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Association between occlusal curvature and food comminution and mixing in human young adults with permanent dentitions

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ARTICLE INFO

Article history:
Accepted 15 June 2012

Keywords:
occlusal curvature
Broadrick flag
Mastication
Food comminution
Food mixing

ABSTRACT

Objective: Occlusal curvatures in human adult dentition such as the curve of Spee, curve of Wilson and Monsons's sphere provide clinical guidance for prosthetic rehabilitation and orthodontic treatment. However, association between occlusal curvature and masticatory function is not known. The aim of this study was to investigate the association between occlusal curvature and food comminuting and food mixing ability in human young adults with permanent dentitions.

Design: Fifty young adults with complete dentitions (mean age, 25.0 years) participated in the study. Occlusal curvature was determined by a three-dimensional analysis of the mandibular arch according to the Broadrick flag method. Food comminuting ability was assessed using a masticatory performance test with peanuts as test food and it was scored as median particle size. Food mixing ability was assessed using a mixing ability test with a two-coloured wax cube and it was scored as mixing ability index.

Results: A linear regression analysis identified the sphere radius of occlusal curvature as significant predictor for both median particle size and mixing ability index after controlling for maximum bite force ($P < 0.001$). These results indicated that subjects with a flatter curvature (larger sphere) in the mandibular arch showed better food comminuting and mixing ability. Coefficient of determination (R^2) of occlusal curvature related to median particle size and mixing ability index was comparable to that of maximum bite force.

Conclusion: Occlusal curvature seems to be associated with food comminuting and mixing ability in human young adults with permanent dentitions.

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] Increase in the radius of curve of Spee is associated with craniofacial morphology such as the decrease in the horizontal position of the dentition with respect to condyle (O-M), decrease in the sagittal position of the mandible to anterior cranial base (SNB), and increase in the ratio between posterior and anterior height (S-Go/N-Me).[4,5] Increase in the depth of the

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0003–9969/$ – see front matter
http://dx.doi.org/10.1016/j.archoralbio.2012.06.006

curve of Spee is associated with increase in over bite and over jet.[5,6] Increase in radius of Monson's sphere is associated with decrease in over bite.[7] Radius of Monson's sphere varies greatly among individuals and the average is found to be very close to 4-in. in the permanent dentition in Caucasian adults,[8,9] but radius of Monson's sphere in Caucasian adults was smaller than that in Japanese young adults.[7]

Clinically, these occlusal curvatures observed in subjects with complete dentition are relevant to acceptable occlusion.[10] Curve of Spee may permit disclusion of posterior teeth in protrusive mandibular movement.[11] As the angle of condylar guidance is greater than the curve of Spee, posterior disclusion is achieved.[12] The curve of Wilson may provide lateral disclusion.[13] Occlusal curvature can be reconstructed by prosthetic restoration or it can be altered with orthodontic treatment. The Broadrick flag (Broadrick Occlusal Plane Analyzer; Teledyne Water Pik, Fort Collins, Colo) 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.[14] On the other hand, it is widely accepted that flattening of the occlusal plane is one of the goals of orthodontic treatment.[15] Levelling of the curve of the Spee is accepted as a routine procedure in treatment of deep bite malocclusion,[16,17] and maintaining the level of the curve after treatment is critical for success of orthodontic treatment.[18–20] Excessive occlusal curvature may be associated with presence of clicking and locking of temporomandibular joint in patients with craniomandibular disorders.[21]

Mastication is a process to digest foods that includes breaking down and comminuting, mixing and kneading and transporting the food bolus into the oropharynx. To evaluate masticatory function objectively, a number of methods has been developed.[22] The most common chewing test is to evaluate ability of food comminution using hard and brittle foods such as peanuts and raw carrot[23,24] or synthetic materials.[25] In recent studies, gum and paraffin wax that have soft and cohesive property have been developed to evaluate food mixing ability.[26,27] Various factors are known to be associated with masticatory function, such as tooth loss, maximum bite force, gender, age, sensory function, tongue motor skill and salivary function.[22] Since the impact of missing occlusal units on objective masticatory function is greater than that of maximum bite force,[22] it may be hypothesised that tooth factors such as occlusal curvature could be associated with masticatory function. However, the association between occlusal curvature and masticatory function remains unknown. Thus, the aim of this study was to investigate the association between the radius of three-dimensional occlusal curvature and food comminuting and mixing ability.

2. Materials and methods

2.1. *Subjects*

Fifty subjects (mean age 25.0 years, 20–32 years) balanced for gender 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. 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. All experimental procedures were approved by the Ethics Committee of Tokyo Medical and Dental University.

2.2. *Occlusal curvature*

Three-dimensional analysis was performed to determine occlusal curvature using a method validated in a previous study.[7] 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)[7,9,13,14] 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 or left side of the mandibular dental arch (Fig. 1), and it was used as an index for occlusal curvature in this study. The measurement side was selected randomly using the coin toss method in each subject. Since SR obtained in this study showed asymmetric distribution (Fig. 2), statistical analyses were conducted after logarithmic transformation of the data.

2.3. *Food comminuting ability*

Food comminuting ability was estimated with a masticatory performance test using peanuts as test food.[23,24] Subjects were directed to chew 3-g portions of peanuts for 20 strokes on the same side for SR. Three experimental trials were performed. The chewed peanuts were retrieved and combined for all three portions of the test on each chewing side. The particles were sieved through a stack of eight sieves with various apertures (sieve diameter; 0.18, 0.25, 0.425, 0.85, 1.7, 2.0, 4.0 and 6.0 mm). The particles remaining on each sieve were stored in an incubator at 80 °C for 3 h. The distribution of particle sizes by weight of the comminuted food can be mathematically described by the cumulative function[25]: