Clark, G.T. (1983) Occlusal therapy: occlusal appliances. In: *President's Conference on the Examination, Diagnosis and Management of Temporomandibular Disorders* (eds D. Laskin, W. Greenfield, E. Gale, J. Rugh, P. Neff, C. Alling, W. Ayer) p. 137. American Dental Association, Chicago, IL.

Dahl, B.L. (1995) The face height in adult dentate humans. A discussion of physiological and prosthetic principles illustrated through a case report. *Journal of Oral Rehabilitation,* **22,** 565.

Dahl, B.L. & Krogstad, O. (1985) Long term observations of an increased occlusal face height obtained by a combined orthodontic/prosthetic approach. *Journal of Oral Rehabilitation,* **12,** 173.

Dahlstrom, L. (1984) Conservative treatment of mandibular dysfunction. Clinical and electromyographic studies of biofeedback and occlusal appliances. *Swedish Dental Journal,* **14** (Suppl. 24), 14.

Dawson, P.E. (1974) *Occlusal Problems, Evaluation Diagnosis and Treatment,* p. 274. C.V. Mosby Company, St Louis, MO.

Didbin, G.H. & Griffiths, M.J. (1976) Observation on the resting posture of the mandible using telemetry. In: *Mastication* (eds D. J. Anderson & B. Mathews), p. 100. John Wright & Sons Ltd., Bristol, U.K.

Drago, C.J., Rugh, J.D. & Barghi, N. (1979) Night guard vertical thickness effect on nocturnal bruxism. *Journal of Dental Research,* **58 (Spec Iss),** 316.

Forsberg, C.M., Eliasson, S. & Westergreen, H. (1991) Face height and tooth eruption in adults – a 20 year follow-up investigation. *European Journal of Orthodontics,* **13,** 249.

Garnick, J.J. & Ramjford, S.P. (1962) Rest position: an electromyographic and clinical investigation. *Journal of Prosthetic Dentistry,* **12,** 895.

Goldspink, G. (1976) The adaptation of muscle to a new functional length. In: *Mastication* (eds D.J. Anderson & B. Mathews), p. 90. John Wright & Sons Ltd, Bristol, U.K.

Gross, M.D. & Ormianer, Z. (1994) A preliminary study on the effect of occlusal vertical dimension increase on mandibular postural rest position. *International Journal of Prosthodontics,* **7,** 216.

Hellsing, G. (1984) Functional adaptation to changes in vertical dimension. *Journal of Prosthetic Dentistry,* **52,** 867.

Hickey, J.C., Williams, B.H. & Woelfel, J.B. (1961) Stability of mandibular rest position. *Journal of Prosthetic Dentistry,* **11,** 566.

Mack, R.M. (1991) Vertical dimension: a dynamic concept based on facial form and oropharyngeal function. *Journal of Prosthetic Dentistry,* **66,** 478.

Manns, A., Miralles, R. & Guerro, F. (1981) The changes in electrical activity of the postural muscles of the mandible upon varying the vertical dimension. *Journal of Prosthetic Dentistry,* **45,** 438.

Manns, A., Miralles, R., Santander, G. & Valivia, J. (1983) Influence of the vertical dimension in the treatment of MPDS. *Journal of Prosthetic Dentistry,* **50,** 700.

McNeill, C. (1990) *Craniomandibular Disorders: Guidelines for Evaluation, Diagnosis and Management* (ed. C. McNeill), p. 41. The American Academy of Craniomandibular Disorders. Quintessence, Chicago, IL.

Miller, S.C. (1953) The practical solution to the prevention and cure of temporomandibular disturbances. *Journal of Dental Medicine,* **8,** 43.

Moller, E. (1976) Evidence that the rest position is subject to servocontrol. In: *Mastication* (eds D.J. Anderson & B. Mathews), p. 72. John Wright & Sons Ltd, Bristol, U.K.

Murphy, T. (1959) Compensatory mechanism in facial height adjustment ot functional tooth attrition. *Australian Dental Journal,* **4,** 312.

Nisswonger, M. (1934) Rest position of the mandible and centric relation. *Journal of the American Dental Association,* **21,** 1572.

