The Effect of Occlusal Appliances and Clenching on the Temporomandibular Joint Space

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It has been suggested that stabilization appliances and mandibular anterior repositioning appliances work by decompressing the temporomandibular joint. To indirectly test this assumption, tomograms of right temporomandibular joints of seven subjects were taken during comfortable closure and maximum clenching in maximum intercuspation and on the two types of occlusal appliances. Outlines of the condyle and the temporal fossa were automatically determined by an edge detection protocol. Upon comfortable closure, the anterior joint space dimension was reduced with stabilization appliances and mandibular anterior repositioning appliances. Upon maximum clenching, the minimum joint space dimension on stabilization appliances was equivalent to that seen in maximum intercuspation, while that on mandibular anterior repositioning appliances was substantially less ($P < .05$). Findings do not indicate that these appliances induce an increase in joint space during clenching.
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Stabilization appliances (SA) and mandibular anterior repositioning appliances (MARA) have been widely utilized for management of temporomandibular disorders (TMD) such as internal derangement and degenerative arthritis. Although these appliances have been assumed to reduce articular surface compression in the temporomandibular joint (TMJ) during closing or clenching,[1] no supporting scientific data have been reported about the decompressive effects on TMJ structures.

There have been three approaches used to assess joint loading during the wearing of occlusal appliances. One method involved a biomechanical model of TMJ loading during clenching onto occlusal appliances. Dos Santos et al[2] used a model for TMJ loading during clenching on both the SA and the MARA by a simple vector calculation. They concluded that insertion of the SA tends to decrease pressure in the TM joints, and insertion of the MARA with a guiding ramp tends to increase pressure in the TM joints. Their model incorporated the following three assumptions: *(1)* The articular surfaces of the mandibular condyle and the disc were in contact directly with the surface of the articular eminence while the appliances were used; *(2)* The resultant muscle force vectors could be located along a line at the level of the posterior teeth (between premolars and mandibular ascending ramus) and perpendicular to the horizontal plane; and *(3)* The disc was in the same position between the bone elements with and without the appliances. Unfortunately, these assumptions and the resulting data have never been validated in humans.[2]

Another method for assessing joint forces involved predicting minute condylar movements induced by clenching tasks from remote mandibular point movements measured with a jaw tracking system. Based on predicted condyle movements, Ito and colleagues[3] assessed the direction and relative magnitude of TMJ loading. They compared condylar movements during clenching on different occlusal splints and concluded that no significant condylar shift was induced by clenching on the SA or the MARA. Based on these data, they assumed that decompressive effects were induced by use of the occlusal appliances. However, this method had two crucial shortcomings. First, the examiners could only measure movement of a hypothetical condylar point that might not reflect the interarticular surface loading in the TMJ. Second, the data might have had inherent errors for condylar movement measurements because the system did not reflect the deformation of the mandible during clenching. It is well known that a decrease in mandibular dental arch width can be measured at open and protruded jaw positions.[4–7] Moreover, deformation of the human mandible during clenching has been estimated to range from 0.46 mm to 1.06 mm by finite element analysis.[8] Those findings demonstrate that deformation levels of the mandible during normal function are too large to assess the relationship of the articular surfaces of the TMJ.

An additional approach for assessing joint loading was an intra-articular pressure measurement at the posterior slope of the eminence in the upper compartment of the TMJ. Nitzan[9] measured intra-articular pressure in 22 TMD patients while they clenched. Pressure measurements were obtained with the jaw at rest and while clenching on a specially constructed interocclusal appliance that uniformly elevated the occlusal plane. Nitzan reported that the interocclusal appliance significantly reduced intra-articular fluid pressure during clenching. Although this can be considered an important finding about fluid pressures of the upper posterior joint compartment, such information cannot be directly correlated to assume changes in inter-articular (surface-to-surface) joint loading. Furthermore, the intra-articular pressure measurement technique used has not been shown to be valid or reliable.

Considering earlier work limitations with TMJ loading and occlusal appliances, the authors of the present study used a helical blurring-motion tomogram enhanced by a computerized image analysis system to directly measure changes in condylar position and joint space dimension during comfortable closure and maximum clenching in the intercuspal position (ICP) and on two different occlusal appliances (SA and MARA). It was hypothesized that there would be an increase in TMJ space while the appliances were used.

