DEVELOPMENT OF THE HYBRID-TYPE ARTIFICIAL ROOT AND CLINICAL APPLICATIONS

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ABSTRACT

Titanium and hydroxyapatite artificial dental root of the gompholic type has been developed in vivo by means of biomechanical stimuli replicating masticatory movement. The gompholic tooth, one of the most important developments of mammals, has three major support structures, i.e., the cementum, periodontal ligament, and alveolar bone proper.

These structures can only be induced when harmony in shape, materials, and function of the artificial root are attained. Synthetic studies of artificial roots were carried out, i.e., biomechanical analysis using FEM, hydrodynamic experiments using models, as well as and experiments implanting artificial roots in animal jawbones to observe trilateral effects (shape, materials and function), after which specimens were made and observed histopathology and compositional analysis (using a microanalyzer) were carried out.

The gompholic joint system is one of articulation with bone marrow hemopoiesis, which is also a characteristic of mammals. In adult mammals, bone marrow hemopoiesis is maintained only in the osseous-cartilaginous-fibrous skeletal joint system. Conventional investigation of dental implants has failed completely because material effects only have been studied while the shape and functional effect of the root upon surrounding tissues has been completely overlooked. As a result, conventional implants have no root supporting system. Artificial roots having a corrugated configuration with 0.1~0.2mm wave induced by definite masticatory movement, the cementoblasts, periodontal fibers, and the alveolar bone proper can be evoked by the gene expression of mesenchymal cells induced by streaming potential. By observing and replicating this, the authors not only verified Wolff's law of the biomechanical adaptation of morphology, but Lamark's Use and Disuse theory as well. In the clinical application, artificial roots have been successfully implanted into a number of patients. Several case studies are presented.

1. INTRODUCTION

In 1989, the author successfully developed for the first time a bioceramic artificial root of the gompholic type around which cementoblast, periodontal ligament and alveolar bone proper can be induced in vivo. To disclose the causal factors of inducting the peri-root supporting system, synthetic research on the behavior of bioceramic surfaces in vivo was done from a trilateral viewpoint, i.e., the material, shape, and functional effects of the artificial root upon the surrounding cells. Animal experiments as well as biomechanical research, i.e., finite element analysis (FEA) and flow dynamics experiments of a model of the masticatory artificial root system with oil pressure were carried out.

From these experiments, the surface behavior of ceramics are disclosed to be the material effect of chemical elements concomitant with the energy effect which can induce the gene expression of mesenchymal cells of periostium to differentiate bone morphogenetic protein (BMP), just as a catalyst in a chemical reaction. In conclusion, a peri-root supporting system just like a gompholic tooth was developed on the surface of a corrugated bioceramic artificial root by hydrodynamic stimuli, i.e., energy, from which fluctuating wave movement was induced by the masticatory function.

About 15 years prior to developing the gompholic artificial root, the author investigated autogenous tooth replantation or transplantation of 50 teeth, which were expected to be extracted due to failures of root canal treatment, severe periodontitis, or impacted teeth without occlusion. For 150 years, autonomous tooth transplantation or replantation was tried in U.S. in vain. All failed to be ankylotic and were absorbed. Using sintered porous hydroxyapatite granules, the authors successfully tried to prevent osseous ankylosis with replanted teeth with loose fixation under moderate occlusal function. After 15 years successful clinical cases, the authors began developing artificial roots with sintered compact hydroxyapatite, titanium, and zirconium oxide.

From the evolutionary studies on vertebrates, the authors disclosed the gomphosis of the mammalian tooth system had evolved by biomechanical loading of mastication, which is a characteristic function of the viscerocranium of mammals, and which is converted into hydrodynamic flow, i.e., energy. To study the causal factors inducing peri-root tissues, i.e., cementoblasts, periodontal ligaments, and the alveolar bone proper from mesenchymal cells, the authors observed surface behavior unifying histological studies, observation of SEM and microanalyzers, obtained FEA results, and conducted model experiments with oil pressure to survey the pressure of amplitude vibrations which are converted by masticatory stresses.

