ORIGINAL ARTICLE

# The spontaneous smile in dynamic motion

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**Introduction:** The purpose of this study was to record and analyze the dynamic nature of spontaneous smiles. **Methods:** Fifteen children (9 girls and 6 boys; average age, 10.5 years) were filmed with a hidden camera while they watched a funny cartoon video. Spontaneous smiles were recorded, and the video frames were digitized. Time-graphs of the measurements were constructed, and plots of the movement of the mouth points were drawn. **Results:** Facial measurements showed that the upper lip elevated by 28%, relative to the rest position, and the mouth increased in width by 27%. The corners of the mouth moved laterally and superiorly at an angle of approximately 47°. Time analysis showed that the smiles developed in a staged fashion. The first stage (attack phase) was the shortest, lasting an average 500 ms. It was followed by a sustaining phase that included waxing and waning. The smile ended with a fade-out stage. The second and third stages were of variable duration and could be interrupted by the attack phase of a subsequent smile. **Conclusions:** The dynamics of the spontaneous smile and the findings of this study raise concerns about the validity of a single photographic capture for esthetic assessment and treatment planning. (Am J Orthod Dentofacial Orthop 2005;128:8-15)

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 smile is rightfully considered a valuable tool of nonverbal social communication, a civilized form of human contact, and a sound criterion of facial attractiveness. As science attempts to keep pace with consumer awareness, the need for more realistic laboratory experiments and research conclusions becomes compelling. The main effort of contemporary evidence-based orthodontics is to create a clear-cut treatment paradigm[1] out of diffuse subjective, scientific, and anecdotal esthetic values that quite often differ between patient and orthodontist.

The smile has been studied by scientists of various specialties. Clinicians in prosthetics and orthodontics[2,3] regard the smile as an integral part of treatment planning and as the cornerstone of treatment objectives. Studies have also been carried out in otolaryngology, and in head and neck surgery, to assess facial paralysis. Plastic surgery has been involved in smile analysis to assess the quality of surgical outcomes and, in some cases, the patient's emotional status.[4] Smile studies have also been performed by psychologists in behavioral sciences, to assess personality and neuromuscular function.[5,6] Finally, scientists from the athletic and kinesiology domains have productively and fruitfully studied smiles.[7]

Although the literature concerning smiles is broad, most studies deal with induced smiles in artificial settings, recorded at a single time point, thus incorporating an unavoidable method error in the collected data. The purpose of this study was to record and analyze the dynamic nature of spontaneous smiles.

## REVIEW OF SMILE STUDIES

The article of Burres[8] is considered a classic and one of the first to use linear and angular measurements from reference points on the face to translate facial expressions into numbers. Smile studies frequently involve manual or digital measuring of standardized photographs.[9] However, in some cases, actual faces were measured with various instruments, such as calipers, hand-held rulers, or other instruments designed specifically for that purpose (such as the faciometers).[10]

Another method that has been used in some smile analysis studies is the subtraction technique, which measures changes of luminance on the face.[11-14] It is essentially a measurement of surface differences between an original image and a final image; changes in area rather than changes in the position of specific points are assessed. Proponents of this method[12,13] believe that area changes are a more rational and informative method of study because, during a facial expression, changes occur even in remote parts of the

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facial topography, with the participation of various groups of muscle fibers of the overall facial musculature. However, some areas do not have clear-cut borders or overlap other areas during movement; this could lead to numerical vagueness and problematic quantification. In addition, although subtraction could make visualizing the overall change easier, the actual direction of change can still be hard to show. All points on the face, even at rest, move; "there is no such thing as a still point on the face."[7]

In cases of facial paralysis, when clinical features are between normality and some degree of residual pathology, estimating a muscular response to the patient's effort to smile follows a very thorough classification, and the amplitude and characteristics of facial function are assessed by either the Stennert scoring system or the more contemporary universal facial nerve grading system of House and Brackmann.[15]

In photometric methods, the process of measuring a face entails specification of the landmarks. This is not an easy task, because the face has only a few well-demarcated landmarks that are easily recognized on photographs, and most of the facial surface moves during a facial expression. Most techniques involve placing adhesive markers on the patient's face[16-18] or drawing marks with a makeup pencil.[14] Markers can be easily (even automatically) digitized from photographs or video frames, but "placing marks on the face may create an unpleasant feeling for the patient and may be a problem."[18] Obviously, producing a natural smile of maximum amplitude and expression with 16 to 20 pieces of tape or "luminant markers" on one's face is not easy.

Even without markers on the face, the problem of spontaneity of the facial expression remains. Is a smile invoked on demand, with or without the help of specific verbal phrases, the same as a spontaneous smile? This question is particularly important to orthodontists seeking to obtain a "good smile" from small children, who might be apprehensive when the records are taken. Also, operator efficacy seems important, with some orthodontists finding the task effortless and others experiencing difficulties even after expert instruction. Psychologists make a clear distinction between deliberate and spontaneous facial movement, focusing on the importance of potential differences in timing and complexity rather than gross morphology.[19] Studies that attempt to capture an expression during its natural development are rare. Zamzam and Luther,[20] who used remote video surveillance to compare the position of lips at rest in normal subjects and subjects with cerebral palsy, did just that.

Another significant parameter of smile studies is the dimension of time. Most studies capture (or attempt to capture) the peak, or maximum extent, of the smile by using a single photographic image. Obviously, in addition to the uncertainty of acquiring the image at the correct moment, this recording lacks information regarding time evolvement. One of the first studies to use duration curves, plotting displacement against time, was that of Neely et al[11] on patients with facial paresis. The time plots were based on only 3 sequential frames from each of the 5 measured facial expressions (including a smile); a double graph was created for each subject, 1 part for the normal side and the other for the paretic side. In a more recent article, Linstrom et al[17] plotted mean displacement as a function of time during a closed-lip smile.

Sarver and Ackerman[21] also advocated the use of video recordings instead of static images and added a profile view to the more customary frontal view to obtain pseudo–3-dimensional (3D) information. Other researchers have used frontal and left and right profile video captures to acquire true 3D data.[22,23] Such research material is regarded as superior in terms of amplitude of facial movement, which 2-dimensional imaging methodologies generally tend to underestimate,[24,25]; but technical difficulties persist.[7,10,26]

## MATERIAL AND METHODS

Fifteen subjects (9 girls and 6 boys) took part in this study. Their ages ranged from 7 to 14 years (average, 10.5). The subjects were seated directly in front of a 21-in television, at a distance of approximately 1.5 meters, and were shown a funny cartoon video while they waited for initial orthodontic examinations. Next to the television, a hidden digital video camera filmed the subjects at 25 frames per second. No cephalostat to constrain head movement was used, and no markers were placed on the faces. The subjects were unaware that they were being filmed; their reactions to the cartoon video were considered spontaneous.

The digital images were transferred to a computer, and the frames encompassing a smile were selected. A total of 2087 frames were processed, for an average of 140 frames per subject. On each frame, the following points were marked: outer canthous of the eyes (ER, EL), corners of the mouth (MR, ML), subnasale (Sn), and center of upper and lower lips (U, L). The points were digitized by using Viewbox software (dHAL software, Kifissia, Greece), and the following measurements were taken (Fig. 1):

1. Commissure (mouth) width: the distance between the corners of the mouth (MR to ML).