

ORIGINAL

Relationship between the Volume of Masticatory Muscle and Volume of the Mandibular Region Corresponding to the Denture Base in Japanese Edentulous Mandible

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Abstract : The volume of masticatory muscle and volume of the mandibular region corresponding to the denture base (V.M. D. B.) of edentulous Japanese cadavers were measured using Spiral X-ray CT to assess the correlation between masticatory muscles and V.M. D. B.. For the results, the average volume was the highest for the masseter ($15.06 \pm 7.12 \text{ cm}^3$, $n = 32$), followed by the medial pterygoid ($6.72 \pm 2.94 \text{ cm}^3$, $n = 32$) and lateral pterygoid ($5.74 \pm 2.76 \text{ cm}^3$, $n = 32$). The average volume of the mandible of the male cadavers was $52.69 \pm 10.01 \text{ cm}^3$ ($n = 18$), and that of female cadavers was $36.11 \pm 6.22 \text{ cm}^3$ ($n = 14$). The average volume of the V.M. D. B. of male cadavers was $6.58 \pm 2.79 \text{ cm}^3$ ($n = 18$), and that of female cadavers was $3.51 \pm 1.36 \text{ cm}^3$ ($n = 14$). The relationship of the masticatory muscles with the volume of the mandible and V.M. D. B. was assessed statistically, and the results showed that the volume of the mandible and V.M. D. B. correlated with the volumes of the medial and lateral pterygoids, but not with the volume of the masseter. The results suggest that various factors may be involved in the relationship between muscle and mandible volumes, and poor denture fit or misuse may play a major role. And if prosthetic factors play a major role in anatomical structure, the volumes of the medial and lateral pterygoids are unlikely to be affected by the use of dentures, but the volume of the masseter can be affected by denture use.

Introduction

Numerous studies¹⁻⁵⁾ have investigated the relationship between mastication and the residual ridge in edentulous Japanese patients from a prosthetics point of view. The assessment of the masticatory force of the masticatory muscle and the effects of masticatory force on the residual ridge are important for design-

ing well-fitting dentures and maintaining sufficient masticatory function. Hence, morphometrical investigations of the masticatory muscle and residual ridges are required.

In the past, studies have been conducted to assess the masticatory force of the muscle by directly measuring the force^{6,7)}, determining the cross-sectional area of the muscle⁶⁻⁸⁾ or calculating the volume of the muscle, based on integration of cross-sectional areas⁹⁾. In the case of residual ridges, studies have been conducted to measure denture base area^{10,11)} and residual ridge height^{12,13)}, or the volume of the

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mucosal surface⁶⁾ of dentures has been determined by means of measuring replicas or using sectional images of the CT.

Spiral X-ray CT has been performed more frequently in recent years, and various body regions are reconstructed in three dimensions for morphological observation and measurement. In 2005, Fukushima¹⁴⁾ performed spiral X-ray CT to measure the volume of the masseter of cadavers donated for anatomical research, and reported that it was possible to measure the volume of the masseter with an error of less than 5%, when compared to the water displacement method. Fukushima¹⁴⁾ further investigated the volume changes occurring before fixation to three months after fixation. This was a valuable study as it showed that the volume of the masseter can be estimated from cadavers.

In the present study, the methods of Fukushima¹⁴⁾ were employed, and measurements of the volume of masticatory muscle and volume of the mandibular region corresponding to the denture base (V.M.D. B.) of edentulous Japanese cadavers were made using X-ray CT to assess the correlation between masticatory muscle and V.M.D. B..

Materials and Methods

1. Materials

Thirty-two cadavers, which were donated for anatomical research to the Tsurumi University School of Dental Medicine, were used in this study. The age of these cadavers ranged from 70 to 105 years with an average age of 82.8 years. There were 18 male and 14 female cadavers. The duration of cadaver storage ranged from 0 to 11 years, with an average duration of 3.66 years.

In the present study, the use of the cadavers satisfied the following conditions : 1) the rules and regulations set forth by the Shiunkai, an association that promotes body donation to Tsurumi University ; 2) a family consent form for anatomical research and education, designed in accordance with the rules and regulations set forth by the cadaver law, was signed by the head of each family ; 3) an informed consent form for the use of the body for educational purposes

and research as specified by the Anatomy Department, Tsurumi University School of Dental Medicine was signed by the head of each family at the time of body donation.

2. Methods

1) Fixation of donated cadavers

The donated cadavers were subjected to perfusion fixation by injecting 4.5 liters of 10% neutral buffered formalin solution into the right femoral artery. The bottle containing the solution was suspended approximately one meter above the body to avoid perfusion into other blood vessels. The entire body was then soaked and preserved in a 40% SOLMIX solution (original solution containing 97% methanol, Shinwa Chemical Co. Ltd., Tokyo).

2) Measurement of muscle and bone volumes by spiral X-ray CT

Spiral X-ray CT (RADIX-Prima, Hitachi Medico Co. Ltd.) was used in this study. Acrylic resin plates, nylon bands and urethane sponges were used to fix the head so that the mandibular plane was orthogonal to the Z axis (direction of table movement), according to the methods of Tsuchida¹⁵⁾ and Yoshida¹⁶⁾. High speed spiral scanning was carried out under the following conditions : tube voltage 120 kV, tube current 100 mA, slice thickness 1 mm, and table speed 1 mm/sec. CT imaging was performed by the same operator in all cases. Based on the resulting CT images, a three-dimensional polygon model was prepared using Zid View (LEXI, Tokyo). Using Rapid Form (Inius Technology, Inc., Korea), the volumes of the masseter, medial pterygoid, lateral pterygoid, mandible and mandibular region corresponding to the denture base were measured by preparing three-dimensional models (Fig. 1). In this study, the temporal muscles were not measured because they had already been dissected by students for educational purposes. According to Fukushima's method¹⁴⁾, the threshold for volume measurement was determined as a binarized threshold, where the anteroposterior and mediolateral diameters mostly matched at the venter of the masseter, and the extent of the masseter was determined based on the area of the density as specified by the threshold. The extents of the medial and lateral ptery-

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