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LIGHT MICROSCOPIC AND SEM OBSERVATION OF TISSUE AROUND NEW TYPE ARTIFICIAL ROOTS

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Abstract Artificial roots of the fibrous tissue attachment type made of sintered hydroxyapatite, zirconium oxide, and titanium were implanted in the premolar region in adult mongrel dogs. These artificial roots had characteristic corrugated configuration with a conic shape. Minor physiological movement was applied to the artificial roots through moderate masticatory function to prevent ankylosis with alveolar bone. To investigate the modalities of attachment to root surfaces of different materials, we observed the surfaces of extracted artificial roots by scanning electron microscopy (SEM) and compared them with findings of decalcified sections by light microscope. We also observed by SEM the surfaces of extracted hydroxyapatite artificial roots which had been implanted clinically, then extracted and reimplanted in order to exchange them for those of a larger diameter. At the artificial root surfaces of titanium and zirconium oxide, a different type of attached substance was observed compared to that of hydroxyapatite. At the clinically-used hydroxyapatite root surface, numerous calcified cells resembling cementoblasts were observed.

INTRODUCTION

We devised a new type artificial root which has quite a different bonding system to the jawbone from the conventional dental implant. This artificial root of the fibrous tissue attachment type has root supporting tissues resembling periodontal ligament and alveolar bone proper [1-3]. In this paper, we investigated the modality of fibrous tissue attachment to the root surface through observation by SEM and light microscopy of hydroxyapatite, zirconium oxide, and titanium artificial roots implanted in adult dogs. We studied especially the attachment tissue at the surface of hydroxyapatite artificial roots which were clinically used and extracted to change to larger-diameter roots or extracted due to traumatic bruise. Various tissues attached to the root surface were observed. We already reported the results of analyses with undecalcified mirror-polished specimens of artificial roots by means of microanalyzer [3]. Fourier-Transmitted-Infrared (FT-IR) analyses of the

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surface substance of the hydroxyapatite artificial root were also done. The findings of SEM were compared with the results of these analyses.

MATERIAL AND METHOD

Several artificial roots of each material were implanted in the upper or lower premolar region of adult dogs. After a fixed interval, we extracted the artificial roots and fixed them with osmium oxide. One of the artificial roots (AR) was extirpated with surrounding periodontal tissue together with the alveolar bone. These specimens were vaporized with palladium platinum and observed. These observations were compared to the light microscopic findings and microanalyzer analyses already obtained. The substance of the clinically-used artificial root surface was also analyzed by FT-IR analysis. The cementum of natural teeth, bone, and synthetic sintered hydroxyapatite were also analyzed and then compared.

RESULT

At the attached gingival region of hydroxyapatite artificial root (HA AR), no inflammation was found in the undecalcified specimen (FIGURE 1), in the decalcified specimen (FIGURE 2) and many cells resembling epithelium were observed by SEM (FIGURE 3). At the surface nearer the apex, various attaching