Materials and Methods

Subjects

Seven male Okayama University Dental School students were selected to participate. General medical and dental histories were recorded from interviews. The inclusion criteria for subject selection were *(1)* no significant medical history, *(2)* men between ages 22 and 24 years, *(3)* absence of acute dental disease, *(4)* presence of all teeth except third molars, *(5)* no history of TMD such as joint pain, joint noise, or masticatory muscle pain, *(6)* no significant tenderness of the masticatory muscles, and *(7)* no palpable noise with normal translatory movements of the condyle during normal open-close cycles. The exclusion criterion for the selection was radiographic evidence of structural changes in the TM joints. Informed consent was obtained from each subject prior to commencement of the experiment.

Experimental Procedures

The SA and MARA were fabricated for each subject prior to the experiment. Dental impressions of the maxillary and mandibular arches were used to make the stone casts. The SA used in this experiment was a maxillary complete appliance with a flat occlusal table. This device was adjusted to provide uniform simultaneous occlusal contact of all teeth except the third molars. The MARA used in this experiment was a maxillary complete appliance with indentations and guiding ramps that were used to keep the mandible in an anterior position. The SA was designed to open the jaw vertically 3 mm from ICP in the anterior teeth region; the MARA was designed to hold the jaw in a straight, forward position 2 mm from ICP, with the mandibular and maxillary anterior teeth in an edge-to-edge relationship. The subjects were instructed to close their jaws comfortably without biting. The interjaw relationship for SA and MARA was registered intraorally with a silicone impression material (Exabite, GC, Tokyo, Japan) by monitoring the position of the mandible with a jaw tracking system (mandibular kinesiograph K6-I, Myotronics, Seattle, WA). The mandibular position was monitored to instruct the subjects on where to position their jaws during the occlusal registration and to check on the postadjustment position of the jaws after completion of the appliances. The appliances were made of poly(methyl methacrylate) resin (Acron MC, Shofu, Kyoto, Japan) and were preadjusted on an articulator. Before the experiment, both appliances were carefully adjusted using articulating paper to obtain a stable position with even contact on all posterior teeth subjectively and objectively. The final interjaw relationship achieved with the appliances was reconfirmed with the jaw tracking system.

For the radiographic assessment, each subject was seated with his head tightly fixed by a head positioner that had individualized bilateral ear rods and pointers placed on his forehead and under his nose so that the Camper's plane was parallel to the floor.

Tomographic slices were perpendicular to the long axes of the mandibular condyles. Beam angles were corrected 15 degrees laterally. Serial sagittal tomograms of the TM joints were obtained using Optiplanimat (Siemens, Erlangen, Germany), with a spiral 45-degree pattern that provided at least three 2-mm-thick slices with intervals of 5 mm (160 mAs, 66 kVp; Fuji G-4 screen, Fuji Photo Film, Tokyo, Japan). The tomogram with the slice level nearest the central part of the condyle was selected. Joint images were obtained at this slice depth with the subjects closing comfortably and clenching maximally in the ICP. This procedure was repeated for both appliances for the seven subjects. Overall, six images were taken for each subject: one baseline condition (comfortable closure in ICP) and five experimental conditions (comfortable closure on the SA and on the MARA; and maximum clenching in ICP, on the SA, and on the MARA). The right TM joints in patients were imaged. The sequence for acquiring each of these six images was randomly assigned for each subject. Three-minute intervals were allowed between the imaging procedures. The radiologic technician was given no information on the specific aim of this study.

Image Analyzing Procedures

All tomograms were numbered sequentially. Two-dimensional joint space measurements were made in a blinded fashion by one of the authors.[10] Tomograms were digitized using a CCD camera (TK-1070, Victor, Tokyo, Japan). Outlines of the condyle and the temporal fossa were then automatically determined by the following steps.

First, after digitizing, imaging data were smoothed by median filtering, which easily removed noise without deteriorating the signal data. Second, to make a binarization of the smoothed image, edge detecting was performed with the following formula, which contains spatial differentiation procedures:

$$e = \sqrt{[\Delta x f(i, j)]^2 + [\Delta y f(i, j)]^2}$$

where e is the edge strength; $f(i, j)$ is the gray level in the coordinates (i, j); $\Delta x f(i, j)$ is $(f[i + 19, j] - f[i, j]) - (f[i, j] - f[i - 19, j])$; and $\Delta y f(i, j)$ is $(f[i, j + 19] - f[i, j]) - (f[i, j] - f[i, j - 19])$. Discrimination analysis was used for thresholds (Fig 1a).

