

GC Evaluation of Carbonate Apatite Bone Graft Substitute in the Beagle Dog 1-wall Peri-implant Defect Model



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1 INTRODUCTION

According to studies of biological apatite, bone apatite is not pure hydroxyapatite (HAp) but contains about 3–8 wt% carbonate ions (CO₃), hence should be rightfully called carbonate apatite (CO₃Ap). We have developed a synthetic carbonated apatite bone graft substitute (CO₃Ap, Cytrans[®] Granules). It was fabricated using phase transformation based on dissolution-precipitation reaction¹⁾. It was confirmed the efficacy and safety of CO₃Ap through a clinical trial conducted in Japan²⁾. A clinical trial using CO₃Ap for maxillary sinus surgery and immediate implantation have indicated that bone resorption does not occur at the CO₃Ap implantation site, that bone height is maintained. Long-term follow-up shows good results. However, the therapeutic limits of using carbonated apatite are still unclear.

In this study, we evaluate the efficacy of CO₃Ap in a severe bone defect model.



Fig 1. Cytrans Granules

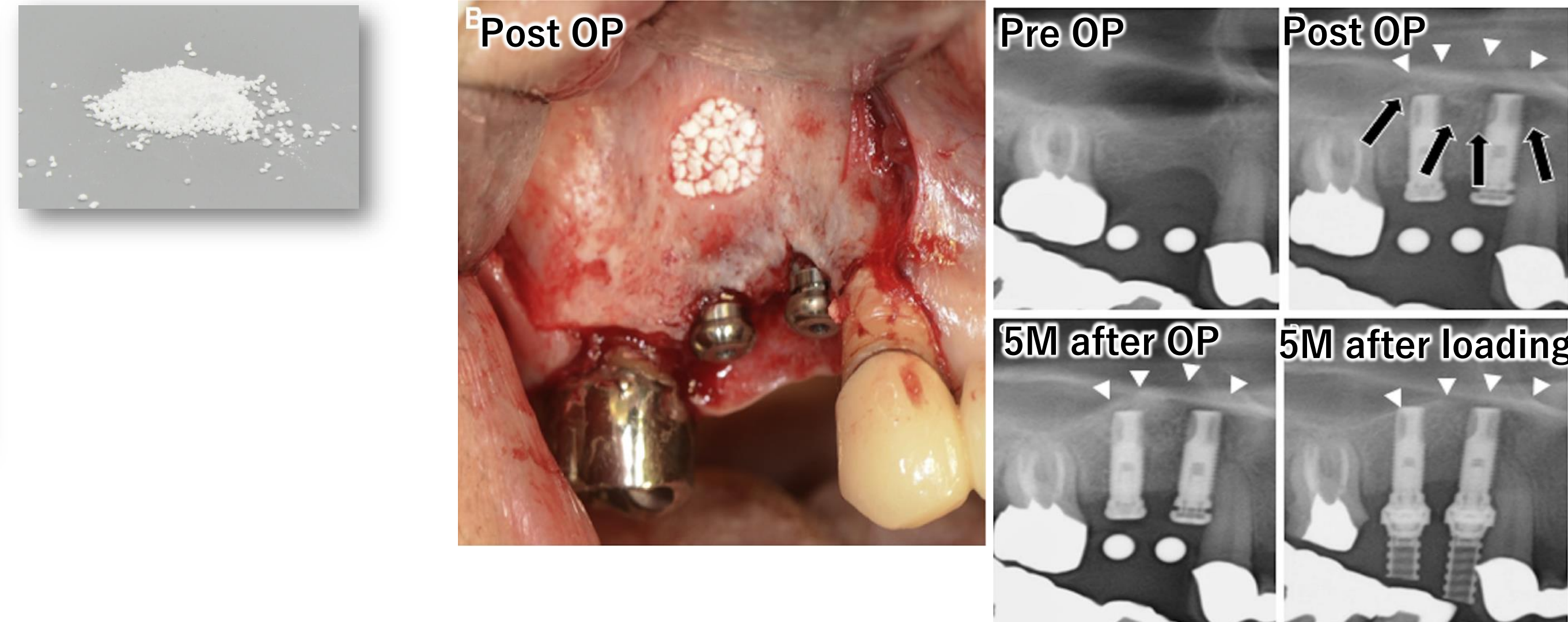


Fig 2. Photographs of sinus floor augmentation

3 RESULTS & DISCUSSION

X-ray examination

Analysis method

The new bone area in the defect was assessed using Image J software.

