●症例報告

A dental implant case with aesthetics using HA bone graft fabricated by CAD/CAM based on CT simulation

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Abstract

A dental implant case with bone defect is shown. The patient had a bone defect in buccal side of #5 and #6 region, an aesthetic area. The bone defect volume was determined by CT simulation data. A HA bone graft was fabricated from HA sintered block using CAD/CAM technology. Anchoring the HA bone graft and implant placement was performed by the guided surgery designed by the same CT simulation software. First, bone defect region and missing teeth were recreated into ideal form by wax-up, and a plaster model was matched and the bone augmentation volume necessary for the bone defect region and precise implant placement position were designed. In order to avoid the contact of the bone graft block and the implant, implant access holes on the bone graft block were designed slightly bigger than the diameter of the implant. One year after the surgery, it successfully maintains its aesthetics and functionality.

Keywords: dental implant, aesthetics, CT simulation, CAD/CAM, HA bone graft

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1. Introduction

For dental implant cases with bone defect, an autologous bone block or GBR method using granular bone substitute and multiple membrane are commonly used. But it is difficult to design the ideal form prior to surgery especially in aesthetic area because of the difficulties involved in prediction of hard and soft tissue volume and amount loss of the grafting material over time.

A little ingenuity was given to the designing procedure of bone augmentation volume data for HA bone graft block on simulation software explained in this paper. First ideal form was reproduced for the missing teeth and bone defect region with wax-up for an implant case with bone defect in labial buccal side, and a plaster model was made. The plaster model and simulation software (SimPlant® manufactured by Materialise Dental Co, hereinafter SimPlant) data of the same region were matched and the bone augmentation volume necessary for the bone defect area and the precise implant placement position were designed. Figure1

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and 2 show the CT images.
The implant case in this study had a bone defect in buccal side of #5 and #6 region, an aesthetic area. HA bone graft were anchored and implants were placed by guided surgery.

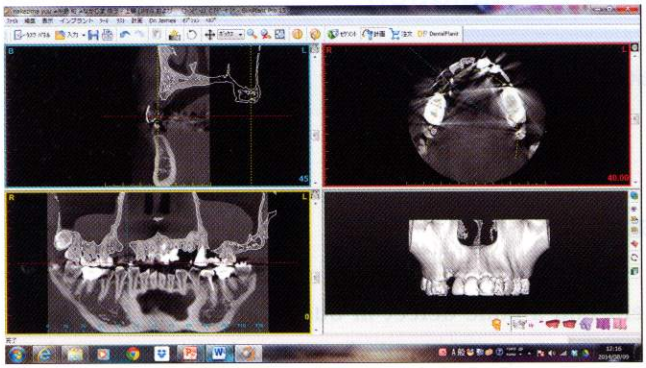

Fig.1: Matching the CT data and the plaster model on simulation software

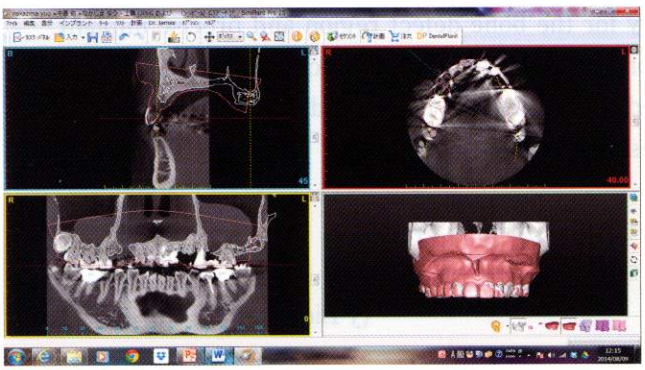

Fig.2: Matching the CT data and the plaster model on simulation software

2. Clinical case

1) Patient

Patient: 32 years old female
First visit: July 2012
Main complaint: Cosmetic disturbance in #5 and #6
Pre existing condition: N/A
Family medical history: N/A
Current medical history: Tooth #6 was extracted by the primary care dentist one month prior to her visit. She wanted implant treatment and the primary dentist referred her to our clinic.
Current status: Countenance was bilaterally symmetric. Horizontal and vertical defect was observed in #5 and #6. Severe vertical and horizontal bone resorption in #6, vertical and horizontal bone resorption in #5 was observed in intraoral photograph. CT image shows extraction socket with severe bone defect on buccal side in #6, and horizontal bone defect in #5 (Fig 3, Fig 4)