Third, the binarization routine included user-interactive identification of the outlines simultaneously on the original and the binarized images. If one threshold in an entire imaging area was not enough to clearly delineate the outlines of the condyle and articular eminence simultaneously, the threshold was partially changed, and a map of several different thresholds was manually composed. Once the thresholds were determined for each joint, no change was made during the whole measurement course for the same joint.

Fourth, after fusion and labeling of the condyle and the temporal fossa (Fig 1b), their outlines were processed by tracing the borders (Fig 1c). The original image formed by the superior line of the condyle and the inferior line of the temporal fossa was selected for measuring condylar positional changes and joint space dimension (Fig 1d).

Outcome Measurement and Data Reduction

To measure condylar positional changes and joint space dimension, a reference point in the condyle was determined and was overplotted onto the images. After each condyle was skeletonized, a circle with its center situated on a condyle skeleton line[11] was moved to locate the position in which its section most closely approximated the condyle outline. The center of the circle was used as the reference point of the condyle (Pc) (Fig 2a).

Relative positional changes in Pc were established by a best fit method using the outlines of the temporal fossa. In all subjects, the position of Pc during comfortable closure in ICP was considered as a zero reference point. Positional changes

Fig 1a *(Left)* Edge detecting and discrimination analysis produces a binarized image of the tomogram.

Fig 1b *(Right)* Fusioning of the binarized image and labeling of the condyle and the temporal fossa eliminate noise and result in a clean image.

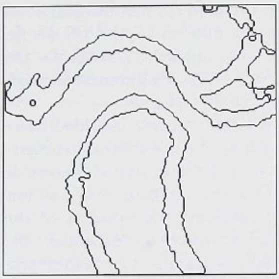

Fig 1c *(Left)* To create the outlines for measurement, the borders of the labeled image are traced automatically. The outermost dots are picked up and connected to make a closed image.

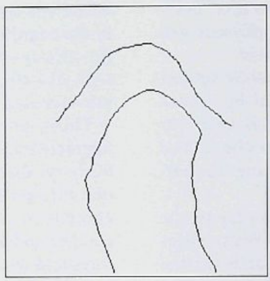

Fig 1d *(Right)* The outer outline of the condyle and the inner outline of the glenoid fossa, which are the closest to the joint space, are selected from the border image.

in Pc with each experimental condition were individually determined for each subject, and the mean positional change in Pc for the seven subjects was calculated for the vertical and horizontal directions (Fig 2b).

Joint space dimensions were measured every 2 degrees from Pc. A vertical reference line connecting Pc with the temporal fossa divided the joint space into anterior (linear measurements from 0 to +90 degrees) and posterior (linear measurements from 0 to –90 degrees) joint spaces (Fig 2c).

The minimum joint space (MJS) for each experimental condition was individually determined for each subject. It was defined as the closest distance between the condyle and the fossa outlines. Measurements were corrected with a mathematical formula because the tomograms were magnified according to the table-to-subject distance:

$$L = a/1150[1150 - (97 + X)]$$

where L is the actual dimension (mm); X is the table subject distance (mm); a is the dimension measured on the tomogram; 1,150 is the film focus distance (mm); and 97 is the table film distance (mm).

Normalized MJS dimension scores for the experimental conditions were calculated dividing the MJS during each experimental condition by the MJS during comfortable closure in ICP (baseline). The normalized joint space dimension in each direction relative to Pc was similarly calculated by dividing the joint space dimension during each experimental condition (degrees) by the corresponding dimension during comfortable closure in ICP (degrees); this was plotted as joint space distribution data. If no change in dimension occurred, a normalized dimension score of 1.0 resulted. A score less than 1.0 represented a reduced space, and a score greater than 1.0 represented an increased space.

All radiographic landmarks were digitized, and calculations were performed using a computer system (NEC PC-9801 RA21, Tokyo, Japan) by means of a special program created by one of the authors.

