

WHAT IS MEANT BY PHYSIOLOGICAL TOOTH MOVEMENT

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The phrase, physiological tooth movement, has crept into orthodontic literature within the last few years with increasing frequency and recently has aroused considerable critical comment. This discussion has been of such a nature as to confuse the reader because of the narrow limitations placed upon the interpretation of the term. Consequently this topic was suggested to the writer as one that needed clarification and it will be his aim to point out the wider boundaries than can, with sound reasoning, be designated as the confines within which this expression is correctly applicable.

Physiology, of course, is the science that has for its object the study of the normal reactions and functional processes of the body. Hence our subject interpreted in such terms would signify that form of tooth movement that is attended by tissue reactions and readjustments that are but expressions of normal cellular phenomena. This seems to be quite definite in its meaning and cannot offer any ground for misinterpretation when viewed from the standpoint of tissue reactions. The contention has its origin in the manner in which these structural modifications have been brought to pass.

As early as 1875, J. N. Farrar wrote a paper entitled, "An Inquiry into Physiological and Pathological Changes in Animal Tissues in Regulating Teeth." This was published in the *Dental Cosmos* in 1876. Weinberger, in his "Historical Review," quotes the following from this paper: "From these considerations (referring to various problems of and means for tooth movement) it will be seen that undue pressure upon the tissues will, if allowed to remain too long, produce inflammation, and will also modify or arrest the action of the absorbents, and all together produce unhealthy changes in the parts involved. On the other hand, tissues can receive a moderate amount of pressure, causing absorption, and yet not passing beyond healthy action. Therefore, there must be a dividing line within which we may operate successfully, and beyond which we cannot."

Although revealing a lack of understanding of the true nature of the tissue changes taking place as a result of pressure applied by mechanical methods, yet the deductions set forth are just as clear and comprehensive as could be stated today, viz., that the character of the forced tooth move-

ment should be such that no inflammatory reactions are started and the changes seen in the tissues should be "healthy."

Dr. Angle, in his writings, has repeatedly referred to the physiological movement of teeth, to appliances that conform to physiological requirements and to the physiological changes taking place in the structures of tooth retention.

Dr. Mary Bercea, in a paper published in the October, 1929, number of the Dental Cosmos, entitled, "Physiology of Tooth Movement," emphasizes the fact that there are three tissues whose normal cellular behavior interests us most intimately. These are bone, peridental membrane and cementum. After a very comprehensive study of these structures, she summarizes her topic as follows:

1. "Tooth movement (by mechanical force) is accomplished through an architectural reconstruction of bone. This process is governed by definite mathematical laws enunciated by Wolff, and is induced by the proper degree of stimulation of the osteoblasts and osteoclasts to increased functional activity.

2. The stimulus to the cells is supplied in the form of an increased amount of nourishment from an increased blood supply, which in turn, is induced by means of applied pressure.

3. Any degree of stimulation (pressure) beyond that necessary to supply an abundance of nourishment to the cells through the medium of the blood supply will result in circulatory disturbances followed by inflammatory changes and destruction (or degeneration) of the tissues.

4. As Dr. Angle has pointed out, mechanical appliances should conform to the physiological requirements of treatment and the force within them should be properly controlled, that is, not too great or too little in amount, and applied in the right direction only.

5. A careful plan of treatment should be made at the beginning of each case and any movement once initiated must be conducted without interruptions or change of direction until the desired change in position has been accomplished.

6. With the exception of those cases where constitutional conditions are responsible, the reason for pathological changes during tooth movement, such as inflammatory changes of the gingival and peridental membrane, destruction of the alveolar process . . . must be sought in one of the two following causes:

- (a) The use of a mechanism which does not comply with the physiological requirements of tissues; (b) improper force control in the use of a mechanism which in itself might comply with these requirements."

Oppenheim, in his classic papers setting forth the tissue changes occurring in orthodontic treatment, refers to the *physiologic* force of an orthodontic device, stating that "the vitality of the periosteum suffers no injury during the application of 'physiological forces'." From this we may infer that Oppenheim considers that when tooth movements are produced by mechanical devices for the purpose of correcting malocclusion, the operative procedure may be termed physiological treatment and the tooth movements induced can be classified as physiological tooth movements provided the force evolved is of such a nature as to result in tissue reactions that are the normal vital manifestation of the cells of the tissues environmental to the tooth.

These four contributors to orthodontic literature, the first, a pioneer of over fifty years ago; the second, the greatest benefactor of the specialty and the most intent student of the natural phenomena associated with the human denture that there ever has been; the third, a younger practitioner; and the fourth, the most thorough and eminent research worker that orthodontia can boast of, all imply that there is such a thing as physiological tooth movement taking place as a result of correctly applied forces that originate in orthodontic appliances.

