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Computer Graphics of Three-dimensional Bone Structure around a Zirconia Ceramic Implant

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INTRODUCTION

Clinical use of dental endosseous implant has been increased in recent years based on the result of the highly long-term successful rate with osseointegration. It is generally accepted that ceramics have a potential for dental implants because of excellent biocompatibility[1-6], chemical stability[4], acceptable mechanical strength[7,8] and high resistance to degradation[7]. However, ceramis are brittle and easily to be fractured. Partially stabilized zirconia has been introduced with unique properties that can overcome the inherent problems of ceramics above mentioned. This ceramic has more favorable mechanical properties than those of fully stabilized zirconia and poly-crystal alumina, and has high fracture toughness which means it behaves like steel[9,10]. Zirconia has also other advantages of ivory color like natural tooth, easy cutting and high radiopacity.

In the literature, only some studies have been done on zirconia implant[2,3,11-13]. Nagai et al.[2,11] and Cranin et al.[3] evaluated bone tissue reaction to the zirconia implant by observing a few histologic tissue sections. Also Akagawa et al.[12] and Cabrini et al.[13] reported histometrical analysis of bone-zirconia implant interface in initial bone healing. Results from these studies have shown that zirconia implant could achieve osseointegration. However, the aspect of osseointegration has not been yet fully clarified, because all of these studies were based on a few bucco-lingual and/or mesio-distal two-dimensional histologic sections and the actual bone structure around zirconia implant is still unknown.

Recently, three-dimensional bone sturucture around a hydroxyapatite-coated implant have been introduced by Akagawa et al.[14]. To use this method, it is expected that the aspect of bone contact to the zirconia implant will be clarified.

The purpose of this study was to investigate the three-dimensional bone structure around a zirconia implant in initial healing by computer graphics.

MATERIALS AND METHODS

One partially stabilized zirconia implant (diameter 4 mm and length 8 mm) (Goei Inc. Akitsu-Hiroshima, Japan) was used in this study (Fig. 1). The implant was placed into the right edentulous area of an adult monkey's mandible where first and second premolars were extracted 3 months before placement. Surgical operation was done under the intramuscular anesthesia with 5 mg/kg of ketamine hydrochloride, 0.05 mg/kg of atropine sulfate and 0.5 mg/kg chlorpromazine hydrochloride. A mucoperiosteal flap was raised at the implant site and a

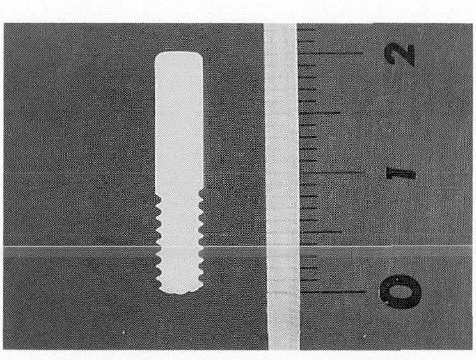

Fig. 1 Partially stabilized zirconia implant (diameter 4 mm, length 20 mm).

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bone socket was prepared sequentially with special cutting drills with diameters of 1.6 mm, 2.2 mm and 3.1 mm. The final threading was accomplished with a manual screw-lock with diameter of 3.8 mm. Finally, the implant was placed into the threaded socket by manual tapping. The mucoperiosteal flap was sutured tightly with the head portion of the implants exposed approximately 6 mm above the gingival margin. The animal was given a soft-pellet food diet and clinical aspect of unloading was maintained. After 3 months of implant placement, the animal was sacrificed and the mandible was removed. The tissue block containing the implant was fixed into 10% neutral formalin. After fixation, the block was embedded in the polyester resin (Riolac, Ohken, Tokyo, Japan) with routine procedure. The block was then ground bucco-lingually at 75 μm intervals with a grinding machine (Exakt Micro-Grinding System, Exakt Apparatebau, Norderstedt, Germany). Each ground surface of the block was stained with toluidine blue for detecting bone structure clearly. Then the block was put on a profile projector (V-16E, Nikon, Tokyo, Japan) and the bone structure around the implant was traced at magnification of 10. Eventually 80 traces were obtained. Each trace was digitized with a stylus pen. Digitized data were serially accumulated and analyzed with originally programmed software. All data were calculated with a personal computer (PC-9801-ES2, NEC, Tokyo, Japan) (Fig. 2) and then three-dimensional computer graphics were produced.

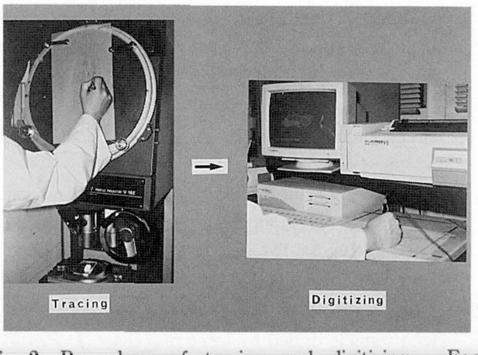

Fig. 2 Procedure of tracing and digitizing. Each ground block is put on a profile projector and the bone structure around implant is traced (left) and digitized (right).

