Cybernetic Concept Of Orofacial Behaviour

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The study of malocclusion requires an extensive investigation into both form and function of the stomatognathic complex. Notwithstanding this sophistication which has inspired a wide variety of works on behaviour and its relevance to occlusion, the broad issue still appears obscure and contradictory where a more rational explanation might be axiomatic. This difficulty is, in no small part, due to limited knowledge of the basic physiology of the stomatognathic complex and, unfortunately, research into this important region has lagged behind that of many others.

A fundamental neurological mechanism is the reflex arc whereby a stimulus received by the afferent or sensory side generates an impulse which, transmitted to the efferent or motor side, instigates an appropriate action. The essential structures for picking up stimuli are the receptor organs; these are highly specialized and respond only to a specific stimulus. Receptors are therefore peripheral analyzers which together cover the whole spectrum of sensory perception. By this discriminatory sensitivity, the central nervous system is kept fully acquainted with the body's relationship to its environment, and as the input is constantly operating, changes are immediately indicated. From the simplest form, reflex arcs can be elaborated to cover complex behaviour patterns based on a wide variety of stimuli, e.g., certain so-called instinctive behaviour and control of the body's mechanisms.

The stomatognathic complex is well provided with sensory receptors, the oral mucosa having an innervation ratio as high, if not higher, than any other body surface, and this is reflected in a large area of sensory cerebral cortex being devoted to this region with a corresponding area of the motor cortex.[1] Proprioception is no less adequately covered with nerve endings in the periodontal membrane for occlusal sense[2,3] and connections to the mesencephalic root of the fifth cranial nerve.[4] The position of the mandible is monitored by receptors in the capsule of the temporomandibular joint which also form a section of the trigeminal afferents.[5] The existence of further sites of proprioceptors is suggested by some workers.[6,7] This large sensory input, coupled to an equally responsive motor capacity, means a quick adaptation to the changing conditions in the mouth.[8]

In the relatively simple movement of closing the mandible to the maxilla, the mandibular position of centric and occlusal as described by Thompson,[9] with their especial relationship, must be thoroughly understood, for only in ideal cases are these two points coincident. All too frequently the existence of a malocclusion separates them and necessitates a deviated path of closure for the mandible to reach an effective occlusion. This displacement is brought about by a reflex coordination of the masticatory muscles,[10] the pattern of which may be shown electromyographically. By a simple technique of monitoring only the temporal and masseter muscles,[11] sufficient data will be provided in most cases to assess quality, i.e., direction, of the displacement. As a corollary the technique may be used for correcting displacements by re-establishing centric.[12] The gist being that changes in the mandible's position evoke changes in sensory feed-back deriving new patterns of reflex coordination — that is adaptation. One case is shown to illustrate the point: the patient, female, age 20, had pain symptoms of a left temporomandibular joint dysfunction. Clinical examination showed a deviation of the mandible to the left on closure (Fig. 1) which was verified electromyographically (Fig. 2A). This lateral swing is interpreted from the imbalances of the paired muscles — posterior temporals (right lower than left) and anterior masseters (left lower than right). Trial bites taken with hard wax to establish centric produced an improved muscular pattern (Fig. 2B) with the paired muscles in better balance. An overlay constructed to this occlusion relieved the symptoms in two days.

Soft tissue behaviour presents a more difficult area of study but this does not preclude an approach from exactly the same standpoint. Physiological function calls for the movements of all participating components in a precise sequence of changes in position and shape. The degree of movement of an individual part in a given function, both in distance and direction, depends upon its morphology relative to that of its environment. Where the tissues are soft and largely muscular, there is a range of adjustment in both the qualitative and quantitative characteristics of their morphology thus ensuring the necessary exactitude of juxtaposition.

The general overall pattern of behaviour is a property of the central nervous system, but this is modified to accord with local conditions and produce a smooth harmonious action. This fine coordination is a reflex activity based on elicitation of contacts and pressures by sensory receptors in the oral cavity. The importance of tactile sensation should not be underestimated, for not only does the subject gauge the state of comminution and readiness for swallowing, but the movement of the bolus is controlled between tongue and neighbouring structures with the most efficacious force, adjustments being made for variations in type and consistency. The introduction into the oral cavity of an artifact, which presents a slight obstacle, will impair function for only a short period, as it is soon circumvented. On the other hand, subjects who have had the tactile accuity of their oral mucosa substantially reduced by surface anesthetics have difficulty in swallowing and make clumsy movements. Therefore a certain measure of positional change is feasible with the contractile elements working in a new sequence to a new pattern of reflex coordination.

