

Basic analysis of facial ageing: The relationship between the superficial musculoaponeurotic system and age

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Abstract

Background: The superficial musculoaponeurotic system (SMAS) is an anatomical structure involved in the facial ageing process. We aimed to evaluate the SMAS laxity using multi-detector row computed tomography (MDCT) as a diagnostic tool, and to analyse the relationship between SMAS laxity and age.

Methods: Fifty-seven female subjects (aged 21-57 years) were enrolled in the study. The subjects were divided into two age groups: one below the mean age (Group Y, 30 subjects) and one over it (Group O, 27 subjects). The Posture Change (PC)-induced SMAS Laxity Index was measured using reconstructed CT images, and the relationship between the PC-induced SMAS Laxity Index and age was analysed.

Results: The PC-induced SMAS Laxity Index was significantly larger in Group O than in Group Y. As well, a strong and significant positive correlation was detected between the PC-induced SMAS Laxity Index and age ($r = 0.72$; $P < 0.001$).

Conclusions: The use of MDCT provides insight into the detailed changes associated with ageing that take place within the cheeks. This study objectively demonstrated that SMAS laxity and age are factors associated with facial ageing, as the SMAS laxity increased with age. Finally, the imaging features confirmed the dermatological and aesthetic knowledge gained from plastic surgery regarding the loss of the SMAS supporting force due to facial ageing.

KEYWORDS

cheek sagging, laxity, multi-detector row computed tomography, posture change, supporting force

1 | INTRODUCTION

Facial ageing is caused by changes in anatomical structures such as the skin, facial expression muscles, soft tissue and adipose tissue.^[1-4]

The superficial musculoaponeurotic system (SMAS), one of the anatomical structures involved in the facial ageing process, is composed of a subcutaneous fibromuscular structure in the parotid and buccal areas.^[2-7] The supporting force of the SMAS is diminished by factors that accelerate ageing, including gravity, subcutaneous fat, musculo-fascial laxity and solar elastosis. Once the supporting force is decreased, the SMAS loses the ability to sustain the facial expression

muscles and the subcutaneous adipose tissue, and signs of ageing consequently appear in the face.^[3,4,6] The close relationship between the SMAS and facial ageing has been established. However, age-related changes in the SMAS have not been elucidated, and only a limited number of papers address the relationship between SMAS laxity and age.

The aim of this study was to evaluate the SMAS laxity using multi-detector row computed tomography (MDCT) as a diagnostic tool. To this end, the SMAS Laxity Index was developed based on changes in facial morphology induced by a change in posture.^[8-10] As well, we analysed the relationship between SMAS laxity and age.