Okeson, J.P. (1996) *Orofacial Pain. Guidelines for Assessment, Diagnosis and Management,* p. 150. The American Academy of Orofacial Pain. Quintessence, Chicago, IL.

Rivera-Morales, W.C. & Mohl, N. (1991) Relationship of occlusal vertical dimension to the health of the masticatory system. *Journal of Prosthetic Dentistry,* **65,** 547.

Rugh, J.D. & Drago, C.J. (1981) Vertical dimension: A study of clinical rest position and jaw muscle activity. *Journal of Prosthetic Dentistry,* **45,** 670.

Schweizer, J.M. (1964) *Oral Rehabilitation Problem Cases: Treatment and Evaluation,* p. 120. C.V. Mosby Company, St Louis, MO.

Schuyler, C. (1939) Problems associated with opening of the bite which would contraindicate it as a general practice. *Journal of the American Dental Association,* **26,** 734.

Sicher, H. (1954) Positions and movements of the mandible. *Journal of the American Dental Association,* **48,** 620.

Swerdlow, H. (1965) Vertical dimension: literature review. *Journal of Prosthetic Dentistry,* **15,** 241.

Talgren, A. (1957) Changes in adult face height due to aging, wear and loss of teeth and prosthetic treatment. *Acta Odontologica Scandinavia,* **15,** 1.

Tench, R.W. (1938) Dangers in dental reconstruction involving increase of vertical dimension of lower third of human face. *Journal of the American Dental Association,* **25,** 566.

Thompson, J.R. (1946) The rest position of the mandible and its significance to dental science. *Journal of the American Dental Association,* **33,** 151.

Thompson, J.R. & Brodie, A. (1942) Factors in the position of the mandible. *Journal of the American Dental Association,* **29,** 925.

van Blarcom, C.W. (1994) Glossary of prosthodontic terms, edn 6. *Journal of Prosthetic Dentistry,* **71,** 43.

Wessberg, G.A., Bruce, N.E. & Elliot, A.C. (1983) Comparison of mandibular rest positions induced by phonetics, transcutaneous electrical stimulation and masticatory electromyography. *Journal of Prosthetic Dentistry,* **49,** 100.

Willis, R.D. & Dicosimo, C.J. (1979) The absence of proprioceptive nerve endings in the human periodontal ligament: the role of perioidontal mechanoreceptors in the reflex control of mastication. *Oral Surgery, Oral Medicine, Oral Pathology,* **48,** 108.

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A 2-year follow-up of mandibular posture following an increase in occlusal vertical dimension beyond the clinical rest position with fixed restorations

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SUMMARY **While resting mandibular posture is continuously changing, repeatable relations of 'physiologic rest position' (PRP) and 'clinical rest position' (CRP) are described in the literature. The PRP is defined as a position of minimal muscle activity and CRP as a more closed clinical reference relation. Relaxed resting posture (RRP) is a repeatable postural range obtained by operator-induced relaxation techniques. This article reports on measurements of mandibular posture in a patient group following an increase in occlusal vertical dimension (OVD) with fixed restorations beyond CRP over 2 years. The relationship of CRP and RRP in the restored and a non-restored control group is compared. The relationship of RRP and corresponding masseteric EMG values to baseline minimal EMG levels is reported for both groups. Resting face height adapted to the increased OVD and remained consistent over 1 and 2 years. The RRP was greater and significantly different from CRP in both groups ($P = 0.0001$). Results indicated that both CRP and RRP were postural ranges and not specific postural positions. The RRP occurred at minimum baseline EMG levels for both groups and appears to be consistent with physiologic rest position. The possibility of achieving minimal EMG levels at varying interocclusal rest space relations is discussed.**

Introduction

Mandibular resting posture may occur at multiple possible instantaneous positions between intercuspation and the position seen when a person is seated asleep and the mandible falls open. It is continuously changing, subject to posture, respiration, vision, swallowing, tongue and cheek pressure, lip competence and speech (Didbin & Griffiths, 1976).