It should not be mere speculation to apply this concept of behaviour to such a point of orthodontic dispute as the position of the upper incisors in relation to their soft tissue environment, especially with respect to deglutition and the effect of changing their position by mechanotherapy. These teeth, we know, left to their own devices, attain perfect equilibrium compounded by the forces on their labial and lingual surfaces. This, however, may result in a sizable discrepancy between the upper and lower incisors which is a matter of some concern to the clinical orthodontist. Correction of the condition is successful in most cases and the profession accepts more than one position of stable equilibrium. Weinstein, et al.,[13] have explained this in terms of minimal energy but biologically there must have been a reconstitution of muscular contractions to regain the balance of forces or a re-education of the neuromuscular mechanism.[14] In that limited proportion of cases which have suffered relapse, and this applies particularly where the upper incisors have been retracted for superior proclination, explanations are more difficult. Many workers attribute this failure to abnormalities of behaviour, such as tongue

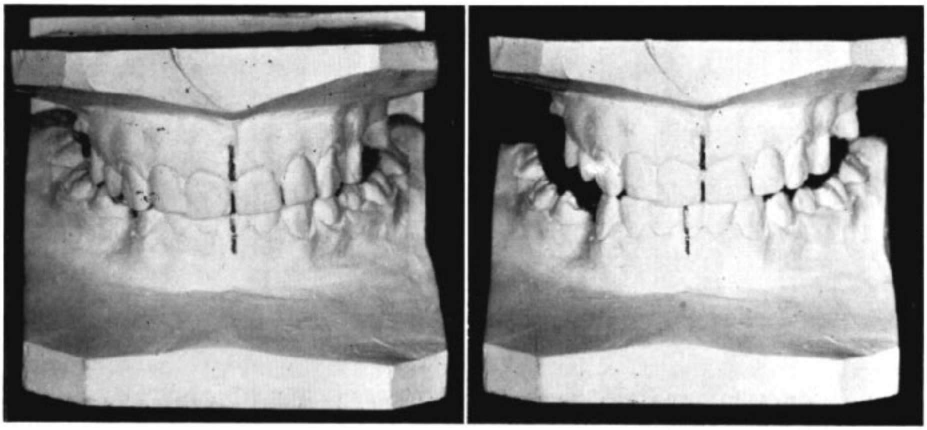

Fig. 1 Left, occlusal position; right, bite on wax in centric position. Note mandible to right of occlusal position correcting left lateral displacement.

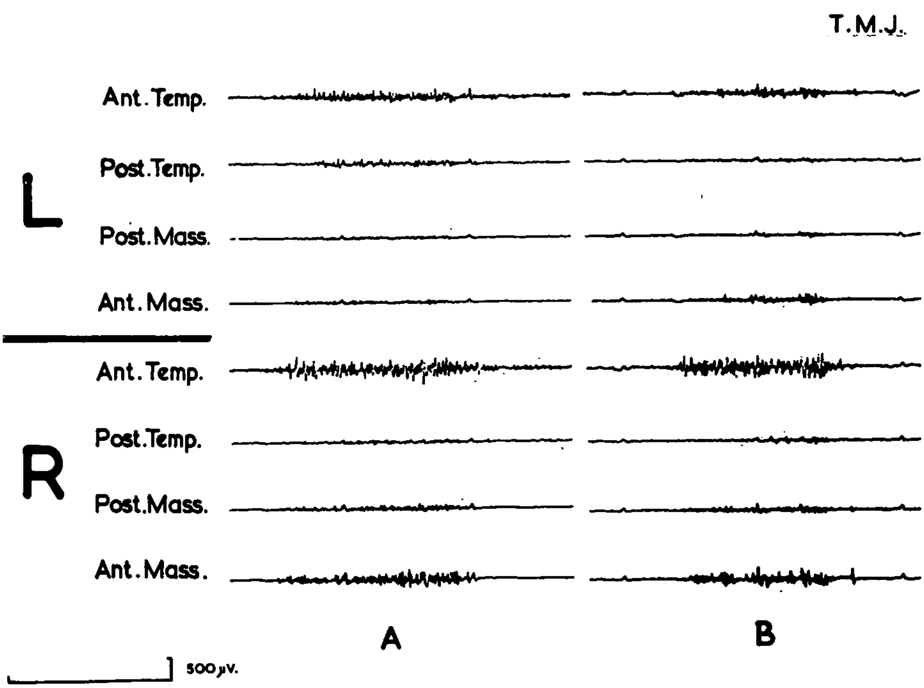

Fig. 2 A, electromyogram of bite in occlusal position. Note imbalance between left and right post. temporals and ant. masseters. B, electromyogram of bite in centric with improved muscle balance.

thrusting during deglutition, although excellent results have been achieved under similar functional circumstances with the addition of speech defects.[15] The fact that these were obtained without any objective myofunctional correction, this being entirely spontaneous, justifies some rethinking of behaviour, especially the act of swallowing.