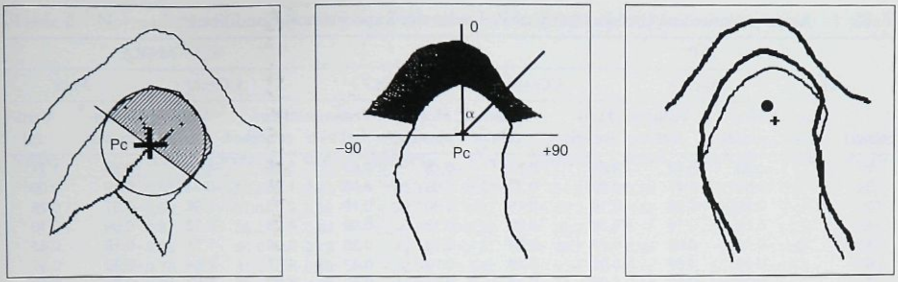

Fig 2a After each condyle is skeletonized, a circle with its center situated on a condyle skeleton line is moved to locate the position in which its section most closely approximates the condyle outline. The center of the circle is used as the reference point of the condyle (Pc).

Fig 2b Minimum joint space (closest distance between condyle and fossa outlines) is determined automatically. A line that starts at Pc and forms angle α with a line perpendicular to the Camper's plane is drawn in a radial manner. The intersections between the radial line and the outline of the condyle and the temporal fossa are determined. The intersections are measured as the joint space dimension in angle α.

Fig 2c Minute condylar movement is measured by a line-fitting method of the outlines of the temporal fossa. Two original images for the measurements before and during clenching are simultaneously input into the computer display so that the outline of the temporal fossa during clenching can be superimposed on the outline before clenching. Minute condylar movement is computed by the movement of Pc in the superoinferior and anteroposterior directions (+, before clenching; •, during clenching).

Statistical Analysis

Means and standard deviations (SD) of the horizontal and vertical shifts in Pc and in the MJS score with each experimental condition were calculated as outcomes variables. One-sample *t* tests were used to analyze whether these changes were significantly different from the corresponding baseline measurements seen during comfortable closure in ICP. A one-way repeated-measure analysis of variance (ANOVA) was used to analyze the mean differences between the different experimental conditions and any possible subject effects. The least significant differences were calculated to determine a threshold difference between two means for a significance level at $\alpha = .05$.

Reproducibility of the Measurements

A test for reproducibility of the above measurement method was performed with a 22-year-old male. Six tomograms were obtained at 3-minute intervals during comfortable closure in ICP. The MJS was measured in the six tomograms as described.

The MJS (mean ± SD) and its relative direction (vector) from Pc (mean ± SD) in these six images were determined as 1.27 ± 0.07 mm and 35.06 ± 5.62 degrees, respectively. The SD was less than the pixel size resolution (0.10 mm) of the initial digitizing procedure of the tomograms.

Results

Positional shifts in Pc induced by clenching in ICP and onto the appliances are shown in Table 1. Maximum clenching in ICP produced a statistically significant superior shift in Pc (mean change = 0.32 mm; $P = .0002$). As expected, comfortable closure on the SA induced nonsignificant inferior (mean change = 0.20 mm; $P = .1307$) and statistically significant anterior (mean change = 0.41 mm; $P = .0116$) shifts in Pc. Comfortable closure on the MARA produced statistically significant inferior (mean change = 2.86 mm; $P = .0001$) and anterior (mean change = 3.72 mm; $P < .0001$) shifts in Pc relative to the position of Pc during comfortable closure in ICP.

Table 1 Relative Positional Changes (mm) of Pc Under the Experimental Conditions*

	ICP		SA				MARA			
	Max		CC		Max		CC		Max	
Subject	Horizontal	Vertical	Horizontal	Vertical	Horizontal	Vertical	Horizontal	Vertical	Horizontal	Vertical
1	–0.09	0.19	0.09	–0.37	–0.19	0.47	3.16	–4.19	–0.56	1.21
2	0.00	0.47	0.08	0.37	0.00	0.00	1.95	–0.74	0.19	–0.09
3	0.00	0.28	0.19	–0.19	0.00	0.19	2.33	–1.95	–0.37	0.28
4	0.18	0.18	0.28	–0.09	–0.19	–0.09	4.88	–3.13	–0.09	–0.18
5	–0.18	0.63	0.27	–0.09	–0.18	0.36	3.06	–1.71	–0.18	0.63
6	–0.19	0.09	0.93	–0.28	–0.19	0.47	4.37	–2.64	–0.28	0.47
7	0.28	0.37	1.02	–0.74	–0.37	0.47	6.32	–5.67	–0.56	0.28
Mean	0.00	0.32	0.41	–0.20	–0.16	0.26	3.72†	–2.86†	–0.26	0.37
SD	0.18	0.19	0.40	0.34	0.13	0.24	1.55	1.65	0.27	0.47
P	1.0000	.0002	.0116	.1307	.0030	.0000	.0000	.0001	.0153	.0000

