CLASSIC ARTICLE

Clinical assessment of vertical dimension

A. J. W. Turrell, MDS[a]
Charles Clifford Dental Hospital, Sheffield, England

Although advances in techniques and materials are being made in prosthodontics, still no accurate method of assessing the vertical dimension of occlusion in edentulous patients is available to dentists. Clinical judgment plays a major role in the assessment of this important component in the construction of dentures.

In this article, many of the methods of assessing vertical dimension will be described. Some techniques are included which may be considered obsolete. Their inclusion is justified because they have been reintroduced in recent years along with the use of more sophisticated devices.

PRE-EXTRACTION RECORDS IN DETERMINING VERTICAL DIMENSION

In spite of the fallibility of most pre-extraction recording instruments, some are more accurate in the assessment of the vertical dimension of occlusion than are the numerous postextraction aids. The Dakometer is reputed to be an accurate measuring device, but the Willis gauge is so inaccurate as to be almost useless.[1,2] A modification of this in instrument enables the approximate angle at which it is applied to the face to be reproduced during denture construction.[1] A more reliable method is to measure the distance between upper and lower labial frena with dividers when the teeth are in centric occlusion.[1]

Turner[3] developed a ''cut-out method'' using a simple pantograph. A headstrap holds a card in a supporting frame close to the median line of the face. The pantograph pointer is brushed against the facial contour which is automatically drawn on the card by a pencil. Olsen[4] painted a strip of plaster of Paris down the midline of the face from which a cut-out is made. Swenson[5] described the construction of a clear resin mask of the lower part of the face. All of these methods displace the skin when the cut-out is formed and when it is applied to the face. The inaccuracy may be 2 mm or more.

USING PHYSIOLOGIC REST POSITION AS A GUIDE TO THE VERTICAL DIMENSION OF OCCLUSION

Many authorities do not accept the concept of a constant rest position in the strictest sense.[6-10] Thompson[11] related variations in rest position to hypotonicity and hypertonicity of the musculature and described short- and and long-term variations. Short-term variations occur in times of stress, respiration, and head movement. Long-term variations occur in debilitated patients, ''mouth-breathers,'' and as a result of attrition of the teeth. Tallgren[7] studied changes which occurred in the vertical dimension of occlusion and rest position and the effect that these changes had on the interocclusal space. She concluded that the vertical dimension of rest position adapted to changes in the vertical dimension of occlusion in both dentulous and edentulous patients. Other research workers have verified her findings.[10,12]

Atwood[13] contended that rest position is a dynamic rather than a static concept and that it varies from person to person and within each person. He stated that the vertical zone of suppressed electromyographic activity found by Jarabak[14] supported this concept of a postural range. Atwood[13] suggested that a cinefluoroscopy technique coupled with electronics could provide a better insight into the variability of rest position.

Tallgren[7] tested the accuracy of three methods in establishing the vertical dimension of rest position cephalometrically on people with normal dentitions. These were fatiguing the jaw musculature, phonetics, and the ''no command'' method of physical and mental relaxation. Cephalometric radiographs showed no significant statistical difference when comparing these three methods. Tallgren[7] preferred a combination of mild fatigue followed by a swallow and relaxation with eyes closed. Carlsson and Ericson[15] found that the phonetic method produced a grater vertical distance reading than did the relaxation method. Atwood[12] used a combination of swallowing and phonetics in cephalometric studies of rest position. He judged relaxation by facial expression. Relaxation is essential in all of these techniques; it is a state of mind which is difficult for the patient to assume when attached to a cephalometer by ear plugs. However, the results obtained by workers using cephalometric radiology as a research tool have given some evaluation of the clinical methods routinely used to establish rest position.

MEASUREMENT OF CLOSING FORCES TO ESTABLISH VERTICAL DIMENSION

This theory is based on the premise that maximum closing force can be exerted when the mandible is at the vertical dimension of rest position.[16] A force meter

[a]Senior Lecturer in Dental Mechanics, Dental Materials, and Prosthetics, University of Sheffield.