To observe the material effect of HA, ZrO_2 and Ti, artificial roots with corrugated forms were developed and implanted into adult dogs and adult Japanese monkeys. To observe the functional effect, namely energy action, animals were separated into two groups, i.e., with and without mastication function fed by hard and soft diets, respectively.

A certain period after the operation, the implanted artificial root with jawbone was recovered and specimens were prepared for light microscopy, SEM, and microanalyzer analysis. As a result, only in the functional group with corrugated form, induction of the peri-root supporting apparatus could be observed.

As a biomechanical study, finite element analyses (FEA) of jawbone specimens in which artificial roots were implanted were carried out. Results obtained were compared with aspects of observed specimens, to disclose what is surface behavior i.e., the surface reaction of ceramics.

2. NEW METHOD FOR DEVELOPMENT OF A GOMPHOLIC ARTIFICIAL ROOT

It is well known that in fracture injuries caused by inadequate fixation, fracture sites often become pseudarthrosis. The articular system can be easily induced by biomechanical stimuli.

The ankylotic tooth system is known in some reptiles. However, crocodiles have a gompholic tooth system. Even in the ankylotic tooth system, if an erupting tooth suffers long term mastication loading, the tooth cannot adhere to the jawbone to develop ankylosis. From these biomechanical stimuli, the author conceived developed the gompholic system.

To develop the gompholic artificial tooth system, the easiest method is to develop an artificial root, on which cementoblasts, periodontal ligaments, and the alveolar bone proper are induced in vivo by recipient mesenchymal cells.
This can be easily fabricated by technicians.
From clinical studies of the masticatory system of the tooth and jawbone, it is known that biomechanical stimuli of fluctuation loading of 0.1mm to 0.2mm, amplitude vibrations are generated by mastication and occlusal movement. This can be attained by precise occlusion without contact between the upper and lower teeth and by feeding soft and hard diets.
From these procedures, a gomphlic as well as an ankylotic artificial root can be easily obtained if an artificial root with an ideal shape made of an ideal material can be developed.
However, it is very difficult to disclose mechanisms to induce cementoblasts at both the surfaces of the root and the alveolar bone proper, and to explain why thin bone of the alveolar bone proper can be induced by these biomechanical stimuli. Causal factors to induce the peri-root system, i.e., cementoblast, periodontal fibrous tissue with capillaries, and the alveolar bone proper can be investigated by analyzing the material, shape and functional effects of the artificial root.

3. MATERIAL AND METHODS

Morphological research by animal experiments as well as biomechanical numerical and model studies were carried out.

To disclose the surface behavior of ceramics upon surrounding cells, morphological research by means of animal experiments was carried out.
Twelve adult male shepherd dogs and six male adult Japanese monkeys were used in these synthetic experiments to develop gompholic artificial roots. Artificial roots of 5mm diameter with a corrugated form of hydroxyapatite were implanted into the premolar site of maxilla and mandibles. The artificial roots with jawbone were recovered and specimens for light microscopy, SEM, and microanalyzer were prepared and observed.
The following shows the morphological research observation with light microscopy, SEM, and microanalyzer.
Light microscopic observation of jawbone regeneration and peri-root supporting structures around gompholic artificial roots and jawbone absorption around ankylotic artificial roots were carried out.
Subsequently, analyses by a microanalyzer (Kevex 8000) to observe cementoblast (fibrous osseous cells) and osteoblast formation of gompholic artificial roots were performed.
To observe the material effect on the morphology of mesenchynal cells, SEM observation of gompholic artificial root surface of HA, ZrO2, and Ti were carried out.
Biomechanical studies on shape effect of artificial roots upon the surrounding tissues were carried out. FEAs to analyze the shape effect of roots of jawbone specimens in which artificial roots had been implanted were carried out.
Consequently, model experiments with an oil pressure system to observe the conversion of masticatory movement to amplitude vibration were performed. Based on specimens of artificial roots implanted in the jawbone, biomechanical model experiments were also performed.

