A Preliminary Study on the Effect of Occlusal Vertical Dimension Increase on Mandibular Postural Rest Position

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The effect of increasing the occlusal vertical dimension on the mandibular postural relation was studied for eight subjects. Interocclusal rest space measurements were made weekly for 1 month prior and subsequent to increasing the occlusal vertical dimension by 3.5 to 4.5 mm interincisally using luted acrylic resin, complete-arch, fixed partial dentures. Interocclusal rest space measurements were made at the clinical rest position, which was established by requesting the subjects to close in maximum intercuspation and immediately relax their mandible. Interocclusal rest space measurements were also made at the more open resting position when the subjects were repeatedly instructed to relax and lapse into a semi-hypnotic condition termed "relaxed resting posture." Initial speech difficulties and muscle discomfort subsided after 1 to 2 weeks. Analysis of variance using repeated measures showed no significant difference in interocclusal rest space after increasing the occlusal vertical dimension for both clinical rest position and relaxed resting posture. A significant difference was found between clinical rest position and relaxed resting posture ($P = .001$), and no interaction was determined between clinical rest position, relaxed resting posture, and time. *Int J Prosthodont 1994;7:216–226.*

Many clinicians are concerned about substantially increasing the occlusal vertical dimension (OVD) using fixed or removable prostheses because of the inability to predict the patient's neuromuscular response. The question of whether the neuromusculature will adapt asymptomatically and develop a new mandibular postural relation, or whether an adverse nonadaptive neuromuscular response will ensue, has not been resolved by clinical research.

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Traditional views have maintained that the rest position of the mandible is fixed and unalterable[1–10] and that increasing the OVD beyond the rest vertical dimension (RVD) will encroach upon mandibular resting posture, which will lead to muscle hyperactivity and symptoms of temporomandibular disorders (TMD).[7–13] Recent evidence has shown mandibular resting posture to be variable and subject to factors such as body posture, drugs, sleep, age, tooth loss, and occlusal devices.[14–23] Removable occlusal devices that often intentionally increase the OVD beyond the clinical rest position (CRP) have proven to be effective in treating myogenic symptoms of TMD.[24–28] This is inconsistent with the contention that exceeding the interocclusal rest space (IRS) with prosthetic restorations will cause TMD symptoms.[7–13]

Studies on the effects of these removable occlusal devices have indicated that a new postural position is created that tends to stabilize over 1 week with decreased elevator and increased depressor activity.[24-28] Investigations of the effects of increasing the OVD with prosthetic devices on human subjects are limited and report reactions after only 1 week. Studies of complete denture wearers report symptoms of TMD in a 1-week period following an increase of OVD beyond the CRP.[29,30] Effects after 1 week were not reported.

The effects of cemented posterior overlay restorations in completely dentate subjects are reported in two studies.[29,31] Christensen[29] raised OVD experimentally beyond the RVD for 1 week using bilateral cemented overlay devices covering only the molars in 20 dentate subjects. Signs and symptoms of TMD were reported with the increased OVD.

Carlsson et al[31] increased the OVD 4 mm interincisally for 1 week in six dentulous subjects using acrylic resin overlay devices cemented from the canines distally. Initial TMD symptoms subsided within 1 week in most subjects, and a new postural position of the mandible was established with a new RVD. The original RVD was re-established on removal of the overlays.

Rivera-Morales and Mohl[32] maintain that since these studies were limited to 1 week, they provide insufficient evidence to support the hypothesis that increasing the OVD may cause symptoms of TMD. They also believe that the study of Carlsson et al[31] suggests the possibility of human adaptability. It is possible that the occlusal instability of the overlays used in these studies exaggerated the neurophysiologic response and that adaptation and functional harmony may ensue after more than only 1 week of observation.

The purpose of this preliminary investigation was to study for 1 month the effect of increasing the OVD on the postural relationship of the mandible. The OVD exceeded the clinical rest and was accomplished using complete-arch, acrylic resin, fixed partial restorations to provide a stable functional occlusion. Interocclusal rest space was electronically recorded at consecutive weekly intervals for 1 month prior and 1 month subsequent to the increase in OVD. By recording symptoms, this study attempted to address questions unresolved by previous 1 week studies.

Materials and Methods

Study Design

The experimental procedure was designed to electronically measure the IRS in human subjects with the mandible at two distinct postural relations. Recordings were made at consecutive weekly visits, five prior and five subsequent to increasing the OVD using stable, complete-arch, acrylic resin, fixed restorations. Measurements were made with a custom electro-optic device (Figs 1 and 2).

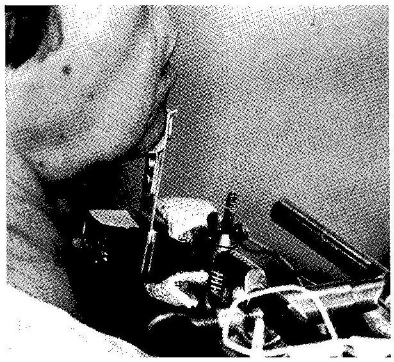


Fig 1 Patient seated with mandible in CRP; a custom LED recording device records the IRS.

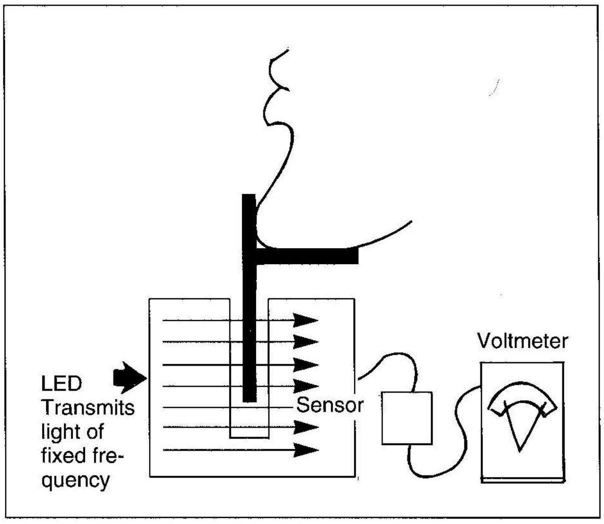


Fig 2 Schematic of custom LED recording device.

Two mandibular postural relations were recorded at each recording session: CRP; and a more opened relaxed rest position, termed the "relaxed resting posture" (RRP). Clinical rest position is the clinical reference position most commonly used to establish the OVD in complete denture fabrication.[32-35] The RRP was first described by Nisswonger[1] and is a more open and relaxed postural relation.

The RRP was recorded with the patient seated in an upright position, with the head securely positioned in the head rest. The patient was repeatedly instructed to relax and let the mandible fall freely to achieve a relaxed, semi-hypnotic, often soporific, condition. With the patient in this relaxed condition, the mandible reached a stable position as a fixed reading on the digital voltmeter. Ten consecutive readings were made at this RRP. Prior to each recording, the instrument was zeroed at intercuspal contact (IC).

Clinical rest position was then induced by the "command method" described by Garnick and Ramjford.[36] This was established with the patient seated upright and relaxed from the previous recordings. Having been aroused with conversation to a mentally alert state, the patient was instructed to look straight ahead, not to move the head, close the teeth together, and then relax the mandible. Ten consecutive readings were made at this CRP at each recording session.

Subject Selection

Eight subjects (6 men, 2 women; age range 30 to 58 years) were selected from a patient population of a dental school clinic and private prosthodontic practice. Patients requiring an increase in OVD with fixed partial dentures (FPDs) were selected. Patients were to be free of signs and symptoms of TMD and possess intact dentitions. Six patients had severe occlusal wear, one had excessive vertical overlap of the anterior teeth, and one had an anterior reverse occlusion.

Instrument Design

The measuring instrument was a custom electro-optic device (for which a patent has been applied) designed to measure changes in the vertical dimension. The device is comprised of optical, electrical, and mechanical subsystems. The optical system contains a point light source of a high emission-intensity, light-emitting diode (LED) having a surface area 0.75 × 2.75 mm (Siemens FS1, Berlin, Germany). Light energy from the LED passes through two planoconvex lenses (PLX Edmunds Scientific, NJ) to a light detector with a sensitivity of 70 milliamperes to 400 amperes (Siemens BPW 34, Berlin, Germany).

The electrical system uses two circuits, one operating the light source and detector, the other measuring a digital voltmeter (Digital Multitester AK528T, Berlin, Germany) that measures the differences in voltage output of the light detector in direct proportion to the incident light.

The optical system is housed in a rigid metal casing that allows fine tuning to ensure passage of parallel light beams through the measuring area. Vertical movement of an aluminum recording flag in the measuring area changes the quantity of incident light falling on the light sensor, which is shown by changes in potential in the voltmeter having a linear conversion to millimeters with a sensitivity of 0.01 mm. Calibration of the recording system was achieved by raising the recording flag attached to a digital calibrator in 0.5-mm increments and recording the corresponding voltage changes. A resulting constant linear function of mm to mV allowed direct linear conversion with an accuracy of 0.01 mm. Prior to the experiment, the device was calibrated for 48 hours, and during the experiment calibration was performed weekly.

Method of IRS Measurement

At each recording period, the patient was seated in a comfortable, upright position in a dental chair with the base of the cranium firmly seated in the head rest. The recording flag was securely adhered to the chin using cyanoacrylate adhesive (Reniert, Sekunden-Kleber, Renfert, Singen, Germany), and the recording device was positioned to allow free vertical movement of the flag in the measuring area. The voltmeter was zeroed at IC prior to the recording. When the patient was deemed to have achieved the desired mandibular postural relation, a recording was made from the voltmeter and the patient was instructed to immediately close the teeth together to confirm a zero voltmeter reading at IC. Thus, measurements were recorded as the difference between the open flag position and the zeroed, closed IC position. The patient was continuously instructed not to move the head during recordings. This and the secure head rest ensured minimal vertical error resulting from head movement during the short duration required to close from the resting postural relation to the intercuspal relation.

Sequence of Recording Sessions

Ten consecutive recording sessions were made at weekly intervals for each subject. Patients were scheduled at 7-day intervals. The first five sessions were performed at the patient's original OVD. Following the recordings at the fifth session, the OVD was increased by 3.5 to 4.5 mm interincisally using processed acrylic resin FPDs in the same visit. The following five weekly sessions were made at the increased OVD. At all recording sessions, 10 RRP measurements were made followed by 10 CRP measurements by the same operator. Additional recordings were made on three subjects.