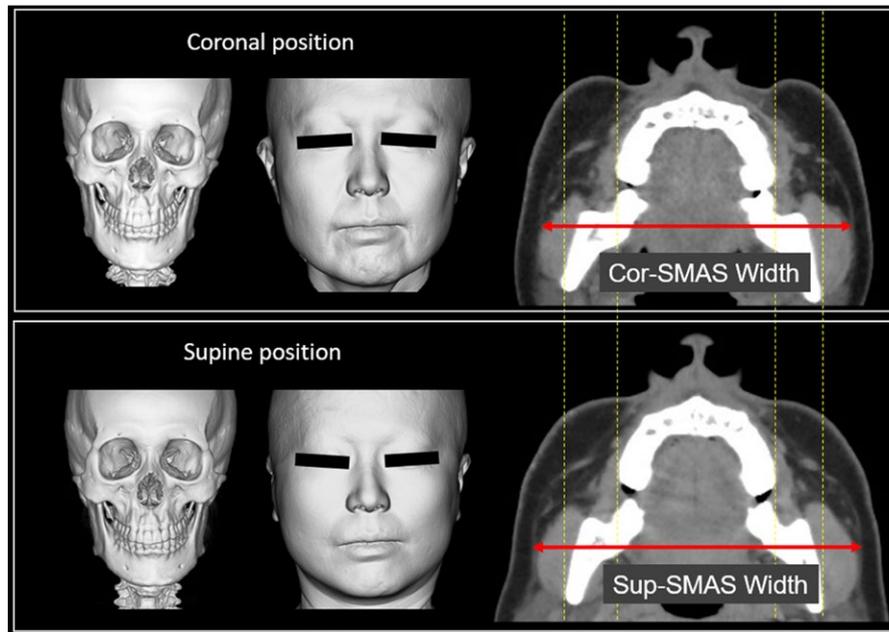


FIGURE 1 Measurement of the Posture Change (PC)-induced SMAS Laxity Index. The upper images show the coronal position, and the lower images show the supine position. The dotted yellow vertical lines are projected lines, indicating the same points of the facial bones when in the coronal and supine positions. The solid red horizontal line in the coronal position indicates the distance between the right and left margins of the SMAS (called the Cor-SMAS Width). The solid horizontal line in the supine position indicates the distance between the right and left margins of the SMAS (called the Sup-SMAS Width).

$$\text{The PC-induced SMAS laxity index} = \left(\frac{\text{Sup-SMAS Width}}{\text{Cor-SMAS Width}} \right) \times 100$$

2 | MATERIALS AND METHODS

2.1 | Population selection

This study was approved by the Mita Hospital institutional review board of International University of Health and Welfare (approval number: 5-14-4). Informed consent was obtained from all of the subjects.

Fifty-seven healthy Japanese female volunteers ranging in age from 21 to 57 years (mean age, 38.7 ± 8.1 years [standard deviation]) without scars or deformities that would influence the superficial facial structure were enrolled in the study. We decided to divide the subjects were divided into two well-defined groups: one below the mean age (Group Y, 30 subjects) and one over it (Group O, 27 subjects).

2.2 | MDCT scan technique

Whole face scans were performed using a 320-MDCT scanner (Aquilion ONE; Toshiba Medical Systems, Tochigi, Japan) and a tube voltage of 120 kVp, a tube current of 130-180 mA, an exposure time of 1.0 second and a slice thickness of 0.5 mm. Whole face scans were obtained for each subject in the supine and coronal positions.

All imaging row data were transferred to a Centricity RA1000 workstation (GE Healthcare UK, Ltd, Buckinghamshire, UK), which had several applications for creating reconstructed and

three-dimensional (3-D) images, and 3-D CT and reconstructed images of the subjects' faces were created.

2.3 | MDCT analysis of the SMAS laxity

The rate of change in SMAS morphology caused by a posture change (PC) was defined as the PC-induced SMAS Laxity Index, which was determined using measurements obtained from axial images reconstructed from the MDCT data of the supine and coronal positions. First, the lower edge of the nose was confirmed on the 3-D CT images of the face and facial bones. Next, the reconstructed axial images corresponding to the same level of the supine and coronal positions were selected. As shown in Figure 1, the SMAS width was defined as the horizontal distance between the right and left margins of the SMAS and was measured in the supine and coronal positions (Sup-SMAS Width and Cor-SMAS Width, respectively). The imaging data used to obtain the SMAS change rate were measured on reconstructed axial images using the digital calibre available on the workstation. The measurements were performed together by two radiologists, one with 24 years of experience (I.O.) and one with 25 years of experience (N.Y.).

The PC-induced SMAS Laxity Index was calculated using the following formula:

$$\text{PC-induced SMAS laxity index} = \left(\frac{\text{Sup-SMAS Width}}{\text{Cor-SMAS Width}} \right) \times 100$$