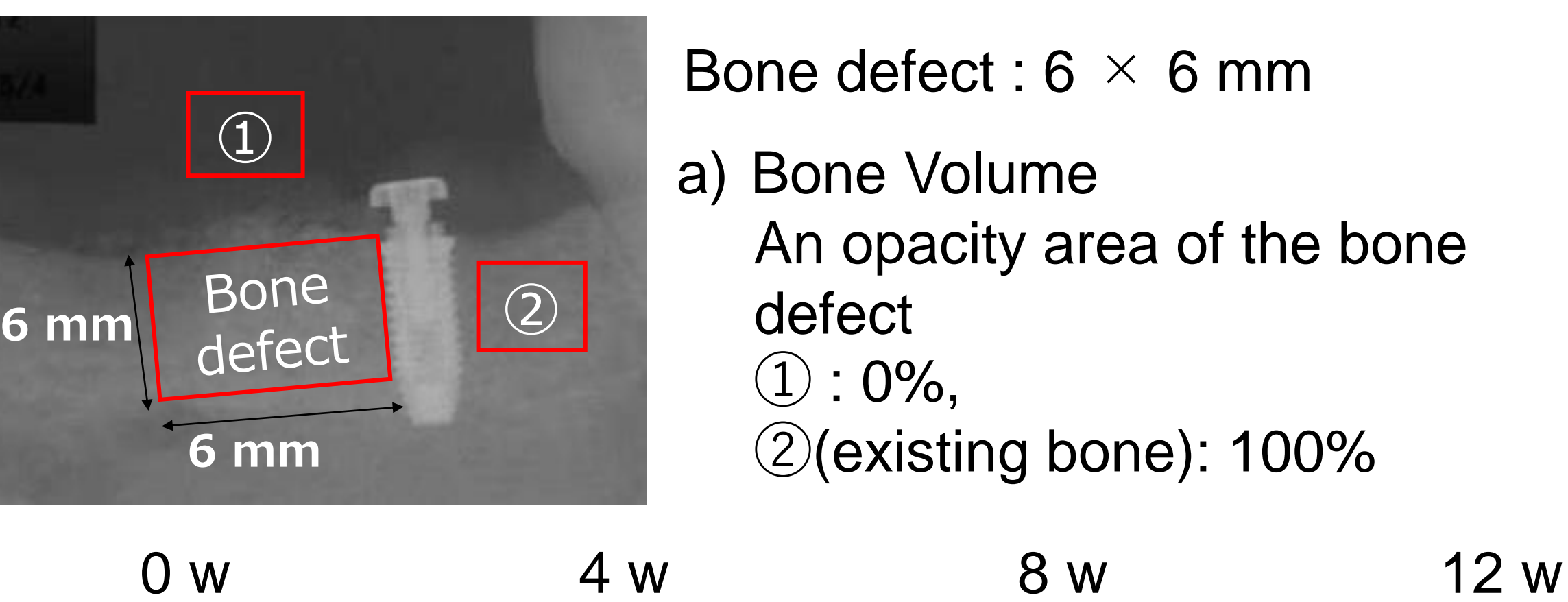


Fig 4. X ray image after