Journal of Craniomaxillofacial Research

Vol. 4, No. 2 Spring 2017

Tooth eruption: a "neuromuscular theory". part two

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ARTICLE INFO

Article Type:
Original Article

Received: 23 Jan 2017
Revised: 28 Feb 2017
Accepted: 15 Mar 2017

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ABSTRACT

Background/Objective: Tooth eruption is a foundational subject for every dental practitioner as well as dental students; and literature is replete with different mechanisms of migration of a tooth from its bony crypt into the oral cavity. The purpose of the part two of this study was to evaluate and test the proposed "neuromuscular theory of tooth eruption" using relevant scientific papers, as supporting bodies of evidence, to unify the currently accepted mechanisms of tooth eruption under single theory.

Materials and Methods: A detailed and systematic analysis, synthesis and integration of the findings from relevant scientific studies (selected according to specific inclusion and exclusion criteria) on mechanisms of tooth eruption was conducted as it was done with part one of this study.

Results: The propelling force of tooth eruption is attributed to piezoelectricity, mechanosensation, mechanotransduction, mechanical pull on the hydroxyapatite crystals; mechano-hydrodynamic force; and mechanics of the mandible and the orofacial muscles with attendant biochemical, electrical, electrochemical, cellular, molecular and enzymic activities to prepare the jaws and other facial bones for coronal migration of a developing tooth from its bony crypt until it emerges in the oral cavity.

Conclusion: "Neuromuscular theory of tooth eruption" is based on neuromuscular forces, arising from muscular contractions in the orofacial region. Mechanosensation, mechanotransduction and piezoelectricity are the three principal processes of converting neuromuscular forces into electrical, electrochemical and biochemical energies for initiation and sustenance of cellular, molecular and enzymic activities during the different phases of tooth eruption process. The clinical relevance of this theory is that it throws more light on the morphological and functional interdependence of the various elements of the maxillo-mandibulo-dental system as well as the need for neuromuscular considerations in the diagnosis, treatment planning, prevention and treatment of pathological conditions of tooth eruption.

Key words: Mechanosensation, Mechanotransduction, Neuromuscular, Theory, Tooth eruption.

Introduction

This is the part two of a two-part article on tooth eruption: a "neuromuscular theory". The part one of this article was devoted to a brief summary of the currently accepted theories (mechanisms) of tooth eruption, a clear definition and explanation of the proposed "neuromuscular theory of tooth eruption", methodology of the review process and the thinking behind the proposed theory.

The methodology employed in this study involved the use of search engines such as PubMed, Medline, Google Scholar and Index Medicus for collection of relevant sci-

scientific articles on tooth eruption mechanisms as contained in the part one of this study. This concluding part (part two of the proposed "neuromuscular theory" of tooth eruption) was devoted to the evaluation and testing of the proposed theory on the basis of supporting scientific evidence from previously published relevant scientific studies on tooth eruption mechanisms and process.

The highlights of the part one included:

1. Basic assumptions of the proposed theory to wit:

(i) The timing, sequence, initiation, formation, growth and development teeth as well as molecular and cellular activities during eruption phases aregenetically controlled [1-7]; (ii) The coordinated neuromuscular forces of the orofacial muscles, while stimulating alveolar and basal bones' growth, are responsible for pre-eruptive, eruptive and post-eruptive movements of teeth [8-17]; (iii) The coordinated neuromuscular forces are converted into electrical, electrochemical and biomechanical energies for the stimulation of cellular and molecular activities within and around the dental follicle and enamel organ to prepare a pathway as well as other cellular functions for eruption of a developing tooth [18-35]; (iv) These forces seem to be active throughout life time. However, they are post-eruptively opposed by antagonistic tooth reactive forces [7, 36]; (v) Eruption speed tends to be associated with the degree of muscular activity [7, 36]; (vi) Period of rapid growth and development of the jaws has been associated with period of rapid growth of orofacial muscles and tooth eruption [7, 36]; (vii) The trajectory of the depressor and elevator muscles' resultant forces is always directed towards the occlusal plane i.e. occlusally orientated in the absence of other disorientating factors [7, 36]; and (viii) The internally or externally generated neuromuscular forces can answer the questions of post-eruptive movements of teeth, eruption of rootless tooth, eruption of implanted plastic replica of surgically removed developing tooth germ without disturbing its surrounding follicle, continuously growing of rodents incisors and guinea pig molars as well as occlusal movement of retained roots of fractured teeth [36-46].