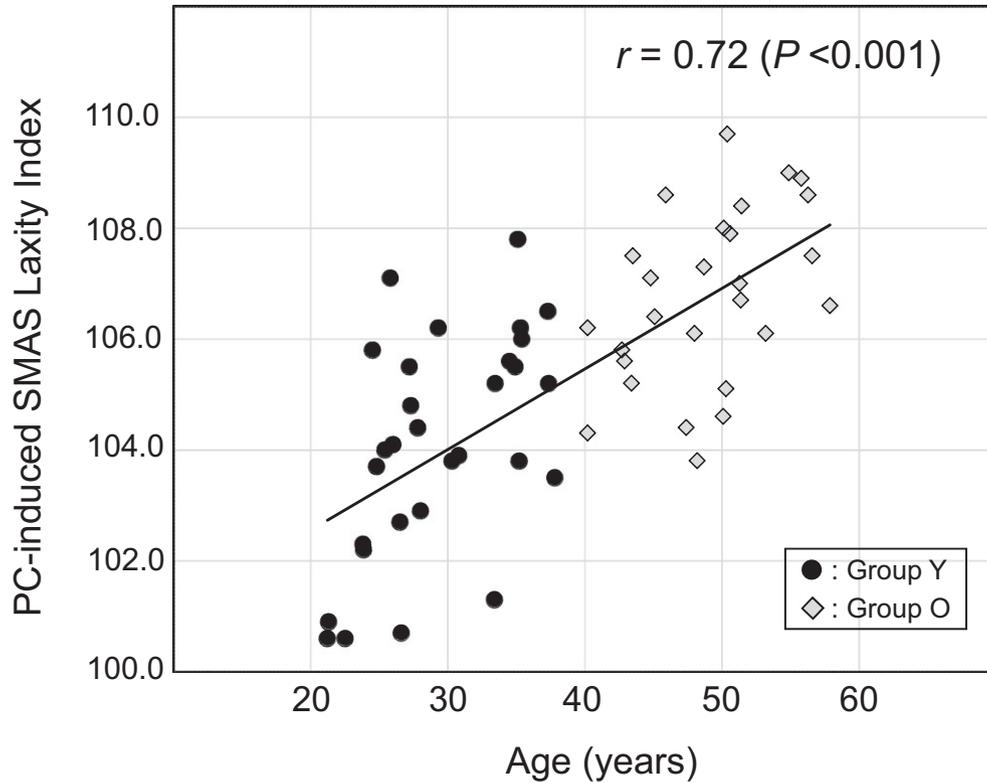


FIGURE 2 Correlation between the PC-induced SMAS Laxity Index and age. A strong and significant positive correlation was detected between the PC-induced SMAS Laxity Index and age ($r = 0.72$; $P < 0.001$). Specifically, the PC-induced SMAS Laxity Index increases with age. ●: subjects of the Group Y, ◇: subjects of the Group O

2.4 | Statistical analysis

The ages of the subjects are presented as the mean \pm standard deviation. The PC-induced SMAS Laxity Index values are presented as the mean \pm standard deviation. The mean values between the two age (Group Y and Group O) groups were compared using an independent sample *t* test. A correlation analysis was performed to determine the relationship between the PC-induced SMAS Laxity Index and age. The statistical analyses were performed with EZR (Saitama Medical Center, Jichi Medical University, Saitama, Japan), which is a graphical user interface for R (The R Foundation for Statistical Computing, Vienna, Austria). Specifically, EZR is a modified version of R commander that is designed to add statistical functions frequently used in biostatistics. *P*-values < 0.05 were considered statistically significant.

3 | RESULTS

3.1 | Measurement of the PC-induced SMAS Laxity Index

The overall quality of the 3-D CT images was adequate and did not hinder the measurement of the SMAS Width. The mean PC-induced SMAS Laxity Index of the 57 volunteers, which was calculated based on the measurements made by two observers, was 105.4 ± 2.38 . The PC-induced SMAS Laxity Index in Group Y (104.1 ± 1.45) was

significantly smaller than the corresponding value in Group O (106.8 ± 1.15 ; $P < 0.001$). Hence, our calculations indicated that the SMAS supporting force in the older subjects was less than the force observed in the younger subjects.