a healing period of 4, 8, 12 weeks Bar : 5 mm

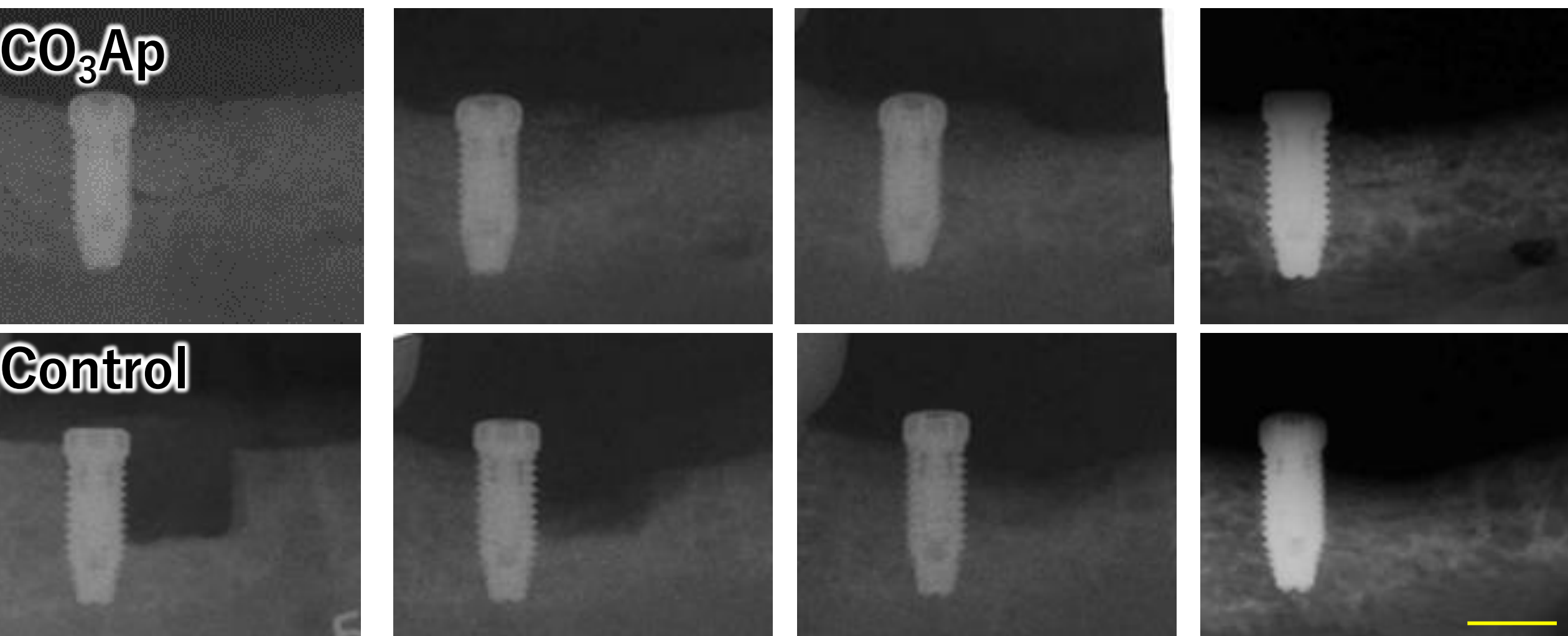
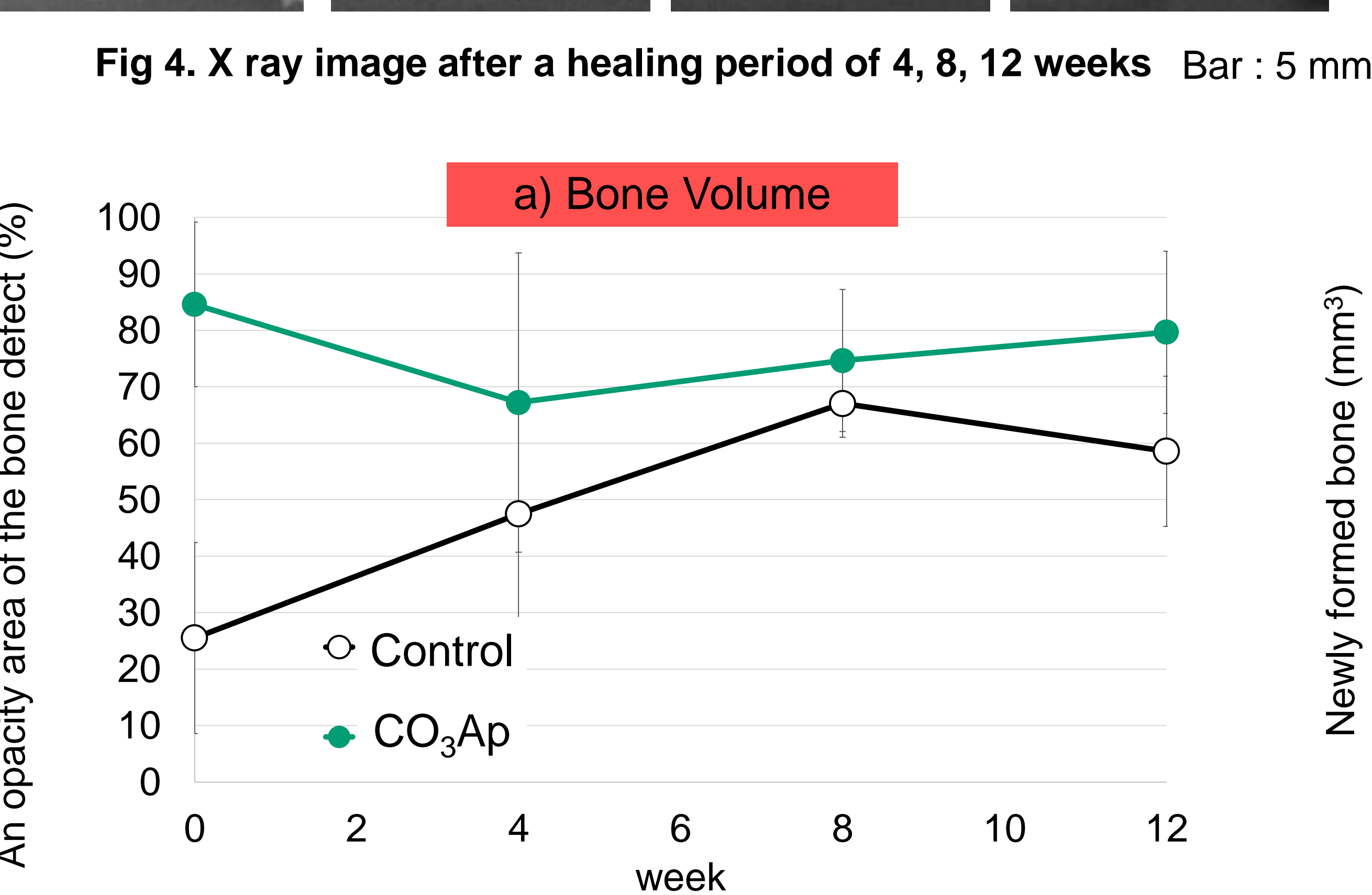