2. Challenging and unanswered questions which should be addressed by the proposed theory to wit:

(i) The three dimensional space movement of the teeth during the pre-eruptive phase of tooth eruption [7, 36-46]; (ii) Post-eruptive movements of teeth owing to attrition and defects in the dental rows [7, 36-46]; (iii) Eruption of rootless tooth [7, 36-46]; (iv) Continuous eruption of incisors of rodents and molars of guinea pigs respectively [7, 36-46]; (v) Eruption of surgically implanted replica of a developing tooth germ without disturbance of its dental follicle [7, 36-46]; (vi) Association of rapid growth and development of jaws in response to tooth formation, tooth growth and development and tooth eruption [7, 36-46]; and (vii) Delayed tooth eruption associated with myopathies, neuromuscular disorders, metabolic and endocrine disorders and congenital TMJ ankylosis [8-14].

The aim of this second part of a two-part study is to use neuromuscular forces to answer or address the challenging and unanswered questions associated with the older tooth eruption mechanisms based on scientific evidence of the role of neuromuscular forces in growth and development of jaw bones, other facial bones as well as eruption process. In this context, the article will be discussed under two major headings namely:

1. Evaluation of the hypothesis (theory); and 2. Testing of the hypothesis.

1.0 Evaluation Of The Hypothesis (Theory)

In order to explicitly understand the exact nature and orientation of the muscular forces and torques being ascribed or associated with the proposed "neuromuscular theory of tooth eruption", it is pertinent to consider the discussion under the following four major sections:

1.1. Section 1 will briefly review postnatal growth and development of facial skeleton and architectural configuration of muscles of the oro-facial region as a basis of understanding the mutual interactions of the structures of oro-facial region during ontogenesis.

1.2. Section 2 will deal with the architecture (anatomy) of the facial skeleton and muscles of the oro-facial region with emphasis on the morphological and functional interdependence of the organs and systems of the oro-facial region.

1.3. Section 3 will deal with the bio-dynamics and physics of the oro-facial muscles and jaw bones as the basis of establishing causal relationships between muscular forces and tooth eruption.

1.4. Section 4 will be devoted to the basic considerations of the newly proposed "neuromuscular theory of tooth eruption" as well as the clinical relevance of this theory.

1.1. Section 1: Growth And Development Of The Jaw Bonbes And Muscles Of Oro-Facial Region

The shape of the bones and muscles of the oro-facial region are genetically determined. However, the products of genes are subject to environmental influences; and the interaction of genetic or endogenous factors and environmental factors will ultimately determine the final outcomes [12-14].

The facial and cerebral parts of the skull underwent shaping and reconstruction during Ontogenesis. The facial region is characterized by growth and development of the jaw bones and development of the muscles and other organs of the oral cavity. The main feature is their continuous development and reconstruction; and in their mutual interactions, the facial skeleton and other organs of the mouth continue to grow in the post-natal period with the bones of the face growing faster than the bones of the cerebral skull [36].

Jaw growth and development is most pronounced during the period of formation, growth, development and eruption of primary and permanent teeth; and this is responsible for changes in the proportions of the facial and cerebral parts. Two periods are distinguished in the development of the jaws during primary dentition. The first period is associated with formation, growth, development and eruption of the anterior teeth; and it is marked by both vertical and horizontal augmentation of the jaws in the anterior region. The second period is associated with the formation, growth, and eruption of the primary molars; and is marked by both vertical and horizontal bone increases in this part of the jaw [7, 36].

During the period of transitional dentition, two periods are also identified in the growth and development of the jaw bones. The first period of augmented growth in the region of the anterior teeth occurring at the age of four-and- a-half or six years when the jaw is being adjusted to the eruption of permanent anterior teeth [7, 36].

The second period coincides in time with the development and eruption of the permanent masticating teeth (augmented growth of this part of the body of the jaw). The process begins at the age of six year (eruption of the first molars) and lasts to age of 12 or 13 years (eruption of the second molars) [7, 36].

The growth and development of the skeleton of the face is also associated with development and growth of all the muscles in the oro-facial region. All the oro-facial muscles develop while functioning and as a result, their bulk increases and their bundles become differentiated. In their development, they influence the skeleton of the face, the connective tissue and skin which determines the general appearance of the face. Through the mutual interaction of skeleton and muscles, the organs of the maxillo-mandibulo-dental region acquire a definite functional trend [36]. Disturbances in the development of the skeleton and muscles may result in malformation of organs with impaired function and low resistance to the effect of unfavorable internal and external factors [36].