Reprinted with permission from J Prosthet Dent 1972;28:238-45.
J Prosthet Dent 2006;96:79-83.

is attached to upper and lower baseplates and registers the pressure the patient can exert as the vertical dimension is varied. Smith[17] stated that the Boos bimeter was the best approach to a simple reliable device for determining the vertical dimension of rest position. However, the bimeter has been condemned, because the closing power of the patient is influenced by pain and apprehension. A correlation of results with the bimeter and those obtained by clinical and electromyographic methods showed that use of the bimeter produced increased vertical dimensions.[18,19]

Tueller[20] used an electronic method to determine the vertical separation of the jaws at which the subjects could exert the maximum closing force. This device consisted of a steel spring and strain gauge mounted in the palate of a resin baseplate. The lower baseplate carried a central-bearing point. The strain gauge was linked to an amplifier and pen recorder. The vertical dimension which produced the greatest deflection was called the *power point*. Tueller, like Boos, considered the power point to represent the rest position of the mandible.

The strain gauge gnathodynamometer technique was described by Ann.[21] He claimed that the closing force increased as the vertical dimension was increased above the vertical dimension of occlusion established by clinical means. The closing force reached maximum levels at vertical dimensions up to 9 mm above the established vertical dimension. He could not produce a typical hyperbolic-type curve as depicted by Boos when closing force and vertical dimension values were plotted graphically, and he deduced that closing force could not be used to determine the vertical dimension of rest position. To determine the effect of pain as a limiting factor in the force which could be applied, Ann[21] administered an anesthetic to all of the denture-bearing tissues. The subjects could not increase the closing force at the established occlusal vertical dimension. However, up to 9 mm above the established occlusal dimension, an increase of up to 20 per cent was recorded in the closing force.

TACTILE SENSE IN ESTABLISHING VERTICAL DIMENSION

In this method, the patient presses a very soft lower wax occlusion rim against the upper occlusion rim. By tactile sense, the patient is supposed to recognize when he has reached the degree of jaw opening which was attained when the natural teeth were present. Lytle[22] and Timmer[23] have adopted a more refined technique using a central-bearing device fixed to upper and lower occlusion rims.

McGee[24] stated that methods which relied upon the patient's muscular perception transferred the responsibility of registering the occlusal dimension from the dentist to the patient. He found patients tended to register a reduced vertical dimension of occlusion because they felt more comfortable in that position.

FACIAL DIMENSIONS IN ESTABLISHING VERTICAL DIMENSION

Ivy,[25] according to Bowman and Chick,[26] mentioned the use of facial measurements to determined vertical dimension for the edentulous patient. Goodfriend[27] suggested that the distance from the pupil of the eye to the junction of the lips equalled that from the subnasion to the gnathion. However, Willis[28] has been given the credit for popularizing these measurements.

Harvey[29] conducted a survey of the Willis measurement on 100 young men with natural teeth. He found the upper and lower measurements corresponded in only 27 per cent of the subjects. Bowman and Chick,[26] in a survey of 133 subjects with natural teeth, found that the measurements corresponded in only 9 per cent, most of these being patients with Class I jaw relationships.

The facial measurements proposed by McGee[24] have the support of Harvey,[29] Pound,[30] and Paquette.[31] McGee correlated the known vertical dimension of occlusion with three facial measurements which he claimed remain constant throughout life. The three measurements are: the distance from the center of the pupil of the eye to a line projected laterally from the median line of the lips; the distance from the glabella to the subnasion; and the distance between the angles of the mouth with the lips in repose. McGee stated that two of these three measurements will be invariably equal, and occasionally all three will be equal to one another. He claimed that, in 95 per cent of his subjects with natural teeth, two or three of these measurements corresponded to the vertical dimension of occlusion.

