Dynamic Evaluation of Facial Muscles: 3D Skin Displacement Vector Analysis

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INTRODUCTION

An objective quantification of minute skin movement has been shown to be provided by 3D skin vector displacement analysis. This study aimed to investigate skin movement using state-of-the-art 3D skin vector displacement analyses and relate the measurements to the shape of facial wrinkles. The results of this investigation led to the for mation of more individualized neuromodulator injection schemata. Therefore, in this study, we sought to develop educational materials that could be used to teach physicians the shape and function of indi vidual muscles. To this end, we drew muscles on the face of a volun teer using body painting and employed 3D skin vector displacement analysis to quantify the movement of the muscles.

Methods

Face painting and 3D skin vector displacement analyses enabled the visualization of all the facial muscles involved in facial expressions working dynamically, and allowed us to visualize the effect of each muscle in the creation of hyperkinetic wrinkles. With this method, we learned various morphological features related to the contraction of facial expression muscles that had been previously overlooked. The outer boundary of the skin that moves in response to muscle contraction is outside the muscle insertion area. Therefore, the range of skin displacement due to muscle contraction was wider than that of the muscle. Even in one muscle, the size of the skin displacement was different, depending on the part. Differences in the extent and size of skin displacement were observed between the same muscle groups on the left and right sides. Although wrinkles occur mainly in areas where skin displacement appears, they may also occur in areas with no skin displacement. In most cases, multiple synergistic muscles contract to make one wrinkle or one expression. When synergistic muscles contract to form a facial expression, the antagonists relax and lengthen. Furthermore, the vector of skin displacement developed by muscle contraction for each muscle has a characteristic direction.

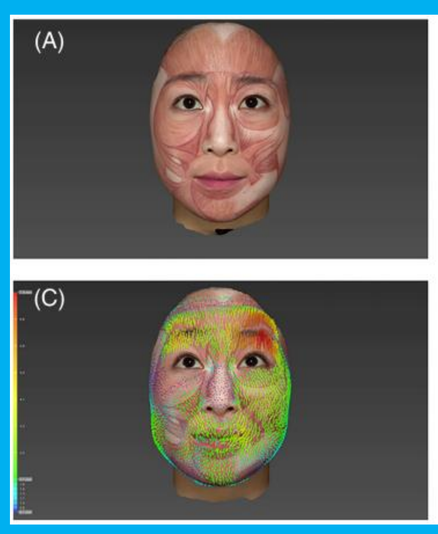

FIGURE 1 Horizontal forehead wrinkle lines. When the frontalis muscle is contracted to raise the eyebrows, the lower part of the frontalis muscle contracts. When the frontal muscle contracts, skin displacement is also observed on the medial side of the temporal region. A, Static status. B, Dynamic status. C, Skin displacement amount shown by arrows

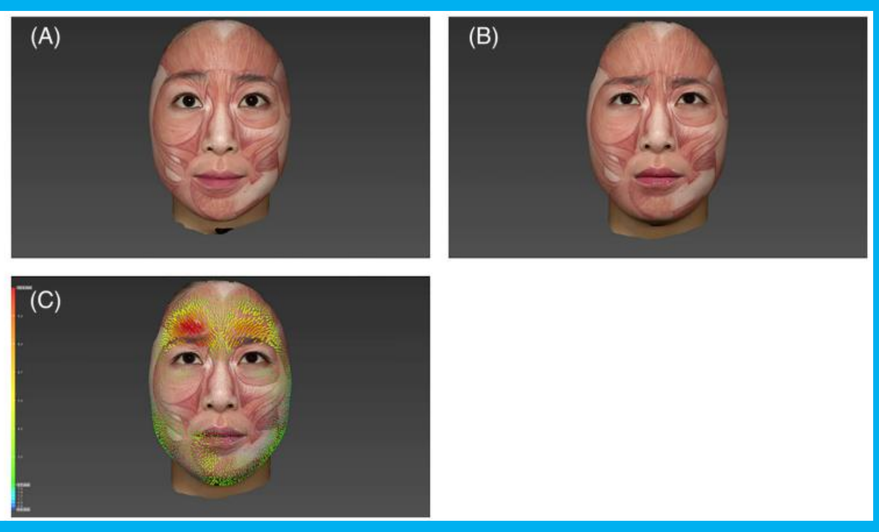

FIGURE 2 Glabellar frown lines. When glabellar wrinkles are made, the entire eyebrow moves downward and inward. In other words, all muscles involved pull the eyebrow medial down. The inner third of the eyebrow is pulled the most, while the degree of outward pulling is weak. A, Static status. B, Dynamic status. C, Skin displacement amount shown by arrows