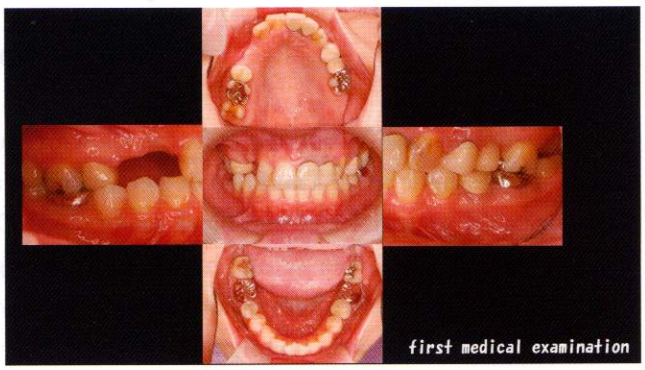

Fig.3: Interoral photograph at the first medical examination

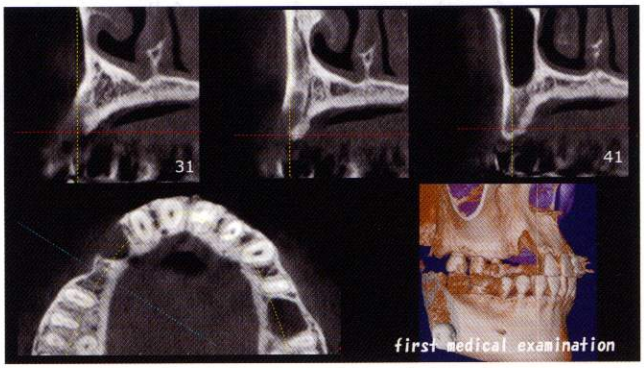

Fig.4: CT images at the first medical software

2) Treatment plan

The implant case in this study had a bone defect in buccal side of #5 and #6 region, an aesthetic area. HA bone graft block was anchored and implants were placed using guided surgery. It was designed to use the fixation pin holes to anchor the bone graft block at the same time as the implant placement.

(1) A plaster model of ideal form of the buccal bone defect region and the missing teeth was

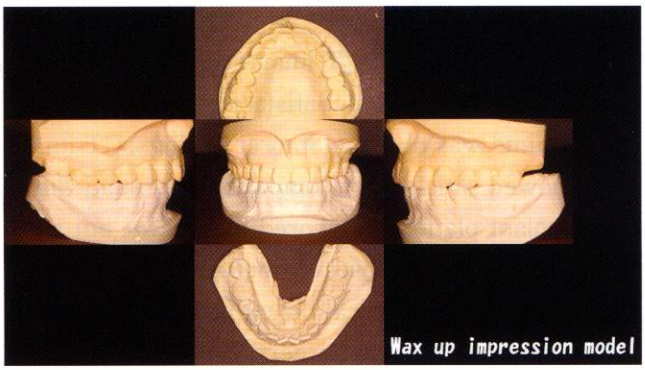

Fig.5: Designing the ideal form of #5 and #6 bonedefect region with wax-up including soft and hard tissues on the inter-oral model at the first visit