The method of adopted by Hurst[32] is based upon the length of the upper lip and the amount of the central incisor that is exposed when the lips are parted in repose. Measurements were made on selected subjects with natural teeth. The subjects were divided into five types whose upper lips ranged from extra short to extra long. He measured the interocclusal distances by a method advocated by Pleasure[33] and found that this space ranged from 1 mm for the group with the shortest upper lips to 10 mm for the group with the longest upper lips. He gave other interocclusal distances for the intervening types. This information enabled him to develop a table which can be used for determining the occlusal vertical dimension for all edentulous patients. Paquette[31] developed a method based on similar facial measurements.

PHONETICS IN ESTABLISHING THE OCCLUSAL VERTICAL DIMENSION

Phonetics to check an arbitrary vertical dimension of occlusion

This theory is dependent upon a correlation during speech of the interocclusal distances, the position of the occlusal plane, and the position of the tongue

relative to the occlusion rims or teeth. The most popular sound used as an aid in determining rest position is the labial *m* sound which can be said without the use of teeth. However, the *m* sound often leaves the lips in contact. As soon as they are parted by the dentist to observe the space between the occlusion rims, the mandible is depressed and the rest position is lost. To overcome this difficulty the sound *m* is often extended to the word *emma* or followed by the labial *p* sound which leaves the lips apart; hence, the popularity of the word *Mississippi*. Some patients depress the mandible when pronouncing *p*.

Larkin[34] developed a device in which wires attached to the upper and lower occlusion rims emerge from the corners of the mouth and are positioned over a millimeter scale. The patient closes into the vertical dimension of occlusion, and a reading is made on the scale. Then, the patient is induced to assume mandibular rest position. The difference between the two readings gives an indication of the interocclusal distance. Langer and Michman[35] designed a similar device, but to avoid wires emerging from the mouth, the gauge is attached to the upper occlusion rim. Both methods are probably more accurate than measuring reference points on the face.

Phonetics used before occlusion is developed

Triangles of adhesive tape are placed on the tip of the nose and the chin, and the distance between them is measured with dividers when the mandible is in rest position.[33] The methods used to guide the mandible into rest position vary. Some dentists prefer the *m* sounds in conjunction with complete relaxation. Boos[36] suggested conditioning exercises. Mild sedation has been suggested by Block.[37] Pound[30] and Terrell,[38] in addition to the *m* sound, prefer to engage the patient in conversation. The measurements are repeated after the patient has stopped talking.

When the vertical dimension of rest position has been measured between the triangles of tape on the face, the occlusion rims are built up until the vertical dimension of occlusion equals this measurement. Then, the height of the lower occlusion rim is reduced 2 to 4 mm according to the beliefs of the dentist. Usually, the older the patient, the greater the reduction. Ismail and George[39] concluded that this method is questionable since the vertical dimension of rest position adapts itself to the vertical dimension of occlusion.

Phonetics used to establish the closest speaking space

Silverman[40] maintains that it is easier and more accurate to record a measurement which relies upon muscular phonetic enunciation when the patient loses voluntary muscular control of the mandible than to record a measurement which relies upon relaxation. Thus, he records the closest speaking space before the teeth are extracted. The patient is seated upright with the plane of occlusion parallel to the floor. With an upper incisal edge as a guide, a pencil line is drawn on a lower incisor when the teeth are in centric occlusion. Then, a second line is drawn above the other after the patient has said *s* or *yes* or *siss* repeatedly. The closest speaking space is the distance between the lines. This space should be same at the try-in when it is again checked phonetically and the vertical dimension of occlusion adjusted if necessary.

DEGLUTITION IN ESTABLISHING VERTICAL DIMENSION

Shanahan[41] indicated that the mandibular pattern of movement during deglutition is the same for the edentulous infant as it is for the edentulous adult. He maintained that eruption of teeth is held at the occlusal plane by the act of swallowing which establishes the vertical dimension of occlusion. When constructing complete dentures, the advocates of the swallowing technique believe that soft wax on the occlusion rim is reduced during deglutition to give the correct vertical dimension of occlusion.[41-43]

Ismail and George[39] checked the swallowing method by using cephalometric radiographs to record the vertical dimension of occlusion before the teeth were extracted and after dentures were inserted. The swallowing technique produced an increase of 0 to 5 mm (mean 2.8 mm) in the vertical dimension of occlusion in the edentulous group. He found that the increase was directly proportional to the number of missing posterior teeth prior to extraction of the teeth.

Ward and Osterholtz[44] concluded that swallowing may be used only as a guide to the vertical dimension of occlusion. They advised that dentures should be removed for some time before recording the occlusal vertical dimension to obliterate the memory of acquired neuromuscular patterns.

Finnegan[45] used a hydraulic system to measure the force exerted by the lower teeth on the upper teeth during swallowing. He hoped to find that the magnitude of this force would change with the vertical dimension. He was unable to establish a relationship between the force exerted between the teeth on swallowing and the correct vertical dimension of occlusion.

ESTHETIC APPEARANCE IN ESTABLISHING VERTICAL DIMENSION

The estimation of vertical dimension by appearance is based upon the esthetic harmony of the lower third of the face relative to the rest of the face, upon the contour of the lips and the appearance of the skin from the margin of the lower lip to the lower border of the chin, and upon the labiomental angel.[46] With the lips in contact,

the elevation of the mandible and the compression of the lips should be just discernible on mandibular closing from rest position to the vertical dimension of occlusion. This guide applies to normal young patients or middle-aged patients with good tonus of the skin. Difficulties arise when the tonus of the skin is poor, when resorbed denture-bearing tissues preclude full restoration of the contour of the lip, in "mouth-breathing" patients, and in those patients described by Ballard[47] with varying degrees of incompetent lip morphology. Under these conditions, different techniques for establishing the vertical dimension of occlusion must be used.

OPEN-REST METHOD IN ESTABLISHING VERTICAL DIMENSION

Douglas and Maritato[48] described the open-rest method of establishing the vertical dimension of occlusion. Open-rest position is an unstrained mouth-breathing position. The lips are slightly parted to permit observation of the mesial marginal ridges of the upper and lower first bicuspids. Their positions, which represent the upper and lower posterior occlusal planes, related to the corners of the mouth. Pre-extraction cephalometric radiographs of 20 patients made with the mandible in the open-rest position indicated that the upper occlusion rim should be 3 mm above the corner of the mouth in the premolar region and that the occlusal plane of the lower rim should be 2 mm below the corners of the mouth. The authors[48] claim that this method is more accurate than a previous study using rest position, tactile sense, and swallowing methods to determine the vertical dimension of occlusion.

Willie[49] conducted a survey to determine the most common methods of establishing the vertical dimension of occlusion. The most popular were the esthetic appearance and phonetic methods. Methods relying on deglutition and tactile muscle sense of the patient were next in popularity. Those dentists who preferred the use of the Willis measurement and Boos bimeter were in the minority. The most popular combination of methods was that employing phonetics, esthetic appearance and deglutition.

Basler, Douglas, and Moulton[50] used cephalometric radiography to evaluate the comparative accuracy of phonetics in conjunction with esthetics, tactile muscle sense of the patient, and deglutition in establishing the vertical dimension of occlusion. They found all three methods to be equally reliable, but all had a tendency toward a reduced vertical dimension of occlusion.

The fact that many writers found that clinical methods usually produced a reduced vertical dimension of occlusion may account for most dentures being well tolerated, especially when the lower residual ridge is markedly resorbed. A vertical dimension of occlusion that is too far closed does not allow the muscles of mastication to function at their normal length resulting in a reduction of their efficiency. Less force is applied during mastication, and less stress is placed on the residual ridges. Unfortunately, this condition results in lack of support to muscles of facial expression. The tonus of the overlying skin suffers giving rise to premature wrinkles, deep nasolabial furrows, and folds at the angles of the mouth. This condition may permit saliva retention, promoting angular cheilosis, and it is also conducive to temporo-mandibular joint dysfunction.