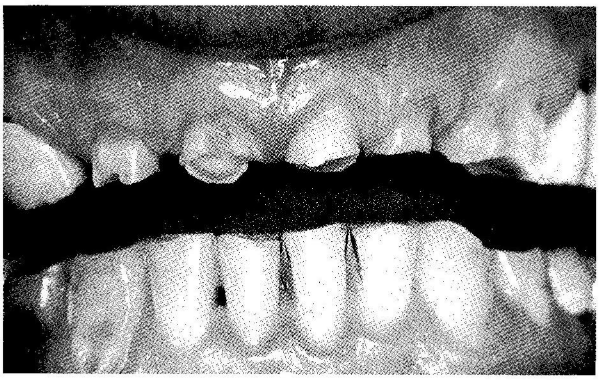


Fig 3a Subject no. 3, with reduced OVD and teeth separated.

Fig 3b Acrylic FPD at increased OVD exceeding original CRP.

Subjective symptoms and reactions resulting from the new OVD were recorded systematically by the same operator at the beginning of each recording session after increasing the OVD with the fixed restoration.

Method of Increasing the OVD

Acrylic resin FPDs were either cemented to prepared abutment teeth or cemented as overlays on unprepared teeth (Figs 3a and 3b). The occlusion provided a stable and definitive intercuspal relationship with anterior disocclusion for seven subjects (four subjects with restorations only on the maxillary arch, two with restorations only on the mandibular arch, and one subject for which both maxillary and mandibular arches were restored). The FPD for the prognathic patient did not disocclude the posterior teeth in eccentric movements.

Statistical Analysis

Statistical analysis was computed by analysis of variance (ANOVA) with repeated measures to test the interaction of CRP, RRP, OVD and time. Recordings from weeks 1 to 5 at the original OVD (OVD 1) were compared with recordings of weeks 1 to 5 at the increased OVD (OVD 2). Paired Student's *t* test was used to compare results of weeks 4 and 5, and standard deviations were used to show the range of variation within and between recording sessions.

Results

Figures 4a to 11b show mean and standard deviations for five consecutive weekly recordings of the interocclusal rest space following the increase of vertical dimension (IRS II) superimposed on the initial five mean consecutive weekly recordings of IRS I for all eight subjects. Week 1 for IRS II denotes the first recordings of IRS II, 1 week after the OVD was increased, and is superimposed on the first IRS I recording. This display allows comparison of IRS I and IRS II over 1 month.

Figures 4a to 11a show the differences in CRP. For all subjects at weeks 4 or 5 after the increase in OVD, values of IRS II either approximated or exceeded the values of IRS I at week 5, with mean differences of 0.23 mm and 0.16 mm. Paired Student's *t* test showed no significant difference. ANOVA with repeated measures showed no significant difference between IRS I and IRS II during 1 month before and after increasing OVD. Pooled mean values for all subjects over 5 weeks were 2.6 mm (SD = 0.33) for IRS I and 1.88 mm (SD = 0.42) for IRS II.

This indicates that a new CRP was established and maintained 1 month after increasing the OVD by 3.5 to 4.5 mm.

Figures 4b to 11b show superimposition of IRS II and IRS I for RRP measurements. The same trend was seen as for CRP; IRS II was not less than IRS I by more than 1 mm for seven subjects and for one subject it was significantly greater. The differences in means between IRS II and IRS I at 4 and 5 weeks were 0.37 mm and 0.33 mm, respectively. Paired Student's *t* test showed no significant difference. ANOVA with repeated measures showed no significant difference between IRS I and IRS II during 1 month before and after increase in OVD. Pooled mean values for all subjects over 5 weeks were 4.4 mm (SD = 0.67) for IRS I and 4.8 mm (SD = 0.51) for IRS II. Thus, for all eight subjects, a new RRP was established and continued during 1 month following the increase in OVD.

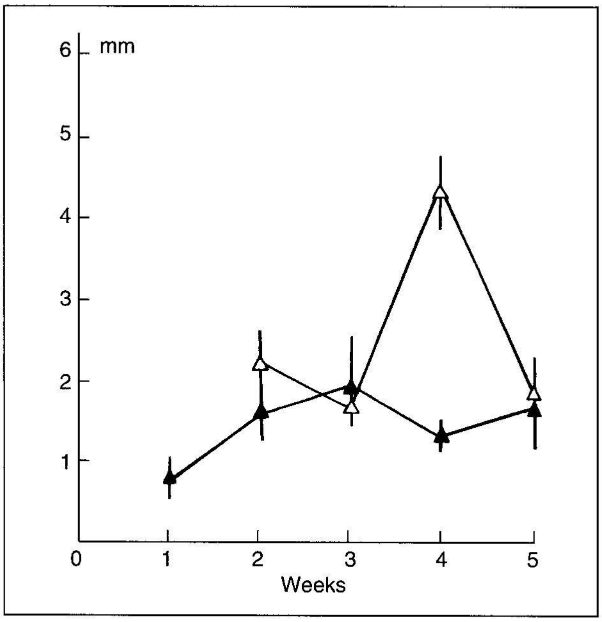


Fig 4a Subject no. 1, registrations at CRP. (For Figs 4a to 11b vertical axis = IRS; hollow triangle = mean IRS at original OVD; solid triangle = mean IRS at increased OVD; vertical bar = SD.)