The author,[16] in a series of lateral cineradiographic examinations of deglutition, emphasized the line of contact between the tongue and lower lip in subjects with a Class II, Division 1 malocclusion who swallowed with an anterior openbite. It was found that the prevailing commissure stretched from the tips of the lower incisors to the cingula of the uppers. In a very few cases contact was made more ventral, sometimes along a line joining the tips of both upper and lower incisors. Following up the cases during their appliance therapy, those whose tongue and tip met in the more ventral position offered greater resistance to movement and later relapsed.

Subtelny and Sakuda[17] have commented that it may be impossible to retrude the anteriors against a large tongue. An observation by Ricketts[18] is also germane in this connection: the condition distinguished by a tongue which may appear large and lying between the teeth at rest, often associated with openbites and spacing, is difficult to treat and may be followed by a relapse. Surely this is an example of morphological imbalance to an extent beyond the limits of adaptation. Moyers[19] and Andrews[20] have related tongue thrusting to chronically inflamed tonsils suggesting that the anterior positioning relieved pharyngeal pressure and painful symptoms during swallowing. Anderson[21] counters with the *enlargement* of the tonsils as the causative factor but, however it is viewed, it still remains a reflex adaptation.

The evidence of the prosthetist also weighs heavily: Fish[22] maintains that it is incorrect but unfortunately common practice to set up artificial teeth on the ridge in full denture prosthesis. As the alveolar resorption following extractions is mainly on the labial aspect, this results in the anterior teeth being placed in a more lingual position than the natural teeth. It is only on rare occasions that difficulties arise from this procedure as the vast majority of patients adapt quite satisfactorily to the new tooth position.

The basic morphological characteristics of soft tissue elements and their relationships to adjacent structures are difficult to assess, as by definition they are always adapting to some environmental influence. Eifert,[23] correlating tongue size to mandibular length from lateral radiographs, found that in most cases a balance was struck but a few discrepancies in form/space relationships were revealed.

Conclusion

From the foregoing, the author argues that it is the morphology which is of prime importance, with behaviour largely subservient to it, given a healthy neuromuscular background. It is of biological significance that the body be allowed to adapt itself to its environment, and compensate for morphological variations, both qualitative and quantitative. These morphological variations constantly arise from disparate growth patterns, from different anatomical elements having different rates of growth, and from imbalances due to gene distribution together with such insults as may be sustained from traumatic and pathological processes. We now see the individual fulfilling a number of set physiological functions with its given anatomical components. Different individuals with components of varying morphological qualities and quantities, i.e., form/space relationships, must of necessity vary the transformations and translations of the elements in order to carry out the same function. The apparent difference in behaviour patterns between different individuals for a similar function is due to differing morphology, not differing physiology. It should be noted that this approach eliminates such terms as normal and abnormal behaviour, (which have never been satisfactorily defined), together with their attendant pitfalls. Abnormal function is best left to those conditions associated with nerve and muscle pathologies. In the event of more than one reflex requiring the same pathway, that with the higher biological priority takes preference, e.g., maintenance of airway patency.

It would be naive and presumptuous to discount entirely the effect of cortical influences. The question of overlaid patterns, mostly of psychogenic origin, is very complex, and while it may contribute to a limited number of malocclusions, it does not detract from the focal point of this paper, that the pattern of behaviour is usually prescribed by the morphology and expressed through the reflex neurological processes. If it is not dogmatically acceptable in its entirety, the basis is more than hypothetical; however, further work is urgently required as extensive gaps remain in our knowledge of the neurology of the stomatognathic complex.

Despite shortcomings in the cogency of this argument, the use of circumstantial and pragmatic evidence, the concept is gaining ground on both sides of the Atlantic as shown by the work of Bosma[24] and Ballard.[25] The principles of control through feedback mechanisms is a study of the new science of Cybernetics and used in automated processes by computors. Certain aspects of neurology, namely reflex behaviour, are similar.