To offset these conditions, particularly with markedly resorbed residual ridges, the degree to which one should restore the vertical dimension of occlusion without impairing stability and comfort is a difficult decision to make. When no pre-extraction records are available, one cannot even determine accurately, as a starting point, the position the mandible should occupy to restore the occlusal vertical dimension. An accurate scientific method of assessing the vertical dimension of occlusion clinically is a pressing need of paramount importance.

SUMMARY

Many methods of assessing and recording vertical jaw relations in edentulous patients have been presented and evaluated. When no accurate pre-extraction records exist, the dentist must rely upon esthetic appearance supplemented by aids which are often misleading.

REFERENCES

1. Turrell AJW. The pre-extraction recording of the vertical dimension by an intra-oral method. Dent Pract Dent Rec 1955;6:68-72.
2. McMillan DR, Imber S. The accuracy of facial measurements using the willis bite gauge. Dent Pract Dent Rec 1968;18:213-7.
3. Turner LC. The Profile Tracer: Method for Obtaining Accurate Pre-extraction Records. J Prosthet Dent 1969;21:364-70.
4. Olsen ES. The Dental Clinics of North America, Complete Denture Prosthesis. Philadelphia and London: W.B. Saunders Company; 1964. p. 611.
5. Swenson MG. Complete dentures. 4th ed. St. Louis: The C.V. Mosby Company; 1959. p. 125.
6. Leof M. Revision of Accepted Dicta on Mandibular Position. N Y J Dent 1950;20:8-14.
7. Tallgren A. Changes in Adult Face Height Due to Ageing, Wear and Loss of Teeth and Prosthetic Treatment. Acta Odontol Scand 1957;15(Suppl. 24):1-112.
8. Berry DC. The Constancy of the Rest Position of the Mandible. Dent Pract Dent Rec 1960;10:129-32.
9. Coccaro PJ, Lloyd R. Cephalometric Analysis of Morphologic Face Height. J Prosthet Dent 1965;15:35-44.
10. Ismail YH, George WA, Sassouni V, Scott RH. Cephalometric Study of Changes Occurring in Face Height Following Prosthetic Treatment. J Prosthet Dent 1968;19:321-30.
11. Thompson JR. Concepts Regarding Function of the Stomatognathic System. J Am Dent Assoc 1954;48:626-37.
12. Atwood DA. A Cephalometric Study of the Clinical Rest position of the Mandible. Part I. The Variability of the Clinical Rest Position Following the Removal of Occlusal Contacts. J Prosthet Dent 1956;16:504-19.
13. Atwood DA. A Critique of Research of the Rest Position of the Mandible. J Prosthet Dent 1966;16:848-54.
14. Jarabak JR. An Electromyographic Analysis of Muscular Behavior in Mandibular Movements From Rest Position. J Prosthet Dent 1957;7:682-710.
15. Carlsson GE, Ericson S. Postural Face Height in Full Denture Wearers. A Longitudinal X-ray Cephalmometric Study. Acta Odontol Scand 1967; 25:145-62.

