Saitoh I, Tokutomi J, Hayasaki H, Iwase Y, Raoquig H, Yamasaki Y and Nonaka K.  
Correlations between incisor and condyle motion during protrusion in children with primary dentition.  

The purpose of the study was to investigate the relationship between incisor and condyle movement during protrusion in children with primary dentition. Subjects were categorized into two age groups. A primary dentition group consisted of 20 children and a permanent dentition group consisted of 25 women. The occlusions and TMJs in both groups were normal, with no history of orthodontic treatment. Three orthogonal excursive ranges, linear distance and curvilinear distance of the incisal and condylar points; Sagittal angle of the condylar rotation; and correlations between incisor and condyle distances during protrusion were estimated by using multilevel statistical models. Protrusion in children with primary dentition was characterized by: 1. significantly smaller superior-inferior ranges for incisal and condylar points in children than in adults; 2. strong positive correlations between incisor and condylar antero-posterior ranges and linear distances, a pattern similar to that in adults.

Buschang PH, Throckmorton GS, Austin D, Wintergerst AM.  
Chewing cycle kinematics of subjects with deepbite malocclusion.  
Am J Orthod Dentofacial Orthop. 2007 May;131(5):627-34.

INTRODUCTION: The notion that chewing cycle shape and cycle dynamics differ between subjects with and without malocclusion is largely based on qualitative studies that combined various types of malocclusion. The purpose of this prospective study was to determine whether chewing cycle kinematics of untreated young adults with deepbite malocclusion differ from those with normal occlusion. METHODS: Twenty-three deepbite subjects (>50% overbite) and 24 controls with normal occlusion chewed gum (right side only) while their jaw movements were recorded at 100 Hz by using an optoelectric jaw tracking system. RESULTS: Differences in cycle duration between deepbite and control subjects were small and not significant (P >.05). The deepbite subjects showed significantly (P <.05) less maximum inferior excursion (7.7 vs 9.0 mm) and significantly greater maximum posterior excursion (5.1 vs 4.0 mm) than subjects with normal occlusion. In addition, the deepbite subjects had significantly smaller maximum vertical velocities than subjects with normal occlusion (49.2 vs 60.8 mm per second). Deepbite subjects also showed significantly (P <.05) less cycle-to-cycle variability in maximum velocities and excursions to the balancing side but significantly (P <.05) greater variability in cycle duration and maximum posterior excursions. CONCLUSIONS: A deepbite malocclusion alters the shape of chewing cycles and the consistency of chewing cycle kinematics.

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Baqaien MA, Al-Salti FM, Muessig D.  
Changes in condylar path inclination during maximum protrusion between the ages of 6 and 12 years.  

The purpose of this study is to quantify the changes in sagittal condylar path inclination during mandibular protrusion between the ages of 6 and 12 years. A total of 172 children (82 males and 90 females) ranging in age from 6.5 to 12.9 years were divided according to their chronological age into five subgroups with mean ages of 7.1, 8, 9, 10 and 11.4 years respectively. The control group consisted of 41 adults with a mean age of 28 years. All subjects had a normal temporomandibular joint function and neutral occlusion. Five maximum protrusion-retrusion movements were recorded with six degrees of freedom in each subject using an ultrasound (JMA) jaw-tracking system. Initially, condylar path inclination angle (CPIA) was calculated stepwise for each millimeter distance, for the first 10 mm of
protrusive tracing path on both sides. A single mean value was then assigned for the entire protrusive path. One-way analysis of variance proved to be significant among the five subgroups of children. Linear regression analysis showed that condylar path had a tendency to become steeper with age, although it was statistically weak. The data indicated that the mean CPIA is 43 degrees -44 degrees at the age of seven, increases annually by 1.2 degrees -1.3 degrees and reaches an average of 49 degrees -50 degrees by the age of 12 at which time it attains around 83-85% of its adult level. In subgroup V, the female population had significantly steeper condylar path on the left-hand side than the male population. Condylar path inclinations indicated a symmetrical growth pattern of the articular eminence.

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The pathomechanics of degenerative joint disease of the temporomandibular joint (TMJ) may involve fatigue produced by mechanical work on the articulating tissues. This study tested the hypotheses that mechanical work in the TMJ (i) varies with the type of mandibular activity, and (ii) is evenly distributed over TMJ surfaces. Ten healthy human participants were recorded with Magnetic Resonance Imaging (MRI) and jaw tracking. The data were used to reconstruct and animate TMJ activity. Aspect ratios, instantaneous velocities, and distances of stress-fields translation were used to calculate work (mJ). The results were analyzed by least-squares polynomial regression and ANOVA. Work magnitudes were related to peak velocity (R(2) = 0.92) and distance of stress-field translation (R(2) = 0.83), and were distributed over the joint surfaces (p < 0.03). During mandibular laterotrusion, average mechanical work was 1.5 times greater in the contralateral joint. Peak magnitudes of work (> 3000 mJ) were 4 times that previously reported.

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PURPOSE: A jaw motion tracking device that measures six degrees of freedom has recently been developed. Understanding jaw motion is useful, but previous measurement methods were impractical for use in dental clinics. The overall aim of this study was to demonstrate the simple operation, low cost, and high precision of a recently developed jaw tracking device. In addition, this study explored its potential clinical applications. METHODS: In this study, we compared two jaw motion tracking devices: a digital system type of device and an optical type of device. First we established a baseline occlusal plane from which to measure jaw motion in the same subject with both devices. The jaw motion signals were sampled at a frequency of 100 Hz. The subjects were three healthy women (mean age +/- SD = 26.3 +/- 1.2 years) who were recruited from among the crown-and-bridge faculty of Tsurumi University of Dentistry. The jaw motions measured were open-close movement, sagittal border movement, and frontal border movement. In addition, the kinematic axis point was calculated from the sagittal border movement. Data from the digital system type of device and data from the optical device were compared. The data were selected to measure rotation and translocation, i.e. jaw position about protrusion, both laterotrusion and maximal opening of the mouth. RESULTS: The root mean square (RMS) error of position measurement was 0.163 mm with MM-JI-E and 0.178 mm with the optical type of device. The
RMS error of jaw motion measurement with the optical type of device was maximum at 0.8mm and minimum at 0.1mm. This was similar to that with digital system type of jaw motion tracking device.

CONCLUSION: This study showed the possibility of developing clinical applications for this jaw motion device.

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This paper describes a method for studying superficial and deep jaw muscle activity during standardized jaw movements under experimental jaw muscle pain. In 22 healthy adults, pain was elicited in the right masseter muscle via tonic infusion of 4.5% hypertonic saline and which resulted in scores of 30-60 mm on a 100-mm visual analogue scale. Subjects performed tasks in five sessions in a repeated measures design, i.e., control 1, test 1 (during hypertonic or isotonic saline infusion), control 2 (without infusion), test 2 (during isotonic or hypertonic saline infusion), control 3 (without infusion). During each session, subjects performed maximal clenching and standardized jaw tasks, i.e., protrusion, lateral excursion, open/close, chewing. Mandibular movement was recorded with a 6-degree-of-freedom tracking system simultaneously with electromyographic (EMG) activity from the inferior head of the lateral pterygoid muscle with fine-wire electrodes (verified by computer tomography), and from posterior temporalis, the submandibular muscle group and bilateral masseter muscles with surface electrodes. EMG root mean square values were calculated at each 0.5 mm increment of mandibular incisor movement for all tasks under each experimental session. This establishes an experimental model for testing the effects of pain on jaw muscle activity where the jaw motor system is required to perform goal-directed tasks, and therefore should extend our understanding of the effects of pain on the jaw motor system.

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Rate of change in movement acceleration (jerk) is a universally accepted quantity to evaluate irregularities of human limb and eye movements. This study was aimed to attest reliability of the jerk measurement of masticatory jaw movements and to identify its sensitivity to discriminate between movements performed with the presence of varied occlusal interference. Jaw movements during gum chewing were recorded with a 3D tracking device. Twelve adult subjects participated in the experiments. For five subjects, normalized jerk-costs (NJC) during jaw closing were compared between those measured on two separate occasions. For seven subjects, the NJCs during closing were compared with those measured with/without introduction of four different types of occlusal interference. The NJCs did not differ significantly between the two recording occasions. The interference at the canine tooth induced greater increase in the NJCs than that at the molar tooth. The comparison between repeated measures revealed reproducibility of the NJCs. In addition, the NJC was shown to be capable of discriminating between irregularities of the movements induced by occlusal interference at the canine and molar tooth sites. These findings suggest that the NJC is a valid indicator of masticatory jaw movement irregularity induced by disturbances of full intercuspation between upper and lower teeth.

The aim of this study was to confirm the precision of our simple and inexpensive jaw tracking system which combined the use of a digital camcorder and a motion capture software developed lately. A marker was attached to the mandibular incisors of the subject, and a mirror was assembled beside the subject's face to detect antero-posterior movement during chewing. Jaw movements, including the mirror images, were recorded by a digital camcorder. The movements were traced by a motion capture software and translated into 3D data using original handmade software. To confirm the beneficial performance of our system in measuring masticatory movement, the masticatory movements of five subjects were simultaneously recorded together with a conventional jaw tracking system. Trajectories obtained from both systems were similar, and the correlation coefficient values by simple regression analysis between both trajectories were 0.9 or higher for all subjects. It was confirmed that our system could record masticatory movement with sufficient precision equivalent to that of a conventional jaw tracking system.