Nisswonger (1934) described both an open and a more closed postural position. The glossary definition defines rest position or relation as 'physiologic rest position' occurring with the muscles in tonic equilibrium or minimal contractural activity (van Blarcom, 1994). This has been equated with electromyographic (EMG) rest (Manns, Miralles & Guerro, 1981; Rugh & Drago, 1981), transcutaneous electric nerve stimulation (TENS) relation (Wessberg, Bruce & Elliot, 1983), and relaxed resting posture (Gross & Ormianer, 1994). A more closed position is described as the 'clinical rest position' (CRP), considered by some authors to be partly governed by a servocontrol sensorimotor feedback from successive intercuspation (Moller, 1976; Willis & DiCosimo, 1979; Wessberg *et al.*, 1983). The CRP is classically established by empirical command, phonetic, or swallowing techniques (Garnick & Ramjford, 1962; Swerdlow, 1965; Attwood, 1966; Boucher, 1970), has a surprising degree of repeatability, and is traditionally used as a vertical reference relation to establish the occlusal vertical dimension (OVD) in a complete denture construction.

Traditional views have maintained that the rest position of the mandible is fixed and unalterable

(Nisswonger, 1934; Tench, 1938; Schuyler, 1939; Thompson & Brodie, 1942; Thompson, 1946; Sicher, 1954; Miller, 1953; Hickey, Williams & Woelfel, 1961; Schweizer, 1964). To increase the OVD with fixed restorations beyond the rest vertical dimension (RVD) was thought to encroach upon mandibular resting posture. The question of whether the neuromusculature will adapt asymptomatically and develop a new mandibular postural relation, or whether an adverse non-adaptive response will ensue, continues to be debated. Claims have been made that this will lead to temporomandibular disorders (TMD), tooth loss, intrusion and regression (Schyler, 1939; Miller, 1953; Hickey *et al.*, 1961; Schweizer, 1964; Beyron, 1969; Dawson, 1974).

Paradoxically raising the OVD empirically, often beyond the CRP with removable occlusal devices (night guards) has proved to be one of the most effective treatments of myogenic TMD symptoms (Drago, Rugh & Barghi, 1979; Clark, 1983; Manns *et al.*, 1983; Dahlstrom, 1984; McNeill, 1990; Okeson, 1996). Adaptation to increasing the OVD after 1 week has been shown with removable occlusal devices with a new postural position created that stabilizes over 1 week with decreased elevator and increased depressor activity (Drago *et al.*, 1979; Manns *et al.*, 1983; Hellsing, 1984; Carr *et al.*, 1991). Short-term stability and the maintenance of a stable new resting postural relation have been reported with fixed restorations after 1 week and 1 month (Christensen, 1970; Carlsson, Ingervall & Kocak, 1979; Gross & Ormianer, 1994). Long-term studies are limited. Dahl & Krogstad (1985) reported stability in occlusal face height after 5 years in 19 cases.

A repeatable postural range has been described by the present authors as relaxed resting posture (RRP) (Gross & Ormianer, 1994). This relation is achieved by repeatedly instructing the patient to relax his body and to allow the jaw to hang loose when seated in an upright position. Using an electronic recording device to record interocclusal distance, it was observed that the jaw achieved a consistent resting range that was significantly different from the CRP. In eight subjects requiring an increase in OVD with fixed partial dentures, CRP and RRP were measured at weekly intervals for 1 month before and 1 month after placing acrylic resin fixed partial dentures. OVD was increased 3·5–4 mm inter-incisally exceeding the RVD at CRP. A new CRP and RRP developed after 4 weeks. The CRP and RRP remained significantly different before and after increasing the OVD.

The purpose of this article is to report on 1- and 2-year follow-up of mandibular posture in cases restored at an increased OVD and on the relation of masseteric EMG levels to RRP.

Materials and methods

Subject selection

Subjects were divided into two groups and fully informed.