Milo Hellman, on the other hand, in his essay entitled, "Physiological Treatment" which is published in the June, 1930, number of the Dental Cosmos, draws a sharp line between tooth movements occurring under the natural forces associated with the denture and tooth movements that result from the use of orthodontic mechanisms. He definitely states that "Physiological Treatment can under no circumstances be construed to mean any sort of mechanical procedure, regardless of what type of orthodontic appliance is used, and how well it is manipulated and controlled."

From this we may imply that Hellman concludes that physiological tooth movement is limited to those changes that take place in tooth positions as a result of the natural forces inherent to the denture and which may be enumerated as developmental, growth, functional and environmental muscular (from pressure). Consequently he assumes, as he necessarily must after such limitations, that "physiological (orthodontic) treatment" is only such a form of treatment as can be carried out by the use and directed control of these natural forces and is expressed tangibly in the form of functional exercises, muscular pressure control and systemic treatment to aid various metabolic processes. He infers that interference with a mechanical device immediately takes the subsequent tissue changes out of the realm of physiology and places them somewhere, but where he did not mention.

This, then, furnishes real ground for argument. Let us now try to unbiasedly ascertain whether the four previously mentioned writers were correct in the interpretation that they have been placed upon the phrases, physiological treatment and physiological tooth movement or whether Hellman is right in the more narrow construction that he suggested as basically sound.

How the Science of Physiology has been Evolved.

The writer would first call your attention to the manner in which the facts of basic relationship to the science of physiology have been determined and proved. All that is known concerning the so-called normal tissue reactions and functional processes of the body are a result of experimental study that has brought into play many varied kinds of forces called stimuli. To emphasize the importance of these stimuli to the science of physiology, let me quote from Dr. Max Verworn, Prof. of Physiology, University of Bonn, "Every change in its normal vital conditions which produces any effect whatsoever upon an organism is termed a stimulus. This is the only general definition we have for a conception which is of such vast importance to physiology. According to it, experimental physiology is entirely a physiology of stimuli. It further follows from this conception of stimulation that there must be an enormous multiplicity of stimuli, since each particular vital condition may be subjected to some change capable of acting upon it as a stimulus From their qualitative nature, stimuli are distinguished as chemical, thermal, photic, *mechanical* and electrical. Each of these several varieties may, however, be applied *quantitatively* in various degrees of intensity and may in consequence produce quite different results But the physiology of stimulation is not only of the greatest value as a means of research, its importance is much increased by the fact that in Nature itself stimuli are everywhere and constantly acting upon the organism and its parts.

Hence the investigation of their action comes to be not merely a *means*, but a direct *end* of research. Physiology—Encyclopedia Britannica, 11th Edition, Vol. XXI, pg. 555).

From a countless number of experiments with these stimuli, it has been determined that a cell exhibits the vital manifestations of irritability, motility, growth, reproduction and metabolism. No one has looked upon a cell in the human body under all of its natural environment and observed these various functional activities. Yet we accept these facts as the normal physiological activities of cells. Organs in turn have been studied experimentally and certain conclusions reached as to their functional activities and so we receive these deductions as the physiological manifestations of the various

organs. No one has actually observed these processes, but the proof is sufficiently strong to lead to conclusions that such vital manifestations do occur.

If the physiologist is contented to formulate basic principles for his special science on the results of experimentation with mechanical stimuli, then the writer feels justified in the claim that tissue reactions resulting from the application of mechanical forces upon the teeth through the agency of orthodontic appliances may be considered as physiological phenomena taking place in response to *mechanical stimuli*. Furthermore, the tangible evidence of these reactions have been studied and presented in photomicrographic form by Oppenheim. Hence I would contest strongly that the correction of malocclusion of the teeth by a mechanical mechanism may, should and only does take place because of the functional activities of the cellular elements in the tissue that support and retain the teeth in positions in the dental arches, and therefore, such treatment is physiological when the stimuli used result in functional responses that are the normal vital manifestations of these cellular elements as outlined in the science of physiology and that the tooth movement occurring as a result of such normal vital reactions of these cellular elements is best designated as "physiological tooth movement."

Experimentation has further demonstrated that normal cellular activities and organ functions only occur under favorable states of environment such as correct temperature, sufficient food supply and absence of injurious substances and conditions. When these necessary environmental prerequisites modify themselves so greatly that normal activities are no longer possible then the phenomena of degeneration begin to appear and the realm of pathology is reached.