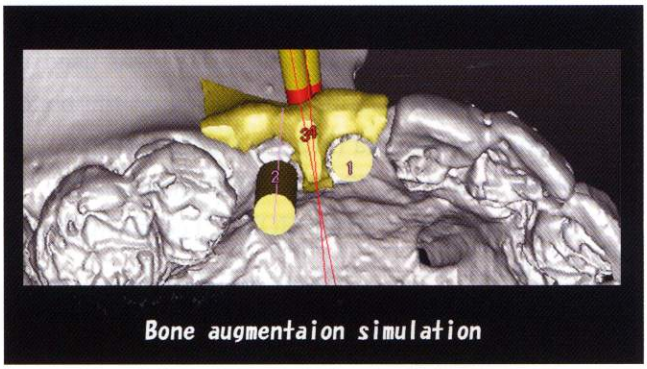

Fig.7: Designing the bone augmentation volume on simulation software

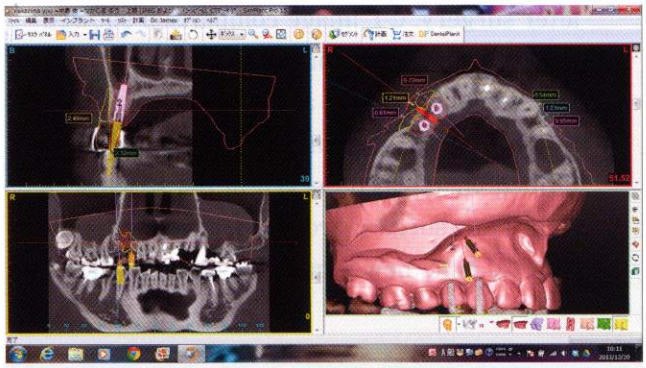

Fig.6: Matching the CT data and wax-up plaster model

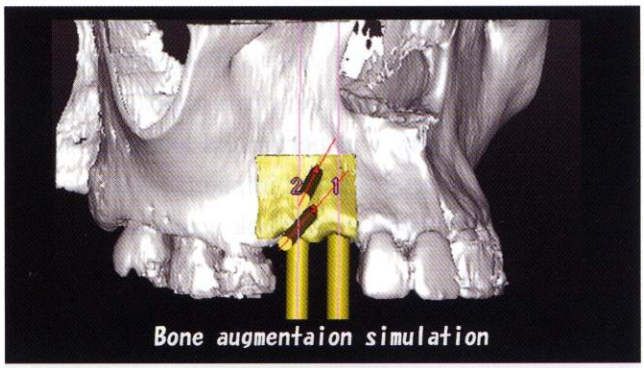

Fig.8: Designing the bone augmentation volume on simulation software

reproduced by wax-up and matched with the simulation software data. Implant placement position was designed in appropriate direction and depth. Mucosal thickness was worked out by the difference of the matching data against the plaster model of #11 and #12 and the CT data of the bone surface. Mucosal thickness was subtracted from the matching data and the bone augmentation volume surface was set at that position (Fig 5, Fig 6). The bone augmentation volume was positioned 1mm away from implant so they do not contact each other (Fig 7) . Transitional alveolar bone scalloped form from the adjacent tooth of the affected area was given. Lastly fixation tack holes (1.8mm in diameter) to anchor the bone augmentation block were designed (Fig 8).

(2) In this study Replace Conical Seal Implant System and its guide system manufactured by Simplant® were used. The same guide system was used to design the fixation tack holes (1.5mm in diameter) for anchoring the bone augmentation block. Dual Top Auto screw System (1.6mm in diameter) manufactured by ProSeed Co. were used as the fixation screw for anchoring the bone augmentation block.

(3) Surgical guide for anchoring the bone augmentation block and placing implants was designed.

(4) Resin bone defect model and bone augmentation model with implant placement position and fixation tack hole for anchoring the bone augmentation block onto the available bone were produced by laser beam lithography rapid prototyping method (Fig 9). After confirming the accuracy, the models were

readjusted as necessary. Processing machine (GM-1000) at GC processing center was used to process the apatite block based on the bone augmentation data (Fig 10). As for apatite block, apaceram-U5 (30x40x10mm, porosity 50%) manufactured by HOYA Technosurgical Co. was used.

(5) Processed HA bone graft block was sterilized by autoclave unit and gamma ray.

3) Surgical procedure

(1) Deaeration was done in normal saline with antimicrobials. Second deaeration was done during surgery with venous blood collected prior to surgery and kept in a plastic syringe.