Chewing or mastication is one of the main functions of the stomatognathic system. The use of devices for quantitatively measuring mandibular motion has recently become more common in scientific and clinical use. Often, the goal has been to provide an objective basis for diagnosing musculoskeletal disorders of the jaws, to monitor the progress of active treatment methods or to evaluate prosthodontic treatment functional results. To better understand differences between various systems to record mandibular motion a review of recording methods presented over the years was made. To give fundamental description for development of existing methods review was divided in three parts. Part II includes analyses of electronic and telemetric methods, magnetometry and opto-electronic methods, describing not only technologies by themselves, but also analyzing essential limitations, possible direction of the functional improvement and, specially, their scientific and clinical significance.
technologies by themselves, but also analyzing essential limitations, possible direction of the functional improvement and, specially, their scientific and clinical significance.

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The aim was to investigate the relationship between the vertical craniofacial morphology and the sagittal path of mandibular movements. The study was carried out in 40 subjects who were free of temporomandibular disorders. Mandibular movements and maximal jaw opening (MO) were recorded by means of a jaw tracking device. The opening-closing angle (OCA) was defined as the angle between the horizontal plane and the opening-closing path of movements. Vertical craniofacial morphology was assessed on profile cephalograms by means of the Frankfort Mandibular Plane Angle (MP). The OCA did not differ between males and females (P>0.05). OCA and MP were negatively correlated (r=-0.62; P<0.001). MO was significantly greater in males that in females (P<0.05). MO was negatively correlated to MP (-0.44<r<-0.49; P<0.05). The findings suggest that the low-angle subjects exhibit a more vertical path of the mandibular movements than that of high-angle subjects. Differences in the sagittal path of jaw movements may be partly ascribed to anatomical factors.

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There is limited knowledge of the effects of the occlusion on temporomandibular joint function. AIM: The aim was to investigate the influence of a working-side occlusal alteration (OA, i.e. interference) on trajectories of working-side condylar points during standardized lateral jaw movements (latero-trusion) tracked by a jaw-tracking system. METHODS: Ten trials of right latero-trusion were repeated under: control 1 (before OA), OA (immediately after placement of a working-side interference) and control 2 (immediately after removal of OA) conditions. RESULTS: During right jaw movement, the paths of the working-side condylar points under OA were significantly more inferior and anterior to those under control at the same amount of mid-incisor-point displacement from the intercuspal position. The OA significantly reduced the rotation of the mandible about the antero-posterior and supero-inferior axes and significantly increased the opening angle. Controls 1 and 2 were not significantly different. CONCLUSIONS: A working-side interference has an immediate, significant effect on working-side condylar movement.

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The purpose of this study is to introduce a new technique for recording the kinematics of the temporomandibular joint and incisors, using an electromagnetic tracking device and custom dental appliance. Five normal subjects took part in this kinematic study (4 females, 1 male, mean age of 34.8
years). Subjects' mandibular motion during maximal opening tasks were recorded on two different days and linear distance (LD) (i.e., the LD between the start and end position) and curvilinear path (CP) (i.e., the curvilinear distance along the curve between the start and end position) were calculated for the lower incisor landmark and both condyles in the sagittal plane (in mm). In the present study, the range of incisal movements (LD: 34.9 to 54.3 mm, CP: 36.5 to 60.3 mm) and that of condylar movements (LD: 7.5 to 25.3 mm, CP: 10.6 to 27.6 mm) in the sagittal plane during opening are in the normal range compared to the previous literature. The ability of subjects to reproduce the same motion between the two sessions was also calculated. Differences due to trial sessions and different repetitions within a session were negligible, indicating that the method can be used to assess changes between testing conditions in healthy subjects, and patients pre- and post-operatively.

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PURPOSE: A comparative study was performed to evaluate the function of the temporomandibular system after open and closed treatment of condylar fractures. MATERIALS AND METHODS: A total of 37 temporomandibular joints were examined that had undergone either open treatment (n = 24) or closed treatment with maxillomandibular fixation (n = 13) for condylar fracture. The joints were investigated clinically and on the basis of radiographs. In addition, the movements of the condyles of the temporomandibular system were recorded in 3 dimensions with a computed electronic jaw tracking system (stereognathograph). RESULTS: The clinical investigation revealed no severe functional abnormality in either of the 2 groups. The mean of the recorded condyle paths was, however, consistently lower in the temporomandibular joints with closed treatment than in those with open treatment, although the difference was only significant for movements without tooth contact (Mann-Whitney U test, P < .05). CONCLUSIONS: In summary, open as well as closed treatment gave clinically acceptable functional results. However, condylar mobility was markedly greater after open treatment than after closed treatment.

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The purpose of this study is to assess the relation between the speaking space of the /s/ sound and the freeway space in two subject groups. One group had natural dentition (Group I, n = 61) and the other comprised complete denture wearers (Group II, n = 33). The analysis was done by means of a jaw-tracking device (K6-I Diagnostic System, Myotronics Research Inc., Seattle, WA, USA). Freeway space was determined by asking the subjects to occlude from the postural rest position. Speaking space of /s/ was measured during the pronunciation of the word "seis" and comprised the mean distance from the /s/ speaking position to maximal intercuspation. A weak correlation was found between the speaking space of /s/ and the freeway space in Group I (r = 0.41, p < 0.01), but in Group II, the correlation was stronger (r = 0.75, p < 0.01). The speaking space of /s/ and freeway space were different in Group I, but statistically similar in Group II (paired t-test, alpha = 0.05). It can be suggested that anatomic changes following prosthetic procedures caused a functional adaptation which resulted in more similar values for the speaking space of /s/ and the freeway space.

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The study of mechanics of the temporomandibular joint (TMJ) is important because its dysfunction and breakdown could be, at least partially, of mechanical origin. The incongruity of the articular surfaces of the TMJ is compensated by a fibrocartilaginous articular disc. Its dislocation and failure seem to be closely related to the development of osteoarthritis of the TMJ. The analysis of mandibular kinematics permits the detection and assessment of irregularities of TMJ function due to internal obstacles such as a displaced articular disc. Furthermore, the measurement of the dynamic relationship between the articular surfaces of the TMJ is useful to determine the strains undergone by the disc that if too high might compromise its integrity. The development of our research in TMJ mechanics has evolved from the acquisition of the traces of single mandibular points to an accurate and compact description of mandibular motion, in which the mechanical advantage of jaw muscles, and forces and torques acting on the jaw are considered as well. The combination of three-dimensional software models of TMJ anatomies obtained from MRI and jaw tracking with six degrees of freedom permits a subject-specific dynamic analysis of the intra-articular space, providing insight into individual disc deformation during function and TMJ loading. Studies performed with this system indicate that both TMJs are loaded during chewing, the balancing more so than the working joint. In fact, during chewing, the intra-articular distance is smaller for hard than for soft food, on closing than on opening, on the balancing than on the working side. This last finding is confirmed by static biting experiments, in which the condyle-fossa distance decreases more on the side contralateral to the bite force, depending on its magnitude. Also studies on the dynamics of compression areas indicate that plowing can occur through the disc during function, especially mediolaterally, due to stress field translation. This effect might contribute to cartilage wear and fatigue also because the disc is weaker mediolaterally. Further data indicate that the lateral area of the disc is mostly exposed to a higher mechanical energy density. This will be more intensively investigated using finite element method. (c) 2005 S. Karger AG, Basel.

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PURPOSE: The purpose of this study was to determine whether rotation and translation of the condyle were useful parameters for identifying causes of limitation of mouth opening in patients with temporomandibular disorders (TMD). METHODS: In 7 healthy volunteers and 55 patients with TMD, rotation and translation of the condyle were measured using a 6 degree-of-freedom jaw movement tracking device. Patients were divided into two groups: those who could open their mouth 40 mm or greater, and those who could not open their mouth 40 mm. In each group, the relationship of rotation and translation of the condyle to maximum mouth opening, condition of the articular disc, and pain was determined. RESULTS: Both correlations between maximum mouth opening and rotation and translation of the condyle were strong, especially the former correlation. There was no marked difference in the distribution of range of mouth opening, and rotation and translation of the condyle with respect to condition of the articular disc. Muscle pain was associated with reduced mouth opening. Even in patients without limited mouth opening, their range of mouth opening was actually reduced when they had muscle pain. Among the patients with limited mouth opening, joint pain correlated to limited translation of the condyle. However, in patients with Wo-Wo condition of articular disc, their translation of the condyle was not limited even with joint pain, but it was limited with muscle pain. CONCLUSIONS: Rotation of the condyle indicated strong correlation with muscle pain, and so is a useful parameter for
estimating treatment methods by a surgical approach. On the other hand, translation of the condyle showed variations in correspondence with combinations of several factors such as opening limitation, condition of the articular disc, and pain.

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Objective assessments of masticatory jaw movements for patients with a high degree of occlusal abnormalities are critical to elucidate the relationship between occlusal function and morphology. This study aimed to test the reliability and validity of measuring specific cycle-by-cycle variability of chewing jaw movements of patients with mandibular prognathism. The lower incisor-point movements were monitored using a 3D tracking device. Analyses consist of evaluations for the planarity of each cycle, cycle-by-cycle variances in orientations of the best-fit planes and instantaneous curvature of the trajectories. These spatio-temporal variabilities of chewing cycles for 12 adult females with good occlusion were compared with those for 12 female adult patients with mandibular prognathism. Five of the control subjects performed chewing on two separate occasions. Measurement outcomes were repeatable within each subject. For both groups, each single chewing cycle was characterized as reasonably planar. Orientations of the best-fit planes and curvatures of the trajectories during closing were more variable for patients than those for the control subjects. These findings suggest certain effectiveness of the present measurements of orientations of the best-fit planes and movement curvatures for scaling the variable nature of patients' masticatory jaw movements.

