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## 論 文 内 容 の 要 旨

### Introduction

Quantifying spatio-temporal changes in the facial soft tissue form during facial expressions is a key element to our better understanding of oro-facial function and esthetics. Neural mechanisms of facial expressions which control natural (involuntary) and posed (voluntary) smiles are explained by distinct pathways. There has been a controversy as to whether there is lateralized asymmetry (asymmetry that favors one side) in the motion of the face such as in the smiling action. Neuro-anatomic evidence indicates that contralateral control of facial musculature exists in the lower face.

Therefore, the purposes of the present study were to examine quantitatively if there were differences in the motion of the lips between the natural smile and posed smile and between the right side and left side during the act of smiling.

### Material and methods

Thirty healthy Japanese volunteer women (mean age, 24y5m) with acceptable good occlusion, no current or past history of facial impairment and no discernible facial asymmetry or oro-facial dysfunction participated in the study.

A three-dimensional infrared motion capturing device of a two-camera unit system (ProReflex Motion Capture Unit, Qualysis, Gothenburg, Sweden) was optimized to record motions of the lips during the act of smile for 5-10s with a sampling frequency of 100 Hz. Four markers (12 mm diameter, 10.5 mm thick) were adhered to the facial surface as reference markers. Similarly, four markers (7 mm diameter, 6.5 mm thick) were placed to measure the motion of the lips.

Positions of the reference markers were as follows : FHM, the upper forehead on the facial midline ; ER, the tail of the right eyebrow ; EL, the tail of the left eyebrow and se, the deepest point on the bottom of the nasofrontal

angle. The markers employed to measure the motion of the lips were as follows :  $CM_R$ , the right corner of the mouth ;  $CM_L$ , the left corner of the mouth ;  $UL_M$ , the upper mid-lip point vermilion border and  $LL_M$ , lower mid-lip point vermilion border.

First, the subjects watched a set of three comic video clips for a total period of 12 minutes so that spontaneous motions of the lips during the natural smile could be recorded. Second, the subjects performed posed-maximum smiles, i.e., the maximal animation of the corners of the mouth turning upwards and backwards. Five animations were obtained for both types of smiles.

To minimize effects of natural head movement on the recorded data when smiling, a new coordinate space was generated using the coordinates of the four reference markers. Displacements from the start until the peak of the smiling action for each marker were normalized with respect to the distance between the  $CM_R$  and the  $CM_L$  markers at frame no. 1, which was defined as the inter-commissure lip distance at rest. The time course from the start until the peak of the displacement was divided into two time bins in each of the three directions for each marker. The displacement of each time bin was calculated as an element to provide 6 variables of movement distances generated for each marker. Twenty-four variables were finally generated for each smile trial in all subjects. Variables of the mean durations for the four measured markers and the mean velocities in the three directions for each marker were also calculated. The mean variables of the five trials for both types of smiles were calculated as representative smiles for each subject. The variables of the representative smiles were compared statistically to examine if there were any differences between the natural smile and the posed-maximum smile as well as between the  $CM_R$  marker and the  $CM_L$  marker for each smile type.

## Results

Normalized movement distances in the lateral direction for the right corner of the mouth ( $CM_R$ ) in the natural smile were significantly shorter than those for the posed-maximum smile ( $P \leq 0.01$ ). Significant differences were not determined between the natural smile and the posed-maximum smile for the movement distances of the left corner of the mouth ( $CM_L$ ) and the mid-lip points markers ( $UL_M$  and  $LL_M$ ).

Greater lateral movement distance determined for the marker  $CM_R$  when compared to the marker  $CM_L$  ( $P \leq 0.00001$ ) ; in contrast, the marker  $CM_L$  exhibited a longer posterior movement distance than the marker  $CM_R$  ( $P \leq 0.001$ ). These findings were consistent in both types of smiles. The natural smile showed longer durations for both corners of the mouth and the upper and the lower mid-lip points than that seen for the posed-maximum smiles ( $P \leq 0.001$ ). In general, the mean velocities in the three directions were found to be slower for the natural smile ( $P \leq 0.01$ ). Slower movement speed was determined for the left corner of the mouth in the lateral direction ( $P \leq 0.001$ ). In contrast, slower movement speed was determined for the right corner of the mouth in the antero-posterior direction ( $P \leq 0.001$ ).

## Conclusions

1. The natural smile had shorter lateral movement distance of the right corner of the mouth, longer movement durations and slower velocities of the lips when compared to the posed-maximum smile.
2. Both the natural smile and the posed-maximum smile showed asymmetry in motions of the corners of the mouth in the lateral direction and in the antero-posterior direction in terms of movement distances and velocities.

## 論文審査の結果の要旨

The purposes of this study were to examine quantitatively if there were differences in the motion of the lips between the natural smile and the posed smile and between the right side and the left side during the act of smiling in 30 Japanese healthy young women.

The natural smile was characterized by shorter lateral movement distance of the right corner of the mouth, longer movement duration and slower velocity when compared to the posed-maximum smile. Both the natural smile and the posed-maximum smile showed asymmetry in motion that was sensitive to the lateral and antero-posterior directions in terms of the movement distance and the velocity.

The results of the present study described above will contribute to assessing dentofacial problems and related treatment outcomes in oral health sciences and also to understand the semantics of emotional expressions in the neuro- and socio-psychological contexts. Therefore, the reviewers of this thesis dissertation agree that the work provided is of great scientific value and strongly recommend Ms. Evelina del Carmen Montero to obtain her PhD doctoral degree.