BIOMECHANICAL STUDIES ON JAWBONE REMODELING AROUND NEW TYPE ARTIFICIAL ROOT

-Biomechanics on Shape and Functional Effect of Artificial Root Upon Surrounding Tissue-

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INTRODUCTION

To investigate the biomechanical influence of artificial roots upon jawbone remodeling, analyses of the shape and functional effect was studied on new type hydroxyapatite artificial roots on functioning jawbone under the plane strain state with the aid of the finite element analysis (FEA). To study the functional effect of artificial roots, attention was paid to the root-fixation system to the jawbone, which corresponds to masticatory function. Therefore, we analyzed ankylotic artificial roots of the same shape, and the results were compared to those of the fibrous tissue attachment type. The numerical results showed that the stress state was mitigated around the root of corrugated configuration. These results were compared to the patterns of bone formation around artificial roots in animal experiment specimens. Osteogenesis in the specimens showed close correlation to FEA patterns. The Mises equivalent stress distribution and principal stress distribution pattern were different between the ankylotic type and the fibrous tissue attachment type. From the obtained results, a gomphotic tooth system and bone remodeling in the jawbone was biomechanically studied.

MATERIALS AND METHODS

1. FEA of different shape artificial roots of fibrous tissue attachment type (gomphotic) were carried out. Comparisons of stress distribution patterns around 5 kinds of artificial roots of different shape were carried out.
2. Comparisons of stress distribution pattern around gomphotic and ankylotic roots were carried out. The stress distribution around newly tailored artificial roots of standard type and ankylotic conditions were also analyzed.
3. artificial roots were implanted in two different states, with and without occlusal function in dogs. Specimens were obtained and compared to the results of FEA.

RESULTS

From numerical experiments, the following results were obtained: (a) Mises equivalent and principal stress trajectory patterns in the jawbone were completely dependent upon the shape of the artificial root. (b) Artificial roots with undulated form not only mitigated Mises equivalent stress distribution but converted the principal stress trajectories into parallel and normal to the root surface. (c) While gomphotic artificial roots equalized and mitigated stress distribution in the jawbone, ankylotic artificial roots concentrated stress on the cortex of the jawbone. (d) While gomphotic artificial roots converted principal stress trajectories in the periimplantium (Fig. 1), those of ankylotic artificial roots oriented continuously to the attaching osseous tissue. From studies of comparison between animal experiment specimens and the patterns of FEA, the following results were obtained: (a) Osteogenesis coincided with the moderate stress distributing zone and bone trabeculae coincided with orientation of the principal stress trajectories in the gomphotic root (Figs. 1, 2, 3). (b) The ankylotic artificial root had no bone remodeling system around the root. Severe bone destruction in the cortex of

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the jawbone coincided with the stress concentrating zone.

DISCUSSION

Recent research on artificial substitutions for mechanical supportive organs has been carried out concerning ankylosis or osseointegration between biomaterials and bone tissue [1]. In studies on the functional effect, an ankylotic condition of the artificial root could be easily induced without loading after operations using newly tailored apatite artificial roots. With mastication function, periimplant tissue resembling the original periodontal structures could also be induced around the tailored apatite artificial roots. In a gomphotic artificial root, osteogenesis for the alveolar bone proper and trabeculae coincided with the principal stress trajectories. Osteogenesis (osteon formation) according to the principal stress trajectories is relevant to Wolff's law of functional adaptation in bone morphology. The stress trajectory pattern was definitely dependent upon the artificial root form. The most important gomphotic tooth system is assumed to be the converting mechanism of the principal stress trajectories by periodontal ligament.

CONCLUSION

From these experiments, the following conclusions were obtained:

1 In a gomphotic artificial root, stress distribution depended upon the shape of artificial root, and principal stress trajectories were converted to parallel and orthogonal elements in periimplant fibrous tissue.

2 Osteogeneses around artificial roots coincided with the moderate stress distributing zone and principal stress trajectories.

3 In an ankylotic artificial root, principal stress trajectories oriented continuously into ankylotic bone tissue. Severe bone destruction coincided in the stress concentration zone.

4 Through integrated triad research on shape, component, and functional effect, a gomphotic tooth was found to be a vehicle of multiple masticatory forces.

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REFERENCE

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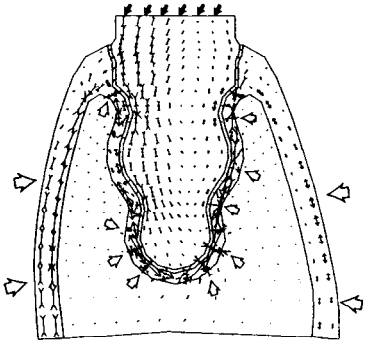

Fig. 1

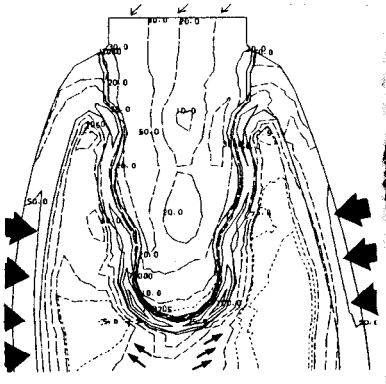

Fig. 2

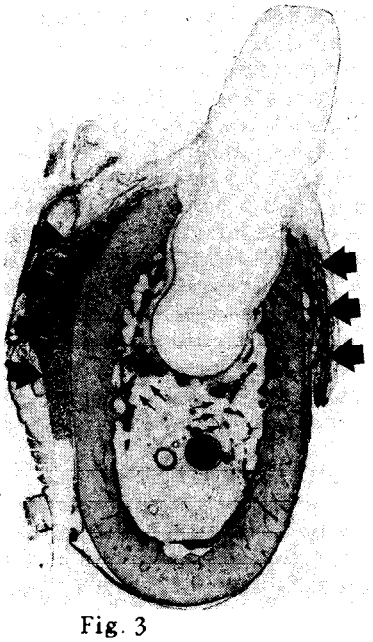

Fig. 3

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