); *Arnett* and *Bergman* (1993a,b) and *Farkas* et al. (1984). The lower lip height (Sto–Sm) was also larger in males. The vertical chin height (Sm–Me) was greater in males ($p < 0.001$) than in females agreeing with the findings of *Fernandez-Riveiro* et al. (2002). *Park* and *Burstone* (1986) found no gender differences on the analysis of vertical chin height.

Observing the facial heights, both measurements: height of the lower face (Sn–Me) and height of the lower

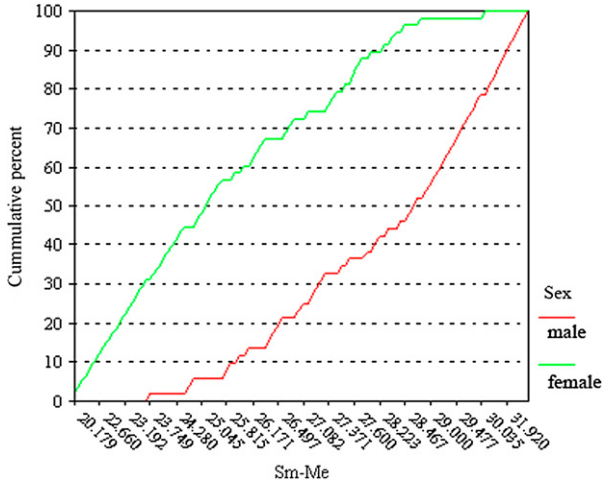

Fig. 4 – Cumulative percentile of the vertical chin length (Sm–Me) regarding gender ($N = 110$).

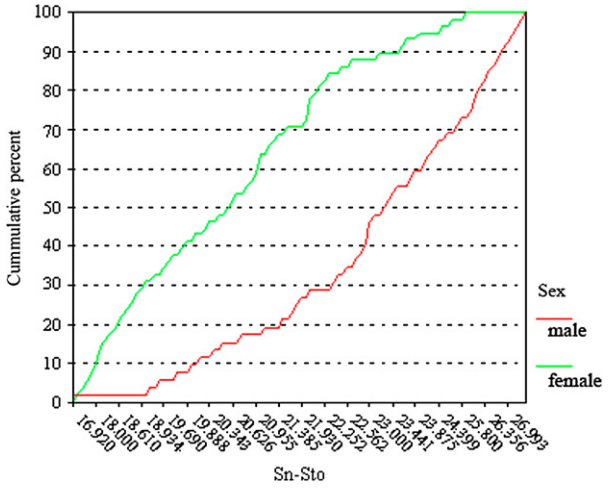

Fig. 5 – Cumulative percentile of the vertical upper lip length (Sn–Sto) regarding gender ($N = 110$).

third of the face (Sto–Me) were greater in males ($p < 0.001$).

The lower third of the face was divided into three vertical segments and we confirmed the findings of *Farkas* et al. (1984) that the largest portion of the lower face was occupied by the chin and the smallest by the lower lip.

The height of the upper vermilion in relation to the upper lip (IND1) was significantly ($p < 0.001$) larger in females (41.6%) than in males (35.7%) in agreement with the findings of *Farkas* et al. (1984). The lower lip proportion (IND2) in females (48.8%) was not significantly greater than in males (46.2%). *Farkas* et al. (1984) reported the same finding regarding gender but with higher values (females: 52%; males: 47%) and with a statistically significant difference.

The relationships between the upper and lower lips (IND3) in this investigation were not significantly different regarding gender; this coincides with the findings of *Farkas* et al. (1984) who also found that the upper vermilion, on average, was thinner in both genders than

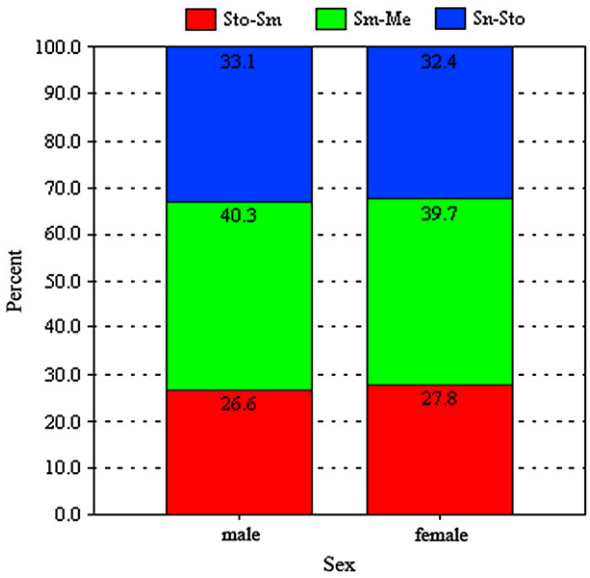

Fig. 6 – Percentage of the contribution of the vertical upper lip length (Sn–Sto), vertical chin length (Sm–Me) and vertical lower lip length (Sto–Sm) in the lower face height.

the lower vermilion. In our study the upper lip height (IND4) occupied about one third of the face in both genders (males 33.04%, females 32.38%). Similar results were obtained by *Farkas* et al. (1984) (males 32.4%; females 31.1%).