3.2 | Analysis of the Relationship between the PC-induced SMAS Laxity Index and age

Our analysis revealed a strong and significant positive correlation between the PC-induced SMAS Laxity Index and age (Figure 2; $r = 0.72$; $P < 0.001$), which confirmed that the PC-induced SMAS Laxity Index increased with age. Specifically, the PC-induced SMAS Laxity Index was smaller and the morphological changes in the face were less pronounced in the younger subjects (Figure 3). Conversely, increased age correlated with higher PC-induced SMAS Laxity Index values and more profound morphological changes in the face (Figure 4).

4 | DISCUSSION

Facial ageing occurs as the anatomical structures in the skin, facial expression muscles, SMAS, retaining ligaments and skull change over time.^[1-4] The SMAS, known as a subcutaneous fibromuscular structure distributed within the subcutaneous adipose tissues in the parotid and buccal areas,^[2-7] was first reported by Mitz

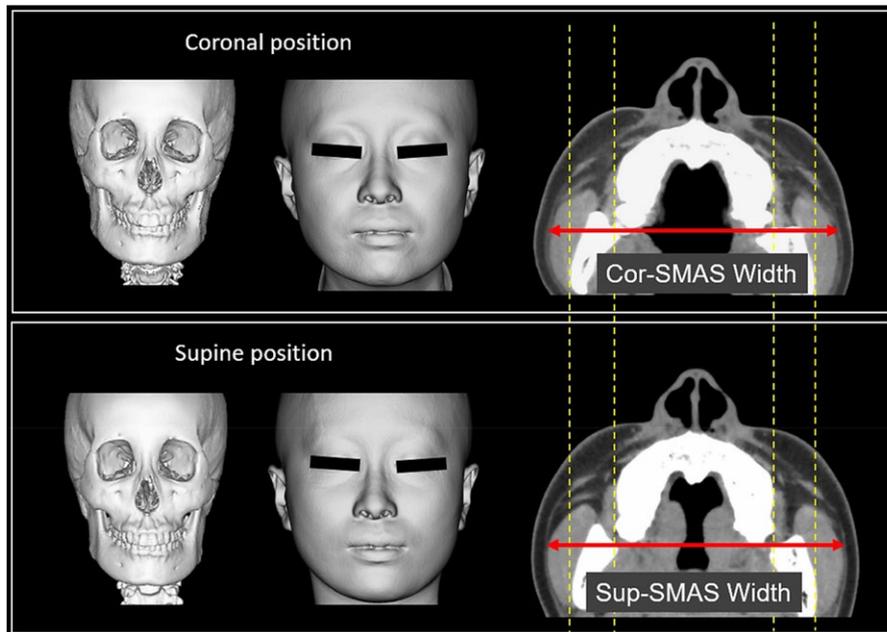


FIGURE 3 A 26-y-old woman. The PC-induced SMAS Laxity Index was 100.7. The PC induced fewer changes in the facial appearance, suggesting that the SMAS supporting force was strong