16. Boos RH. Intermaxillary Relation Established in Bitting Power. J Am Dent Assoc 1940;27:1192-9.
17. Smith ES. Vertical Dimension and Centric Jaw Relation in Complete Denture Construction. J Prosthet Dent 1958;8:31-4.
18. Q'Rourke JT. Significance of Tests for Biting Strength. J Am Dent Assoc 1949;38:627-33.
19. Boucher LJ, Zwemer TJ, Pflughoeft F. Can Biting Force be Used as a Criterion for Registering Vertical Dimension? J Prosthet Dent 1959;9: 594-9.
20. Tueller VM. The Relationship Between the Vertical Dimension of Occlusion and Forces Generated by Closing Muscles of Mastication. J Prosthet Dent 1969;22:284-8.
21. Ann LK. Determination of Vertical Dimension by Biting Force. Malaysian Dent J 1967;7:23-38.
22. Lytle RB. Vertical Relationship of Occlusion by the Patient's Neuromuscular Perception. J Prosthet Dent 1964;14:12-20.
23. Timmer LH. A Reproducible Method for Determining the Vertical Dimension of Occlusion. J Prosthet Dent 1969;22:621-30.
24. McGee GF. Use of Facial Measurements in Determining Vertical Dimension. J Am Dent Assoc 1947;35:342-50.
25. Ivy RS. Dental and Facial Types. The American System of Dentistry. Operative and Prosthetic Dentistry, vol. 2. Pentland: Edinburgh; 1887. p. 1030.
26. Bowman AJ, Chick AO. A Note on Facial Proportions. Br Dent J 1962;112: 288-9.
27. Goodfriend DJ. Symptomatology and Treatment of Abnormalities of the Mandibular Articulation. Dent Cosmos 1933;75:844, 947, 1106.
28. Willis FM. Features Involved in Full Denture Prostheses. Dent Cosmos 1935;77:851-4.
29. Harvey W. Investigation and Survey of Malocclusion and Ear Symptoms With Particular Reference to Ottic Barotrauma. Br Dent J 1948;85:221-5.
30. Pound E. Recapturing Esthetic Tooth Position in the Edentulous Patient. J Am Dent Assoc 1957;55:181-91.
31. Paquette NJ. Establishing Positive Vertical Dimension Without Appliances. Dent Survey 1966;42:62-5.
32. Hurst WW. Vertical Dimension and Its Correlation With Lip Length and Interocclusal Distance. J Am Dent Assoc 1962;64:496-504.
33. Pleasure MA. Correct Vertical Dimension and Free-way Space. J Am Dent Assoc 1951;43:160-3.
34. Larkin JD. Means of Measuring Interocclusal Distance. J Prosthet Dent 1967;17:247-50.
35. Langer A, Michman J. Intraoral Technique for Recording Vertical and Horizontal Maxillomandibular Relations in Complete Dentures. J Prosthet Dent 1969;21:599-606.
36. Boos RH. Physiologic Denture Technique. J Prosthet Dent 1956;6:726-40.
37. Block LS. Common Factors in Complete Denture Prosthetics. J Prosthet Dent 1953;3:736-46.
38. Terrell WH. Fundamentals Important to Good Complete Denture Construction. J Prosthet Dent 1958;8:740-52.
39. Ismail YH, George WA. The Consistency of the Swallowing Technique in Determining Occlusal Vertical Relation in Edentulous Patients. J Prosthet Dent 1968;19:230-6.
40. Silverman MM. The Speaking Method in Measuring Vertical Dimension. J Prosthet Dent 1953;3:193-9.
41. Shanahan TEJ. Physiologic Vertical Dimension and Centric Relation. J Prosthet Dent 1956;6:741-7.
42. Geller JW. Prosthetic Dentistry. J Prosthet Dent 1960;10:33-6.
43. Malson TS. Recording Vertical Dimension of Occlusion. J Prosthet Dent 1960;10:258-9.
44. Ward BL, Osterholtz RH. Establishing Vertical Relation of Occlusion. J Prosthet Dent 1963;13:432-6.
45. Finnegan FJ. Determination of Maxillofacial Force Generated During Deglutition. J Prosthet Dent 1967;17:134-43.
46. Turrell AJW. Vertical Dimension as It Relates to the Etiology of Angular Cheilosis. J Prosthet Dent 1968;19:119-25.
47. Ballard CF. Mandibular Posture. Dent Pract Dent Rec 1967;17:377-83.
48. Douglas JR, Maritato FR. "Open Rest," a New Concept in the Selection of the Vertical Dimension of Occlusion. J Prosthet Dent 1965;15:851-6.
49. Willie RG. Trends in Clinical Methods of Establishing an Ideal Interarch Relationship. J Prosthet Dent 1958;8:243-51.
50. Basler LF, Douglas JR, Moulton RS. Cephalometric analysis of the vertical dimension of occlusion. J Prosthet Dent 1961;11:831-5.

0022-3913/$32.00

doi:10.1016/j.prosdent.2006.05.015