Fig 6. Xray analysis of Bone volume (%)



X-ray image revealed a higher opacity of the bone defect for CO₃Ap groups compared to control overtime. CO₃Ap showed good regeneration especially in the upper part of the bone defect. These results suggest that the CO₃Ap and the control groups produce similar bone healing at the lower part of the bone defect, but CO₃Ap granules showed faster bone formation at the upper part.

4 CONCLUSION

Our finding indicate that volume of newly formed bone was higher in the CO₃Ap than in the control at 1-wall peri-implant defect model, suggesting that CO₃Ap is a useful bone graft substitute for use in bone defects in severity.

2 MATERIALS & METHODS

Materials

Sample : CO₃Ap (granule size of 0.3-0.6 mm)
 Control : Only defect
 Implant : φ3.0 mm × d 8.0 mm dental implant

Methods & Timeline

Premolar extraction
 After extraction of the bilateral mandibular anterior molars of the Beagle dog, it healed for 8 weeks.

Surgical bone defect / Transplantation

1-wall peri-implant bone defect was prepared, and dental implants were placed in distal side of the defect. The bone defect was filled with material.

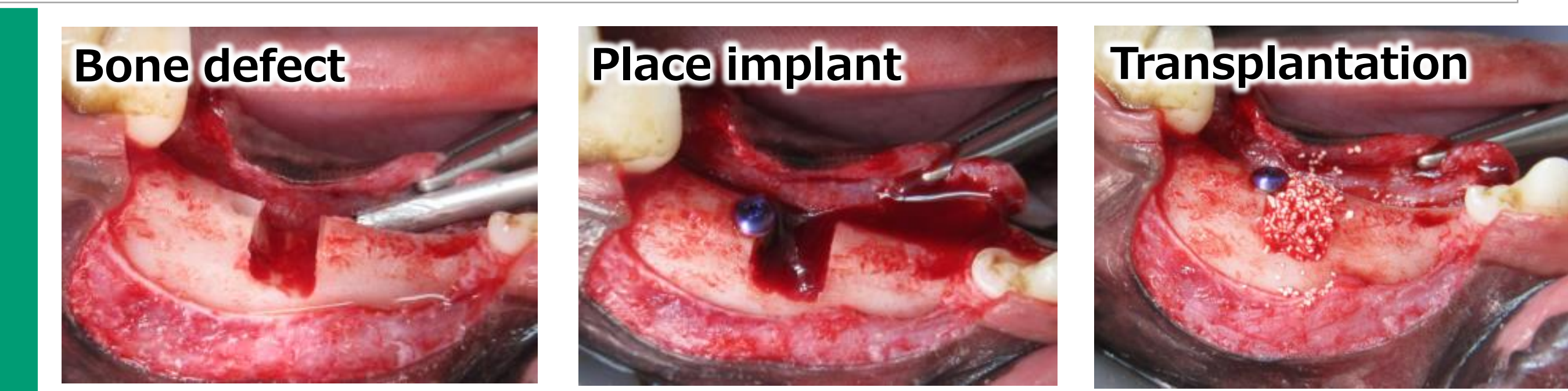
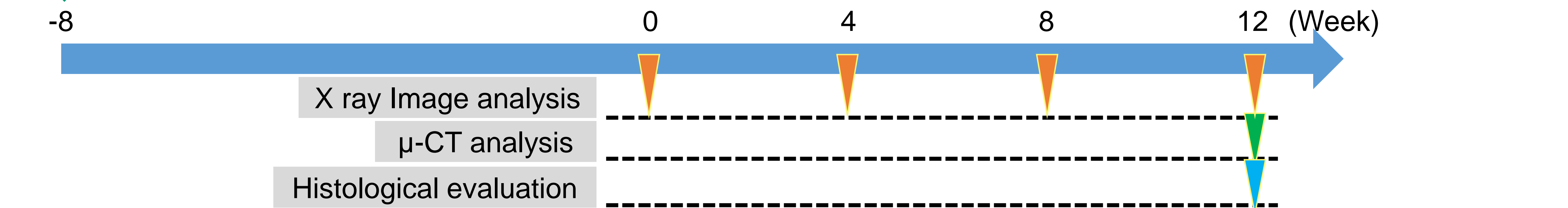


Fig 3. Photographs of sinus floor augmentation



Statistical analysis

The Mann-Whitney U test were performed using BellCurve for Excel version 2.15. (*: p < 0.05, N.S. : Not Significant)

μ-CT analysis

Analysis method

Micro-CT (SMX-100CT, SHIMADZU, Tokyo, Japan) scans of the bone biopsy specimens were obtained and stored using 3D Creator software (VG Studio MAX, Volume Graphics, Heidelberg, Germany).