Owing to the fact that malocclusion of the teeth is not a pathological process, it is fair to assume that the cellular activities accompanying this condition are the normal vital manifestations of living tissue. True it is that the traumatic forces that attend certain malocclusion positions of teeth may eventually result in pathological states of the supporting tissues of the tooth, but in early life, when we are called upon to treat these cases, such degenerative and inflammatory states are seldom seen. We, as orthodontists, are expected to restore these malposed teeth to correct relationship with the "line of occlusion," viz., nature's architectural line for the denture units. We have two means of doing this. First, we can employ the natural forces inherent to the denture, strengthen those that are too weak, modify those that are too strong or correct the one that are acting detrimentally and thus direct the teeth into their proper positions, or secondly, we can place mechanical

devices on the tooth crowns which, when properly adjusted, carry these component dental arch units to their normal position.

When analysed in the *modus operandi* of their action, these two methods of treatment execute the tooth shifting by exactly the same force, that of pressure. The former force is limited to the push action while the latter includes the push and pull force. The choice of the two methods of treatment is wisely made by the experienced operator who will always use the first method whenever there is a possibility of its producing the required changes and will just as quickly resort to the latter force when complications are present that render the first method of treatment inefficient and he seldom, if ever, uses the latter method without combining it with the former. When viewed from this angle, mechanical devices are but supplementary agents of force that are used to supply that which is lacking in the natural inherent forces of the denture and to undo the damage produced by the action of these latter forces gone astray.

The question now arises as to whether cellular reactions to these two forces are any different. No one will question but that the phenomena taking place in the tissues under the action of the natural forces inherent to the organ of mastication are physiologic in character, viz., that they are the natural cellular reactions of vital, healthy bone, peridental membrane and cementum. If they were not, then symptoms of morbid changes would be manifested. The proof herein accepted is the absence of lesions and signs that indicate pathologic states of the vital tissues that are environmental to the tooth roots and that are modified by reactions when the tooth position is changed by these natural forces. It seems reasonable then to accept the same proof in our judgment of the response of the tissues to mechanical forces applied on the teeth. When these forces are of such a character as to effect changes in the positions of various teeth without being accompanied by any of the symptoms of tissue inflammation or degeneration, then by the same right that we say the former type of tooth movement is physiological, so can we deduct that the latter type is. Tooth movements accompanied by pain, tenderness and swelling are not physiological.

Oppenheim's classic experimental work on monkeys and dogs, demonstrating the tissue changes that take place when teeth are moved under mechanical pressure, must be accepted as proof of the actual cellular activity that occurs when teeth are shifted by orthodontic appliances. He clearly shows that a mechanical force, when not too powerful, initiates and keeps active, certain cellular functional manifestations that are the normal activities

of these particular cells and by such actions are the bony tissues altered, the periodontal membrane fibers cut loose and reattached, all in a most purposeful manner, and, as a result of these various modifications, the tooth position is changed as the mechanical pressure directs.

On the other hand, he also proves that pressure that passes beyond a certain degree of power does not result in these favorable cellular responses, but produces microscopic signs or symptoms of pathological reactions. Knowing just what are the clinical symptoms of early pathologic lesions, we have a very accurate gauge indicating the boundary line between tissue physiology and pathology. Therefore, tooth movements produced by orthodontic mechanisms that are attended by tissue reactions that show no clinical symptoms of the pathologic states of inflammation, degeneration or necrosis, may be considered to be physiologic in character and treatment that produces such normal reactions of the cellular structures concerned in this tissue modification and co-incident to the change of tooth position, may be considered as physiological treatment, no matter whether the force that the operator actually uses to produce the tooth movement is derived from the natural forces of the denture or from mechanical devices.

From these deductions it seems to the writer that Hellman's interpretation of physiological treatment is extremely narrow and limited, so much so as to justly be open to criticism because in order to be consistent it must eliminate, as physiologic phenomena, any tissue reactions that are the result of artificial stimulation which includes mechanical stimulation as well as thermal, chemical, photic and electrical and, as previously stated, this removes from the science of physiology, practically everything that is known concerning cellular functions. Furthermore, it does not account for the normal vital manifestations of cellular activity that occur in direct response to the forces emanating from orthodontic mechanisms.

Therefore, the writer would offer the following definition of physiological tooth movement, in the belief that it conforms to the requirements of sound scientific reasoning.

Definition of Physiological Tooth Movement

Physiological tooth movement is that type of tooth movement, no matter whether accomplished by the natural forces inherent to the denture or by forces evolved from mechanical devices, that is attended and made possible by tissue changes that are the expression of the vital reactions and functional manifestations of the cells that constitute the living units of the structures that are undergoing this purposeful modification.