*Max = maximum clenching; CC = comfortable closure.
CC in ICP was used as a reference (0) for comfortable closure on the SA and on the MARA. Each CC was used as a reference for MAX. Positive values for the horizontal component indicate anterior; positive values for the vertical component indicate superior.
P was based on one sample *t* test (CC in ICP = 0).
Least significant differences at α = .05 are .7636 (horizontal) and .8405 (vertical).
†Mean positional change of comfortable closure on the MARA was significantly different from that of others (one-way repeated-measure ANOVA, $P < .05$).

A repeated-measure ANOVA performed on these data revealed a strong main effect for the experimental conditions in both vertical ($P < .0001$) and horizontal ($P < .0001$) directions. However, this significant main effect occurred because comfortable closure on the MARA mean change was significantly different from the other four clenching conditions. The other four conditions were not significantly different from each other (least significant difference = 0.7636 in vertical, 0.8405 in horizontal).

Changes in the normalized MJS dimension scores induced by maximum clenching in ICP and onto the appliances are revealed in Table 2. A statistically significant reduction in the mean normalized MJS dimension score was observed during all the experimental conditions relative to the corresponding baseline measurements seen during comfortable closure in ICP. Mean angular directions of the MJS from Pc showed that during maximum clenching in ICP and on the SA, the location of the MJS varied among the subjects. However, during comfortable closure on the SA and during maximum clenching on the MARA, the MJS was located in the anterior joint space in all subjects.

A repeated-measure ANOVA performed on these data revealed a significant main effect for the experimental conditions ($P < .0001$). However, no statistically significant differences were observed among changes in the mean normalized MJS dimension scores during comfortable closure on the SA, maximum clenching on the SA, and maximum clenching in ICP (least significant difference = 0.0976). In other words, the SA did not induce an increase in the MJS dimension. Furthermore, the normalized MJS dimension scores during comfortable closure and maximum clenching on the MARA were significantly lower than those during comfortable closure on the SA, maximum clenching on the SA, and maximum clenching in ICP ($P < .05$). Therefore, it can be stated that MARA induced a significant reduction of the anterior joint space relative to the corresponding measurements during maximum clenching in ICP and maximum clenching on the SA.

Relative changes of joint space distribution induced by maximum clenching in ICP and onto the appliances are shown in Figs 3 to 5. A slight reduction of the superior joint space was observed during maximum clenching in ICP; however, joint space distribution did not change substantially. Comfortable closure on the SA induced a slight reduction of the anterior joint space and an increase in the posterior joint space. During comfortable closure on the MARA, the posterior joint space was dramatically increased, and the anterior

Table 2 Normalized Minimum Joint Space Dimension Scores Under the Experimental Conditions*

	ICP		SA				MARA			
	Max		CC		Max		CC		Max	
Subject	Normal-ized-score	Angle (degrees)	Normal-ized score	Angle (degrees)	Normal-ized score	Angle (degrees)	Normal-ized score	Angle (degrees)	Normal-ized score	Angle (degrees)
1	0.86	–52.8	0.83	67.4	0.82	–51.9	0.33	35.0	0.40	36.3
2	0.90	–51.8	0.92	35.7	0.87	–62.2	0.70	23.2	0.76	29.6
3	0.87	55.2	0.85	48.8	0.80	53.6	0.71	44.0	0.59	51.1
4	0.79	50.0	0.79	40.3	0.81	40.2	0.68	17.1	0.65	25.9
5	0.78	41.2	0.68	52.9	0.80	53.1	0.46	50.5	0.57	54.8
6	0.90	–50.0	0.88	55.3	0.81	–45.0	0.95	46.4	0.71	47.6
7	0.81	55.8	0.81	52.8	0.73	55.8	0.50	51.1	0.48	43.8
Mean	0.85	6.8	0.82	50.5	0.81	6.2	0.62†	38.2	0.60†	41.3
SD	0.05	54.8	0.08	10.4	0.04	55.9	0.20	13.5	0.13	11.0
P	.0000	–	.0000	–	.0000	–	.0001	–	.0000	–

*Max = maximum clenching; CC = comfortable closure.
CC in ICP was used as a reference (1) for every intervention.
P was based on one sample *t* test (CC in ICP = 1).
Least significant differences at α = .05 is .0976.
†Mean normalized minimum joint space dimension scores for the MARA were significantly different from those under the other three experimental conditions: MAX in ICP; CC on SA; and MAC on SA ($P < .05$).