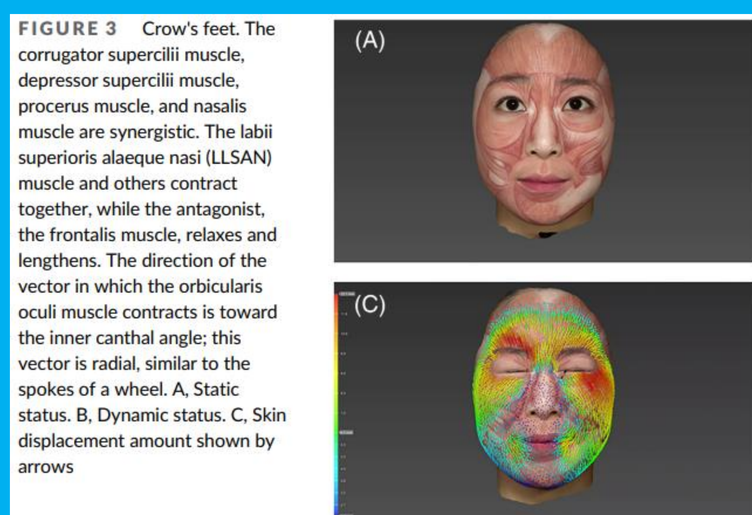

FIGURE 3 Crow's feet. The corrugator supercilii muscle, depressor supercilii muscle, procerus muscle, and nasalis muscle are synergistic. The labii superioris alaeque nasi (LLSAN) muscle and others contract together, while the antagonist, the frontalis muscle, relaxes and lengthens. The direction of the vector in which the orbicularis oculi muscle contracts is toward the inner canthal angle; this vector is radial, similar to the spokes of a wheel. A, Static status. B, Dynamic status. C, Skin displacement amount shown by arrows

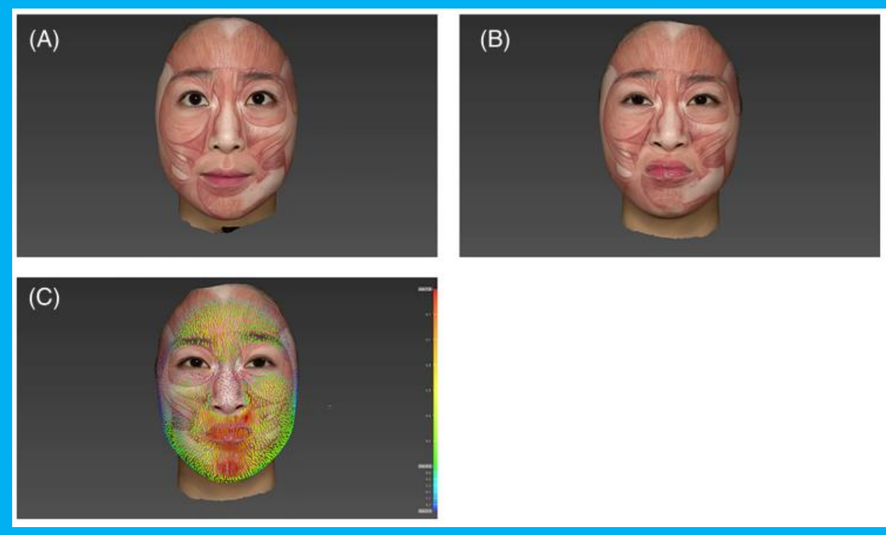

FIGURE 4 Nose. The wrinkles of the nasal dorsum are mainly caused by the nasalis muscle. However, in the current study, there was little skin displacement on the nasalis of the model, with the majority of the contractions found in the LLSAN muscle. A, Static status. B, Dynamic status. C, Skin displacement amount shown by arrows

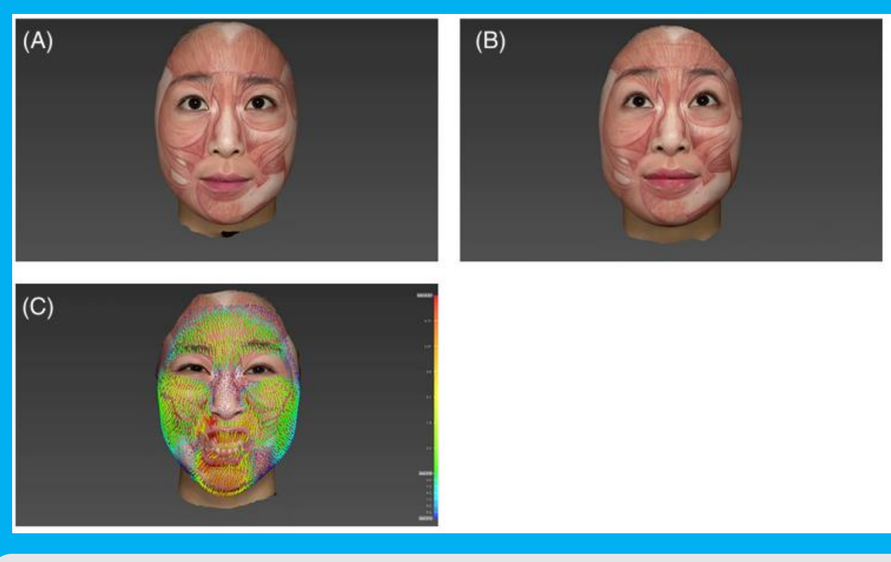

FIGURE 5 Gummy smile. The target muscles to improve excessive gingival display were the zygomaticus minor muscle, LLSAN muscle, and levator labii superioris (LLS) muscle. The muscles involved in raising the upper lip were the zygomaticus minor muscle, LLSAN muscle, and LLS muscle. A, Static status. B, Dynamic status. C, Skin displacement amount shown by arrows

DISCUSSION

The development of facial expression wrinkles are part of a natural aging process caused by repetitive facial muscle contraction and skin damage. Botulinum toxin A can be used to eliminate dynamic wrinkles by affecting the muscles involved with facial expressions. It is, there fore, essential to know the location, origin, insertion, function, and changes of the facial expression muscles according to their contrac tion. Existing anatomical knowledge based on cadaver dissection has limitations in that the dynamic changes caused by muscle contraction have not been determined.

The botulinum toxin A injection educational model using face painting and 3D skin vector displacement analyses can provide a deeper understanding of actual moving muscle anatomy and, consequently, lead to a more practical and safe treatment.

REFERENCES

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