CASE REPORT ON ARTIFICIAL ROOT THERAPEUTICS

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ABSTRACT

This paper presents a case report on artificial root therapeutics, i.e., the occlusal restoration systems by means of artificial roots.

The natural tooth system has two important functional components: the periodontal ligament and the alveolar bone proper (the lamina dura). At present, the periodontal structures around the dental implants are considered to be of little importance. However, in regard to the human mastication system with delicate movements of the temporomandibular joint, we believe that peri-implant structures similar to the periodontal ligament and the alveolar bone proper are needed for the long-term function of the artificial roots.

A preliminary type of artificial root of the fibrous tissue attachment type has been devised. It was applied to selected patients and evaluated clinically for its function. The shape of the root seems to be the most important factor in the remodeling and turnover of bone in periodontal tissues. The preliminary type of artificial root was modified to improve this functional state in different sites of the jaws. Four types of hydroxyapatite artificial root of the fibrous tissue attachment type were developed. These artificial roots were applied to cases in which dental implants have traditionally been considered difficult.

INTRODUCTION

Great strides are presently being made in the field of artificial root therapeutics, the occlusal restoration system by means of artificial roots. In 1910, Greenfield developed an artificial root made of reinforced wire loops of gold and iridium. He stated that artificial roots represent a new system of occlusal restoration that was audacious, revolutionizing prosthetic dentistry.

It was noted that the morphological characteristics of roots and the structure of periodontal tissue, and devised an artificial root of the fibrous tissue attachment type by using sintered hydroxyapatite in order to develop a root approximating the natural tooth in function.

Morphologically, noting the cone shaped and corrugated configuration of the root, which is common to all human teeth, induced the formation of periodontal tissue resembling the alveolar bone proper and periodontal ligament. For this purpose, weak masticatory force was applied to the artificial root after implantation for physiological mobility. As a result of animal experiments, satisfactory epithelial attachment was induced, and bone resembling the alveolar bone proper was formed around the root.

A preliminary type hydroxyapatite artificial root was devised and applied to select patients. It was then carefully evaluated clinically for its function. The "Field Theory" indicates that certain sites of the maxilla and mandible influence the shape of the teeth into three types: incisor, canine, and molar (Butler 1939). This suggests that the difference in tooth shape in different sites of the jaws is important in maintaining bone remodeling around the root during the masticatory function. From the results of the clinical experiments and the viewpoints of the "Field Theory", four new types of hydroxyapatite artificial roots were modified and developed, which differed in shape according to the implantation site in the jaws (Figures 1,2). These artificial roots were applied to the following cases in which dental implants have conventionally been considered difficult, and favorable results were obtained.

1) Free end edentulous cases in the maxillary molar area.
2) Free end edentulous cases in the mandibular molar area.
3) Edentulous cases of the molar region with concomitant advanced periodontal disease of the remaining teeth.

Figure 1. Different shapes according to different sites.

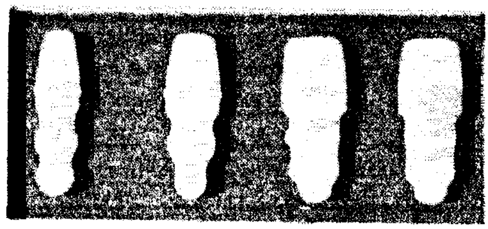


Figure 2. Four kinds of artificial roots.

MATERIAL AND METHODS

Fabrication of a New Type Artificial Root

A new type hydroxyapatite artificial root was developed on the basis of the following findings:

1) Enamel like sintered hydroxyapatite being developed at the present time has a very weak biological attachment to soft tissue.
2) As peri-artificial-root tissue, periosteum like fibrous tissues which attach to the artifical root surface are considered to be differentiated from mesenchymal cells, if the artificial root is prevented from forming osteo-ankylosis with the alveolar bone by physiological movement.
3) By emphasizing the corrugated pattern of the root surface, artificial roots can be fixed and held by the surrounding bone. The periosteum like fibrous tissues can biologically bind the artificial root surface to the surrounding bone. Thus, this type of artificial root can possess functions quite similar to those of natural teeth.

A preliminary new type artificial root has been devised, and was then modified. The following four kinds of artificial roots were developed (Figures 1,2).

1) a standard type for the cuspids and premolars for the upper and lower jaws.
2) a molar type for the upper jaw.

3) a molar type for the lower jaw.
4) an incisor type for the upper and lower jaws.

OPERATION PROCEDURES

The natural abutment teeth were preliminarily prepared. The gingiva and alveolar bone were directly cut under local anesthesia with a trephine bur. A round gingiva and alveolar bone segment was removed with a currett, and the socket was sequentially enlarged under physiological saline irrigation and shaped with burs corresponding to the artificial roots. The artificial roots were implanted and fixed to the adjacent teeth with an acrylic resin template without occlusion. Four to eight weeks after implantation, impressions were taken and a porcelain fused metal bridge was prepared and set.