Group 1. This group consisted of eight subjects, six men and two women, who were restored with definitive full arch fixed partial dentures to increase the original OVD by 3·5–4 mm inter-incisally (prosthetic group). Ages ranged from 30 to 58 years, mean age 38. Subjects were free of signs and symptoms of TMD. Six patients had severe occlusal wear, one had excessive vertical overlap of the anterior teeth, and one had an anterior reverse occlusion. Provisional full arch acrylic restorations were placed for 1 month at the same increased OVD. Observations of CRP and RRP at weekly intervals 1 month prior to and following placement of the provisionals has been reported (Gross & Ormianer, 1994). Final restorations were fabricated with the same occlusal scheme as the provisionals. The cases were restored in the retruded contact relation with anterior guidance discluding posterior contact in eccentric excursions.

Group 2. The control group (non-restored) consisted of eight young healthy dental students, mean age 27 years, in their second clinical year, with intact stable dentitions having no signs or symptoms of temporomandibular disorders (TMD). Subjects were selected on the basis of availability and compliance.

Time frame of measurements. Group 1: for each subject, 10 consecutive interocclusal rest space (IORS) measurements of CRP, RRP and masseteric EMG were made in each session at intervals of 1 month, 1 year and 2 years after increasing the OVD with fixed partial dentures. Group 2: for each subject, 10 consecutive measurements of CRP, RRP and masseteric EMG were made in one session.

Table 1. ANOVA for RRP in Group 1. OVD 1 – IORS at OVD 1 month before increasing OVD. OVD 2 – IORS at increased OVD

Groups	Count	Sum	Average	Variance
RRP 1 month OVD 1	48	214·5	4·46875	1·418364
RRP 1 month OVD 2	48	240·0	5·00000	0·404681
RRP 1 years OVD 2	48	265·2	5·52400	8·710851
RRP 2 years OVD 2	48	208·0	4·33333	1·049929

Source of variation	SS	d.f.	MS	F	P-value	F_{crit}
Between groups	42·6764	3	14·22547	4·912183	0·002614	2·652648
Within groups	544·4398	188	2·89596			
Total	587·1162	191				

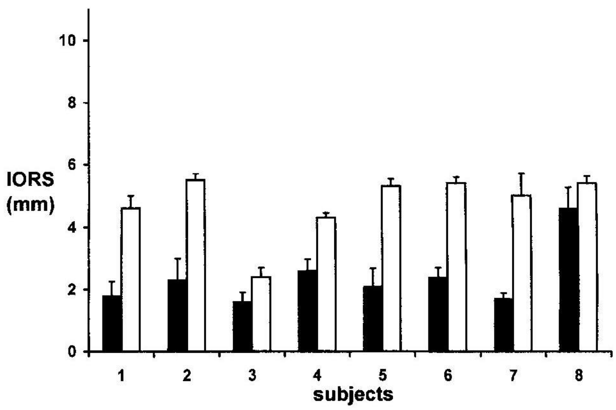

Fig. 1. Mean CRP & RRP interocclusal rest space readings (IORS) 1 month prior to increasing OVD. Black bar, CRP; white bar, RRP; vertical line shows s.d.

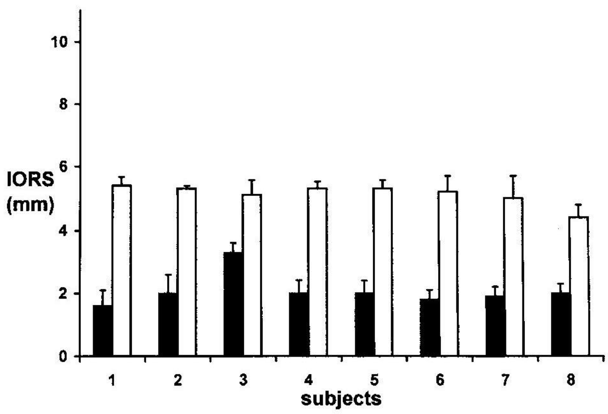

Fig. 2. Mean CRP and RRP interocclusal rest space readings (IORS) 1 month after increasing OVD. Black bar, CRP; white bar, RRP; vertical line shows s.d.