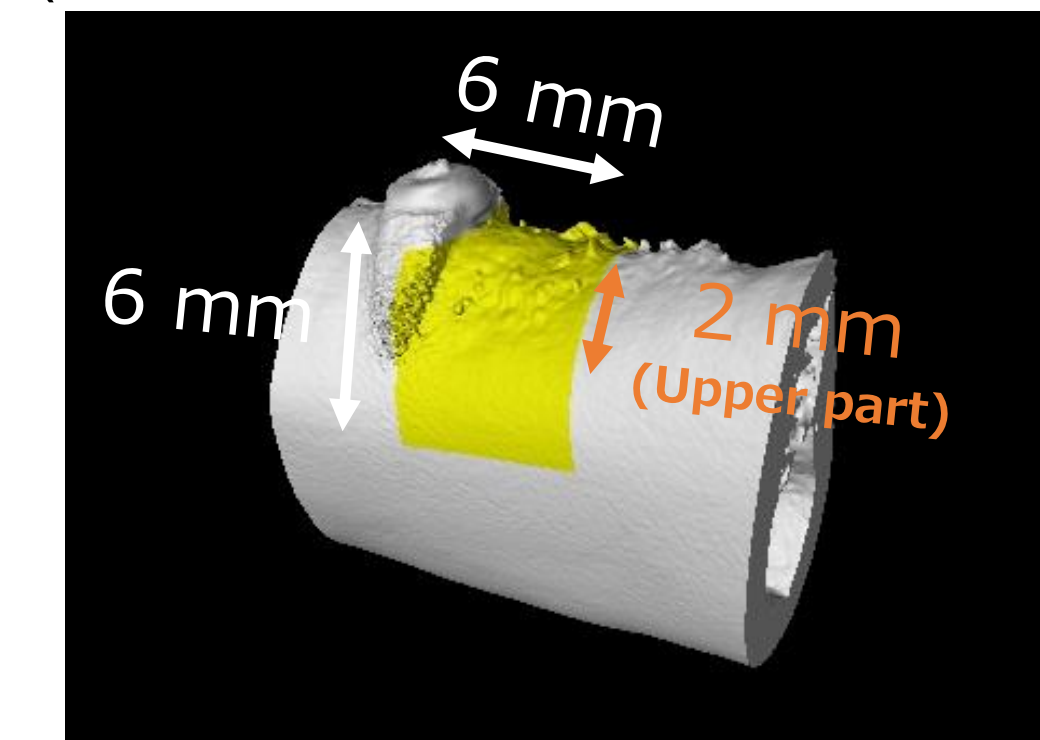
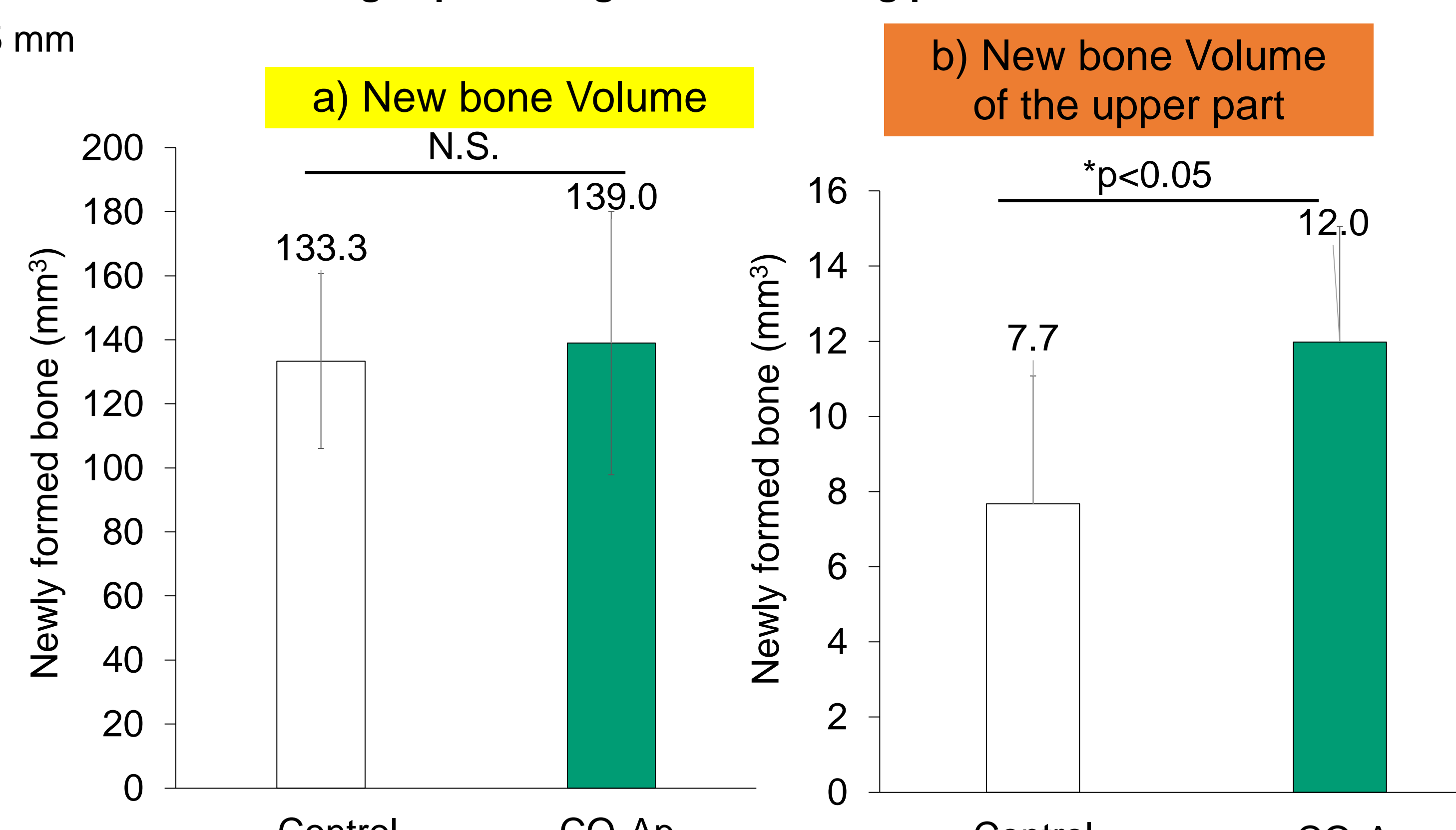