The lower lip in relation to the lower third of the face height (IND5) was significantly greater in females 41.20% than in males 39.70%. *Farkas* et al. (1984) found that lower lip height, on average occupied a similar proportion of the lower third of the face in both genders (males 38.7%; females 37.4%).

The lower lip on average, in females the lower lip height reached 70.75% of the entire chin height (IND6) which was significantly greater ($p = 0.035$) than in males 66.54%. On the contrary, *Farkas* et al. (1984) found no gender difference (males 63.7%; females 59.9%).

The chin proportion in relation to the lower third of the face (IND7) showed gender differences. In males, the chin occupied 60.21% and 58.75% in females of the facial area below the labial fissure. On the contrary *Farkas* et al. (1984) found no gender differences (males 61.9; females 62.9%). The percentage of the contribution of the upper lip height, chin height and lower lip height to the lower face height is very similar to those presented by *Farkas* et al. (1984) (Fig. 6).

In general, there is a great variability of the individual measurements, allowing great variation in proportions, which is one of the most important requirements for individuality (*Legan* and *Burstone*, 1980). The proportion of the lower face height is relatively constant throughout development (*Farkas*, 1981), but in patients with excessive lower face height, it is necessary to control the vertical dimension (*Bergman*, 1999).

Most facial changes occur before 18 years of age, but it has been shown that growth and facial reshaping continue throughout life. The nose and the chin grow through the years and the lips become more retrusive

Table 2 − Relationships between vertical profile measurements in the lower face and the results of the *t*-test

No.	Related measurements	Index		*N*	Pearson correlation coefficient (*r*)	Mean	SD	*p*
IND1	Upper vermilion height−upper lip height	Ls−Sto × 100 Sn−Sto	M F	52 58	$r = 0.62$* $r = 0.38$*	35.69 41.60	4.42 6.38	<0.001
IND2	Lower vermilion height−lower lip height	Li−Sto × 100 Sto−Sm	M F	52 58	$r = 0.29$** $r = 0.45$*	46.24 48.84	8.96 7.31	0.098
IND3	Upper vermilion height−Lower vermilion height	Ls−Sto × 100 Li−Sto	M F	52 58	$r = 0.48$* $r = 0.26$	99.01 101.10	19.41 20.25	0.584
IND4	Upper lip height−Height of the lower face	Sn−Sto × 100 Sn−Me	M F	52 58	$r = 0.81$* $r = 0.69$*	33.04 32.38	2.35 2.32	0.142
IND5	Lower lip height−Height (lower third of the face)	Sto−Sm × 100 Sto−Me	M F	52 58	$r = 0.68$* $r = 0.50$*	39.70 41.20	3.64 3.54	0.031
IND6	Lower lip height−Chin height	Sto−Sm × 100 Sm−Me	M F	52 58	$r = -0.12$ $r = -0.22$	66.54 70.75	10.09 10.50	0.035
IND7	Chin height−height (lower third of the face)	Sm−Me × 100 Sto−Me	M F	52 58	$r = 0.64$* $r = 0.74$*	60.21 58.75	3.69 3.56	0.037

*$p = 0.01$; **$p = 0.05$.

(*Nanda* et al., 1990; *Bishara* et al., 1995; *Prahl-Andersena* et al., 1995). These changes in both hard and soft tissues are significantly greater in males than in females (*Formby* et al., 1994; *Skinazi* et al., 1994).

It is well known that the soft tissue can differ to such an extent that the dentoskeletal jaw relationship can be an inadequate guide for evaluation of facial disharmony (*Burstone*, 1959, 1967; *Legan* and *Burstone*, 1980) and that the treatment which is based on skeletal standards can result in disharmonious facial proportions (*Burstone*, 1959; *Neger*, 1959; *Bloom*, 1961; *Merrifield*, 1966; *Peck* and *Peck*, 1970). Linear measurements (*Anic-Milosevic* et al., 2008a,b) and a knowledge of the proportions within the lower face can provide valuable information in addition to the angles of this area (*Arnett* and *Bergman*, 1993a,b; *Bergman*, 1999; *Anic-Milosevic* et al., 2008a,b) for planning orthodontic and surgical corrections in order to improve facial features. The analysis should also be of interest to patients expressing concern about their facial profile, and in instances of moderate deviation, can help in the decision to treat without surgery. It is also possible to determine how a dimensional change, resulting from surgical correction or orthodontic treatment may affect facial proportions.

Many authors (*Nanda* et al., 1990; *Formby* et al., 1994) have suggested that vertical factors may contribute to anteroposterior imbalance in many cases, in contrast to the traditional emphasis placed on craniofacial anteroposterior balance influenced by Angle's classification of malocclusion. The present study demonstrates that vertical factors play an important role in treatment planning regarding occlusion and aesthetic profile. It should be acknowledged that vertical factors and facial proportions are of great importance for orthodontic diagnosis and treatment planning.

CONCLUSION

Some known aesthetic guidelines must be followed when determining the orthodontic plan for optimal facial attractiveness. Knowledge of the proportions in the upper lip−lower lip−chin area should be of help in surgical correction of the lower face. The lower one third of the face has a major impact on the perception of facial aesthetics. The proportional relationships found in our sample are a valuable contribution and can serve as a template for vertical facial analysis of the lower face in this patient population. They should be particularly useful for patients whose facial proportions are severely affected by dentofacial abnormalities.

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