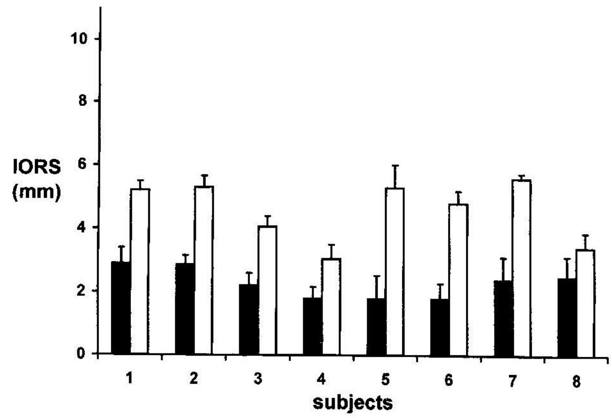

Fig. 3. Mean CRP and RRP interocclusal rest space readings (IORS) 1 year after increasing OVD. Black bar, CRP; white bar, RRP; vertical line shows s.d.

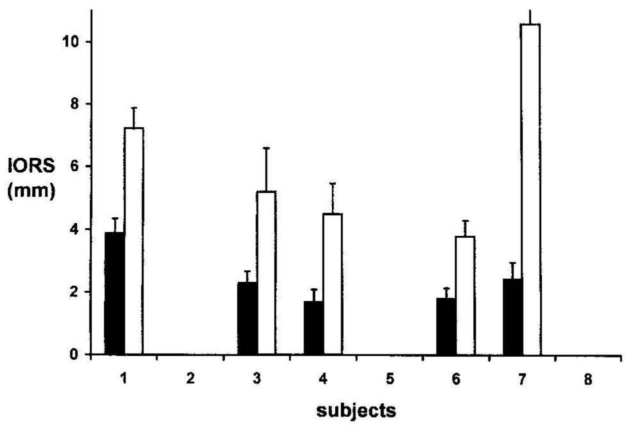

Fig. 4. Mean CRP and RRP interocclusal rest space readings (IORS) 2 years after increasing OVD. Black bar, CRP; white bar, RRP; vertical line shows s.d.

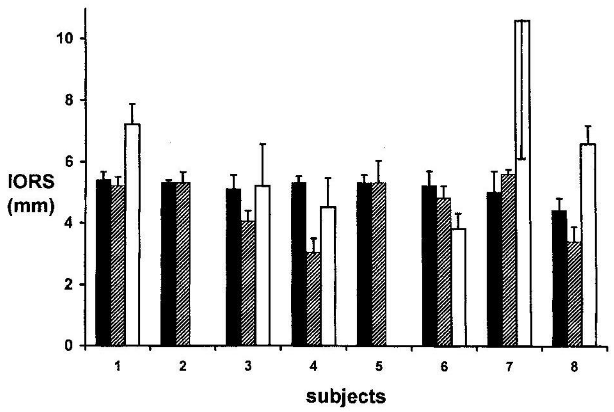

Fig. 5. RRP at 1 month, 1 year and 2 years with increased OVD. Black bar, 1 month; shaded bar, 1 year; white bar, 2 years; vertical lines show s.d.

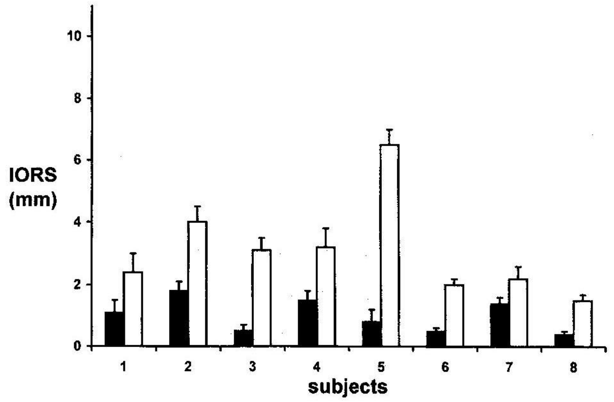

Fig. 7. Mean IORS of CRP and RRP. Black bar, CRP; White bar, RRP (Group 2); vertical line shows s.d.