(2) Guided surgery was performed following the standard procedure, and implants were placed and the HA bone graft block was anchored (Fig 11).

4) Progress

(1) Oral findings and CT image right after the surgery are follows. Satisfactory horizontal volume was obtained in oral findings. CT image showed satisfactory compatibility around the implant platform anchored by screws, but a slim space was observed between the implant apex and the cortical bone(Fig 12).

(2) 6 months after the surgery, secondary surgery was performed and its oral findings and CT images are as follows. Stable prognosis was provided without any infection for 6 months after surgery. CT image comparison showed the bone augmentation block had high affinity for surrounding bone and surrounding bone was remodeled in transitional form. Newly formed bone was observed in the space seen right after surgery around implant apex. Cortical bone newly growing towards the apex

Fig.9: Fablication the bone augmentation model and the bonedefect model with 3DP

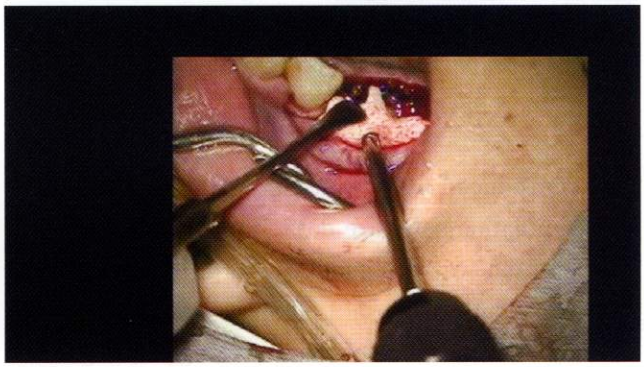

Fig.11: Bone augmentation block was anchored with screws during surgery

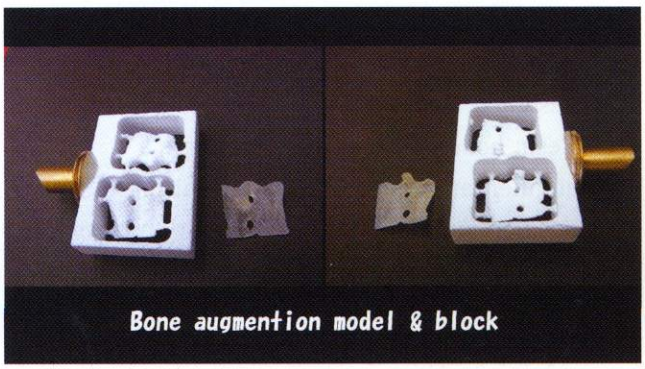

Fig.10: HA bone graft made by CAD/CAM

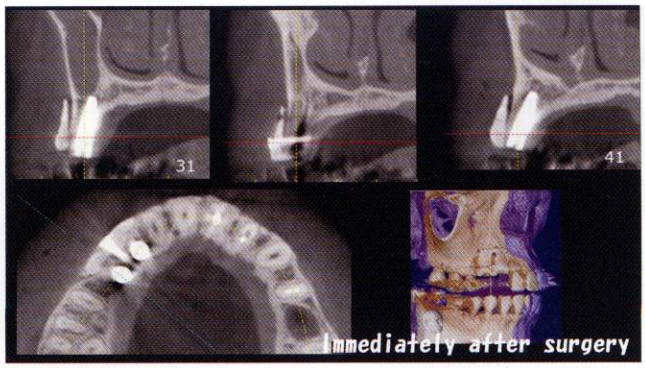

Fig.12: CT imges immediately after surgery

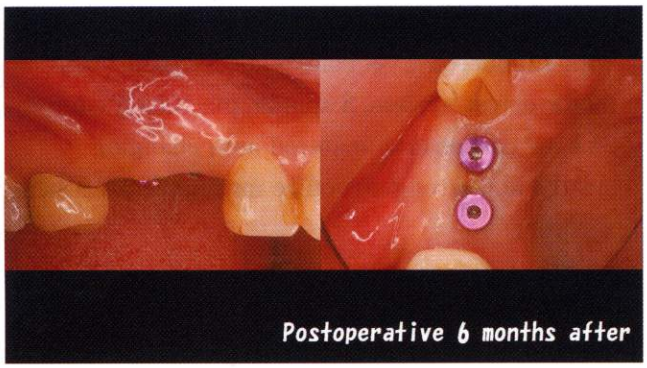

Fig.13: Interoral photograph after 6 months

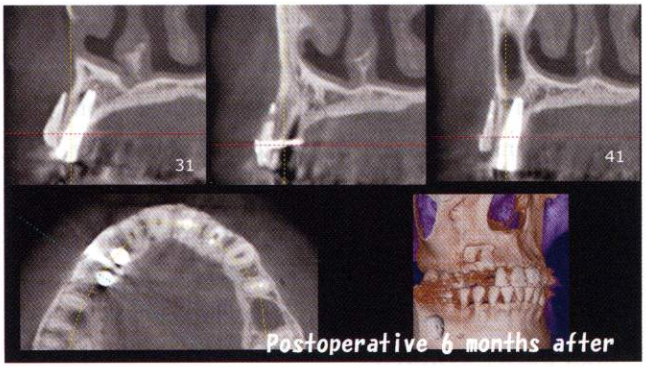

Fig.14: CT images after 6 months

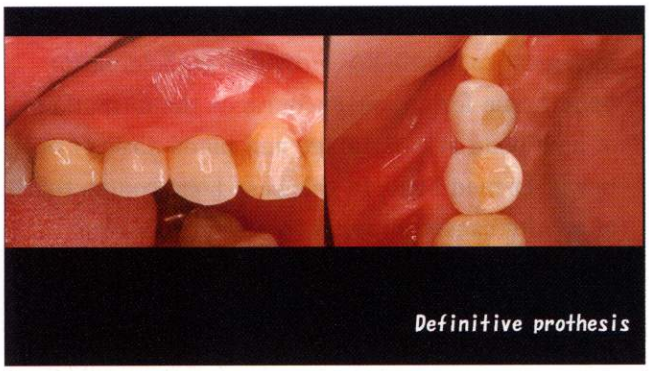

Fig.15: Intraoral photograph of final prosthetic restoration

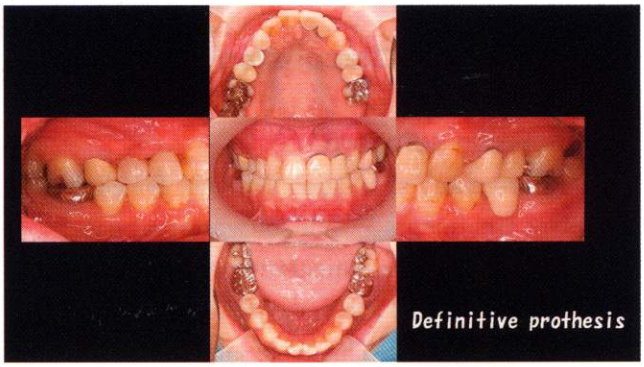

Fig.16: Intraoral photograph of final prosthetic restoration

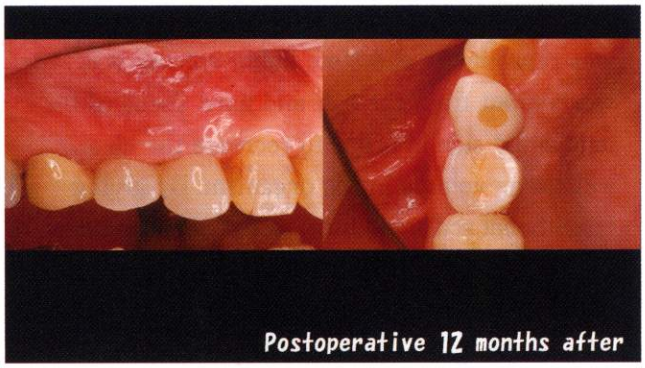

Fig.17: Intraoral photograph after 12 months

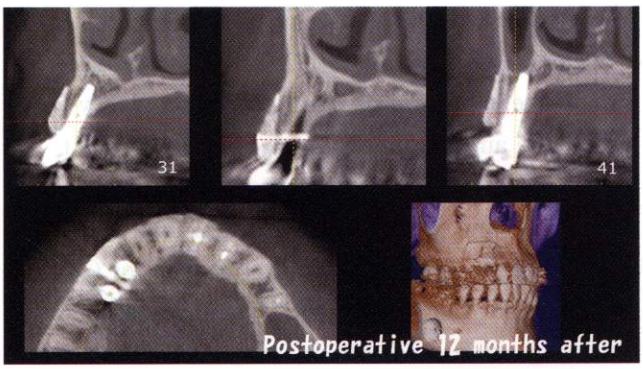

Fig.18: CT images after 12 months