The muscles are the working organs of the nervous system, and their activity is governed by the central nervous system (CNS) through impulses, those that are produced in the external environment and those that arise in the organism itself. Studies have shown that severing or detachment of a muscle from its attached bone would result in failure of growth and development of both the bone and the detached muscle [37-43].

1.2 Section 2: Morphological Features Of Oro-Facial Muscles, Jaws And Other Facial Bones

The mandible is made of a body, two rami, two condylar processes, two coronoid processes and one alveolar process with the teeth clearly established and distinguished in it. The mandible is the only mobile bone in the facial skeleton and it is the site of attachment of many muscles which cause its movement. This specific feature of mobility determines its complex structure and influences the development of the facial skeleton and overlaying soft tissues [36].

The maxilla's construction, as a functional structure, is considered with respect to its abutments which are supports that receive the pressure of mastication and the impact suffered when the upper and lower teeth are brought together [36]. Four abutments are distinguished namely: fronto-nasal, zygomatic, pterygopalatine and palatine. The palatine processes form the horizontal abutments while the other three abutments are vertical columns for transmission of vertical occlusal forces to the cranium. The mandible and maxilla, together with their dental rows and supported by alveolar processes, are u-shaped or somewhat spherical in shape in conformity with the characteristic features of their investing layers (muscles) [36].

The morphological topographies of the muscles of oro-facial region in terms of arrangement, shape, size and orientation are similar to the geometric characteristics of the underlying bones [44-46]. The infra-hyoid muscles are triangular or conical in shape and they are arranged in triangular or conical shape with apex of the cone located at the hyoid bone. The supra-hyoid muscles are also triangular in shape and they are arranged in triangular or conical shape with the apex of the cone located at the hyoid bone and base of the cone located at the floor of the mouth. The tongue and the masticatory muscles are triangular as well as conical in shape.

The upper and lower jaws, together with their dental rows, are located in between two muscular "screens". The outer screen is made up of buccinators, orbicularis oris and other muscles of facial expression. The posterior aspect of the outer screen is completed by the superior pharyngeal constrictor. The inner screen is made up of the tongue and its external muscles. Anteriorly, the outer screen has an opening that separates the orbicularis oris into upper and lower lips thus creating an entrance into the mouth proper. Posteriorly, there is an opening in the inner screen thus creating an entrance into the pharynx and larynx. These muscular screens are designed to keep the relative positions of the jaws and their dental rows [44-46].

The facial skeleton cannot work alone without the input of the oro-facial muscles which constitute the investing layers or coverings for the skeletal framework. The jaws and other facial bones provide surfaces for the attachments of oro-facial muscles; and the functions of these muscles are controlled by the central nervous system (CNS). The shape, size, orientation, origin and insertion of each oro-facial muscle are structurally designed for effective performance of its individual function/s as well as its contribution to combined muscular actions. A close observation or examination of the origins and insertions of the muscles that are attached to maxilla and mandible reveal close approximation of the apices of the teeth in their alveoli [7]. The locations or areas of these muscles' attachments are of great importance during muscular activity because the orientation of the origins and insertions of the muscles determine the trajectory of the generated forces [44-46].

1.3 Section 3: Biodynamics And Physics Of The Oro-Facial Muscles And Jaw Bones

During functional contractions of the oro-facial muscles; active and passive forces are generated. These forces are applied on the jaw bones and other facial bones. The applied pressures influence the growth and development of the jaw bones and other facial bones as well as the growth, development and eruption of teeth [7, 44-46].

One may ask: how would muscle forces (being generated during sucking, speech, smiling, swallowing, mastication and other orofacial functions) provide the necessary stimuli for tooth eruption?