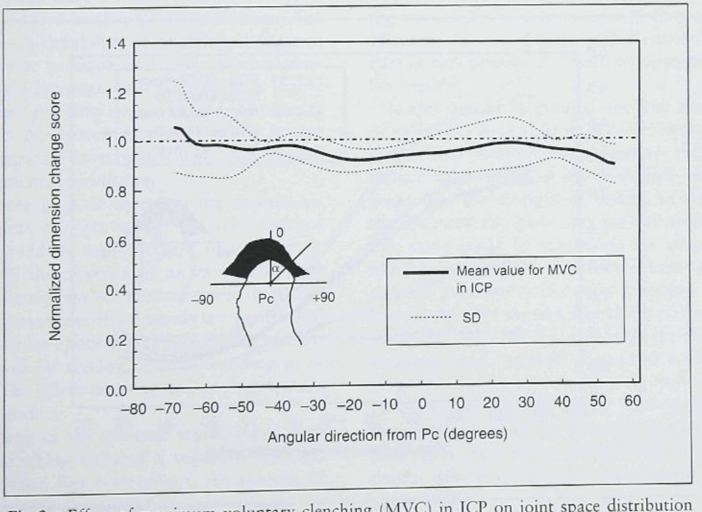

Fig 3 Effect of maximum voluntary clenching (MVC) in ICP on joint space distribution for seven subjects. Mean normalized dimension change scores during maximum clenching in ICP are plotted against the angular direction from Pc. Scores were calculated by the following equation: normalized value = joint space dimension during maximum clenching in ICP/joint space dimension during comfortable closure in ICP. Positive values for angular direction from Pc correspond to anterior direction. Scores less than 1 *(dotted line)* occurred when the joint space was reduced by clenching.

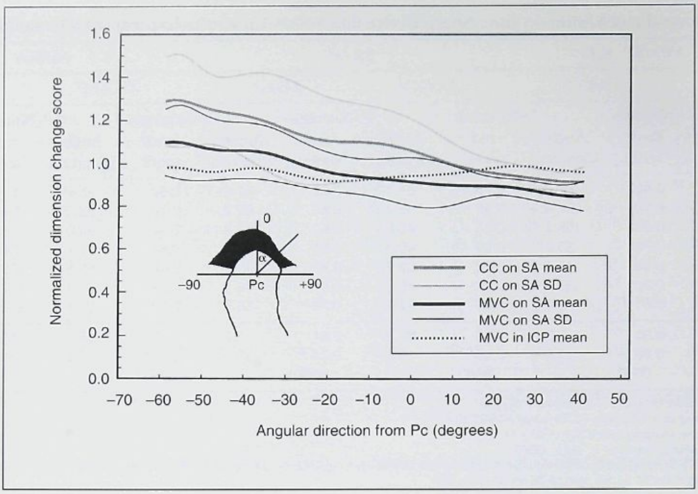

Fig 4 Effect of comfortable closure (CC) and maximum voluntary clenching (MVC) on SA on joint space distribution for seven subjects. Mean normalized dimension change scores during comfortable closure and maximum clenching on the SA were plotted against the angular direction from Pc. Positive values for angular direction from Pc correspond to anterior direction. Scores less than 1 occurred when the joint space was reduced relative to the level during comfortable closure in ICP.