of the HA bone graft was also confirmed (Fig 13, Fig 14).

(3) Oral findings at prosthesis application are as follows. Temporary prosthesis was applied after the secondary surgery. After adjusting the form and functionality, permanent prosthesis was applied. After application of the permanent prosthesis, it had not been long enough to see the full reproduction of papilla, but symmetry with the unaffected side was obtained(Fig 15, Fig 16).

(4) Oral findings and CT images 12 months after surgery are as follows. Papilla had been fully reproduced after 12 months. Comparing with the CT image of 6 months after surgery, newly formed bone had filled the border between the surrounding bones (Fig 17, Fig 18).

3.Discussion

1) Simulation software

There are many simulation software for clinical implant treatments [1,2], but software that can simulate the bone augmentation volume or match with plaster model are very limited. In this study SimPlant was used. This bone augmentation simulation had maximized the advantage of SimPlant. Ideal form (soft/hard (teeth, bone) tissues) of the defect region on a plaster model was reproduced and bone lining volume was worked out from the soft and hard tissue of the unaffected side in order to recreate the ideal soft tissue volume in the organism. By giving transitional scalloped form to the alveolar bone border from the adjacent tooth of the affected area, papilla with bone (apatite) lining was formed. Also avoiding contact of the implant and the bone augmentation block reduced the external stress (such as occlusal load) on the bone augmentation block and lead to remodeling of the autologous bone around the implant. This is important for a long term prognosis. Using guided surgery for bone augmentation simulation and implant placement simplified the surgery procedure. Surgical time for this case was less than 1 hour including anesthesia. Literature search for CT and apatite showed a report [3] on procedure for making actual size models using Helical volume scan CT data but apatite reproduction was analog and its reproduction was not as accurate as in this study.