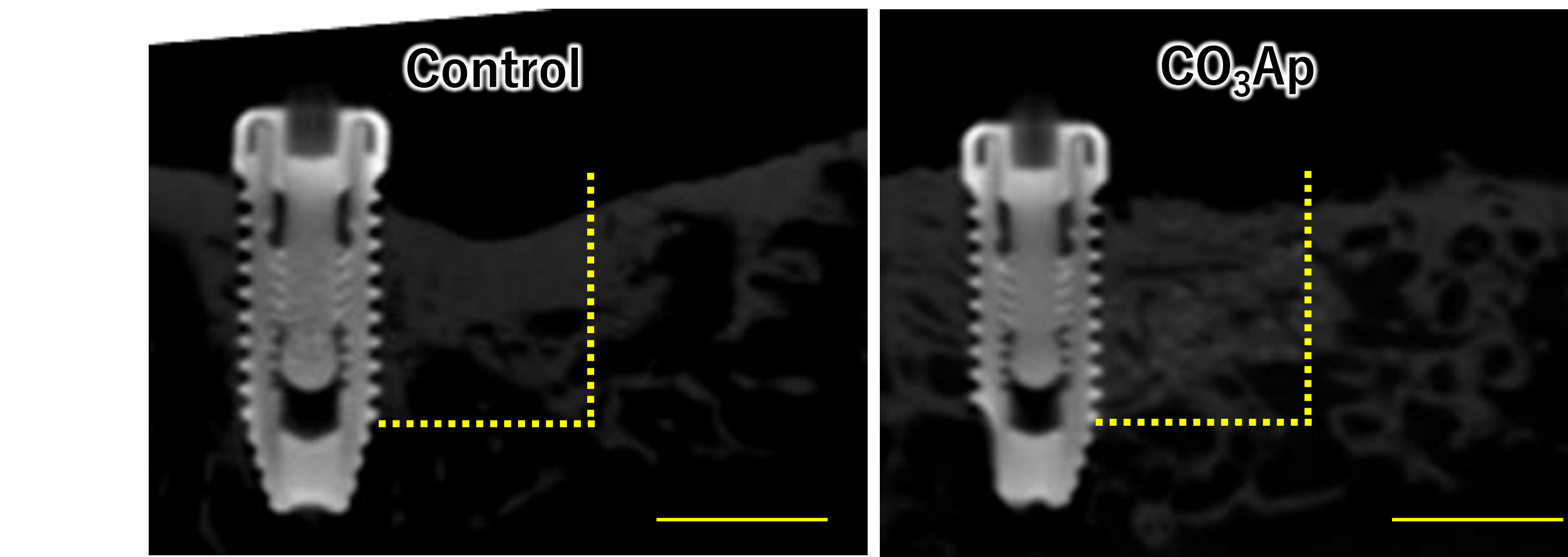