CASE REPORT

1) Case Report 1. (Figures 3-7). A 60 year-old female with edentulous mandibular molars. Two molar-type artificial roots designed for the lower jaw were implanted.

Figure 3. Preop photo.

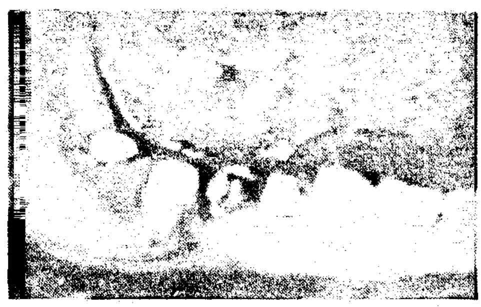


Figure 4. Immediately after implantation of 6-mm diameter photo artificial root.

Figure 5. Photo, 21 months postop. The bone surrounding the artificial root is beginning to build up.

Figure 6. Radiograph immediately after operation.

Figure 7. Radiograph, 22 months postop. Marked functional turabeculation and lamina dura similar to that of the original tooth can be observed.

2) Case Report 2. (Figures 8-13). A 54 year-old female with marked mobility of anterior teeth without upper molars. After treatment of remaining mobile teeth, artificial roots were implanted in the edentulous area.

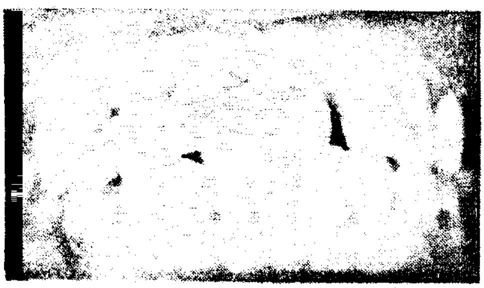


Figure 8. Preop photo.

Figure 9. Postop photo, 15 months after molar artificial root implantation.

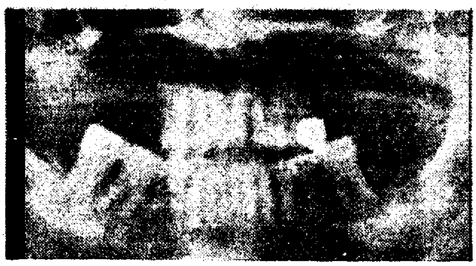


Figure 10. Preop orthopantomograph.

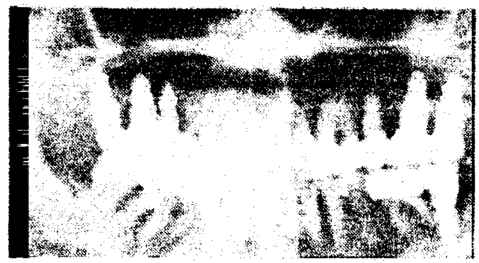


Figure 11. Orthopantomograph of completed case. The upper molars are 15 months postop, and the lower molar is 3 months postop.

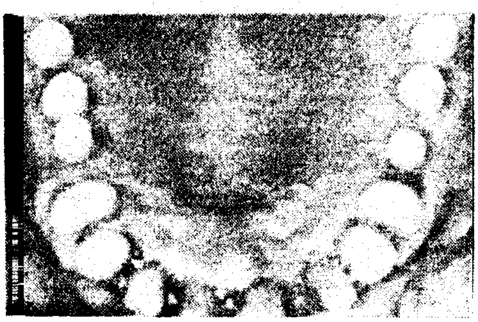


Figure 12. Postop photo.

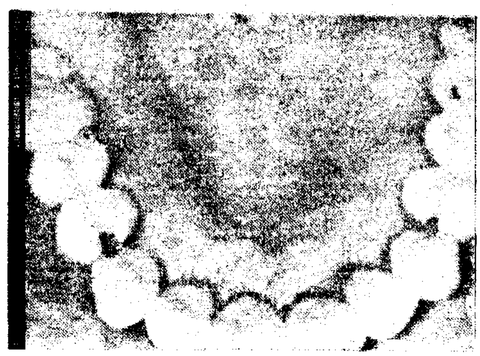


Figure 13. Completed case with porcelain-fused titanium metal bridge with key-ways.

3) Case Report 3. (Figures 14-18). A 64 year-old male with thin alveolar bone at the left edentulous maxillar and alveolar absorption at the right edentulous mandible. Artificial roots of upper and lower molars were implanted respectively.

Figure 14. Preop orthopantomograph.