2) CAD/CAM technology

In order to precisely reproduce the bone augmentation image, GM-1000 [4,5], ultra precise processing machine at GC processing center seemed to be the best system. In preliminary experiment bone augmentation block made by 3DP exactly matched the resin bone defect model. GM-1000 is the world's top Japanese technology with submicron level control mechanism, linear motor driver system, 5 spindle machining control, 24 hour consecutive material auto changing system and strong structure for higher processing accuracy.

3) HA bone graft

The HA block used in this study was apaceram-U5 (30x40x10mm, porosity 50%) manufactured by HOYA Technosurgical Co.) [6,7]. Reducing the porosity of HA sintered block will increase the strength but reduce the bone conductivity [8,9]. This case was an application to an external bone defect and it was necessary to maintain high bone conductivity and was designed to get the least effect from external force in aesthetic area, the HA bone graft with 50% porosity was used [10,11]. This product is made of high purity synthetic hydroxyapatite and is a bone substitute of the same quality to biological apatite which is the basic component of bone tissues. It has high biological compatibility, provides scaffolding for bone tissue formation, encourages the formation of new bone at early stage and binds directly with newly formed bone. In this case bone conductivity of apatite caused dramatic bone reproduction between HA bone graft and surrounding bones in 12 months after surgery. (Fig 19, Fig 20, Fig 21, Fig 22, Fig 23)

