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Association between occlusal curvature and masticatory movements with different test foods in human young adults with permanent dentitions

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ABSTRACT

Objective: Occlusal curvatures such as the curve of Spee, curve of Wilson and Monsons's sphere exist in the human adult mandibular arch. A previous study showed that human young adults with flatter occlusal curvatures had higher ability of food comminution and mixing. The aim of this study was to clarify functional significance of occlusal curvatures in terms of masticatory movements. This study investigated the association between occlusal curvature and mandibular movements while chewing a variety of food items.

Design: Forty-six young adults with complete dentitions (mean age, 25.0 years) participated in the study. Sphere radius of occlusal curvature was determined by a three-dimensional analysis of the mandibular arch based on the Broadrick flag method. Mandibular movements during unilateral chewing of six test food items (chewing gum, cheese, kamaboko, boiled beef, gummy jelly and raw carrot) until the subjects felt ready to swallow were recorded using a six-degrees-of-freedom mandibular movement recording system, and 11 parameters for masticatory movements of a lower incisal point of the mandible were analysed.

Results: Linear regression analyses identified the sphere radius as a significant predictor for closing velocity in all test food items, occluding/cycle duration in 3 items, opening velocity, closing duration and chewing time in 2 items, and opening duration in 1 item ($P < 0.01$). The results suggest that subjects with larger sphere radius (flatter occlusal curvature) in the mandibular arch could prepare food bolus effectively for swallowing.

Conclusion: Occlusal curvature seems to be associated with masticatory movements in young adults with permanent dentition.

1. Introduction

Occlusal curvatures are normally observed in the human adult dentition. In sagittal view, the anteroposterior curve that contacts the tips of buccal cusps of mandibular molars and canine, and appears concave, is called the curve of Spee.[1] In frontal view, the mediolateral curve along the buccal and lingual cusp tips of mandibular molars on each side of the arch, which is also concave, is called the curve of Wilson.[2] Monson proposed a concept that the sagittal and frontal curves form a sphere with 4-in. radius (Monsons's sphere).[3]

It is believed that occlusal curvatures are associated with contacts between maxillary and mandibular posterior teeth in

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eccentric movements. The curve of Spee may permit disclusion of posterior teeth in protrusive mandibular movement[4,5] and the curve of Wilson may allow lateral disclusion.[6] Thus, it is possible that the occlusal curvatures are associated with masticatory function. However, there is limited evidence regarding this. A study on primates suggested that orientation of the masseter muscle is related to curve of Spee and that it affects bite force in food comminution.[7]

Occlusal curvature can be reconstructed by prosthetic restoration. The Broadrick flag (Broadrick Occlusal Plane Analyzer; Teledyne Water Pik, Fort Collins, CO) is utilized for analysing the existing occlusal plane or reconstructing the posterior dentition using Monsons's 4-in. sphere as an ideal occlusal plane for providing harmonious occlusion. However, it is not well known whether occlusal curvature is associated with masticatory function.

Recently, cross-sectional studies on human adults showed that occlusal curvatures were associated with masticatory function with respect to bite force,[8] food comminuting, and mixing ability.[9] Subjects with three-dimensionally flatter occlusal curvatures in mandibular arch showed greater force during maximal voluntary clenching,[8] higher ability of comminuting peanuts and mixing a wax cube.[9] On the other hand, some studies have shown that masticatory movement parameters are predictors for food comminuting and mixing ability.[10–13] Greater vertical amplitude and closing velocity of mandibular movements while chewing test foods were related to higher ability of food comminution[10,11] and food mixing.[12,13] Thus, it can be hypothesized that subjects with flatter occlusal curvatures would show masticatory movements with greater vertical amplitude and faster closing velocity for chewing stroke. In addition, it is not clear whether subjects with flatter occlusal curvatures could prepare food bolus for swallowing with less number of chewing strokes and chewing time. It is well known that masticatory movement patterns are affected by food type[14] and property such as hardness.[15,16] The association between occlusal curvature and masticatory function may be mediated by food type. In fact, the chewing ability for a hard food (peanuts) was strongly related to occlusal curvature compared to mixing ability of a soft wax.[9] Therefore, we employed a variety of food items for chewing test. The aim of this study was to investigate the association between occlusal curvature and masticatory movements in human young adults.

2. Materials and methods

2.1. Subjects

Forty-six subjects (21 females, 25 males, mean age 25.0 years, range 20–32 years), with completely natural dentition and Angle Class I molar relationship, participated in this study. They were recruited from among the students and clinical staff of Tokyo Medical and Dental University and had participated in a previous study.[9] Subjects with severe periodontal disease, orthodontic treatment and clinical signs or symptoms of temporomandibular disorder and salivary dysfunction were excluded. Each subject received a written and oral description of the experimental procedure, and informed consent was obtained prior to enrolment into the study.

2.2. Occlusal curvature

A three-dimensional analysis was performed to determine occlusal curvature using a method validated in a previous study.[17] The procedure is described briefly as follows. Upper and lower dental casts of each subject were mounted on a semi-adjustable articulator. The mandibular cast mounted on the lower member of the articulator was fixed to a three-dimensional measuring gauge (QM-measure 353, Mitsutoyo Mfg., Tokyo, Japan). The coordinates of the mid-points of the canine cusps, and the buccal and lingual cusps of the premolars, first and second molars were measured and digitized. The mandibular arches were mathematically oriented according to a common intrinsic orientation (y-axis, antero-posterior; x-axis, right-left; and z-axis, caudo-cranial). The approximate spheres were calculated from the measurements according to the Broadrick Occlusal Plane Analyzer (Denar Corporation, Anaheim, CA, USA)[6,17–19] using a custom made software. For each arch in the subject, the three-dimensional curvature of the occlusal surfaces was modelled using a sphere. The radius of the sphere was estimated using a special computer program. The sphere was set to cross the coordinates of canine and second molar disto-buccal cusps. The radius was estimated using progressive approximations that minimized the sum of the squared differences between the distances from the premolar and molar cusp tips to the centre of the fitted sphere. The sphere radius (SR) (mm) was determined on the right and left sides of the mandibular dental arch (Fig. 1), and it was used as an index for occlusal curvature in this study. Since SR showed asymmetric distribution,[9] statistical analyses were conducted after logarithmic transformation of the data.

2.3. Test food items

Test food items with a variety of textures such as chewing gum (Free zone, LOTTE Co., Ltd. Tokyo, Japan), processed cheese (Q.B.B. Cheese, Rokko Butter Co., Ltd., Kobe, Japan), kamaboko (Kibun Foods Inc., Tokyo, Japan), boiled shank beef (80 °C, 30 min), gummy jelly (UHA Mikakuto Co., Ltd., Osaka, Japan) and raw carrot, were offered to subjects. The chewing gum has a soft texture and can be easily chewed by denture wearers. The weight of the chewing gum was 2 g, which was recommended by other researchers since the 2-g bolus of soft gum provides the least within-subject variability.[20,21] Kamaboko is a Japanese traditional food made of boiled surimi (fish myofibrillar proteins) and it has soft and elastic texture like gelatine. The gummy jelly used in this study was developed for evaluation of masticatory performance and it has elastic and tough texture.[22,23] The cheese, kamaboko, boiled beef, raw carrot and gummy jelly were prepared with dimensions 10 mm × 10 mm × 20 mm that corresponded to the volume of chewing gum (2.0 g).

2.4. Assessment of hardness of the test food items

Subjective (perceptive) hardness of the test foods was examined using a method applied in a previous study.[24] Twelve subjects with compete dentition were asked to bite down on a test piece once, between the molar teeth on their

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