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3D analysis of smiling function in healthy people: influence of sex and age

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Smiling has a special importance from aesthetic, psychological and social points of view. Smiling may be altered or deleted by several pathological conditions, including surgical procedures. Partial or full restoration of mimicry is the task of reconstructive surgery, usually through facial reanimation procedures[1]. Three-dimensional (3D) image acquisition systems can quantify the residual function in patients affected by facial palsy[1], and the degree of mimicry restoration after facial reanimation surgery, but normal standards from healthy subjects are needed[1,2]. As current literature is divided about the effect of sex and age on facial movements in healthy adults[2-5], the aim of the present study was to define a set of reference values for smiling function in healthy males and females in a wide age range.

3D surface analysis of smiling movements was applied to 30 males and 30 females aged between 40 and 82 years (mean age 54.4 years, SD 10.5 years), equally divided among three age groups (40-49 years; 50-59 years; ≥60 years). Exclusion criteria were facial scars and deformities, facial surgical treatments, traumas and local or systemic neuromuscular pathologies affecting facial mimicry. The study was performed according to the Declaration of Helsinki and was approved by the local ethic committee (Università degli Studi di Milano, 92/2014). All the volunteers read and signed an informed consent. For each subject, two 3D facial images were obtained at few seconds of distance through a stereophotogrammetric system (VECTRA® M3: Canfield Scientific Inc., Fairfield, NJ): one in rest position (neutral expression) and one in smiling position (corner-of-the-mouth, or Mona Lisa smile)[1]. The subjects were shown the requested facial expression and practiced before acquisitions.

A facial area of interest was defined between trichion, frontotemporale, zygion, tragion, gonion and gnathion landmarks in both neutral and smiling 3D facial digital images. The facial area included within the selected perimeter was automatically segmented (Vectra Analysis Module, Canfield Scientific Inc., Fairfield, NJ), and divided into facial thirds defined according to the trigeminal territories distribution[1]. For each subject, the 3D digital image of the smiling face was then automatically registered on the neutral one to reach the least point-to-point distance between the two surfaces. The point-to-point root mean square (RMS) distance between the two surfaces was calculated separately for each facial third: the larger the facial movements during smiling, the larger the RMS value. The amount of movement during smiling was visualized using chromatic maps (Figure 1). In addition, mouth width (cheilion-cheilion distance) in rest position was calculated.

RMS values did not differ significantly between the right and the left side of the face, independently from sex or age group (Student's t, $p>0.05$; Table 1). A two-way ANCOVA found no significant differences according to sex or age, independently from the side and facial third (covariate cheilion-cheilion distance, $p>0.05$).

In healthy adult subjects, point-to-point RMS distances between the rest and the smiling facial images do not change significantly according to side, sex or age (among the 5th and the 8th decades of life).

Literature about sexual dimorphism in smiling is divided: from a morphological point of view, facial expressions in males are more extensive than in females because the facial skeleton and soft tissues are more expanded[2], with thicker and larger facial muscles, containing proportionally more fibres[3]. Differences in RMS values according to sex were reported for a surprise expression, for cheeks inflating and in the pronunciation of the /u/ sound, while the smile animation had similar displacements in both sexes[3,4]. In studies based on the assessment of 3D landmark displacement, the sexual dimorphism disappeared after correcting for the different facial dimensions in the two sexes[2]. Accordingly, in the current study we used covariate analysis to limit this possible bias.

Influence of aging on facial mimicry is also debated: facial movements were reported to be wider after 50 years of age[4] and in 60-70 years old subjects[5], possibly as a consequence of the increase in facial surface area in aged people[4]. A previous study analyzed landmark displacement in healthy subjects and did not observe differences according to age, but persons aged over 50 years were not included[2]. The present investigation included volunteers aged 60 years or more, but no significant differences according to age were found in both sexes, although RMS values were somehow higher in subjects aged 60 years or more than under 60 years. The different experimental protocol may explain these discordances: in the present case, calculation of RMS point-to-point distances between two registered surfaces, geometric morphometry analysis for Veleminskà et al[4].

In conclusion, the present study provides control reference values for 3D surface modifications during smiling. The movements do not depend upon sex or age, thus simplifying the definition of reference values. Data can be used to evaluate the residual mimic function of patients affected by facial palsy and to calculate the amount of movement restored by surgical intervention.

Conflict of interest statement

None.

Role of funding sources

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Legend to figure

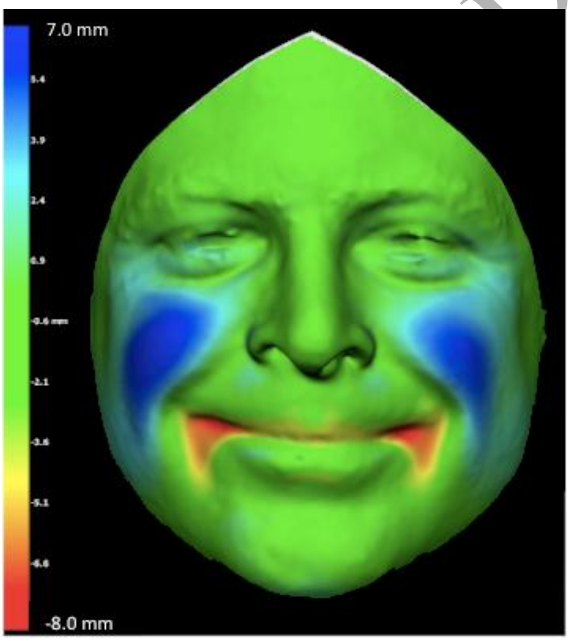

Figure 1: Superimposition between the two facial surfaces in neutral position and in smiling expression and illustration of point-to-point distances through a chromatic analysis (in green,

areas that do not move; in red –posterior direction- and blue –anterior direction- areas of movement). The subject is a 40 years old man.

Table 1: RMS values divided according to sex, age, side and facial thirds, and width of the mouth (ch-ch) distance.

		Males (n = 30)						Females (n = 30)					
		40-49 y		50-59 y		≥60 y		40-49 y		50-59 y		≥60 y	
		R	L	R	L	R	L	R	L	R	L	R	L
Upper third	Mean	0.53	0.48	0.61	0.63	0.70	0.72	0.60	0.58	0.59	0.57	0.61	0.67
	SD	0.29	0.27	0.35	0.34	0.32	0.31	0.29	0.29	0.27	0.22	0.24	0.20
Middle third	Mean	1.67	1.62	1.75	1.81	1.63	1.81	1.46	1.44	1.34	1.36	1.57	1.60
	SD	0.85	0.89	0.55	0.59	0.83	0.91	0.57	0.60	0.50	0.60	0.78	0.79
Lower third	Mean	1.22	1.19	1.39	1.42	1.30	1.36	1.07	1.01	0.95	1.04	1.23	1.29
	SD	0.58	0.53	0.42	0.33	0.58	0.62	0.42	0.42	0.35	0.44	0.58	0.62
ch-ch	Mean	55.2		54.5		54.7		48.3		50.6		48.8	
	SD	2.7		4.8		4.6		4.4		3.2		3.0	

All the values are expressed in mm. R: right; L: left