The answer lies in the analysis, synthesis and integration of information from the dynamics and physics of the oro-facial muscles and jaw bones as well as their mutual interactions. The role of muscle forces, as a major factor, in the process of tooth eruption can be explained under the following mechanisms:

1.3.1. Piezoelectricity;

1.3.2. Mechanosensation and mechanotransduction;

1.3.3. Mechanical pull on the hydroxyapatite crystals;

1.3.4. Mechano-hydrodynamic force; and

1.3.5. Mechanics of the mandible and the orofacial muscles.

1.3.1. **Piezoelectricity**:

Bone possesses an inbuilt growth pattern and it is equally clear that a bone does respond to forces applied externally. It has long been known that deformation of many materials including bone, dentine, cementum, skin and many others lead to development of electrical potentials which are reversed in polarity when the deformation ceases [47-50]. This phenomenon is known as piezoelectricity. Basset developed the concept that minute electric currents produced in the bone when pressure is applied may control the activity of cells concerned with bone remodeling [47-50]. Piezoelectric effects are detectable in bone, dentine and cementum and probably generated during normal mastication and other orofacial muscular functions [47-51]. In bones, this may account for the increased activities of growth factors, enzymes, mononuclear cells and bone cells during tooth eruption. It is suggested that electrical currents would affect cellular activity as well as alter the distribution of ions and thus induce bone growth (in areas of negative pressure) and bone resorption (in areas positive pressure) the key factor in the process of tooth eruption and orthodontic treatment. Thus, the coronal portion of the eruption pathway is characterized by bone resorption while the apical portion is characterized by bone deposition [47-51].

1.3.2. Mechanosensation And Mechanotransduction

Mechanosensation is a mechanism by which mechanical stimuli are converted into nervous impulses [52-56]. It is the physiological foundation upon which the senses of touch, hearing and balance are based. For examples, pain is the conversion of mechanical stimuli into neuronal signals; and mechanoreceptors of the skin, called cutaneous mechanoreceptors, are responsible for touch. Mechanotransduction is a mechanism by which cells translate mechanical stimulus into electrochemical or biochemical activity [52-56]. This is a form of energy conversion that is responsible for a number of senses such as proprioception, touch, balance, and hearing and other physiological processes in the body. Living cells, tissues organs or systems of every multicellular organism respond to internal and external mechanical stimuli throughout life time [55]. Unicellular organisms also behave in similar manner.

Therefore, mechanosensation and mechanotransduction are two major mechanisms of adaptation of organisms to their internal and external environments. Muscles are the working organs of the skeletal framework of human beings. The internal and external mechanical stimuli (being generated by muscular contractions of orofacial region owing to functional processes such speech, swallowing, smiling, sucking, laughing etc.) are mediated through mechanosensation and mechanotransduction mechanisms during the mutual interactions between orofacial muscles and facial skeleton including jaw bones [56-68].

The mechanical stimuli or impulses being generated by the neuromuscular system are transmitted to the jaws and other facial bones via tendons and periosteum which form the attachment of the muscles to the bones. These mechanical forces or stimuli, which act on a given area of a given bone, are sensed (as pressure, stress, strain or deformation) and transduced or converted into electrical, electrochemical or biochemical stimuli or signals by mechanoreceptors [69-87]. These mechanoreceptors act as sensors as well as transducers [86-94]; and they are specialized proteins embedded in the cell membrane and sandwiched between extra cellular matrix and the cytoskeleton of the cells [87-94]. The most notable groups in man and other mammals are referred to as mechanosensitive channels, mechanosensitive ion channels and stretch-activated channels [87-94].

Mechanoreceptors work on the principle of "gating" i.e. they open the gate or close the gate based on the levels or intensities of the incoming signals and the thresholds of the concerned mechanoreceptors [69-79]. The mechanical signals, being generated owing to muscular contractions, are received, sensed and transduced or converted into electrical, electrochemical and biochemical energies for the purpose of effecting some specific changes in molecular, cellular and enzymic activities in the jaw bones and periodontal ligament (PDL) during the intraosseous stage or phase of tooth eruption [94].

Mechanosensation and mechanotransduction are important mechanisms or processes which are associated or accompanied with cascades of events such as metabolic, oxidative, transport and enzymic activities in cells, tissues, organs and systems [52-55, 84]. They are indispensable mechanisms in growth, development and adaptation of cells, tissues, organs and systems [52-55, 84]. Consequently, the role of mechanosensation and mechanotransduction in tooth eruption is probably to effect some increase in molecular, cellular and enzymic activities for preparation and sustenance of the eruption pathway in the alveolar crypt of the erupting and developing tooth until its emergence into the oral cavity. The increased molecular, cellular and enzymic activities in the jaw bones and periodontal ligament (PDL), during the intraosseous stage of tooth eruption, will decrease to the basal levels of sustaining molecular, cellular and enzymic turnovers in the jaw bones and PDL after the emergence of the tooth into the oral cavity [1-7]. A detailed examination and exposition of mechanosensation and mechanotransduction is not within the scope of this discourse.