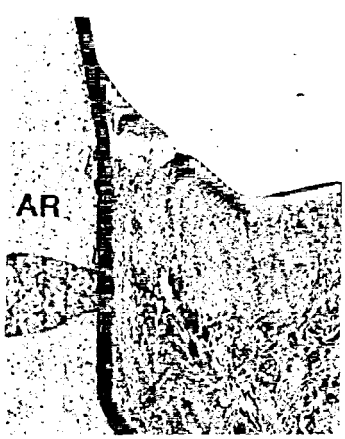

FIGURE 1
Undecalcified HA AR
3 weeks postop

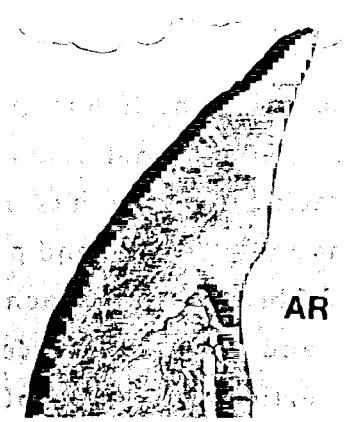

FIGURE 2
Decalcified HA AR
6 weeks postop

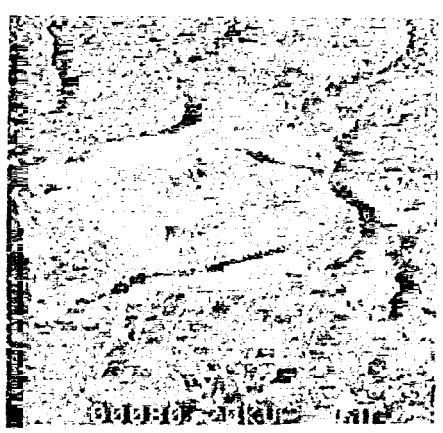

FIGURE 3
Epithelial cells
observed by SEM
7 months postop

structures made of microplatelets were observed (FIGURE 4).

At the surface of the hydroxyapatite artificial root, a laminated layer resembling calcified materials 20 μm in thickness was observed in a 11-

month-postop specimen of a dog by SEM (FIGURE 5). Quite a few cells resembling cementoblasts were observed at the concave surface of clinically-applied hydroxyapatite roots 11 months postop (FIGURES 6,7). In some areas of a clinically used 24-month-postop artificial roots, these cells appeared to be covered with calcified substance (FIGURES 8-11). Occasionally, cementoblast-resembling cells were thought to be calcified with fibrous tissue (FIGURE 10). Cementoblast-resembling calcified cells observed by SEM at the concave surface 24 months postop, were corresponding to the numerous cells seen at the surface of the lamellae (arrows) with light microscopic specimen of dog 6 months postop (FIGURES 11,12). The surface substance attached to the artificial root was analyzed by FT-IR. As a result, the attached substance proved to be a calcified thin layer resembling cementum (FIGURE 16).

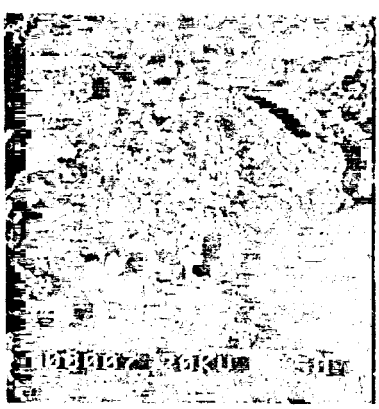

FIGURE 4
Microplatelet
observed by SEM
7 weeks postop

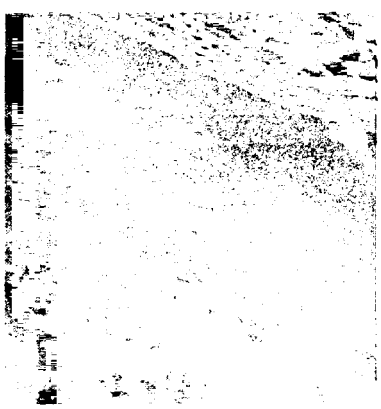

FIGURE 5
Laminated layer
observed by SEM
11 months postop

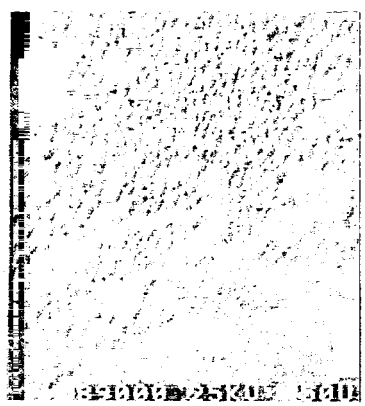

FIGURE 6
Cells resembling
cementoblast
11 months postop

Microscopic findings also showed a calcified layer attached to the root surface 17 months postop (FIGURE 13). By microanalyzer, calcified substance attached to the artificial root surface was shown to be porous, which suggested remineralization at the surface of the sintered hydroxyapatite by mesenchymal cells (FIGURES 14,15). Cementum-like deposition was substance-specific to sintered hydroxyapatite (FIGURES 8-11,13-15). At the surface of zirconium oxide or titanium artificial roots, plain lamellae resembling the surface of these roots were observed (FIGURE 17). By light microscopy and microanalyzer, there were no calcified substances observed at the surface of the zirconium oxide or titanium artificial roots. Compact lamellae similar to cartilage were observed attached to the zirconium root surface.