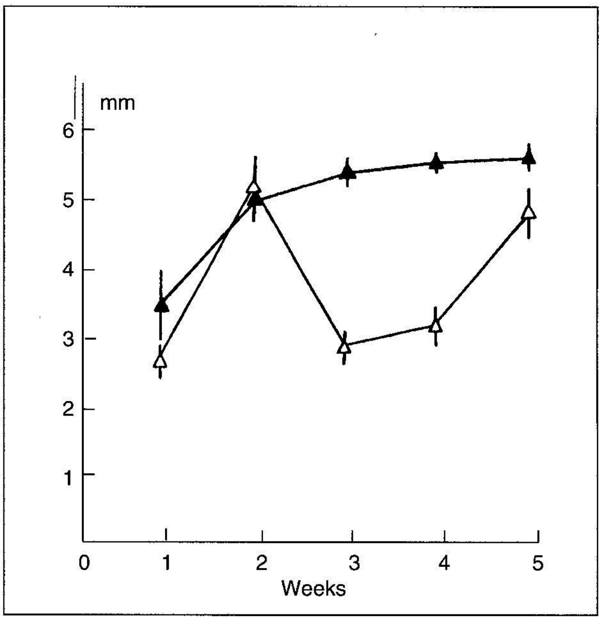


Fig 4b Subject no. 1, registrations at RRP.

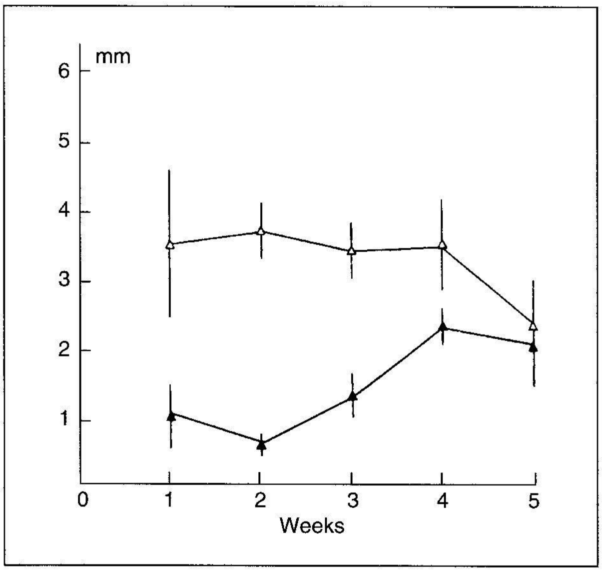


Fig 5a Subject no. 2, registrations at CRP.

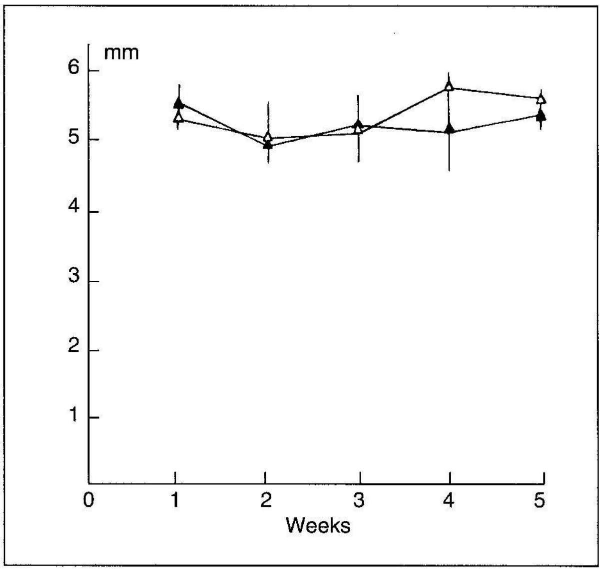


Fig 5b Subject no. 2, registrations at RRP.

Fig 6a Subject no. 3, registrations at CRP.

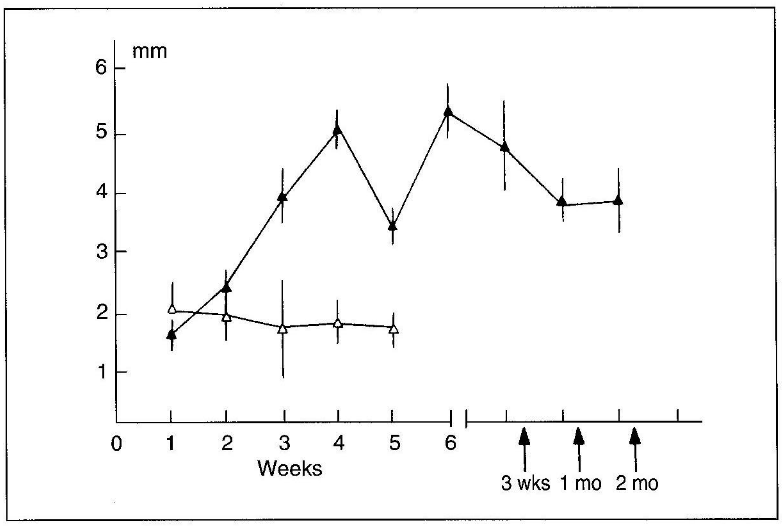
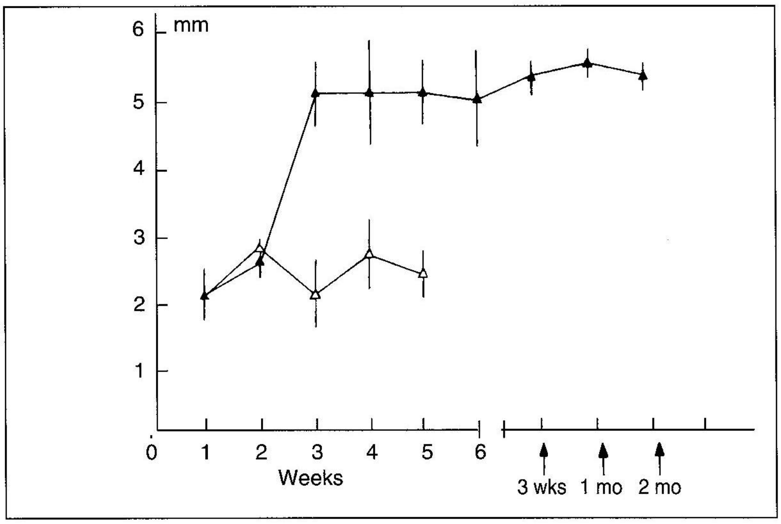


Fig 6b Subject no. 3, registrations at RRP.