1.3.3. Mechanical Pull On The Apatite Crystals

When muscle forces act on any bone, the bone may resist the force or allows the pressure to pass through the bone for the purpose of distributing the pressure [1-7]. The occlusal acting resultant forces pull the apatite crystals of the alveolar bone surrounding the erupting tooth which in turn pulls the collagen fibers of the periodontal ligament occlusally [1-7]. The stress on the oblique fibers of the periodontal ligament pulls the tooth coronally. The pressure of the pull on the root of the tooth also aids osteoclatic activities/ resorption of the bone coronally while the apical space created by occlusal movement of the tooth is filled by deposition of bone at the apical region [1-7].

Studies have shown that the orientation of the collagen fires of the periodontal ligament during eruption of teeth and at the completion of eruption is cervico-apically directed i.e. the fibers are attached to the alveolus cervically and to the cementum apically, thereby enhancing the pulling effect of the occlusally directed resultant muscle force on the apatite crystals [95-98].

1.3.4. Mechano-Hydrodynamic Force

Intermittent muscle pressures applied to jaw bones are transmitted through the bone into the periodontal space by means of the flow of the interstitial fluid in the bone [95-98]. The flow of the fluid into the periodontal pace increases the pressure within the periodontal space as well as the intra-pulpal pressure because of the flow of the fluid into the pulp cavity through the apical aperture. The combined effect of the increased pressure in the pulp cavity and periodontal space could account for eruptive movement of tooth within the bony crypt [95-100]. The coronal portion of the bony crypt is subjected to pressure with a resultant resorption of bone aided by osteoclastic activities while the space created by occlusal movement of the tooth is filled with deposition of bone [95-97]. In other words, the increased pressure in the coronal portion of the erupting tooth creates a sort of mechano-physiologically induced inflammatory reaction leading to increased cellular, molecular and enzymic activities with a resultant osteoclastogenesis [95-97]; and the apical region of the tooth, being subjected to tension, is associated with osteoblastogenesis for the purpose of filling the space left as a result of coronal movement of the erupting tooth [95-97].

The orientation of the oblique fibers of the periodontal ligament is in accord with this mechanism of tooth movement within the bony crypt. The oblique fibers of periodontal ligament are attached (at different levels to the root) to cementum apically and to the cortical plate of the alveolus coronally; and whenever hydraulic pressure is applied to the periodontal space, the root is moved coronally taking into consideration the orientation of the oblique fibers [95-100].

1.3.5. Mechanics Of The Mandible And Oro-Facial Muscles

The mandible is the only mobile bone of the maxillofacial region. The impulses for generating muscular contractions that cause mandibular movements can be generated internally or externally. During mandibular movements active and passive forces are generated. Every moving body, including mandible and teeth, obeys Newton's Laws of motion. Newton's first law states that a body at rest stays at rest and a body in motion continues to be in motion with the same speed and in the same direction unless it is acted upon by an unbalanced force [101-103]. Prior to the initiation of root formation, crown of a developing tooth stays in its bone crypt; and movement is first noticed at the initiation of the root formation and in response to jaw growth, both in horizontal and vertical planes [1-7]. It is well documented that bone growth is associated with adequate myofunctional activity of the jaws [7].

The Newton's second law of motion states that if a body in motion is acted upon by an unbalanced force, it will accelerate and its acceleration is directly proportional to the magnitude of the net force and inversely proportional to its mass [101-103]. This law may determine the rate of eruption of individual tooth in the jaw; and this will be typical of the eruptive and post-eruptive movements of teeth. It can also explain the issues of continuous tooth eruption, mesial drift, supra-eruption, occlusal migration of retained roots and eruption of rootless tooth.

The Newton's third law of motion states that a pair of force is generated when two bodies interact; and these forces are known as action=reaction forces [101-103]. These forces are equal in magnitude but in opposite direction. This law operates when the erupting tooth comes in contact with its antagonist; and it is said to be functional occlusion [1-7]. It is responsible for the maintenance of the occlusal positions of the teeth when they are fully erupted and there is a state of equilibrium between the upper and lower dental rows. Any defect in the dental row either in the upper or lower jaw will result into disequilibrium of occlusal forces with a resultant post-eruptive movement.