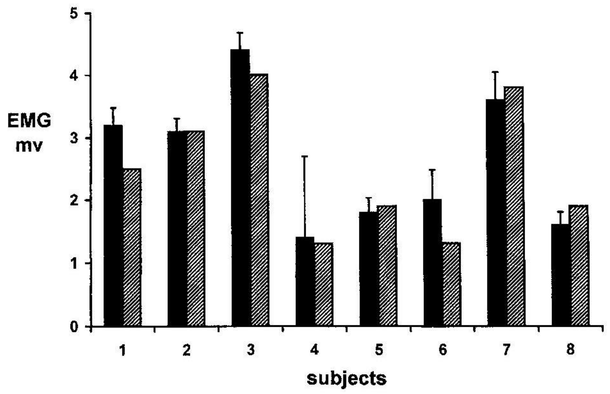

Fig. 6. Histogram of baseline EMG and EMG at RRP for right masseter at 1 year. Black bar, EMG at RRP; shaded bar, baseline EMG (Group 1).

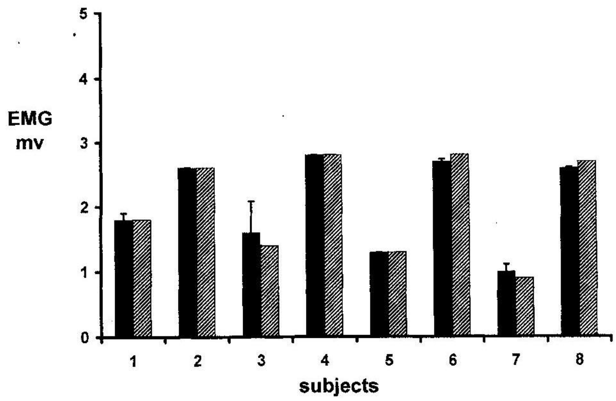

Fig. 8. Histogram of baseline EMG and EMG at RRP for right masseter. Black bar, EMG at RRP; shaded bar, baseline EMG (Group 2); vertical line shows s.d.

1994) relate solely to a 'physiologic rest position' defined by the mandibular musculature being in states of 'equilibrium, tonic contraction, tonic equilibrium, or minimal contractural activity'. These do not relate to the more closed 'clinical rest position' (Garnick & Ramjford, 1962; Swerdlow, 1965; Attwood, 1966; Boucher, 1970) classically used as the clinical reference relation in complete denture construction. The more open relation of the PRP has proved difficult to define. Rugh & Drago (1981) reported a specific vertical dimension of minimal EMG activity of mean IORS 8·6 mm, ranging from 4·5 to 12·6 mm, while Manns *et al.* (1981) found a circumscribed point for the masseter at an IORS of 10 mm, a range of 13 mm for the anterior temporal, and a range of 16 mm for the posterior temporal.

When IORS is measured following relaxation techniques as in the RRP, a resting range is seen that is significantly larger than CRP and corresponds to minimum baseline masseteric EMG levels. This was seen in both groups in this study.

Prior to and following an increase in OVD of 3·5–4 mm inter-incisally in Group 1, the CRP values were significantly different from the RRP values ($P < 0{\cdot}0001$). The mean RRP values ranged from 4·3 to 5·5 mm over 2 years. Both CRP and RRP were seen to adapt to the increase in OVD over the short-and long-term.

Long-term studies showing adaptation to increased OVD with fixed restorations are limited. Dahl & Krogstad (1985) showed stability in the occlusal face height after increasing the OVD by an average of 1·9 mm in 12 out of 19 cases after 5·5 years. They pointed out that the mode of reaction was highly individual. Dahl (1995) discussed the adaptation to increased occlusal facial height from a single case where occlusal face height was stable after 10 years in spite of wear and increased overlap of the restorations. Compensatory eruption was cited (Talgren, 1957; Murphy, 1959; Forsberg, Eliasson & Westergreen, 1991). Reports of long-term observations on resting face height could not be found. This study shows that the increased adaptive resting face height remained stable after increasing the OVD over 1 and 2 years in eight subjects. Speculation as to the mechanism of postural adaptation to changes in OVD has been made (Mack, 1991) with immediate adaptation (Hellsing, 1984) governed by a neuromuscular response (Moller, 1976) and long-term adaptation involving structural reordering of muscle sarcomeres as shown in animal models by Goldspink (1976) and Akagawa, Hiromasa & Tsuru (1983). While limited to small sample sizes, these reports further attest to the adaptability of occlusal and resting face height to moderate increase in OVD and support conclusions of Rivera-Morales & Mohl (1991) that such changes are not detrimental. The question of whether age is relevant to the adaptation of the postural resting position to an increase in OVD has not been answered by controlled clinical studies. Adaptation by the eight subjects in this study, mean age 38 years (range 30–58 years) appears consistent with clinical experience that in fixed restorations, a tolerance to moderate changes in OVD is not age-dependent.