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Patients with unilateral posterior crossbite often show reverse sequential jaw movement patterns on the frontal view during mastication on the crossbite side. Recent studies show that such patients are prone to suffer from temporomandibular joint (TMJ) disc displacement, particularly the lateral portion. The purpose of this study was to examine the movement of the lateral and medial poles of the working condyle during mastication in such patients. Subjects were 12 consecutive patients with unilateral posterior crossbites and without TMJ disc displacements and 12 normal subjects. An optoelectronic jaw-tracking system with 6 degrees of freedom was used to record the motion of the lateral and medial poles of the working condyle during mastication of standardized hard, gummy jelly. The data from the first 10 cycles were analyzed. The lateral and medial poles of the condyle on the crossbite side moved more in the medial direction and less in the lateral direction during mastication in the crossbite patients than the condyle in the normal subjects. The lateral pole of the working condyle moved more in the posterior and inferior directions and less in the anterior direction than the medial pole in all subjects. These results suggest that these condylar movements in patients with unilateral posterior crossbites might be related to the susceptibility to TMJ disc displacement, particularly the lateral portion.

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Humans with normal occlusion usually perform gum-chewing movements in a characteristic manner. The purpose of present study was to examine whether the variability of masticatory jaw movement in children with incisor crossbite is greater than that in children with normal occlusions, and if so, to examine whether correction of the crossbite results in a significant reduction in the variability. The variance in masticatory jaw movement trajectory was investigated in 10 children with acceptable occlusion and 11 children with crossbite of one or two incisors. The lower incisor-point movements during chewing of standardized gum were monitored using a 3D tracking device. The deviation of the jaw-closing trajectory from a best-fit plane was then evaluated for each chewing cycle. Subsequently, variance in angles of the best-fit planes and variance in the instantaneous curvature of the jaw-closing trajectories were evaluated. Pitch angles of the best-fit planes and curvature of the trajectories during closing in patients were more variable than those in control subjects (P < 0.05). After treatment, the variances decreased significantly (P < 0.05). These findings suggest that the achievement of good occlusion is associated with a reduction of variability of jaw movements in a gum-chewing task.

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The purpose of this study was to determine how bolus size alters the human chewing cycle. This prospective within-subject design evaluated chewing cycles of 38 young adults between 20 and 38 years of age (21 males and 17 females). An optoelectric jaw tracking system was used to record movements of the chin during unilateral (right sided) chewing of four randomly ordered bolus sizes (1, 2, 4 and 8 g) of gum. Using each subject's 10 most representative cycles, multilevel statistical procedures were used to evaluate jaw kinematics. The results showed that bolus size has no consistent effect on opening, closing or total cycle duration. Cycle excursions increased significantly with increasing bolus size. With increasing bolus sizes, chewing cycle excursions along the three axes increased 52-115%. The greatest differences between bolus sizes occurred when the jaw was changing direction (i.e. passing from opening to closing and from working to balancing sides). However, the increases were proportionate and the shape of the chewing cycle was maintained. In order to maintain cycle duration while increasing excursive ranges, jaw velocities increased significantly, with the greatest differences occurring at approximately 70% of opening and 30% of closing. We conclude that humans adapt to larger bolus sizes by increasing chewing cycle perimeter and by increasing cycle speed, while maintaining cycle shape and duration.

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This study compared the mandibular kinematics during mastication of patients treated for unilateral fractures of the mandibular condylar process with those of control subjects. We used a Sirognathograph (Siemens, Bensheim, Germany) to record the chewing cycles of 81 male patients with unilateral condylar process fractures while they chewed a constant bolus unilaterally on the same side as the fracture and on the opposite side. Recordings were made at 6 weeks, 6 months, 1 year, and 2 years after treatment.
Similar chewing cycles were recorded for 15 male controls (Class I dental and Class I skeletal occlusion) without fractures of the condylar process. The chewing cycles of both groups were analyzed with a custom computer program, and the duration, excursive ranges, and 3-dimensional cycle shape were compared at each time interval with multilevel linear modeling statistics. Fracture patients had significantly slower chewing cycles, with significantly less maximum excursion toward the working side during the closing phase and significantly greater excursion toward the balancing side during the opening phase than the controls. The opening pathway of the incisors showed greater differences between patients and controls than the closing pathways. Differences in chewing cycle shape persisted for up to 2 years, especially when chewing was on the side opposite the fracture. Unilateral condylar process fractures produce long-lasting changes in chewing cycle duration and chewing cycle shape of adults.


Previous authors have described four frontal gum-chewing patterns associated with normal and abnormal TMJ disk-condyle relationships. The objective of this study was to create an automatic detection capability (expert system) by training an artificial neural network to recognize non-reducing displaced disks from frontal chewing data. Sixty-eight (68) subjects, 29 with normal joints, 18 with unilateral non-reducing displaced disks and 21 with bilateral non-reducing displaced disks were selected from a continuous series of patients seeking treatment for TMD. Right-sided gum chewing was recorded from all patients. Left-sided chewing was also recorded from the right unilateral patients. 50% of the vertical, lateral and timing values at 10%, 65% and 100% of opening and at 30%, 70% and 90% of closing were used to train an artificial neural network. The remaining 50% were used for testing. All normal subjects were detected as normal (specificity = 100%). Two bilateral and two unilateral patients were not detected (sensitivity = 91.8%). Four (4) patients received the wrong classification (unilateral vs. bilateral) and one patient received both (undecided) for an overall accuracy = 86.8%. The artificial neural network detected, at an acceptable level of error, the presence and type of nonreducing disk displacement from frontal plane jaw recordings of gum chewing in a group of real patients seeking treatment for TMD. Since it is very inexpensive to conduct, mastication analysis appears to have the potential of an excellent cost/benefit ratio.


PURPOSE: The aim of this study was to investigate the changes in interocclusal distance during the pronunciation of /m/ and /s/ sounds in the Portuguese language, in partially edentulous patients before and after insertion of new dentures. MATERIALS AND METHODS: Subjects were divided into a control group consisting of 18 completely dentate patients and an experimental group consisting of 18 patients who were edentulous in the maxilla and classified as Kennedy Class I in the mandible. The experimental group had new dentures placed and the occlusal vertical dimension corrected. A magnetic jaw-tracking device measured the interocclusal distance during pronunciation of the /m/ and /s/ phonemes. Interoocclusal distance evaluations were carried out in a single session for the control group. In the experimental group, the measurements were carried out before insertion of new dentures; immediately after insertion; and after 6 and 24 hours; 2 days; 1 and 2 weeks; 1, 2, 3, and 6 months; and 1 year. RESULTS: Comparison between groups revealed significant difference in interocclusal distance for the /m/ sound both before and after insertion of dentures up to 2 months. For the /s/ phoneme, there was no difference between the groups before prosthesis insertion, or after 3, 6, and 12 months of prosthesis use. There were significant differences for the /m/ sound only at 6 and 12 months after new denture insertion, and for the /s/ sound at all periods evaluated. CONCLUSION: Insertion of new dentures, with
the vertical dimension corrected, changes the interocclusal distance of speech during phonation of /m/ and /s/ sounds.


In order to find the most suitable food and chewing side for evaluating the stability of masticatory movement, three types of food with varying textures, as well as both free chewing and unilateral chewing, were utilized in analyzing the masticatory path during mastication. A piece of chewing gum, one peanut, and a slice of crispy bread were used as test foods. For 20 healthy subjects, movement of the incisal point while masticating a test food for 10 s on the free side and the habitual side was recorded. Indicators representing movement path stability were calculated and compared among the foods and between the chewing sides. Masticatory movement was most stable when masticating chewing gum, and less stable for the peanut, and most unstable for the crispy bread. There was a statistically significant difference between each pair of foods for almost all of the indicators. The indicators for peanut were approximately 1.5 times larger than those for masticating chewing gum and the indicators for crispy bread were double those for the chewing gum. When comparing free chewing with unilateral chewing, the masticatory movement of unilateral chewing was significantly more stable than that of free chewing for all test foods. From these results it was suggested that, for evaluating masticatory movement path stability, the most suitable type of food was softened chewing gum and the most suitable chewing method was unilateral chewing on the habitual chewing side.


Sound development of mandibular function during childhood is indispensable to establishing healthy function in adults. To examine this developmental process, longitudinal recordings of basic mandibular movements were done using an optoelectronic analysis. Mandibular movements were recorded on five separate occasions in one boy, from an age of six years and five months to 14 years and five months. The incisor pathways during protrusion and lateral excursion were initially shallow, with more anterior than inferior movement, but as he grew the amount of inferior movement and the amount of rotation both increased. Similarly, at his first recording there was very little hinge-like rotation during mouth closing, but rotation increased markedly after eruption of his permanent second molars. These findings suggest that mandibular movements change from being relatively simple with more translation in younger children to more complex movements with more rotation once the permanent dentition is established.


Associations between articulatory speech disorders and mandibular movement capacity, as well as between malocclusions and jaw movements, were examined in two groups of adolescents, i.e. 52 individuals with and 45 without misarticulations of speech. The mean age of the whole sample was 19.2 years. Articulatory speech disorders and functioning of the speech articulators were diagnosed by a phoniatrician. Mandibular movement capacity, malocclusions, occlusal interferences, and signs of temporomandibular dysfunction were recorded by an orthodontist. Multiple regression analyses showed that subjects with articulatory speech disorders were likely to have smaller opening capacity than subjects with a correct speech articulation. Excessive overjet, lateral cross bite, and a tendency to anterior open bite were associated with large movements of the jaw. These results suggest that in young adulthood mandibular movement capacity seems to vary depending on occlusion and is related to misarticulations of speech.
The purpose of this study was to estimate the length of the occlusal glide during gum chewing at the lower incisal point. Mandibular excursions with occlusal contacts in 25 females with permanent dentition were recorded using an optoelectronic system that can measure mandibular movement with 6 d.f. at a sampling frequency of 100 Hz. A curved mesh diagram of incisor coordinates during maximum mandibular excursions (CMDME) was plotted. Gum chewing movement was also measured using the same system and computer software which divided the chewing movement into cycles at each maximum opening position. Each cycle was standardized at 0.1 mm intervals from the most closed position. Finally, the distance between the CMDME and each position of the incisor during a chewing cycle was calculated. Whenever, this distance was less than 0.2 mm opposing teeth were considered to be in contact. The occlusal glide was defined as the distance traveled by the lower incisal point as the mandible moved along occlusal contacts of the CMDME. The vertical coordinates at the beginning of the occlusal glide (during closing) and at the end of occlusal glide (during opening) were also calculated. The lengths of the occlusal glide pathway averaged 1.29 mm during closing and 1.55 mm during opening, a total length of 2.84 mm. Mean vertical coordinates at the beginning and end of the glide were -0.95 and -1.12 mm from intercuspal position, respectively.