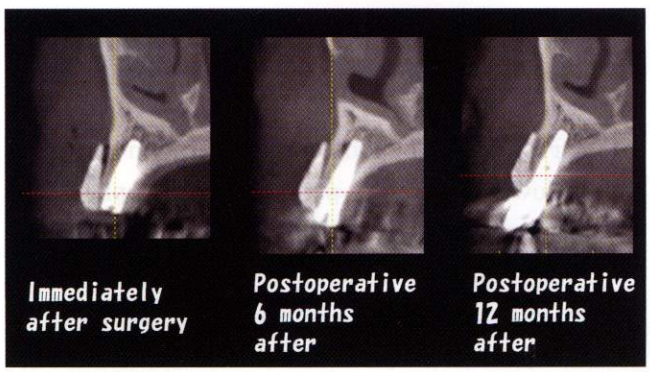

Fig.19: CT image changes

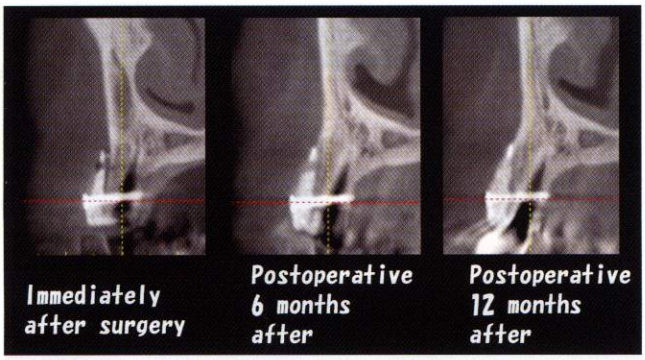

Fig.20: CT image Changes

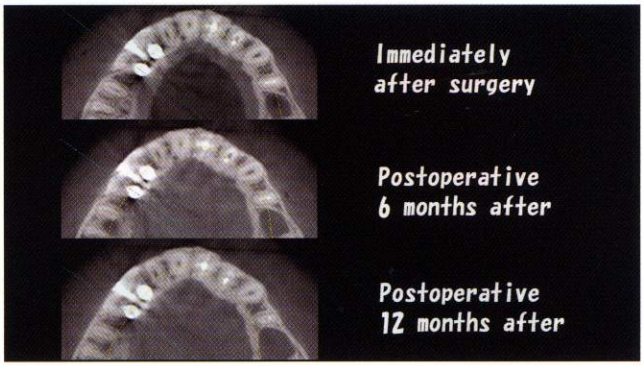

Fig.22: CT image Changes

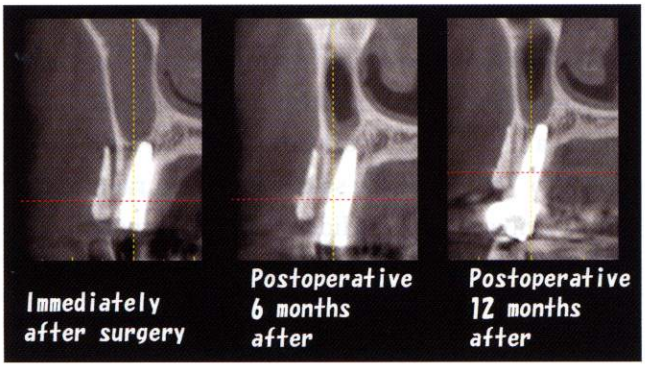

Fig.21: CT image Changes

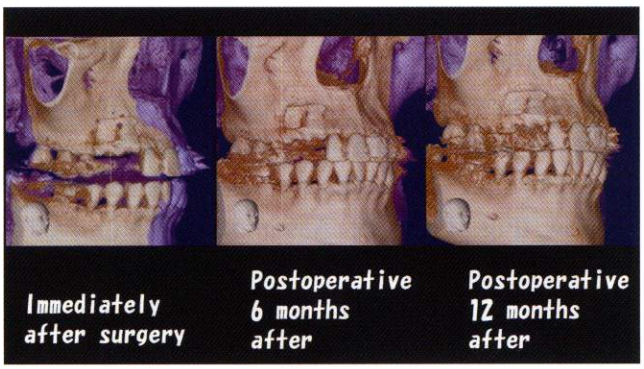

Fig.23: Bone formation

In this study bone graft block shaped out by CAD/CAM was sterilized with autoclave treatment and gamma ray sterilization, and no change was observed in its structure or strength according to HOYA Technosurgical Co.