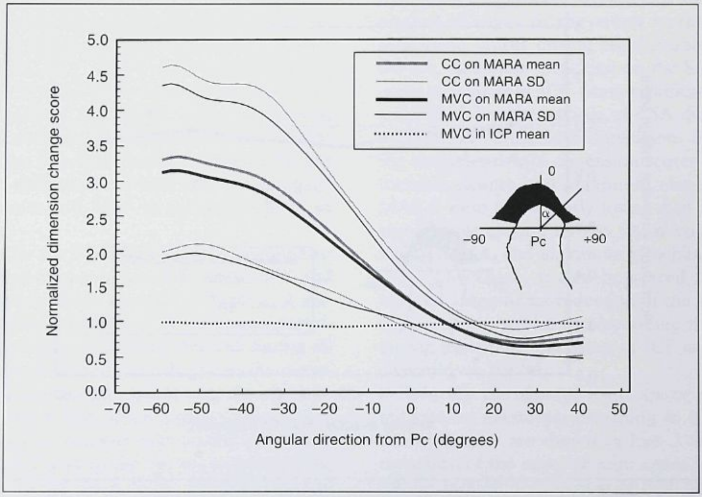

Fig 5 Effect of comfortable closure and maximum voluntary clenching on MARA on joint space distribution for seven subjects. Mean normalized dimension change scores during comfortable closure and maximum clenching on the MARA were plotted against the angular direction from Pc. Positive values for angular direction from Pc correspond to anterior direction. Scores less than 1 occurred when the joint space was reduced relative to the level during comfortable closure in ICP.

joint space was reduced (Fig 5). These angle-based mean curves do not necessarily show the actual change in the MJS dimension because the MJS direction (vector) from Pc differed among the subjects. Averaging produced estimates that are slightly lower than the actual reduction. A more accurate reflection of joint space changes would be the normalized MJS scores (see Table 2).

Discussion

The present study has several advantages over other studies. The present study was based on direct measurements of condylar movement using TMJ imaging. Therefore, our data include any mandibular deformation effects during clenching, avoiding errors associated with assumptions of condylar movement from a hypothetical condylar point. In addition, changes in condylar position and joint space dimension in our study were automatically measured on a helical blurring-motion tomogram enhanced by a computerized image analyzing procedure with a very high resolution (0.10 mm); other digital imaging techniques (eg, computer tomography or magnetic resonance imaging) provide no more than 0.5-mm resolution. Thus, our computer-aided analog imaging technique has a relatively high capability of detecting changes in minute condylar position and joint space dimension. Another advantage with our system is that it was automatic, and thus avoided bias in measuring the outcome. Measurements were made in our study by a separate investigator who was blinded to the experimental conditions.

Our ultimate goal of assessing the surface-to-surface pressure changes within the joint was not directly achieved by measurement of joint space dimension. In the absence of an in vivo human joint direct compression measurement method, however, measurement of condylar positional changes and joint space dimension during clenching is as good an analog of joint loading as is available.[12] The assumption of this analogy awaits direct verification.

Overall data in the present study show that maximum clenching induced a superior condylar positional change. For both splints, the amount of superior condylar positional change induced by maximum clenching was comparable to the condylar positional change induced during clenching without the splint in ICP. Upon maximum clenching, the minimum joint space dimension for the SA was equivalent to that seen in ICP; the dimension for the MARA was significantly less. These data show that neither the SA nor the MARA increases joint space. If the analogy between joint space and joint loading is correct, then these appliances do not decompress joint articular tissues. What is likely to result from the use of an occlusal appliance is the transfer of loading to a slightly (SA) to moderately (MARA) different zone of joint articular tissues. Less joint tissue compression is also likely to occur because of the behavioral effect that appliances induce on jaw function. In our opinion, the hypothesis that these appliances automatically induce an increase in joint space and therefore decompress TMJ articular tissues cannot be accepted. However, the appliances may have a beneficial effect on the clinical symptoms of patients because of their tendency to change clenching behavior. Clark et al[13] emphasized this latter aspect of appliance therapy as an explanation for their efficacy.

It was noted that a reduction in joint space could also be a result of changes in disc position; however, it is believed that the disc is a passive structure that moves with the condyle. Although changes in disc position occurred, they did not alter the results. The basic premise is that any loading in the TMJ is transferred across the condyle and fossa surfaces via the disc; if the loading is enough, the joint space will decrease because of compression of the disc and the articular tissues. Part of this premise has been confirmed in an earlier study.[14]

It also should be pointed out that some sources of variability may exist in our joint space measurements. It is possible that closure on the SA might induce fulcruming of the mandible, which may mean that the amount of seating of the condyle, the disc, and the fossa may vary between subjects. The same could be speculated for closure on the MARA because this position is inherently more variable than any of the other positions. It was for this reason that the exact position of the mandible produced with the SA and with the MARA was measured and carefully controlled with the kinesiograph as a way of reducing the variability. However, even if fulcruming were induced easily, the result would be an increased variability in our joint space data, thus making it harder to find statistical differences between the various conditions in our study.