RESULTS

Computer graphics of the three-dimensional bone structure around the zirconia implant showed direct bone contact to the implant surface (Fig. 3). The bone structure around the implant in bucco-lingual, mesio-distal directions and horizontal portions were also shown (Figs. 4, 5 and 6). Bone apposition to the implant was clearly shown and this aspect was different among the sites and portions of the implant.

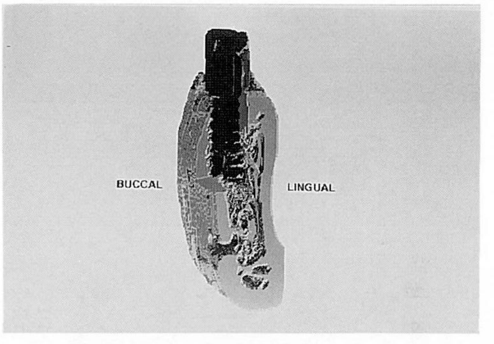

Fig. 3 A three-dimensional graphic of bone around the implant. Bone was partially removed to obtain access to the implant.

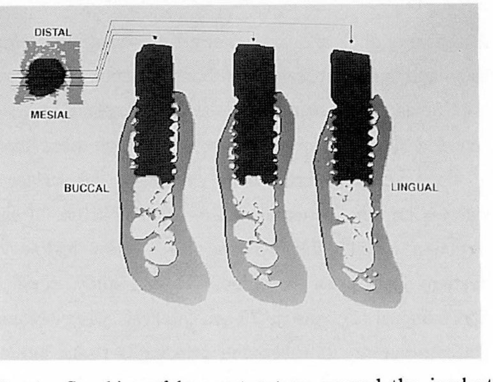

Fig. 4 Graphics of bone structure around the implant in bucco-lingual direction.

DISCUSSION

In the present study, the graphics have clearly shown the three-dimensional bone structure around the zirconia implant. These graphics are helpful for visualizing the bone-implant interface in any bucco-lingual directions and horizontal portions.

In the past years, Nagai et al.[2,11], Cranin et al.[3],

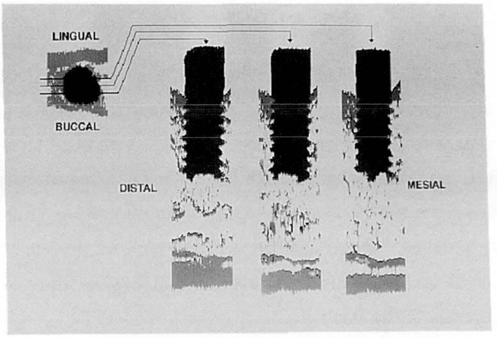

Fig. 5 Graphics of bone structure around the implant in mesio-distal direction.

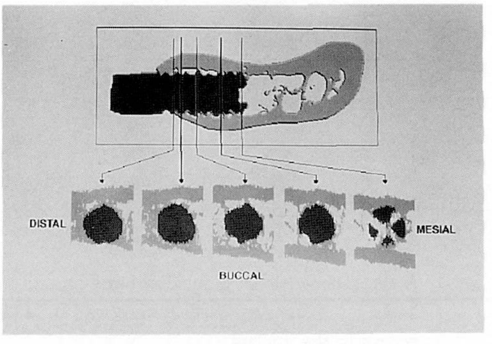

Fig. 6 Graphics of bone structure around the implant in horizontal portion.

Akagawa et al.[12] and Cabrini et al.[13] evaluated histologically and histometrically the bone reaction to zirconia implant and they showed the zirconia implant was surrounded by new bone trabeculae. Although these showed the findings of direct bone contact to the surface of zirconia implant, actual aspect of bone structure in each direction is still unknown, because a few histological sections have been evaluated. In this study, serial 80 bucco-lingual sections at 75 μm intervals were obtained and integrated. In this point, grinding of tissue block is most critical to clarify the bone structure around the implant. The thickness of the specimen should include possible small bone trabeculae. In this study 75 μm thickness was adopted in grinding[14] and it could offer better results on bone structure. A three-dimensional graphic of bone around the implant was produced by analysis of all serial ground surfaces at 75 μm intervals by originally programmed software. Three-dimensional bone structure graphics also may permit morphometric analysis of the bone-implant interface in any directions.

Further study should be done morphometrically by calculating these computer graphics in any directions to clarify the aspect of osseointegration in initial healing period around the zirconia implant.

CONCLUSION

The three-dimensional bone structure with the use of computer-assisted integration method was shown around a zirconia implant that was placed into the monkey's mandible for three months. Three-dimensional graphics in bucco-lingual and mesio-distal directions and horizontal portions clearly showed direct bone interface of the implant at initial healing stage in clinically unloaded condition. These graphics provide more actual information on the initial bone-implant interface.

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