4) CAD/CAM technology and application of HA bone graft

For the last couple of years 2 papers reported application of the HA bone graft fabricated with CAD/CAM technology. One paper reported the results of animal testing on temporomanibular condyle [12] and the other paper reported the application of bone replacement for sinus floor elevation [13] so none of them were similar to this study.

5) Surgery

This case being the application towards external bone defect, bleeding from residual bone caused by decortication during surgery, formfitting of HA bone graft and residual bone and anchoring of the HA bone graft block were well considered in designing the surgery procedure. Kusumoto et al. reported, "Formation of new bone was observed in cortical bone rather than periosteum in the HAP bone graft." [9] The HA bone graft with 50% porosity was used and pores were filled with antimicrobials and venous blood during surgery to prevent infection and encourage early bone formation. Keeping venous blood in plastic syringe will slow down clotting. By taking this step right before anchoring the HA bone graft, pores of the HA bone graft can be filled with fresh blood after surgery. As a result, excellent bone conductivity of apatite encouraged bone formation and new bone was formed transitionally in the border between HA bone graft block and the residual bone.

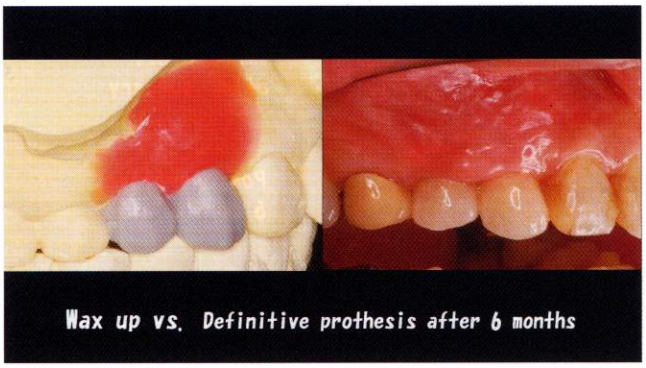

Fig.24: Wax-up design befor operation and final prothesis after 6 months

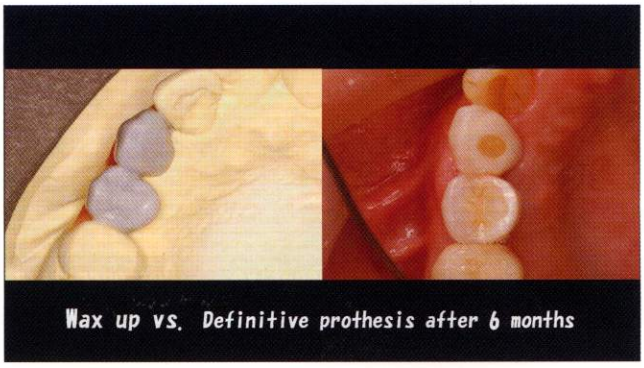

Fig.25: Wax-up design befor operation and final prothesis after 6 months

6) Aesthetics

Comparison photos of the wax-up model at the time of planning, 12 months after surgery and 6 months after prosthetic restoration are shown below. (Fig 24, Fig 25) Aesthetics was improved to almost ideal state as planned including soft tissues. Traditional bone augmentation methods cannot improve sensuousness of soft tissues, especially gingival papilla with one surgery. Second or third surgeries are often necessary to recreate the soft tissues [14]. Therefore HA bone graft block in this study can be considered as effective.

4. Conclusion

A dental implant case with bone defect was showed. The bone defect volume and precise position of an implant were estimated by a CT simulation. The HA bone graft was fabricated from a sintered HA block by CAD/CAM. The bone defect was filled with the HA bone graft. Then, a dental implant was placed into the precise position. One year after the operation, the HA bone graft and implant successfully maintains with aesthetics and functionality.

Acknowledgements

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