In Group 1, when measured at weekly intervals (Gross & Ormianer, 1994), a noticeable inconsistency between sittings was apparent. This indicates that both CRP and RRP, while being significantly different, are postural ranges which are subject to variation and not specific postural positions. This is illustrated by subject 8 in Fig. 1, where CRP and RRP showed similar mean IORS values of 4 mm at that sitting. At subsequent measurements and following adaptation to the increased OVD (Fig. 2), the CRP values were significantly less for that subject. This indicates that CRP registrations are inconsistent and are likely to overlap with RRP and that for absolute parameters for establishing therapeutic OVD they should be used with caution. The results of Group 2 confirmed that CRP and RRP are different entities in a non-restored population.

The question arises as to the relationship of RRP to EMG activity levels. In both groups, the RRP corresponded to minimum baseline masseteric EMG levels, suggesting that the RRP is equivalent to 'physiologic rest' (van Blarcom, 1994), EMG rest (Rugh & Drago, 1981) and TENS-induced rest (Wessberg *et al.*, 1983).

In Group 2, a significant RRP range at the baseline EMG level was apparent with IORS values from 1·5 to 6·5 mm. This appears lower than the previously reported minimum massester EMG IORS ranges of 4·5–12·6 mm (Rugh & Drago, 1981), and 8·0–11 mm (Manns *et al.*, 1981).

Several of the subjects in Group 2 showed reduced EMG levels compared with the originally recorded minimum baseline values at IORS distances close to CRP. This is inconsistent with the minimum EMG rest point concept (Manns *et al.*, 1981; Rugh & Drago, 1981). A possible explanation is that these subjects opened at the minimum end of their potential RRP range and at the same time reduced EMG levels to minimum baseline values as operator 1 coached them to relax the musculature. This would suggest that a relaxed subject has the ability to open to any resting posture and by audio or visual biofeedback, voluntarily achieve minimum EMG levels. Further study is needed to verify this point in order to test whether resulting masseteric EMG values plateau or achieve a specific minimum point and then rise on subsequent opening as previously described by Manns *et al.* (1981) and Rugh & Drago (1981).

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References

AKAGAWA, Y., HIROMASA, N. & TSURU, H. (1983) Histological changes in rat masticatory muscle subsequent to experimental increase in occlusal vertical dimension. *Journal of Prosthetic Dentistry,* **50,** 725.

ATTWOOD, D.A. (1966) A critique of research of the rest position of the mandible. *Journal of Prosthetic Dentistry,* **16,** 848.

BEYRON, H.R. (1969) Optimal occlusion. *Dental Clinics of North America,* **13,** 537.

BOUCHER, C.O. (1970) *Swensons Complete Dentures* (ed. C.O. Boucher), 6th edn, p. 111. Mosby, St. Louis, MO.

CARLSSON, G.E., INGERVALL, B. & KOCAK, G. (1979) Effect of increasing vertical dimension on the masticatory system in subjects with natural teeth. *Journal of Prosthetic Dentistry,* **41,** 284.

CARR, A.B., CHRISTENSEN, L.V., DONEGAN, S.J. & ZIEBERT, G.J. (1991) Postural contractile activities of human jaw muscles following use of an occlusal splint. *Journal of Oral Rehabilitation,* **18,** 185.

CHRISTENSEN, J. (1970) Effect of occlusion-raising procedures on the chewing system. *Dental Practitioner,* **20,** 233.