The aim of this study was to investigate the relationship between parameters of facial morphology, maximal voluntary mouth opening ability, and condylar movements in 21 adult females, aged between 20 and 24 years. The subjects had a normal occlusion without signs or symptoms of temporomandibular joint (TMJ) dysfunction. Mandibular movements were recorded using an opto-electric jaw movement recording system with six degrees of freedom under a series of maximal mouth opening-closing movements. Maximal jaw opening and coincident condylar movement were measured three-dimensionally. The mean values of the incisor and condylar path were 41.1 +/− 3.5 mm (range 35.6-50.9 mm) and 12.8 +/− 2.8 mm (range 8.1-19.2 mm), respectively. Although the positive correlation between maximal jaw opening and facial morphology was significant, none of the variables significantly differed between the value of the condylar path and facial morphology. The length of the path of maximum incisor movement and the condylar path during mandibular movement also did not correlate. Stepwise multiple regression analysis indicated a positive association between the maximal length of the incisor path and the cephalometric value of mandibular ramus inclination (R2 value was 0.369). The results of this study suggest that facial morphology size has a limited effect on maximal voluntary mandibular opening and condylar movements in normal adult female subjects.

This study investigated how jaw kinematics, including cycle duration, three-dimensional (3-D) excursive ranges and velocities, and cycle shape, changed with increasing hardness of chewing gum. Twenty-six subjects (13 males and 13 females; mean age 23.6 +/− 2.5 years) with Class I normal occlusion were asked to chew two brands of gum with differing hardness. Jaw motion during chewing was tracked with an Optotrak camera at 100 Hz, and all movements were recorded as pure 3-D mandibular movements relative to Frankfurt horizontal. Cycle duration did not change significantly with harder gum, but 3-D excursive ranges and velocities increased, except during the occlusal phases of the chewing. Cycle shape was similar for hard and soft gum, but the overall size of the cycle was larger with hard gum. These
results suggest that greater muscular effort when chewing harder gum produces a greater acceleration of the mandible in all phases except when the harder gum slows the mandible during the occlusal phases.


The aim of the present study was to investigate the influence of local anthropometric (mandibular length and width) and kinematic (forward and downward condylar translation and angle of rotation) variables upon the maximum mouth opening (MMO). Thirty-five healthy individuals, 17 men and 18 women, mean age 23 years with a range from 18 to 31 years, performed six to eight maximal, symmetrical and pain-free open-close movements during a 20-s recording. Mandibular movements were recorded by means of the OKAS-3D jaw movement recording system. A stepwise regression analysis showed that differences in MMO are mainly explained by differences in the angle of rotation and in mandibular length ($R^2_{adj}=91.5\%$). Including the downward and forward component of condylar translation into the regression model increased the explained variance with only 4.7%. A second stepwise analysis showed that the angle of rotation is positively related to the forward component of the condylar translation and negatively related to its downward component ($R^2_{adj}=52.7\%$). In conclusion, differences in MMO between healthy individuals are, to a large extent, explained by differences in the angle of rotation and in mandibular length. In its turn, differences in the angle of rotation are related to differences in condylar translation.


The masticatory cycle is a complex process and it depends on many factors. In our study we wanted to prove to what extent various types of food consistency influence the masticatory motions, especially the extent of forward, downward and lateral motions of the mandible. Nineteen study subjects aged from 20 to 37 years and with intact teeth rows were asked to chew three types of food of various consistency (banana, bread and carrot). The motions of the mandible were recorded by stereo-photo-grammetric system. Study results have shown that in all 19 study subjects the increase in food consistency increases the extent of masticatory motions. The average size of forward mandibular motion in all 19 study subjects when chewing banana amounts to 2.65 mm, when chewing bread it is 2.96 mm and 3.64 mm when chewing carrot. The average size of downward mandibular motion for all 19 study subjects amounts to 6.79 mm when chewing banana, 7.17 mm when chewing bread and 8.09 mm when chewing carrot. The average size of lateral mandibular motion in all 19 study subjects amounts to 2.46 mm when chewing banana, 2.80 mm when chewing bread and 3.40 mm when chewing carrot. Although varying from subject to subject, the masticatory cycle significantly depends on food consistency. By increasing the consistency of a mouthful, the extent of mandibular motion increases in every single study subject.


The chewing cycle is a functional movement, closely related to occlusion, the neuromuscular system and the central nervous system. Although actual chewing paths are complicated and vary from individual to individual, there are two typical patterns. One is more vertical in nature and is similar to a chopping movement. The other is a more lateral type that is similar to a grinding movement. The purpose of this study was to evaluate the effects of chewing patterns on occlusal wear. Fifteen subjects exhibiting a chopping-chewing pattern and 15 subjects exhibiting a grinding-chewing pattern were selected using a jaw tracking device. The occlusal wear values, obtained by both ordinal and Woda's arbitrary scales, and frequencies of non-working facets were calculated for each group. The occlusal wear values in all teeth and in each segment, obtained by the use of the ordinal scale did not vary significantly between the
chopping and the grinding type group. However, the occlusal wear values of the grinding type group in all teeth and in posterior teeth segments, obtained by the use of Woda's arbitrary scale, were significantly greater than those of the chopping type group. Frequencies of non-working facets in posterior teeth showed no significant differences between the groups.


This study evaluated the sex differences in maximum 3-dimensional opening and closing movements. The sample included 29 men (ages, 23-39 years) and 27 women (ages, 23-35 years), who were selected for normal Class I occlusion, temporomandibular function, and skeletal patterns. Condylar (hinge axis) translation and mandibular incisor movements, were recorded with an optoelectric jaw-tracking system; each participant performed 4 maximum opening/closing cycles. The results showed significant (P <.05) sex differences for incisor opening and closing movements, with most of the differences in the vertical component. Male incisor straight-line distances and curvilinear pathways averaged 52.1 mm and 54.8 mm, respectively. Female straight-line distances and curvilinear pathways averaged 46.0 mm and 48.1 mm, respectively. There were significant (P <.05) sex differences for condylar translation, with most of the differences in the anteroposterior component. Male condyles translated 15.4 to 17.6 mm (straight-line distances) and 20.5 to 20.7 mm (curvilinear pathways); female condyles translated 12.4 to 12.7 mm (straight-line distances) and 16.2 to 17.9 mm (curvilinear pathways). Mandibular length accounted for some of the sex difference in interincisal opening and for most of the sex differences in condylar translation. Closing movements showed the same pattern of sex differences as opening movements. Mandibular opening rotation was approximately 4 degrees larger in men than in women. The shapes of the condylar opening and closing pathways also differed significantly between men and women. For both sexes, condylar translation did not correlate with incisor opening or closing movements. It was concluded that (1) significant sex differences exist in incisor opening movements that are independent of mandibular size, (2) sex differences in condylar translation are dependent on mandibular size, (3) incisor opening movements should not be used as an indicator of condylar translation, and (4) sex differences in the shapes of the condylar pathways indicate sex differences in articular eminence morphologic features.


The influence of reduced anterior disc displacement on condylar motion has not been fully examined in young adults. Reduced anterior disc displacement was hypothesized to inhibit condylar motion. Using a six-degrees-of-freedom jaw-tracking system, we recorded bilateral condylar motion during maximum open-close jaw movement and gum-chewing on both sides in ten young adults with unilateral reduced anterior disc displacement and in ten control subjects without temporomandibular disorders. The bilateral condylar motion during both maximum open-close jaw movement and chewing on the disc-displacement side was inhibited in the test group. The condylar motion on the disc-displacement side during chewing on the non-disc-displacement side was also inhibited in the test group. These results suggest that the limitation of condylar motion on the disc-displacement side may influence condylar motion on the non-disc-displacement side during maximum open-close jaw movement, and mastication on the disc-displacement side in young adults.


Translation and rotation of the mandible during habitual mouth opening movements were studied in 13 children with skeletal-based anterior reverse bite (reverse bite group) and in 13 children with normal
occlusion (normal occlusion group) whose dental stage was the primary dentition. Movements were recorded by an opto-electronic movement-analyzing system that could measure mandibular movements with six degrees of freedom. Inferior translation of the mandible was analyzed at the left primary central incisor, both of the primary canines, and both of the primary second molars. Anterior translation of the mandible was analyzed at both of the condyles. Rotation of the mandible was measured in the sagittal plane. The results showed that the associations between the translation and rotation of the mandible during habitual mouth opening in the reverse bite group differed from those in the normal occlusion group. The reverse bite group had greater anterior translation of both of the condylar points than did the normal occlusion group. No significant differences were found in the inferior translation or rotation of the mandible between the two groups.


It has been reported that loading to the mandible during closing movement makes the condylar path move more in the superior direction than that during the free closing movement. In this study, the hypothesis was tested that the displacement of the condyle on the chewing side is greater in the direction of the mandibular fossa than that on the non-chewing side. Using a six-degrees-of-freedom jaw movement recording system, we recorded condylar motion in 12 healthy adults without TMD, during the chewing of a large hard gummy jelly. The maximum displacements at the condyle on the chewing side from the maximum intercuspation (CO) position were significantly larger in the superior and medial directions at the initial stage and in the posterior direction at all stages (0.5 mm, 0.5 mm, and 0.6 mm, respectively) than those on the non-chewing side (0.0 mm, 0.1 mm, and 0.1 mm, respectively). This suggests that, in healthy adults, the condyles at CO are located in a position such that excessive load is not applied to the temporomandibular joint when there are the aforementioned displacements.