4. CLINICAL APPLICATIONS

1) Case Report 1.
A 62-year-old female patient with interstitial pneumonia from which she had suffered since she was 24 years old. The major causes of interstitial pneumonia are mouth breathing, cold drinks and inadequate bone rest, namely a shortage of sleeping time as well as an improper lateral-sleeping posture.
The authors first treated her interstitial pneumonia by applying a nose-lift (to enlarge the nostrils), a breath trainer (product name), and lip-closure tape, corrected her poor sleeping posture habit and changed cold drinks to hot.
From her incorrect sleeping posture, most teeth became loose due to head-weight pressure on the teeth. The teeth became movable and the gums infected (periodontitis). She also suffered from severe chronic periodontitis, which can be treated by learning the correct sleeping posture.
As her symptoms of pneumonia recovered dramatically several months after this treatment, the author recommended artificial-root therapeutics. She had this done about five years ago. The patient received nine artificial roots implantations at the same time to recover all maxillary teeth.
Following that success, she accepted another operation of 4 artificial roots in the mandible. After that operation, her body condition markedly improved. See the figure exhibited here.

2) Case Report 2
A 48-year-old male businessman that for 10 years had suffered from hypertension and diabetes and was treated for these conditions.
After two months of weight-loss therapy he had severe asthma and received steroid hormone therapeutics during hospitalization.
Following that he felt better.
To lessen mouth breathing he used a nose-lift (to enlarge the nostrils), a breath trainer (product name), and tape for lip-closure. After that, his asthma syndrome dramatically improved. However, he still had a heavy sensation on the heart and lungs, so he called the Nishihara Institute. After breathing exercises and sunlight irradiation to excite hemoprotein, eliminating cold drinks, and avoiding cold wind, he recovered completely.
Following that, he had four artificial root therapeutic treatments. After the implantation of the artificial roots, his lung capacity increased by about 40 percent. The masticatory apparatus, i.e., jawbone and various muscles, namely the masticatory muscles, muscles of facial expression, swallowing muscles, as well as tongue muscles, are all derived from branchial respiratory smooth visceral muscles. Therefore, removing the functional defects of the dental arch completely by completion of the functional part of the jawbone, lung diseases can be eliminated.

3) Case Report 3
A 63-year-old female, suffering deterioration of occlusions with missing teeth and a poor physical condition. Occlusal deterioration takes place as a result of the unhealthy habits of mouth breathing, lateral sleeping, and unilateral chewing. They were completely eliminated by expanding her badly deteriorated narrow dental arch. After the dental arch was sufficiently widened, artificial root therapeutics were successfully carried out.

DISCUSSION

The vertebrates can be defined as cordates having vertebrae with various degrees of ossification. Characteristic organs are the gut respiration system of the gills and lungs. Mammals can be defined as animals born with a suckling system which later changes into masticatory apparatus. Both suckling and masticatory muscles derive from branchial respiratory smooth visceral muscles of the gut.
Therefore, mammals respirate during eating and masticate during respiration.
Suckling is concomitant with the respiration system in babies. The alimentary canal is incomplete until the child is two years old. Therefore, food except mother's milk is very dangerous.
The most important characteristics of the higher animals are the respiration, masticatory as well as alimentary and reproductive systems that allow animals to be mobile. The most important hormones for these systems are produced by the pituitary and adreno-cortical glands, both derived from oral and branchial (aorta) membranes. Therefore, masticatory as well as respiratory movement are not sufficient, or if functional bias as such as oral breathing, unilateral mastication and lateral sleeping posture habits can not be cured, these hormonal glands easily become infected intracellularly by GALT of the throat, i.e., Waldeyer-ring. At the same time, facial deformity, scoliosis and/or warping of iliac bone occur by muscle contraction and gravity action upon mass of the head, chest, and legs.
The functional effective system of masticatory apparatus are dentitions with gompholic teeth. The manbible and maxillary bone are derived from dermal bone.
The mandible with the gompholic articulation system is itself a hemopoietic organ. However, if teeth are missing, hemopoietic function of the manbible is lessened, even though dentures or conventional dental implants without articulation are applied. The gompholic system is vitally important to overall health and well being.

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