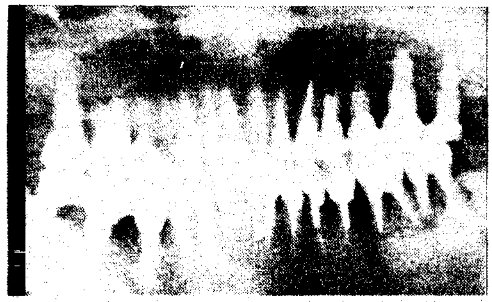


Figure 15. Orthopantomograph, 24 months postop in maxillary and 2 months postop in right mandible.

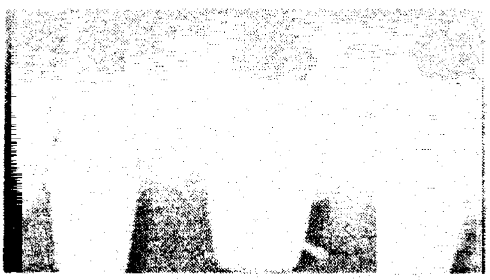


Figure 16. Radiograph immediately after operation. Two of three artificial roots were perforated intentionally.

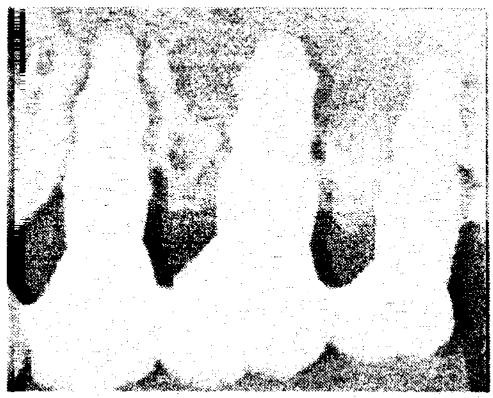


Figure 17. Radiograph, 24 months postop. Bone formation and remodeling have begun.

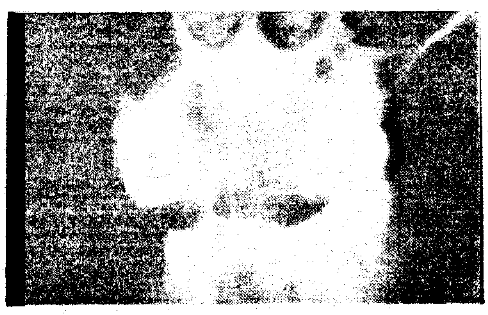


Figure 18. X-ray tomograph of perforated area. Marked bone formation of cortical bone can also be seen (arrow).

DISCUSSION

Artificial roots of the fibrous tissue attachment type were applied to free end edentulous cases in the upper and lower molar regions and to edentulous cases in the molar region with advanced marginal periodontal disease of the remaining teeth. Radiographic examination revealed a lamina dura-like layer around the artificial root with thin radiopaque space resembling that of the natural tooth. Through x-ray tomography, bone formation was clearly observed around the artificial root in the case of perforation into the maxillary sinus (Figures 19-21). In the case of marginal periodontal disease with severe alveolar bone absorption and marked mobility in all teeth, artificial roots were implanted after periodontal treatment. The artificial roots have functioned properly without complications, and marked improvement of marginal periodontal infection and bone regeneration around the affected teeth have been observed.

Figure 19. Artificial root implantation in the maxilla of a dog. The artificial root was perforated to the nasal cavity intentionally.

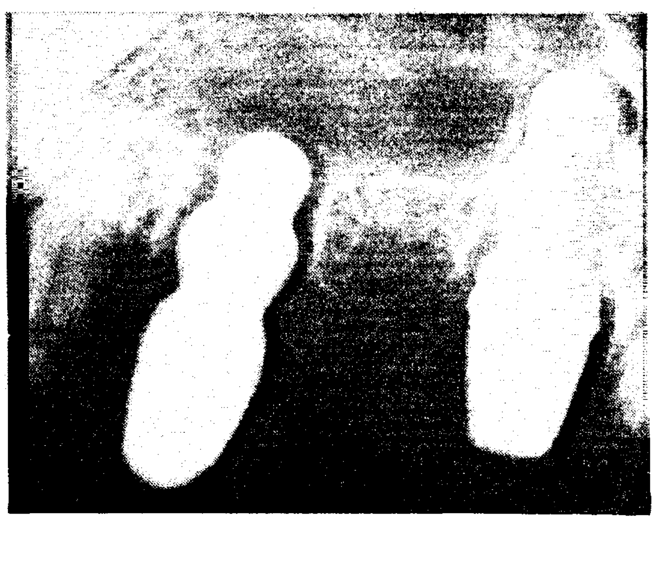


Figure 20. The lamina dura can be clearly observed though around the artificial root of a deeply perforated root.