Previous studies have indicated that the selection of condylar referencing points can significantly influence condylar point trajectories, and the use of radiographically determined condylar points is essential for accurate representation of condylar movement. The aim of this investigation was to determine the accuracy with which the three-dimensional locations of condylar points could be determined in the coordinate system of the JAWS3D tracking device when an ipsilateral fiducial marker is used. A perspex mandible containing condylar radiographic markers was constructed. A JAWS3D target frame and a fiducial marker, supporting radiographic markers, were secured to the perspex mandible. The image data from computer tomography scans of the condyles and fiducial marker, together with photographs of the fiducial marker and the JAWS3D target frame were used to calculate condylar point coordinates in the JAWS3D coordinate system. These data were then compared with the data obtained by direct measurement of the condylar radiographic markers in the JAWS3D coordinates. The results suggest that a unilateral fiducial marker is sufficient to allow the registration of ipsilateral condylar point coordinates to an accuracy of approximately 1.0 mm.


It is known that small head movements accompany the movements of the jaw during mastication; however, it is unknown whether these movements occur rhythmically and synchronously. The objective of this study was to determine whether there exists a functional coupling between the head and mandibular movements. Four healthy male adults (mean age 25.5) with normal occlusion and without
TMD history were selected as subjects. Using the Trimet system, we measured tridimensionally both the movement of the head and the mandible by tracking upper and lower incisal points, respectively, during tapping movements with different opening range and frequency, then analysed the vertical component of these movements. The upper incisal point moved in opposite direction to the mandible in all tapping strokes in all subjects, during opening the head moved in a cranial direction and during closing in a caudal direction; the incidence rate for this concomitant movement was 98%, implying that the head moves periodically and rhythmically, as the mandible does. The cycle time of these coincident movements showed a correlation coefficient of 0.94. Moreover, the vertical range of head movement was within 10% of the jaw's movement. From these results we concluded that, at least during teeth tapping, the head moves in rhythmical coordination with mandibular movement.


The purpose of this study was to determine the rate of recovery of mandibular motion in patients treated for fractures of the mandibular condylar process. One hundred and thirty-six patients (111 men, 25 women), 74 treated by closed and 62 by open methods, were included. They underwent testing of mandibular and condyle mobility at 6 weeks, 6 months, and 1, 2, and 3 years post surgery. Their ranges of motion were compared to those of 52 controls (26 men and 26 women). A jaw-tracking device was used to assess mandibular motion. Multilevel statistical models were used to assess differences between groups, and to estimate rate of recovery in the fracture patients. In general, patients with unilateral fractures of the condylar process had maximum excursions that returned to normal values within 3 years after fracture, regardless of treatment. Patients treated open exhibited a faster rate of improvement in maximum interincisal opening than patients treated closed (0.43 mm/month vs 0.15 mm/month, respectively), but part of the difference was due to a significantly smaller opening after 6 weeks for the patients treated open (38 mm vs 42 mm, respectively). Patients treated open also exhibited a faster rate of improvement in maximum excursion toward the fracture side than patients treated closed (0.10 mm/month vs 0.04 mm/month, respectively). Based upon this study, patients with unilateral fractures of the condylar process, who are treated closed and not put into maxillomandibular fixation but are instructed in physical therapy, can be expected to achieve normal maximum excursions within 3 years after treatment. Patients treated open will have reduced maximum opening initially, but may reach normal levels of opening sooner than patients treated without surgery. Patients treated without surgery may have smaller than normal excursion toward the non-fracture side for at least 3 years after fracture, especially if their fracture was at or above the condylar neck. Improvement rates for other maximum excursions are similar for patients treated with or without surgery.


This study evaluated the correlations between condylar translation and incisor movements during maximum protrusion and lateratrusion. The sample was 27 adult females (23--35 years old), selected for normal temporomandibular function, occlusion, and skeletal patterns. Condylar and mandibular central incisor movements [linear distances (LD) and curvilinear pathways (CP)] were recorded in three dimensions for 20 s with an optoelectric (Optotrak) jaw-tracking system while each participant performed multiple maximum protrusive and lateratrusive cycles. Masticatory analysis and multilevel statistical programs computed the three-dimensional movements of the incisors and condylar hinge axis during protrusion and lateratrusion. CP of the incisor point averaged 12.0 mm (9.3 mm LD) during protrusion, 13.0 mm (11.5 mm LD) during right excursion and 12.3 mm (11.0 mm LD) during left excursion. CP of the condyles averaged 11.9--12.9 (9.2--9.5 LD) mm during protrusion. During
laterotrusion the contralateral condyles moved anteroinferiorly 11.6--14.1 mm (9.5--10.2 mm LD); the ipsilateral condyles moved posterolaterally 5.8-6.8 mm (2.3--2.5 mm LD). The left condyles demonstrated more movement than the right condyles during protrusion and than the contralateral condyles during laterotrusion. Relative variation, as measured by the coefficient of variation, was greater for the movements of the ipsilateral than contralateral condyles. Incisor movements were only moderately related to condylar movements between individuals and between replicates; LDs showed stronger correlations than CPs; and correlations were stronger for laterotrusion than protrusion. While incisor and condylar movements were not affected by repeated protrusion, incisor CP (approx. 0.2 mm/cycle) and LD (approx. 0.1 mm/cycle) increased significantly with repeated excursive movements to the left and right. It was concluded that (1) incisor protrusion and laterotrusion provide moderately reliable measures of condylar translation; (2) the linear distances that the incisors move during laterotrusion provide the best measure of contralateral condylar translation; and (3) condylar movements are not affected by repeated protrusion or laterotrusion.


It is generally assumed that children with posterior crossbites have abnormal mandibular movements; however, this assumption has not been clearly evaluated. The purpose of this investigation was to study the movements and the resting position of the mandible in 2 samples of 30 subjects, one aged 10 to 14 years with right posterior crossbite, the other aged 10 to 15 years with normal occlusion. Subjects in both groups exhibited a Class I skeletal relationship and mesofacial growth pattern. A mandibular kinesiograph was used to record both the mandibular resting position and dynamic movements. Mandibular movements were recorded during (1) maximum excursions (opening-closing, protrusion, right and left excursions), (2) swallowing, and (3) mastication. The results showed no differences between groups in the extension of the movements during closing and protrusion. However, crossbite patients exhibited a significant lateral shift during these movements. Right and left excursions were also similar between groups. The dimension of the freeway space was similar between groups, but the lateral shift found in centric occlusion was also present in the crossbite group when the mandible was at rest. The crossbite group more frequently showed a pattern of abnormal swallowing. No differences were found in any of the parameters studied during the masticatory cycle. There was no relationship between the side of the crossbite and the masticatory preference side. In conclusion, posterior crossbite patients showed a lateral shift in some movements that persisted when the mandible was at rest.


Condylar and incisor trajectories are often used for the study of mandibular movements. Condylar trajectories, however, depend on the location of the reference point and can be interpreted erroneously. In contrast, the helical axis analysis yields an unequivocal description of rigid body kinematics. The aim of this study was to analyze the mandibular helical axis during mastication. Seven subjects without signs and symptoms of craniomandibular disorders and with class I occlusion were recorded by means of the opto-electronic system Jaws-3D during unilateral mastication of bread cubes (2-cm side). The helical axis was computed every 14 ms with a rotation threshold of 1 . Parameters describing its spatial orientation and position relative to the condyles were calculated. The helical axis changed orientation and position more pronouncedly during the closing than during the opening phases of mastication. The orientation varied significantly from beginning to end of closing but not of opening, indicating less fluctuation of the helical axis on opening than on closing. Also, the distance dCP between helical axis and reference condylar point varied more significantly (p < 0.05) on the working than on the balancing side: On the working side, dCP decreased during both opening and closing, whereas on the balancing side, dCP increased only for closing. Furthermore, the helical axis pathway often showed a bowing
ventrally to the balancing condyle, indicating that, during closing, the balancing condyle still translated backward while essentially only rotation occurred around the working condyle. Thus, the helical axis changed its position and orientation continuously during mastication.


BACKGROUND: The authors conducted a study to determine if reducing mandibular denture movement through the use of a denture adhesive improves chewing function in edentulous patients. METHODS: The authors compared the mean chewing rates of 10 denture wearers who used and did not use a denture adhesive with that of a control group of 10 dentate people. The authors recorded mandibular movements using a multichannel magnetometer tracking system while the subjects chewed standardized pieces of dried apricots and fresh white bread. They made recordings for the test subjects without the use of denture adhesive and at zero, two and four hours after Fixodent denture adhesive cream (Procter & Gamble Co.) was applied to the mandibular denture. RESULTS: The mean chewing rate for the control group was significantly faster than that of the test group at baseline (P < .01). The authors found statistically significant increases in the mean chewing rates for the test group after the denture adhesive was applied at all time points for both foods. None of the after--adhesive-application rates were significantly different from the control group's rate (P > .05). CONCLUSIONS: Use of denture adhesive increased the mean chewing rate in test subjects immediately after and at two and four hours after denture adhesive was applied to a rate that approximated that observed in control subjects (P > .05). CLINICAL IMPLICATIONS: These findings show that using a denture adhesive promotes a faster and more natural rate of chewing.