Our data were produced with a tomogram taken in a corrected sagittal plane. Changes in joint space dimension were not measured three-dimensionally. Animal experiments[7] have shown that a mammalian mandibular corpus can deform transversely and parasagittally, and in a rotational manner during function. Using a three-dimensional finite element computer model of the human jaw, Korioth and Hannam[8] predicted the complicated three-dimensional deformations (including rotational deformations) that occur in the human mandible even during clenching in ICP. The aim of future studies will be to apply this image analysis procedure to a three-dimensional imaging format. A more direct measurement method for assessing actual interarticular joint loading pressures (or intratissue pressure) in relation to jaw position and movement would also be desirable.

Summary and Conclusions

The effect of the stabilization appliance (SA) and the mandibular anterior repositioning appliance (MARA) on joint space dimension was assessed using helical blurring-motion tomograms enhanced by a computerized image analyzing procedure. Overall data in this study show that maximum clenching induced a superior condylar positional change. Comfortable closure on the SA induced a slight reduction in the anterior joint space and an increase in the posterior joint space. During comfortable closure on the MARA, the posterior joint space was dramatically expanded, and the anterior joint space was reduced. The minimum joint space dimension seen during maximum clenching on the SA was equivalent to that seen during maximum clenching in ICP, the dimension during maximum clenching on the MARA was significantly less. The findings do not support the hypothesis that these appliances induce an increase in joint space during clenching.

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Resumen

Efecto del Apretamiento Dentario y de las Placas Oclusales sobre el Espacio de la Articulación Temporomandibular

Se ha sugerido que las placas de estabilización y las placas reposicionadoras anteriores de la mandíbula producen un efecto descompresivo sobre la articulación temporomandibular (ATM). Con el propósito de probar indirectamente ésta suposición, tomogramas de la ATM derecha de 7 sujetos sanos fueron obtenidos en posición intercuspidea, sobre placas de estabilización y sobre placas reposicionadoras anteriores bajo dos condiciones de mordida: cierre confortable y máximo apretamiento dentario. Los contornos del cóndilo y de la fosa temporal fueron automáticamente determinados utilizando un protocolo de detección de bordes. El espacio articular anterior se redujo durante cierre confortable sobre la placa de estabilización y sobre la placa reposicionadora anterior. Durante máximo apretamiento dentario sobre la placa de estabilización, el mínimo espacio articular que fué definido como la distancia más corta entre los contornos del cóndilo y la fosa glenoidea fué equivalente al observado durante máximo apretamiento dentario en posición intercuspidea, mientras que se redujo significativamente durante máximo apretamiento dentario sobre la placa reposicionadora anterior. Basándonos en los resultados obtenidos podemos concluir que la hipótesis de que éstas placas inducen un aumento del espacio articular durante apretamiento dentario no debe ser aceptada. Si consideramos que la reducción del espacio articular está directamente relacionada con presión en los tejidos articulares, entonces se puede concluir que ninguna de éstas placas produce una reducción de la presión que ocurre sobre los tejidos articulares como resultado del apretamiento dentario.

Zusammenfassung

Die Wirkung von okklusalen Schienen und Pressen auf die Kiefergelenke

Es wird vermutet, dass Stabilisierungsschienen und den Unterkiefer nach anterior repositionierende Schienen durch Entlastung des Kiefergelenkes arbeiten. Um diese Annahme indirekt zu prüfen wurden Tomogramme des rechten Kiefergelenkes bei sieben Personen während komfortablem Schiessen und maximalem Pressen in maximaler Interkuspidation, sowie mit beiden Typen der okklusalen Schienen aufgenommen. Die Umrisse des Condylus und der Fossa Temporalis wurden automatisch bestimmt durch ein Kantenentdeckungsprogramm. Beim komfortablen Schliessen war der anteriore Gelenkspalt verkleinert mit der Stabilisierungs- und der Repositionsschiene. Beim maximalen Pressen war der minimale Gelenkspalt mit der Stabilisierungsschiene gleich dem gesehenen in maximaler Interkuspidation, während derjenige mit der Repositionsschiene wesentlich kleiner war ($P < .05$). Die Befunde weisen nicht darauf hin, dass diese Schienen einen vergrösserten Gelenkspalt während des Pressens herbeiführen.