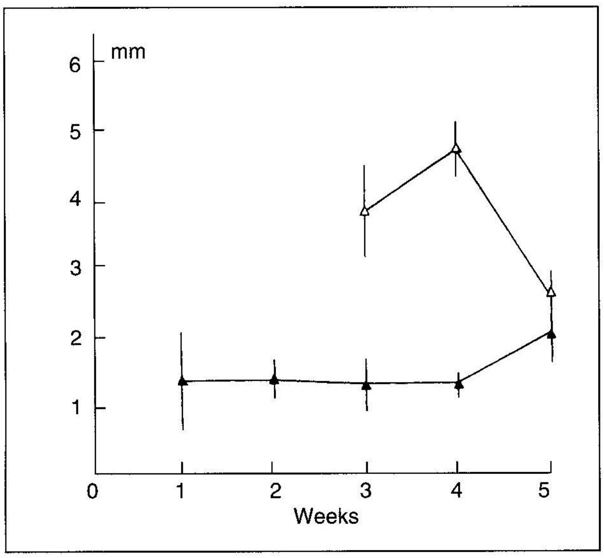


Fig 7a Subject no. 4, registrations at CRP.

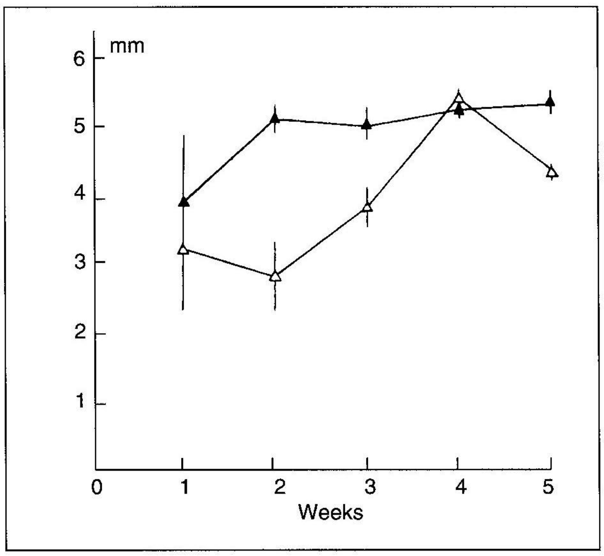


Fig 7b Subject no. 4, registrations at RRP.

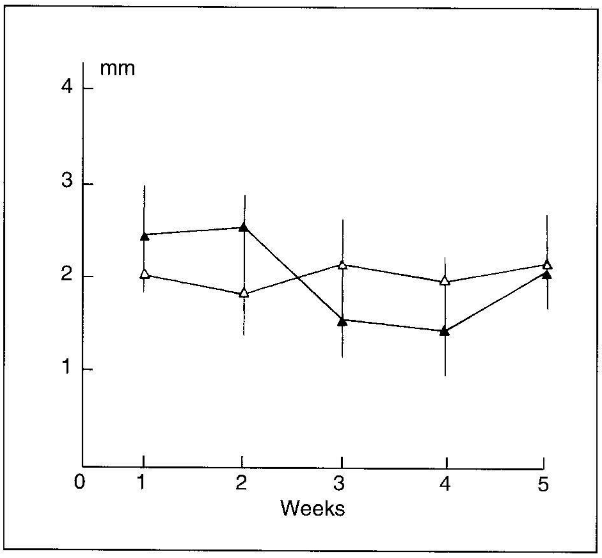


Fig 8a Subject no. 5, registrations at CRP.

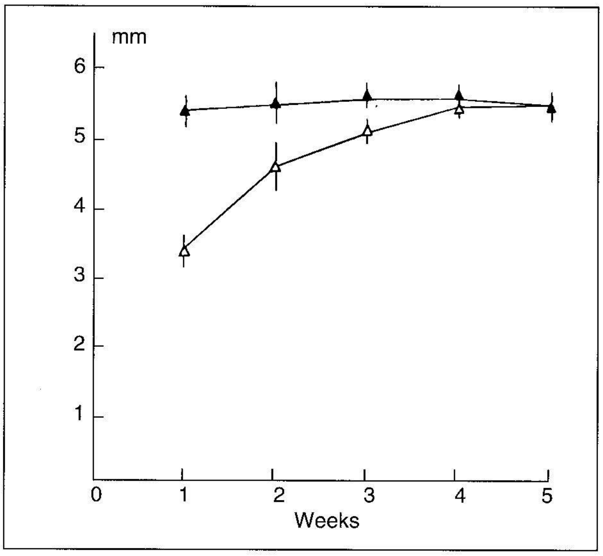


Fig 8b Subject no. 5, registrations at RRP.