Recent observations in man of concomitant mandibular and head movements during single maximal jaw-opening/-closing tasks suggest a close functional relationship between the mandibular and the head-neck motor systems. This study was aimed at further testing of the hypothesis of a functional integration between the human jaw and neck regions. Spatiotemporal characteristics of mandibular and associated head movements were evaluated for 3 different modes of rhythmic jaw activities: self-paced continuous maximal jaw-opening/-closing movements, paced continuous maximal jaw-opening/-closing movements at 50 cycles/minute, and unilateral chewing. Mandibular and head-neck movements were simultaneously recorded in 12 healthy young adults, by means of a wireless opto-electronic system for 3-D movement recordings, with retro-reflective markers attached to the lower (mandible) and upper (head) incisors. The results showed that rhythmic mandibular movements were paralleled by head movements. An initial change in head position (head extension) was seen at the start of the first jaw-movement cycle, and this adjusted head position was retained during the following cycles. In addition to this prevailing head extension, the maximal jaw-opening/-closing cycles were paralleled by head extension-flexion movements, and in general the start of these head movements preceded the start of the mandibular movements. The results support the idea of a functional relationship between the temporomandibular and the cranio-cervical neuromuscular systems. We therefore suggest a new concept for human jaw function, in which "functional jaw movements" are the result of activation of jaw as well as neck muscles, leading to simultaneous movements in the temporomandibular, atlanto-occipital, and cervical spine joints.


This study introduces new methods of quantifying and evaluating the human chewing cycle. These methods were validated on a sample of 26 young adults (11 women and 15 men) between 20-35 years of
age. Movements of the mandibular central incisors were recorded (100 Hz) using an optoelectric computer system while the participants chewed gum. A subsample of 10 cycles was automatically selected, based on multiple objective criteria to ensure representative cycles for each individual. Once representative cycles had been identified, multilevel statistical models were used to evaluate and describe the sample's kinematic patterns. The multilevel procedures allow for missing observations, they do not assume equal intervals, and variation can be partitioned hierarchically. Two-level models showed significantly shorter cycle duration for males (835 msec) than females (973 msec). Inferior-superior (IS) cycle range was 2.6 mm larger and maximum IS velocity was 19.6 mm/sec faster in males than females. There were no significant differences in medial-lateral (ML) and anteroposterior (AP) excursive ranges or velocities. With the exception of cycle duration and ML ranges of motion, random variation was three to five times larger between individuals than between cycles. The three-level models showed that eighth-order polynomials were necessary to describe IS, AP, and ML chewing movements of the entire cycle. The models identified highly significant sex differences in cycle kinematics (excursions, velocities, accelerations, etc.) for each aspect of movement (AP, IS, and ML). It is concluded that this approach provides several important advantages over existing methods, including (a) its objectivity, (b) a more complete description of kinematic patterns, (c) a hierarchical description of variation, and (d) its ability to test hypotheses statistically.


Analyzing mandibular movements by magnetic methods involves some compromises and errors. Certain movements, e.g. repositioning the magnet to the mandibular incisors and reattaching the magnet sensing devices to the head by means of spectacle frames, cannot be precisely duplicated in repeated measurements. Additionally, inherent non-linearities result in distortion of the spatial location of the intraoral magnet. A new analysis device (BioPAK) has been developed so that the magnet can be constantly repositioned with a "magnet positioner (JT-3)." The purpose of this study was to record and evaluate the accuracy of mandibular movements with BioPAK. The results were as follows: 1) The BioPAK system is highly accurate in measuring both tapping and masticatory movements. 2) In cases where the measurements were repeatedly performed at different times and days, repositioning the magnet and reattaching the sensing devices were correctly completed using the "magnet positioner (JT-3)." 3) In normal subjects, tapping movements are kept rhythm constant nothing to do with different time and days within the same individual.

Murakami T; Harada T; Abe K; Tanaka T. Masticatory movement in two cases with unusual alignment of the maxillary canine. J Oral Rehabil 2000 Apr;27(4):317-31

Masticatory function was analyzed before and after orthodontic treatment in two cases where tooth alignment remained unusual after treatment. The Sirognathograph Analyzing System was used to analyze the masticatory function. In both cases, the right maxillary first premolar was located where the maxillary canine is normally positioned. The results of orthodontic treatment were satisfactory both morphologically and aesthetically, and masticatory function was greatly improved. However, some problems remained in the mandibular movement due to the abnormal contact between the mandibular teeth and the maxillary first premolar. These findings support the need for examination of masticatory function when treating patients with an unusual tooth alignment even if the results of orthodontic treatment are both morphologically and aesthetically successful.

The mandibular rotational angle and distance were measured during various movements of temporomandibular joint (TMJ) closed lock patients (17 women, 23.9 +/- 6.6 years). The measurements were compared with those of the healthy controls (18 women, 24.0 +/- 1.4 years) using the BioPAK system (BioResearch Inc. Milwaukee, USA), which can analyze mandibular rotational torque movements. During maximum mouth opening movement, the parameters of the patient group were significantly larger than those of the control group in horizontal plane (p < 0.05) but vice versa in frontal plane (p < 0.001). During protrusive movement, the parameters of patients were significantly larger than those of control group in frontal and horizontal plane (p < 0.01, p < 0.05). During lateral excursive movement to the affected side of patients, the parameters were significantly larger than those to the unaffected side in frontal plane (p < 0.05).


The purpose of this study was to investigate normal physiologic tremor in jaw movement as a factor that may influence chewing performance more directly than either muscle activity or jaw displacement. Chewing performance was defined in terms of the reduction in food particle size after 15 chewing strokes. Data on chewing particle size and electromyographic activity were available for 24 asymptomatic adults from an earlier study. Jaw movements during chewing were recorded using electrognathography (BioEGN), and velocity and acceleration in three planes were determined. Power spectrum for acceleration was calculated during opening and closing phases of the chewing cycle. The frequency of the peak amplitude in the power spectrum represented physiologic tremor of the jaw. Tremor frequencies during both opening and closing phases of the chewing cycle were strong predictors of chewing performance. A multivariate model composed of variables derived from acceleration, together with electromyographic and jaw movement variables, produced a multivariate model that was able to predict chewing performance with an adjusted R2 value of .78.


Chewing performance can be defined in terms of the reduction in food particle size after 15 chewing strokes. In this study, the relationship between chewing performance and electromyographic activity was investigated to develop optimal values of electromyographic variables, based on their ability to predict chewing performance. Electrognathographic (BioEGN) and electromyographic recordings from surface electrodes over the digastric (abductor), masseter, and temporalis (adductors) muscles were made from 24 subjects while they chewed a hard fruit gum. A moderate negative correlation was found between the food particle size and the root mean square calculation for masseter activity (-.48; P < .01). Weaker positive correlations were found between particle size and the asynchrony of ipsilateral and contralateral anterior temporalis muscles (.36; P < .05). A multiple regression model of electromyographic and electrognathographic variables was able to predict chewing performance with an R2 value of .66. If chewing performance is used as an output measure of masticatory function, it may be possible to determine optimal ranges for electromyographic variables and jaw movements.


Using the mouth as an "in vivo articulator," the bilateral nonmasticatory ("empty") contact patterns of opposing cuspid and first molar teeth were determined in two healthy subjects with well-defined cuspid function and two healthy subjects with well-defined group function. The electronically recorded "empty" contact patterns pertained to the static intercuspal position and dynamic laterotrusion to the right and the left. On the basis of the "empty" tooth contact patterns and the number of electronically recorded
masticatory cycles of one masticatory sequence (BioEGN), we postulated two simple models that attempted to predict the masticatory ("functional") tooth contacts of one sequence of unilateral mastication of apple and banana. Statistical comparisons between the predictions of the two models and the actual ("functional") contacts of in vivo mastication showed that the models predicted fairly well the observed tooth contacts on the nonchewing-side of the mouth, but not the observed tooth contacts on the chewing-side of the mouth. In consequence, "empty" (nonmasticatory) tooth contact patterns should not be equated with "functional" (masticatory) tooth contact patterns.


In order to evaluate the therapeutic effect of continuous passive motion (CPM) on the outcome of TMJ meniscectomy, chewing movement was recorded with BioEGN and analyzed before surgery and six months after surgery in 31 patients receiving CPM (CPM group), 26 patients without CPM (non-CPM group), and in ten normal subjects. The surgical procedure consisted of either total meniscectomy or partial meniscectomy with disk repair. It was found that chewing in patients receiving CPM was closer to the normal range than for patients in the non-CPM group. The results from the CPM group demonstrated chewing parameters for patients with partial meniscectomy returning to the normal range. However, for the patients with total meniscectomy, some parameters remained out of the normal range. From these results, we conclude that CPM has a positive influence on the outcome of TMJ surgery.


In order to evaluate the influence of different types of postoperative treatments on the results of TMJ surgery, chewing movement recorded postoperatively with BioEGN was compared in 32 patients with unilateral total meniscectomy, 42 patients with partial meniscectomy with disk repair, and 10 normal subjects. Postoperative treatment was of three different types depending on its strategy. It was found that postoperative treatment had a significant positive effect on the results of both total and partial meniscectomy. Postoperative treatment which included both physical medicine modalities and dental treatment demonstrated better results than only dental treatment or no postoperative treatment. However, none of these studied techniques could recover chewing movement to the normal range.