Figure 21. Osteogenesis can be observed by x-ray tomograph in a case of maxillary sinus performation (arrow).

The following conclusions were arrived at through these clinical experiments. By the combined application of three factors, i. e., bioactive materials, proper morphology, and a physiologically functioning artificial root, a structure resembling the periodontal membrane formed around the artificial root. Artificial roots of the fibrous tissue attachment type have functioned properly, and the alveolar bone around the artificial roots seem to be remodeling well, and turnover of the bone is believed to be continuing.

The shape of mammalian dental crowns and roots varies according to their site in the jaws. It is also known that the shape of the crown and root varies according to the nature of the specie's specific natural diet. This fact indicates that teeth have anatomical configurations related to their function. It also indicates that teeth possess some mechanism which disperses the stress evoked by masticatory forces.

From animal experiments and analysis of the finite element method (FEM), the following results were obtained. The pattern of osteogenisis in the specimens and the FEM analysis pattern of loading under similar occlusal conditions show a close correlation (Figures 22, 23). This pattern of osteogensis means that the proper shape of the root, adequate direction of the load, and optimal amount of the load lead to bone formation in accordance with Wolff's law of trajectory architecture in cancellous bone. The principal stress trajectory by FEM analysis reveals perpendicular and parallel patterns in relation to the artificial root in the periodontal tissue space between the artificial root and the alveolar bone proper (Figure 24). Osteogensis is assumed to coincide with the principal stress trajectory.

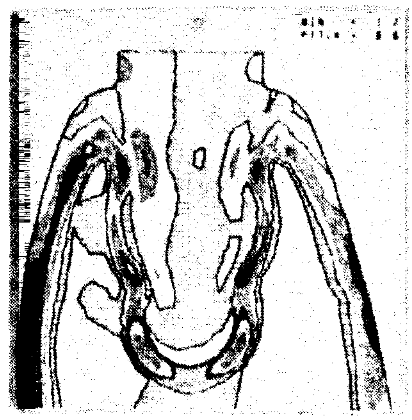
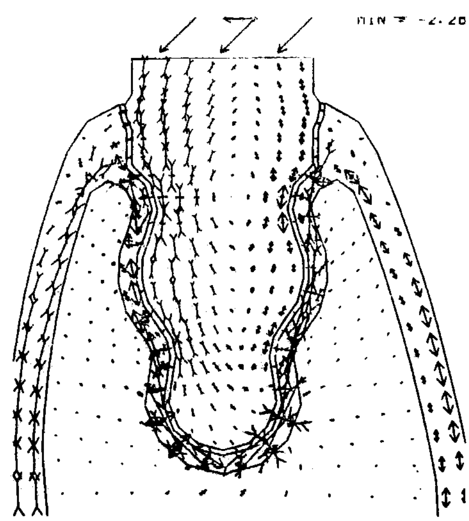


Figure 22. Stress distribution analyzed by FEM.

Figure 23. Osteogenesis observed in the mandible of a dog 8 weeks postop. Moderate stress distribution in FEM analysis and osteogenesis in experimental specimen are in close carreltion.

Figure 24. Principal stress analyzed by FEM.



One hundred years ago, Wolff theorized that bone morphology and trabecular formation depend on the force applied. Conventionally, Wolff's law cannot be applied to the complex morphology of the mandible and maxilla. Through mastication, food is broken up by the cusps of the teeth. By this process, the strong forces work on the teeth. The resulting stress is dispersed by the crown morphology and is transmitted to the root. The characteristic root morphology, in turn, disperses the stress toward the surface of the root. The stress should be distributed in parallel and perpendicular patterns almost equally in the periodontal ligament surrounding the root surface.

The periodontal ligament should be considered an important joint which transmits stress evenly to the surrounding connective tissues. The ligament transmits this stress and induces osteogenesis and connective tissue formation around it, probably by some electrical mechanism. In a word, the multidirectional force exerted on the crown by mastication and occlusion should be evenly dispersed by tooth morphology so that equal stresses are transmitted to the periodontal ligament. This means that the tooth is one of the most important mechanical supportive organ systems to bear these complicated forces as a vehicle and then disperse equally and moderately around the jawbone.

In dentistry to introduce the concept of the tooth as a vehicle for dispersing occlusal load. By this concept, Wolff's law can be applied to the maxilla and mandible, which have a very complicated arrangement with the teeth. From this clinical experiment we can understand "What is a tooth?" as an entity and introduce the same vehicular concept to other regions with mechanical supportive organ systems. From this concept, the clear formation of lamina dura with trabeculation and marked osteogenesis in the site of sinus perforation can be explained. Artificial root therapeutics should be established with this line of thought in the near future.

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