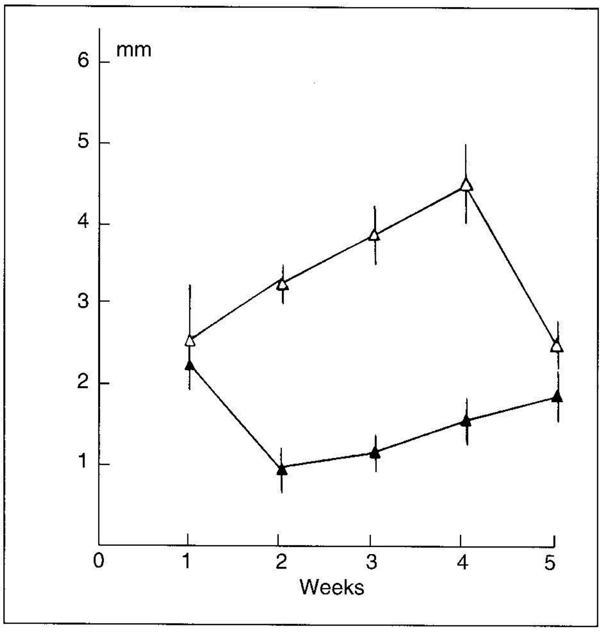


Fig 9a Subject no. 6, registrations at CRP.

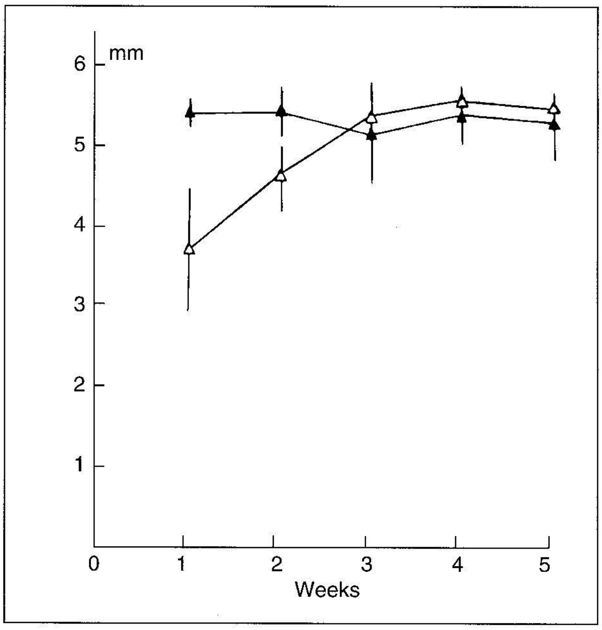


Fig 9b Subject no. 6, registrations at RRP

ANOVA with repeated measures showed a significant difference between CRP and RRP (P = .001) both before and after increasing OVD. No interaction between CRP I, CRP II, RRP I, and time was shown. Interaction of RRP II and time was shown (P = .028). While Figs 4a to 11b show some degree of variation of mean IRS values between sessions, the small standard deviations of consecutive recordings per session (Table 1) would indicate that CRP and RRP were not specific points but consistent postural ranges.

Subjective Symptoms

All eight patients reported discomfort in the mandibular musculature and speech difficulties

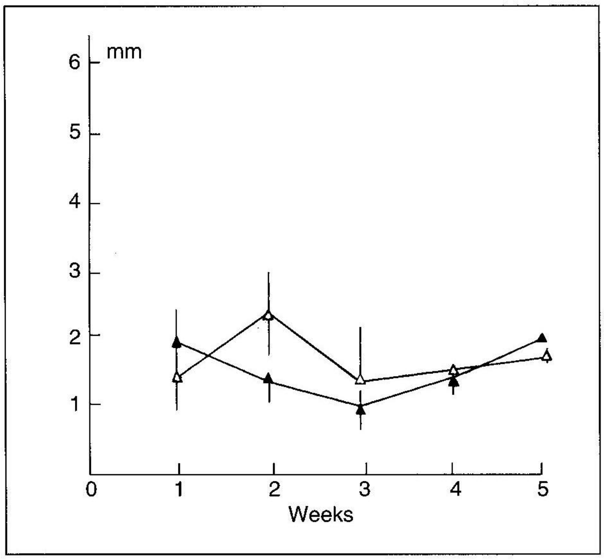


Fig 10a Subject no. 7, registrations at CRP.

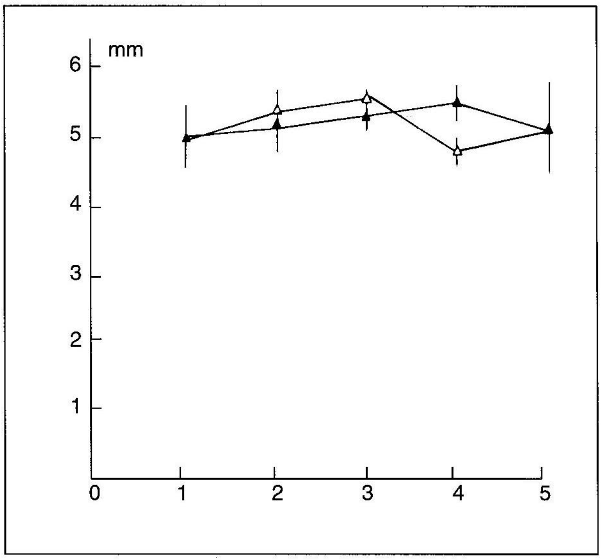


Fig 10b Subject no. 7, registrations at RRP.