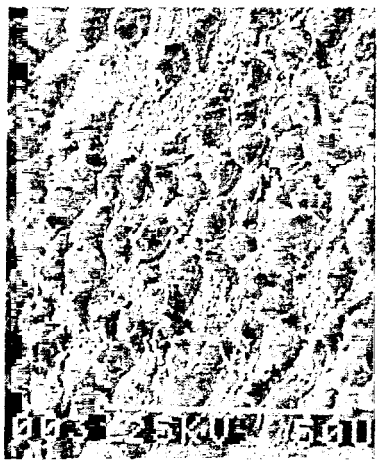

FIGURE 7
Cells resembling cementoblast
11 months postop

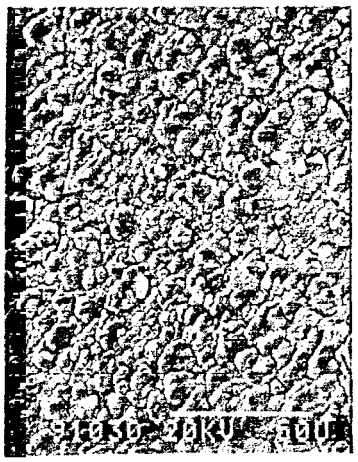

FIGURE 8
Cementoblast-like cells covered with calcified substance
24 months postop

FIGURE 9
Cells covered with calcified substance
24 months postop

FIGURE 10
Calcified cells with fibrous tissue
24 months postop

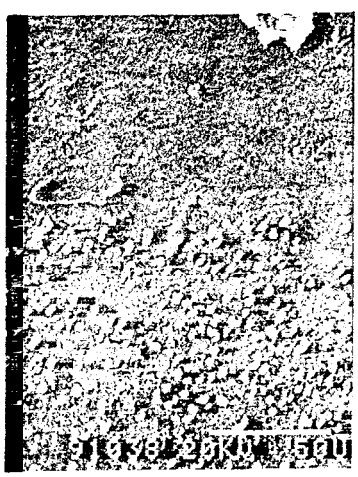

FIGURE 11
Cementoblast-like cells covered with calcified substance at the concave surface of AR
24 months postop

FIGURE 12
Numerous cells at the concave surface of AR (arrow) corresponding to the cementoblast-resembling cells observed by SEM
6 months postop
decalcified specimen

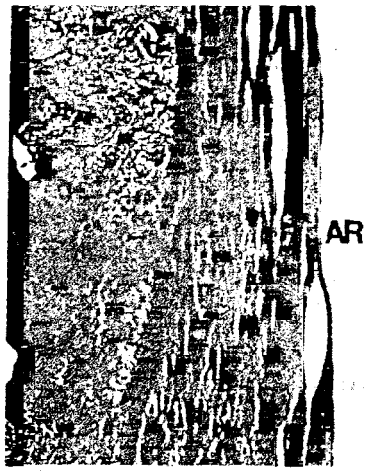

FIGURE 13
Cellular calcification observed in HA AR decalcified specimen by light microscopy 17 months postop

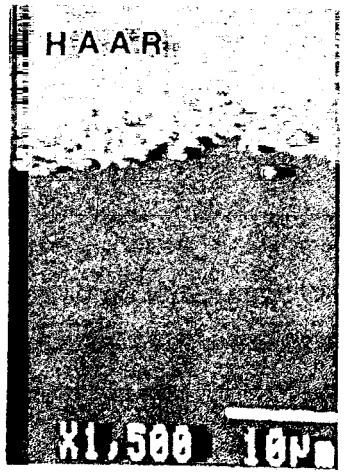

FIGURE 14
SEM finding of mirror-polished HA AR specimen cementum-like substance observed 17 months postop

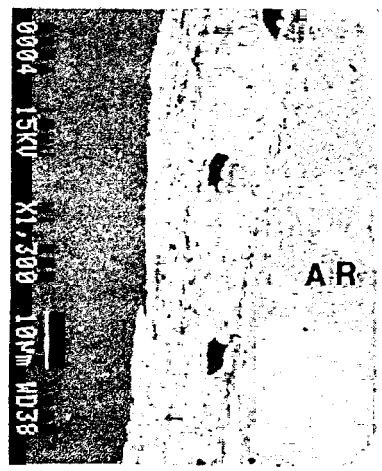

FIGURE 15
SEM finding mirror-polished HA AR specimen porous deposits observed at the surface of AR 17 months postop