The existence of facial deformity is only a matter of degree in departure from the ideal morphological proportions and balance. We have been willing to accept the malocclusion from deformities in association with pathological processes; should we not recognize malocclusions due to variations in morphology? Change of position is a qualitative morphological factor and is limited by the existing form/space relationship and the ability of the neuromuscular mechanism to readjust the contractile elements to give efficient function. Thus is provided a range of adaptation which represents the orthodontists' valid licence.

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REFERENCES

1. Penfield, W. and Rasmussen, T.: The Cerebral Cortex of Man, *Macmillan and Co.*, 1950.
2. Pfaffman, C.: Afferent Impulses from the Teeth and Noxious Stimulation, *J. Physiol.*, 97: 207-219, 1939.
3. Stewart, D.: Some Aspects of Innervation of the Teeth. *Proc. Roy. Soc. Med.*, 20: 1675, 1927.
4. Corbin, K. B. and Harrison, F.: Function of Mesencephalic Root of Fifth Cranial Nerve, *J. Neurophysiol.*, 3: 423-435, 1940.
5. Thilander, B.: Innervation of the Temporomandibular Joint Capsule in Man, *Trans. Roy. Schools Dent.*, Stockholm and Umea, No. 7.. 1961.
6. Lammie, G. A., Perry, H. T. and Crumm, B. D.: Certain Observations on a Complete Denture Patient, pt. III, *J. Pros. Dent.*, 9: 34-43, 1959.
7. Blyth, P.: Mandibular Posture and Displacement, *Trans. Brit. S.S.O.*, 18-29, 1962.
8. Brill, N.: Aspects of Occlusal Sense in Natural and Artificial Teeth, *Dent. Prac.*, 13: 114-121, 1962.
9. Thompson, J. R.: Concepts regarding Function of the Stomatognathic System, *J.A.D.A.*, 48: 626-637, 1954.

10. Perry, H. J., Jr.: The Physiology of Mandibular Displacement, *Angle Ortho.*, 30: 51-69, 1960.
11. Greenfield, B. E. and Wyke, B. D.: Electromyographic Studies of Some of the Muscles of Mastication, *Brit. D. J.*, 100: 192-207, 1956.
12. Timms, D. J. and Greenfield, B. E.: Some Electromyographic Observations on Maxillo-Mandibular Relationship in Orthodontics, *Trans. Eur. Orth. Soc.*, 312-327, 1961.
13. Weinstein, S., Haack, D. C., Morris, L. Y., Snyder, B. B., and Attaway, H. E.: On an Equilibrium Theory of Tooth Position, *Angle Ortho.*, 33: 1-25, 1963.
14. Grossmann, W., Greenfield, B. E., and Timms, D. J.: Electromyography as an Aid in Diagnosis and Treatment Analysis, *Am. J. Ortho.*, 47: 481-497, 1961.
15. Blyth, P.: The Relationship between Speech, Tongue Behaviour and Occlusal Abnormalities, *Trans. Brit. S.S.O.*, 11-22, 1959.
16. Timms, D. J.: A Cineradiographic Study of the Oral Tissues during Deglutition, *Trans. Eur. Orth. Soc.*, 319-326, 1962.
17. Subtelny, J. D. and Sakuda, M.: Open Bite: Diagnosis and Treatment, *Am. J. Ortho.*, 50: 337-358, 1964.
18. Ricketts, R. M.: Vistas in Orthodontics, p. 125, *Henry Kimpton,* London, 1962.
19. Moyers, R. E.: Handbook of Orthodontics. p. 118, *Year Book Publishers, Inc.*, Chicago, 1955.
20. Andrews, R. G.: Tongue Thrusting, *J. South. Calif. D. A.*, 28 47-52, 1960.
21. Anderson, W. S.: The Relationship of the Tongue-thrust Syndrome to Maturation and Other Factors, *Am. J. Ortho.*, 49: 264-274, 1963.
22. Fish, W.: Principles of Full Denture Prosthesis, 5th Ed., *Staples Press*, 1952.
23. Eifer, D. F.: A Roentgenographic Study of the Tongue. (abstract), *Am. J. Ortho.*, 46: 226, 1960.
24. Bosma, J. F.: Maturation of Function of the Oral and Pharyngeal Region, *Am. J. Ortho.*, 49: 94-104, 1963.
25. Ballard, C. F.: Variations of Posture and Behaviour of the Lips and Tongue which determine the Positions of the Labial Segments; the Implications in Orthodontics, Prosthetics and Speech. *Trans. Eur. Orth. Soc.*, pp. 67-88, 1963.