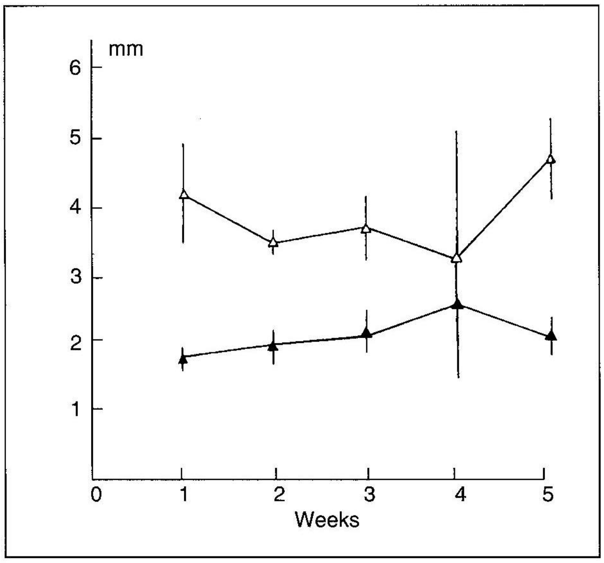


Fig 11a Subject no. 8, registrations at CRP.

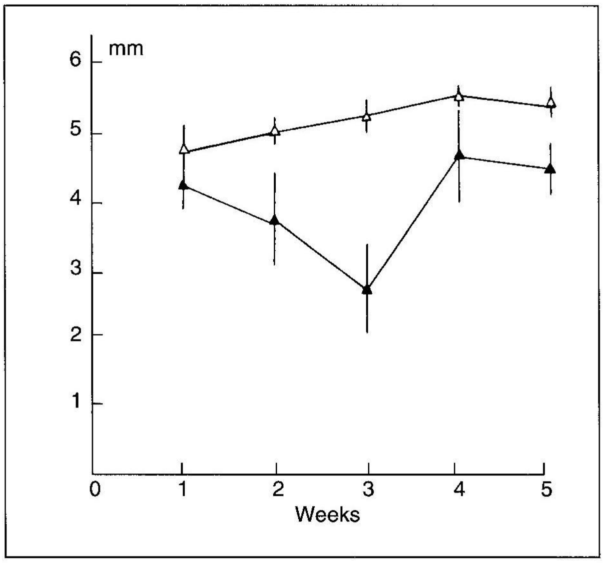


Fig 11b Subject no. 8, registrations at RRP.

during the first week. Subjective symptoms subsided after 1 week in seven patients. The eighth patient experienced discomfort and daytime clenching for 2 weeks. An occlusal adjustment reducing and smoothing lateral excursive inclines, but not reducing OVD, was carried out on this subject, after which the symptoms subsided.

Discussion

The results of this pilot study indicate that a new postural rest position of the mandible was established 1 month after an increase in the OVD beyond the vertical dimension of rest. This supports the findings of Carlsson et al,[31] Rugh and

Table 1 Means of 10 IRS Measurements and SD, for Successive Weekly Visits at Original OVD (1) and Increased OVD (2)

		OVD 1				OVD 2			
		CRP (mm)		RRP (mm)		CRP (mm)		RRP (mm)	
Patient no.	Visit no.	IRS I	SD	IRS I	SD	IRS II	SD	IRS II	SD
1	1	–	–	2.5	0.24	0.8	0.24	3.3	0.58
	2	2.2	0.4	5.0	0.5	1.6	0.38	4.8	0.33
	3	1.5	0.25	2.7	0.28	1.9	0.6	5.2	0.32
	4	4.3	0.49	3.0	0.33	1.3	0.23	5.2	0.1
	5	1.8	0.46	4.6	0.39	1.6	0.5	5.4	0.27
2	1	3.5	1.1	5.3	0.21	1.0	0.5	5.5	0.34
	2	3.7	0.4	5.0	0.54	0.6	0.15	4.9	0.36
	3	3.4	0.4	5.1	0.5	1.3	0.36	5.2	0.07
	4	3.5	0.72	5.7	0.06	2.3	0.28	5.1	0.69
	5	2.3	0.7	5.5	0.2	2.0	0.6	5.3	0.09
3	1	1.9	0.3	2.1	0.4	1.5	0.3	2.1	0.6
	2	1.8	0.45	2.8	0.3	2.3	0.3	2.6	0.3
	3	1.6	0.83	2.1	0.52	3.8	0.5	5.1	0.5
	4	1.7	0.4	2.7	0.5	4.9	0.35	5.1	0.76
	5	1.6	0.3	2.4	0.3	3.3	0.31	5.1	0.47
4	1	–	–	3.2	0.09	1.4	0.67	3.9	1.0
	2	–	–	2.8	0.51	1.4	0.3	5.1	0.23
	3	3.8	0.68	3.8	0.32	1.3	0.41	5.0	0.26
	4	4.7	0.41	5.3	0.2	1.3	0.22	5.2	0.12
	5	2.6	0.38	4.3	0.15	2.0	0.42	5.3	0.23
5	1	2.0	0.05	3.3	0.25	2.4	0.59	5.3	0.27
	2	1.8	0.47	4.5	0.39	2.5	0.31	5.4	0.34
	3	2.1	0.49	5.0	0.22	1.5	0.41	5.5	0.11
	4	1.9	0.3	5.3	0.14	1.4	0.52	5.4	0.26
	5	2.1	0.54	5.3	0.24	2.0	0.4	5.3	0.27
6	1	2.5	0.7	3.7	0.78	2.2	0.3	5.4	0.2
	2	3.2	0.2	4.6	0.43	0.9	0.3	5.4	0.3
	3	3.8	0.36	5.3	0.14	1.1	0.2	5.1	0.7
	4	4.4	0.5	5.5	0.08	1.5	0.3	5.3	0.4
	5	2.4	0.3	5.4	0.2	1.8	0.3	5.2	0.5
7	1	1.4	0.53	4.9	0.5	1.9	0.5	4.9	0.6
	2	2.3	0.67	5.3	0.73	1.4	0.4	5.1	0.5
	3	1.3	0.83	5.5	0.1	0.9	0.3	5.2	0.3
	4	1.5	0.23	4.7	0.25	1.4	0.3	5.4	0.3
	5	1.7	0.19	5.0	0.71	1.9	0.3	5.0	0.7
8	1	4.1	0.8	4.6	0.54	1.7	0.2	4.2	0.4
	2	3.4	0.3	5.0	0.26	1.9	0.3	3.7	0.7
	3	3.6	0.5	5.2	0.34	2.1	0.4	2.7	0.7
	4	3.2	1.9	5.5	0.19	2.1	0.63	4.7	0.7
	5	4.6	0.67	5.4	0.23	2.0	0.3	4.4	0.4