Furthermore, the discussion on the role of neuromuscular function in the process of tooth eruption will be incomplete without mentioning the effect of reduced muscle tone on tooth eruption. Pathological conditions such as Down syndrome, Benign Congenital Hypotonia, Barther syndrome, Cohen syndrome, Floppy infant syndrome, congenital ankylosis of temporomandibular joints and many other nutritional, hormonal, metabolic and genetic disorders have been associated with delayed tooth eruption amongst other physical manifestations [104-117]. Muscles, under the influence of nervous system, are the ultimate providers of forces in human organs and systems; and the origin of the forces, that are probably responsible for tooth eruption, can be traced to muscular contractions and their interaction with jaw bones and other facial bones.

1.4. Section 4: Basic Considerations Of The Newly Proposed "Neuro-Muscular Theory Of Tooth Eruption"

The basic considerations of the newly proposed theory of tooth eruption, to be called "neuromuscular theory of tooth eruption" or "unification theory of tooth eruption", are as follows: (i) The cerebral and facial parts of skull constitute the hard framework of the cranio-facial region which is morphologically and architecturally designed to support the complex functional activities of the maxillo-mandibulo-dental system; (ii) The working organs of the cerebral and facial skeleton are the muscles of the orofacial region; (iii) Active and passive muscular forces and torques are generated under the influence of the central nervous system and these muscles work on the principles of lever systems [117]; (iv) The central theme of the proposed "neuromuscular theory (hypothesis) of tooth eruption" is the transduction of neuromuscular forces into electrical, electrochemical, biochemical and biomechanical events in the jaw bones for the purpose of occlusal or coronal translation of the developing tooth; (v) The periodontal ligament is the bridge between the bony crypt of the tooth and the root surface. It is a bio-material, derived from the dental follicle; and its importance in the process of tooth eruption cannot be over-emphasized. It acts as one of the centers of mechanosensors and mechanotransducers of the neuromuscular forces, with differentiation into electrical, electrochemical, biochemical (molecular, enzymic and cellular) events, for the promotion of tooth eruption process [95-100]; (vi) The greatest proportion of the required forces for tooth eruption is probably provided by the muscles of mastication which are attached to the mandible -the only mobile bone in the oro-facial region by virtue of its complex special joints (TMJs) with the cranium. This could be the reason for earlier eruption time of mandibular teeth compared to maxillary teeth [1-7]; and (vii) The Newton's laws of motion are clearly exemplified in the process of tooth eruption; and they can be used to explain the mechanisms of pre-eruptive movements, eruptive movements and post-eruptive movements [101-103].

2.0 Testing Of The Hypothesis

This hypothesis can be explained and tested in the light of the following conditions: (i) Failure of tooth eruption owing to ankylosis of the concerned tooth [108, 111]; (ii) Immovability of dental implant; (iii) Delayed eruption owing to degenerative neuromuscular disorders [104]; (iv) retention of a tooth in its alveolus owing to local barriers on the pathway of the erupting tooth [106]; (v) mesial drift of a tooth owing to loss of a tooth or teeth in a dental arch [1-3]; (vi) Supra-eruption of a tooth without an antagonist [1-3]; (vii) Eruption of rootless tooth [1-3]; (viii) Eruption of retained roots [1-3]; (ix) Eruption of implanted replica of a tooth without destruction of its dental follicle [1-3]; and (x) severance of muscles from bones and denervation of muscles of mastication resulting in delay and /or absence of tooth eruption [114-116].

Conclusion

It is concluded that muscles, under the influence of nervous system, are the ultimate providers of forces in human organs and systems. Those forces, that are probably responsible for tooth eruption, can be traced to muscular contractions and their interaction with jaw bones and other facial bones under the influence of nervous system. The central theme of the proposed neuromuscular theory (hypothesis) of tooth eruption is the transduction of neuromuscular forces into chemical, electrochemical, biochemical and biomechanical events in the jaw bones for the purpose of occlusal or coronal translation of the developing tooth.

The clinical significance of this theory is that neuromuscular system plays a significant role in normal eruption process. Therefore, attention should be focused on neuromuscular disorders among other general factors such as nutritional, hormonal, metabolic and genetic disorders in the diagnosis, treatment planning and treatment of abnormal tooth eruption and its associated occlusal problems.

Conflict of Interest

There is no conflict of interest to declare.

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Please cite this paper as:
Adolphus Odogun L; **Tooth eruption: a "neuromuscular theory". Part two**. J Craniomax Res 2017; 4(2): 328-339