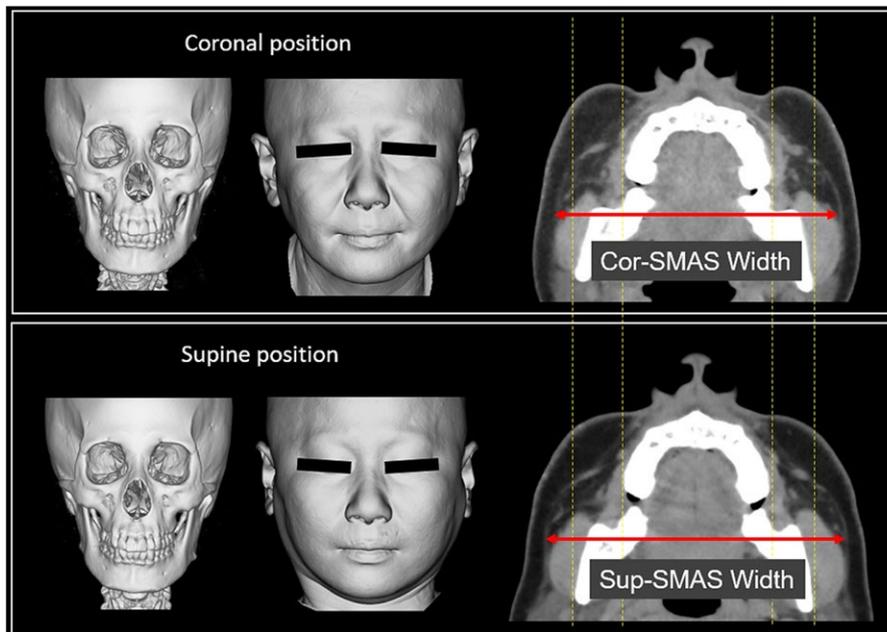


FIGURE 4 A 50-y-old woman. The PC-induced SMAS Laxity Index was 107.9. The SMAS supporting force has been lost, as indicated by changes in the facial appearance easily induced by the PC

and Peyronie^[7] in 1976. Age-related decreases in the SMAS supporting force reportedly result in signs of ageing, such as cheek sagging.^[3,4,6] Accordingly, a facelift surgery is performed to pull the SMAS up to relieve cheek sagging and to restore a youthful appearance.^[3,4,6,11,12]

To evaluate the SMAS supporting force, we focused on morphological changes in the face following a posture change.^[8-10] Because we expected that a change in posture would induce different morphological changes in older adults with apparent signs of

ageing, we attempted to develop a SMAS Laxity Index that incorporated the effects of posture change. To this end, the MDCT imaging modality was used to accurately measure the morphological changes in the SMAS that were associated with a posture change. Current CT imaging technology can provide high-resolution images, allowing detailed visualization of the facial appearance and the subcutaneous anatomic structures.^[13,14] Moreover, the workstation, which serves as the image analysis device, can create various 3-D CT images as well as reconstructed images. Maxillary

and mandibular morphology was used as a reference to generate cross-sectional images of the supine and coronal positions at the same level. Using this approach, we were able to achieve highly reproducible measurements.

The results of our study demonstrated that ageing could promote SMAS laxity and reduce the ability of the SMAS to support the face. In addition, we determined that SMAS laxity was greater in older subjects and that changes in their facial appearance were easily induced by a PC (Figure 4). Our previous studies, in which the SMAS laxity was quantified using MDCT, revealed the usefulness of the imaging modality.^[13-15] Nonetheless, our current results provide objective evidence of the relationship between age and SMAS laxity, which is a significant cause of cheek sagging. As a reason for the correlation between the SMAS laxity and age, we concluded that the SMAS lost its supporting force with age and the SMAS configuration changed easily by PCs.

In summary, our study entailed a SMAS laxity analysis based on a single axial section. In the future, it would be preferable to examine SMAS, which is widely distributed over the temporal and neck regions under the skin of the head and neck, using additional sections.^[3,4,7,16] Nevertheless, we were able to detect age-related SMAS laxity. As well, because the MDCT evaluation method is highly objective, we were able to confirm our knowledge of the loss of the SMAS supporting force due to facial ageing obtained via dermatology and aesthetic plastic surgery. Finally, our results indicate that clinical applications could contribute to the elucidation of the mechanisms underlying the facial ageing process.

CONFLICT OF INTEREST

The authors have declared no conflicting interests.

AUTHOR CONTRIBUTION

NY and IO designed the study, reviewed the information from the 57 subjects who comprised the study population, analysed the SMAS laxity data, gathered the SMAS Laxity Index results, engaged in the overall discussion of the results and wrote the manuscript. KA provided

information on prior SMAS anatomic studies, validated the SMAS analysis method and discussed the study results from an anatomical standpoint. YS contributed insight into the clinical considerations and the SMAS laxity analysis, and participated in the discussion in terms of the aesthetic plastic surgery. All authors agreed to the submitted and revised version of the manuscript.

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