In order to determine if there are characteristic chewing patterns for specific types of TMJ internal derangements, chewing movement recorded with BioEGN was analyzed in 210 TMD patients with unilateral internal derangement (MDR early, 40; MDR late, 41; MD, 80; MDP, 49), and in 94 TMD patients without internal derangement, and 10 asymptomatic subjects with normal TMJ imaging. Each internal derangement subgroup demonstrated a significantly restricted envelope of motion and a reduced chewing velocity especially when they chewed on their normal TMJ side. Comparing different types of internal derangement, the MDR early group demonstrated relatively normal chewing, while the MDR late, MD and MDP groups showed severely impaired chewing movements. Among these three groups, the MD group demonstrated the most impairment, followed by the MDP and the MDR late groups. These results demonstrate that different types of internal derangement have specific impairments upon chewing, suggesting use of this analysis as a diagnostic tool.
Mandibular movements near the maximum intercusp position were analysed for the location of the mean instantaneous centre of curvature of the interincisal point path. Measurements were performed using a kinesiograph in 28 healthy young adults with sound dentitions and free from temporomandibular joint disorders. The subjects performed habitual open-close cycles at different speeds; opening movements starting from the centric relation occlusion were also analysed. In none of the 28 subjects was the interincisal point path derived from pure rotation movements performed around the intercondylar axis, not even in the first millimetres of motion. Translation and rotation were always combined, and the position of the centre of curvature changed during the motion, showing different characteristics in the open and close movements; these patterns were also dependent upon motion speed. The results show that the hinge axis theory cannot explain the mandibular movements because a pure rotation did not occur around the intercondylar axis.


Frontal plane mandibular rotations and corresponding hemimandibular translations were studied in vitro by using direct observations of a human cadaver mandible and in vivo by using the indirect observations of rotational electronegathography (BioEGN). A comparison between the two methods showed that rotational electronegathography erred in measuring the clinically relevant hemimandibular translations resulting from mandibular rotations having a unilateral molar point (simulated occlusal interference) as the pivot of frontal plane torque. In vitro frontal plane rotations about a unilateral mandibular molar tooth (simulated occlusal interference) suggested that the resulting hemimandibular upward translations of the lateral portion of the mandibular condyle, contralateral to the molar tooth, would cause considerable compressive loading of the temporomandibular joint disc.


In 12 subjects, a pliable, yet unbreakable, intercuspal interference (aluminum shim onlay splint; uniform height of 0.25 mm) was placed between either the right or left maxillary and mandibular second premolars and first molars. During brief and forceful biting (dynamic chewing stroke of about 20 kg force) the interference emulated a semisoft food bolus, and at the end of biting (subsequent static clenching stroke of about 20 kg force) it emulated a rigid metal interference. During dynamic/static biting, rotational electronegathography measured maximum frontal and horizontal plane torque of the right and left mandibular condyles (BioEGN). Eleven subjects (92%) showed frontal plane upward rotation (mean of 1.0 degree) of the condyle contralateral to the interference, and one subject (8%) showed frontal plane upward rotation (0.4 degree) of the condyle ipsilateral to the interference. Two subjects (17%) showed no horizontal plane rotation; seven subjects (58%) showed backward rotation (mean of 0.4 degree) of the condyle contralateral to the interference; and three subjects (25%) showed backward rotation (mean of 0.3 degree) of the condyle ipsilateral to the interference. It is suggested that, in the presence of an occlusal interference, mastication may have both short- and long-term detrimental effects.

A rigid intercuspal interference (minimum mean height of 0.24 mm) was placed on either the right or left mandibular second premolar and first molar of 12 subjects. During brisk and forceful biting on the interference, rotational electrognathography measured maximum torque of the right and left mandibular condyles in the frontal and horizontal planes of orientation (BioEGN). All subjects showed frontal plan upward rotation (mean of 0.7 degrees) of the mandibular condyle contralateral to the interference. In 33% of the subjects there was no horizontal plane backward rotation. In 58% of the subjects there was horizontal plane backward rotation (mean of 0.5 degrees) of the mandibular condyle ipsilateral to the interference, and in one subject (8%) there was backward horizontal plane rotation (0.1 degree) of the mandibular condyle contralateral to the interference. It was inferred that the masseter muscle, ipsilateral to the interference, generated negative work in order to decelerate frontal plane 'unseating' of the mandibular condyle ipsilateral to the interference. It was inferred that the masseter muscle, contralateral to the interference, produced positive work in order to accelerate frontal plane 'seating' of the mandibular condyle contralateral to the interference. Finally, it was speculated that the impact forces of frontal plane 'seating' of the mandibular condyle, contralateral to the interference, might lead to 'vacuum sticking' of the temporomandibular joint disc because of the formation of negative hydrostatic pressures.


In order to evaluate chewing in temporomandibular disorder (TMD) patients with unilateral and bilateral internal derangement of the temporomandibular joint (TMJ), the envelope of motion and velocity of chewing were recorded (BioEGN) and analyzed in 103 TMD patients with unilateral internal derangement, 42 patients with bilateral internal derangement and 10 normal subjects. It was found that patients with bilateral internal derangement demonstrated a significantly restricted range of motion and reduced velocity than patients with unilateral internal derangement or normal subjects. The analysis of chewing patterns in the frontal and sagittal planes revealed that patients with bilateral internal derangement had no specific pattern while patients with unilateral internal derangement demonstrated a specific pattern. The analysis of chewing velocity pattern suggested that opening and closing patterns without any obvious peak velocity was significantly more frequent in patients with bilateral internal derangement than patients with unilateral internal derangement or normal subjects.


In 12 subjects, a rigid unilateral intercuspal interference (minimum mean height of 0.24 mm) was placed on either the right or left mandibular second premolar and first molar (sagittal physiological equilibrium point of the hemimandibular dental arch). During brisk and forceful clenching on the interference, bipolar surface electromyograms were obtained from the right and left masseter muscles (BioEMG). On the side opposite the interference, myoelectric clenching activity was significantly reduced. Correlation analyses showed that the interference elicited a non-linear (complex) co-ordination of the amplitude, but not the duration, of bilateral masseteric clenching activity, i.e. frequently there was significant motor facilitation on the side of the interference, and significant motor inhibition on the side opposite the interference. Theoretical considerations predicted that brief clenching on the interference would easily lead to frontal plane rotatory motions of the mandible which, indeed, occurred clinically (BioEGN).


This review shows that experimental occlusal interferences (prematurities) may cause changes in the myoelectric contraction patterns of the human jaw muscles, and changes in the translatory motion patterns of the human mandible. However, it has not been unequivocally established that the observed
changes have specific long-term detrimental effects. On the other hand, it is apparent that experimental occlusal interferences are associated with short-term clinical symptoms and signs, such as jaw muscle fatigue and pains, headaches, pains and clickings in the temporomandibular joints. This review suggests that new paradigms involving experimental occlusal interferences should be introduced.


In order to investigate the chewing movement of temporomandibular disorders (TMD) patients with and without internal derangement of the temporomandibular joint (TMJ), the velocity of chewing movement was recorded (BioEGN) and analyzed in 103 TMD patients with unilateral internal derangement (ID group), 94 TMD patients without internal derangement (NID group) and 10 normal subjects (normal group). The ID group showed a significantly reduced maximum opening velocity, a significantly smaller standard deviation for the velocity and a significantly frequent opening velocity pattern with a deceleration in the middle of opening compared to the NID or the normal groups. The NID group demonstrated significantly frequent opening velocity patterns without any velocity peak compared to the ID or normal groups.


In order to investigate the chewing movement of temporomandibular disorders (TMD) patients with and without internal derangement of the temporomandibular joint (TMJ), analysis of the envelope of motion during chewing was performed in 103 recorded (BioEGN) TMD patients with unilateral internal derangement (ID group), 94 TMD patients without internal derangement (NID group) and 10 normal subjects (normal group). The analysis of numeric parameters revealed that the ID group demonstrated a significantly restricted range of motion compared to the NID or normal groups, and the NID group demonstrated significant irregularity of chewing compared to the ID or normal groups. The analysis of chewing also demonstrated that the chewing pattern for the ID group demonstrated more frequent deviation of the turning point to the nonchewing side in the frontal plane and a narrow anteroposterior pattern in the sagittal plane compared to the other groups. No characteristic chewing patterns were identified for the NID group.


In order to evaluate the influence of postoperative treatment on the results of temporomandibular joint (TMJ) menisectomy, the maximum voluntary opening and closing movements of 67 patients who underwent either total menisectomy or partial menisectomy with disk repair were recorded (BioEGN) and analyzed and compared to those of 10 normal subjects. The postoperative treatment was classified into three different types depending on its strategy. It was observed that postoperative treatment which emphasized physical medicine modalities could produce opening and closing movements of the mandible closer to the normal range. The effect of the postoperative treatment on the results of total menisectomy was more significant than that on the results of partial menisectomy with disk repair. Partial menisectomy with disk repair resulted in better opening and closing movement than total menisectomy.

A retrospective study on the results of temporomandibular joint (TMJ) surgery was performed in 74 patients with total menisectomy, 90 patients with partial menisectomy with disk repair, and 66 patients with arthroscopic lysis of adhesion and lavage of the joint space. TMJ pain during jaw movement, TMJ noise (recorded with BioJVA) and maximum jaw opening (recorded with BioEGN) were evaluated one year after surgery. TMJ pain and TMJ noise were significantly reduced by all three procedures. However, TMJ clicking was more significantly observed in patients with arthroscopy. Maximum jaw opening was significantly increased by all three procedures. However, maximum opening of patients with total menisectomy was significantly smaller than in the other two procedures.


To investigate the effect of malocclusion on mandibular movement during speech, the Sirognathograph Analyzing System was used to analyze the form of the envelope of motion during speech, as well as the relationship between the envelope of motion and eccentric movement paths, in 10 normal subjects and 60 subjects having malocclusion. Location of the envelope of motion, and the relationship between the envelope of motion and eccentric movement paths, were closely related to specific malocclusions. It is suggested that analysis of the envelope of motion during speech has diagnostic value in speech function assessment and that its detailed analysis offers valuable information for diagnosis and initiation of dental treatment.