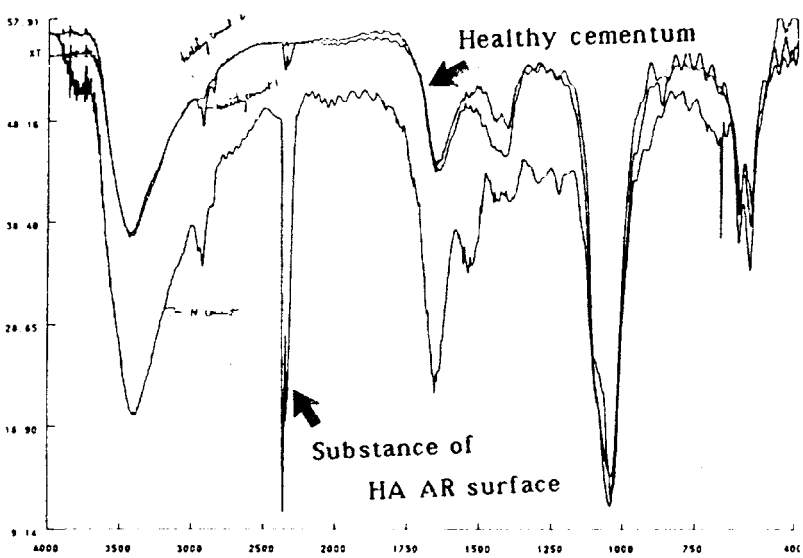

FIGURE 16
FT-IR analyses pattern of human natural cementum and attached substance on clinically-used HA AR

FIGURE 17
Plain lamellae are observed at the surface ZrO2 AR 7 months postop specimen of the dog

Although without cementum-like substance, the artificial roots of zirconium oxide and titanium were observed as very stable in the mandible and maxilla with fibrous tissue attachment and alveolar bone proper.

DISCUSSION

Through light microscopic observation, attachment with cellular calcification between fibrous tissue and hydroxyapatite artificial root was found. Quite a few numbers of cells were also observed at the concave surface of the hydroxyapatite artificial roots, which were clinically used and extracted several months postop for exchange. This attaching surface substance was scratched and analyzed by FT-IR, which revealed calcified substance resembling bone or cementum in pattern (FIGURE 16). We analyzed the artificial roots by observing mirror-polished specimens of artificial root with a Kevex 8000 microanalyzer. Porous layers of calcified material were observed specifically in the hydroxyapatite specimen. From these findings, we concluded that, at the surface of the hydroxyapatite artificial root, calcified tissue resembling cementum was remineralized cellularly by mesenchymal cells. On the contrary, titanium and zirconium oxide artificial roots could not develop calcified substance even 17 months postop. However, fibrous periosteum can also attach to the surface of zirconium oxide and titanium artificial roots, forming a typical periodontal structure. The titanium artificial root is assumed to have very weak fibrous attachment from the light microscopic finding. On the contrary, the zirconium oxide artificial root appears to have firm fibrous attachment exhibiting a resemblance in light microscopic findings to that of the hydroxyapatite artificial root. From this experiment, we reached following conclusion: Artificial roots with a corrugated conic shape induced periodontal tissue regardless of materials, therefore, the shape is important factor for artificial root function. However, sintered hydroxyapatite exhibited the best form of attachment system with cellular calcification resembling the cementum.

REFERENCES

1) K. Nishihara and T. Akagawa, Oral Implantology and Biomaterials, edited by Kawahara, (Elsevier Science Publisher 1989) 7, pp.41-46..
2) K. Nishihara and T. Akagawa, 5th Biennial Congress of International Association of Oral Pathologists, p.52, (Tokyo, 1990)
3) K. Nishihara, T. Kobayashi and T. Akagawa, Studies on Periodontal Tissues Around a New Type Hydroxyapatite Artificial Root, The proceedings of 3rd International Symposium on Ceramics in Medicine (Terre Haute, 1990) in press