Drago,[22] and Manns et al,[27] who showed adaptation to an increase in OVD after 1 week. These findings would also support the contention that the CRP is not fixed, but is subject to changes in the occlusal feedback mechanism.

The fact that all symptoms subsided after 1 week in 7 of the 8 patients, and after 2 weeks in the eighth, would indicate that increasing the OVD beyond the CRP only caused transient TMD symptoms, after which adaptive normal muscle function was re-established. Other studies[29–31] have reported symptoms in the week following an increase in the OVD that subsided on restoring the original OVD, perhaps creating a false impression that the longer observation time of this study would appear to dispel. Carlsson et al[29] reported symptom-free adaptation to an increased OVD of 4 mm in 6 out of 7 students over 1 week. The other student experienced extreme discomfort, indicating that while the capacity to adapt to an increase in OVD exists in many individuals, in others this may be lacking, possibly because of underlying factors of psychogenic or psychophysiologic origin.

The fluctuant nature of both CRP and RRP is seen by variations between recording sessions. However, values were consistent for the consecutive recordings at each session as indicated by the SD for each session, suggesting that the CRP and RRP are not rigid points in space, but repeatable resting ranges.

The SD of individual measurement sessions did not appear to be subject to variables of head movement and mentalis chin movement of the recording flag. In a previous study,[37] the SDs obtained from multiple measurements of CRP using this recording system were very small, 0.004 to 0.04 mm in 24 subjects compared with the SD of 0.2 to 0.6 mm using standard skin marking and caliper measurements of CRP. Garnick and Ramjford[36] used a device that was adhered to the chin, resulting in a SD of 1.8 to 2.3 mm. In the present study, the mean CRP IRS I and II measurements of 2.6 and 1.8 mm showed SDs of 0.33 and 0.42 mm, respectively. These were smaller than those reported by Burdette and Gale[38] (1.63 to 1.93 mm), who used a kinesiograph with an intraoral magnet not affected by mentalis movement. Head movements were deemed insignificant because of the head rest and the short elapsed time between measurement and closure to intercuspation.

The findings of this pilot study that the CRP and RRP are distinct and repeatable resting ranges that adapt to an increase in OVD beyond CRP necessitate confirmation by studies using a larger sample population. However, the results are of interest when considering the nature of mandibular posture. Nisswonger[1] first mentioned two postural relations in 1937: the CRP and another more open position that has since received little attention. Intuitive observation would indicate that there are many possible instantaneous postural resting mandibular relations between intercuspation and the position occasionally observed when a person is seated in sleep and the mandible falls open. In the past, clinical literature has focused mainly on the CRP established by empirical command, phonetic, or swallowing techniques,[32-34] producing a surprising degree of consistency and being useful as a vertical reference relationship for establishing the OVD in complete denture fabrication. Other descriptions are based on minimum EMG levels and minimum muscle activity describing a more open "physiologic rest position,"[22,39] more in the range of the "relaxed resting posture" encountered in this study.

That both CRP and RRP were re-established at increased vertical dimensions of rest indicates that both adapted to an increased OVD and are, therefore, not absolute functions of muscle length.

Examination of diagnostic casts did not reveal wear of the occlusal surfaces, changes in the gingivoincisal ridge dimensions, or changes in maxillomandibular gingival dimensions. This indicates that loss of OVD resulting from wear and intrusion of the teeth was not a contributory factor.

Further studies with larger population samples are needed to support these findings, and the nature of RRP and its relation to EMG rest requires further investigation.

Conclusions

Acrylic resin restorations were luted to the teeth of eight subjects to increase the vertical dimension of occlusion from 3.5 to 4.5 mm. Based on this limited study, the following conclusions may be made:

1. The command clinical rest position and an operator-induced relaxed resting posture are two distinct and repeatable mandibular postural relations (P = .001) that exhibit a small range of variability between weekly recording sessions.
2. The clinical rest position and relaxed resting posture both changed as a result of increasing the occluding vertical dimension to exceed the original vertical dimension of rest.
3. The interocclusal rest space was re-established for both clinical rest position and relaxed resting posture.

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