Chewing performance is an expression of the functional capacity of the jaws and teeth. In a recent study of fully dentate subjects, the variation in chewing performance could not be explained by differences in occlusal contact area. It was now decided to investigate the possibility that chewing performance might be associated with certain patterns of jaw movement. (BioEGN) data from two previous studies using the same subjects were analysed using a step-wise regression to select variables of jaw movement that could predict chewing performance. A multivariate model with an R2 value of 0.79 (p < 0.000) was generated with particle size as the dependent variable. Eight components of jaw movement made up the independent variables. Some of the more dominant variables in the model were those that describe a wide, bilateral chewing cycle with a predominantly lateral path of closure. Another powerful predictor of efficient chewing was a smooth, flowing movement with minimal changes in velocity. The inclusion of occlusal contact area in the model did not enhance its predictive capability. It was concluded that selected jaw-movement variables were significant determinations of chewing performance, and therefore could contribute to developing a baseline for normal masticatory function.


Measuring mandibular rotations by sensing changes in a magnetic axis is described for simple mandibular motions (BioEGN). The motions described include; a) open wide and close, b) closure from rest to centric occlusion, 3) lateral excursions from centric occlusion and 4) mastication. The author describes the use of simple trigonometry to convert rotational measurements (in degrees) into differential translations in millimeters. The author concludes that with the addition of the sagittal rotation (to the
frontal and horizontal) it will be possible to measure mandibular motion with 6 degrees of freedom and thereby substantially increase our understanding of stomatognathic function.


To investigate the effect of malocclusion on mandibular movements during speech, the location, width and height of the envelope of motion during speech were analyzed in 25 normal subjects and 60 subjects with malocclusion using the Sirognathograph Analysing System. Location of the envelope of motion was closely related to the specific types of malocclusions. It is suggested that the analysis of the envelope of motion during speech has diagnostic values in speech function and dental treatments.


Chewing is influenced by a number of factors, which include jaw and tongue movements, the activity of circumoral muscles, bite force and hard oral surfaces, but it is not clear which of these factors is most crucial to efficiency. The mere presence of surfaces such as the hard palate, or teeth, does not insure that chewing will be efficient. The purpose of this study was to explore the relationship between occlusal contact area, and chewing efficiency and to observe the influence of chewing-side preference on efficiency. These variables were recorded for both left- and right-hand sides, in a sample of 26 normal young adults. Chewing efficiency was estimated by the size of food particles collected after a predetermined number of chewing strokes. The particles were measured using image analysis and the median size calculated. Comparisons were made, firstly within subjects, between the left- and right-hand side, and secondly between subjects. Correlations were found between chewing efficiency and occlusal contact area which were more pronounced within, than between, subjects. It was concluded that while occlusal contact area influenced chewing efficiency within the same individual, it could not account for the differences in chewing efficiency found between individuals. Differences in the movement of the jaw and in the bite force may have a greater influence on chewing efficiency than occlusal contact area.


Preference for a particular chewing side may be influenced by several factors, one of which could be the functional contact area on each side of the dentition. In this study, interocclusal wax records were made for each of the 30 subjects. A digital image of the transilluminated wax record was analysed to group 'grey' values into categories of wax thickness. The total area for tight and intermediate tooth contacts was calculated for both the left- and right-hand sides of each subject. The chewing-side preference was recorded. No correlation was found between the area of occlusal contact on one side and the preference for chewing on that side. Occlusal contact area does not appear to be a determinant of chewing-side preference.


To investigate the chewing patterns of patients with TMJ disorders, analysis of mandibular movement (BioEGN) was performed in 25 normal subjects and 150 patients with stomatognathic dysfunction using the Sirognathograph analyzing system. Patients with TMJ disorders demonstrated different chewing
patterns than those of normal subjects. Chewing patterns in the frontal, horizontal, and sagittal projections were classified into four, two, and two different patterns, respectively, and each distinct chewing pattern appeared to be associated with a specific TMJ disorder.


This paper evaluates a new instrument for the analysis of jaw movements in three planes of space. The range of linearity, the saturation point, and the effect of the different positions of the magnet in relation to the sensors are presented. It is concluded that linear analysis of chewing movements via this system is reasonably adequate without major distortion, whereas linear analysis of maximal mandibular movements should be viewed with caution.


Three-dimensional electrognathography (BioEGN) of an incisor point was used to detect peripheral correlates of deprogramming of the jaw elevator muscles. Putative deprogramming was attempted through the clinically recommended use of a leaf gauge, placed for 10-15 min between the maxillary and mandibular anterior teeth and disoccluding the posterior teeth by about 2 mm. Studied mandibular displacements were those that occurred during voluntary elevation of the mandible from the postural to the intercuspal position. Use of the leaf gauge did not affect the displacement patterns. Within a freeway space of about 2.2 mm, the incisor point moved about 2 mm vertically, about 1 mm sagittally, and about 0.2 mm laterally.


A method of analysing jaw movement data (BioEGN) was developed by converting jaw displacements into a matrix of frequency distributions. Low frequencies were first filtered out; then quartiles and modes were used to describe the remaining core. Eight different types of measures (variables) were developed to describe the proportions and density of a core of movement. These variables were repeatable at successive recording sessions, yet accurate enough to reveal differences in chewing patterns between right- and left-sided chewing. All eight variables of jaw displacement were required to discriminate between the chewing sides of 15 subjects. A statistical model was developed to express the principal components of jaw movement. The first component consisted of variables that expressed the shape of the chewing cycle; the second, its distribution about the midline; the third, the prevalence of a bimodal pathway in the sagittal plane. There was a wide variation in patterns of chewing movements, which appear to be consistent with normal masticatory function. A multivariate model appears to be required to describe chewing movements.


Jaw movements during voluntary chewing were recorded from 15 normal subjects with a sirognathograph. A computer program was used to provide a graphic display of the closing strokes in the frontal plane. A record was made of the side from which the jaw approached a central occlusal position. An average of 90 closing strokes was recorded for each subject. In 10 of the subjects, statistical differences were found between the use of the right- and left-hand sides. In these subjects this preference was confirmed by analysis of results from a second set of observations. A model was derived, using multiple regression analysis, which identified a relationship between four jaw-movement variables and
an index of preference. A broad chewing pathway, with a bilateral distribution, together with a wide sagittal pathway were characteristics associated with preference. An indication of optimal jaw-movement patterns may be derived from identifying movement variables associated with preferred chewing.


Mandibular movements were evaluated for border and functional movements in 24 adult normal subjects and 26 adult patients with muscle pain associated with a craniomandibular disorder. The mandibular incisor position was tracked with an electromagnetic system in three planes by use of either a Myotronic Kinesiograph or a Siemens Sirognathograph instrument while the subject sat in an upright position. In the normal subjects, the maximum movements of the mandible in lateral, protrusive, and vertical directions were compared with the envelope of movement during speech and mastication. The range of the rest position was 1 to 5 mm in relation to the intercuspal position; the range of maximum excursion during speech was 30% to 36% of maximum opening; the vertical extent of excursion during mastication was 18% to 90% of the maximum vertical opening dependent on the bolus. Protrusive movements were straight forward, dividing the angle evenly between left and right laterotrusion. Laterotrusive movements were of equal length and similar to the length of protrusion. Twenty-six patients with muscle pain, in many instances, demonstrated asymmetry in the length of laterotrusive movements. Different pathways for moving the mandible away from the intercuspal position and returning to this position could be seen during laterotrusion. Unequal laterotrusive excursions and asymmetrical, nonparallel movement patterns for mandibular protrusion and retrusion were often observed. In contrast, the extent of the speech envelope and the envelope of mastication were similar to that of the controls.


Opening and closing mandibular border movements of 250 subjects, 130 with clinical signs of TMJ pathosis and 120 normal subjects, were evaluated by measuring incisal interocclusal distance and recording mandibular movement on a tracking device (sirognathograph). Both maximal opening and closing pathways were divided into initial and secondary phases, and were further classified into seven patterns on the basis of anomalous mandibular movements. Subjects with TMJ sounds tended to show mandibular deviations in the second phase, while those with tenderness to muscle palpation tended to show deviations in both phases. Subjects with bruxism demonstrated twice as many deviations in the second phase.


Mandibular rest position, swallowing occlusal position, and maximum opening were evaluated in a sample of healthy young adults (52 male, 27 female) using a mandibular kinesiograph. It was found that males have a significantly greater vertical dimension of rest than do females, while there were no gender differences in the maximum opening. Most of the subjects had a swallowing occlusal position that coincided with or was very near to the position of maximum intercuspation. Reported data allow the definition of a three-dimensional normal range of variability of maxillomandibular positions during the functional tests most frequently used.

Mandibular border movements were studied in a group of 74 healthy young men and women with sound dentitions and class I molar relationships. Movements were directly performed by the subjects and recorded with a mandibular kinesiograph, and slopes of the first millimeters of motion in the anterior and lateral guidances were calculated. In anterior guidance, the sagittal plane slope was steeper in men than in women, whereas the horizontal plane slope showed no gender differences. In the lateral guidances, frontal plane slopes were steeper in men than in women, with no side differences. The horizontal plane slope presented no side or sex differences. Most of the subjects demonstrated asymmetric guidances for both protrusive and the laterotrusive movements. These findings suggest that criteria for defining the norm should include asymptomatic asymmetry instead of strict morphologic symmetric appearance.


Jaw movements during voluntary chewing were recorded from 15 normal subjects with a sirognathograph. A computer program was used to provide a graphic display of the closing strokes in the frontal plane. A record was made of the side from which the jaw approached a central occlusal position. An average of 90 closing strokes was recorded for each subject. In 10 of the subjects, statistical differences were found between the use of the right- and left-hand sides. In these subjects this preference was confirmed by analysis of results from a second set of observations. A model was derived, using multiple regression analysis, which identified a relationship between four jaw-movement variables and an index of preference. A broad chewing pathway, with a bilateral distribution, together with a wide sagittal pathway were characteristics associated with preference. An indication of optimal jaw-movement patterns may be derived from identifying movement variables associated with preferred chewing.


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