Fig 7. μ-CT image after a healing period of 12 weeks Bar : 5 mm



In the results of μ-CT analysis, the new bone volume after the healing period of 12 weeks was 139 mm² at CO₃Ap, which was higher than the control 133 mm². The new bone area of the upper part of the defect was 12 mm² at CO₃Ap and 7.7 mm² at the control and CO₃Ap was higher than the control statistically. Newly formed bone was maintained in the CO₃Ap group at the upper part of the bone defect which is difficult to heal. These results suggest that CO₃Ap is a reliable bone replacement material for bone defects and prevents significant vertical bone loss.

Histological evaluation

Analysis method

The newly formed bone area was measured by using microscopic images of undecalcified section and Image J (NIH).

Stain : Villanueva Goldner stain (Calcified bone : Yellow green)

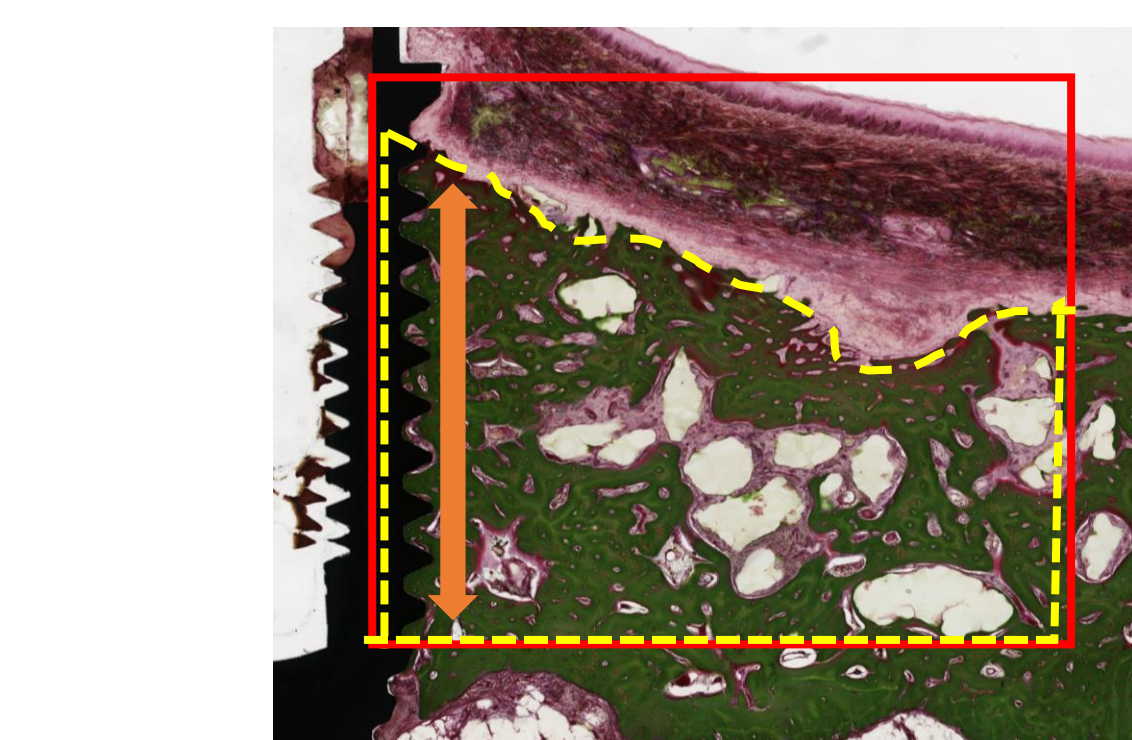
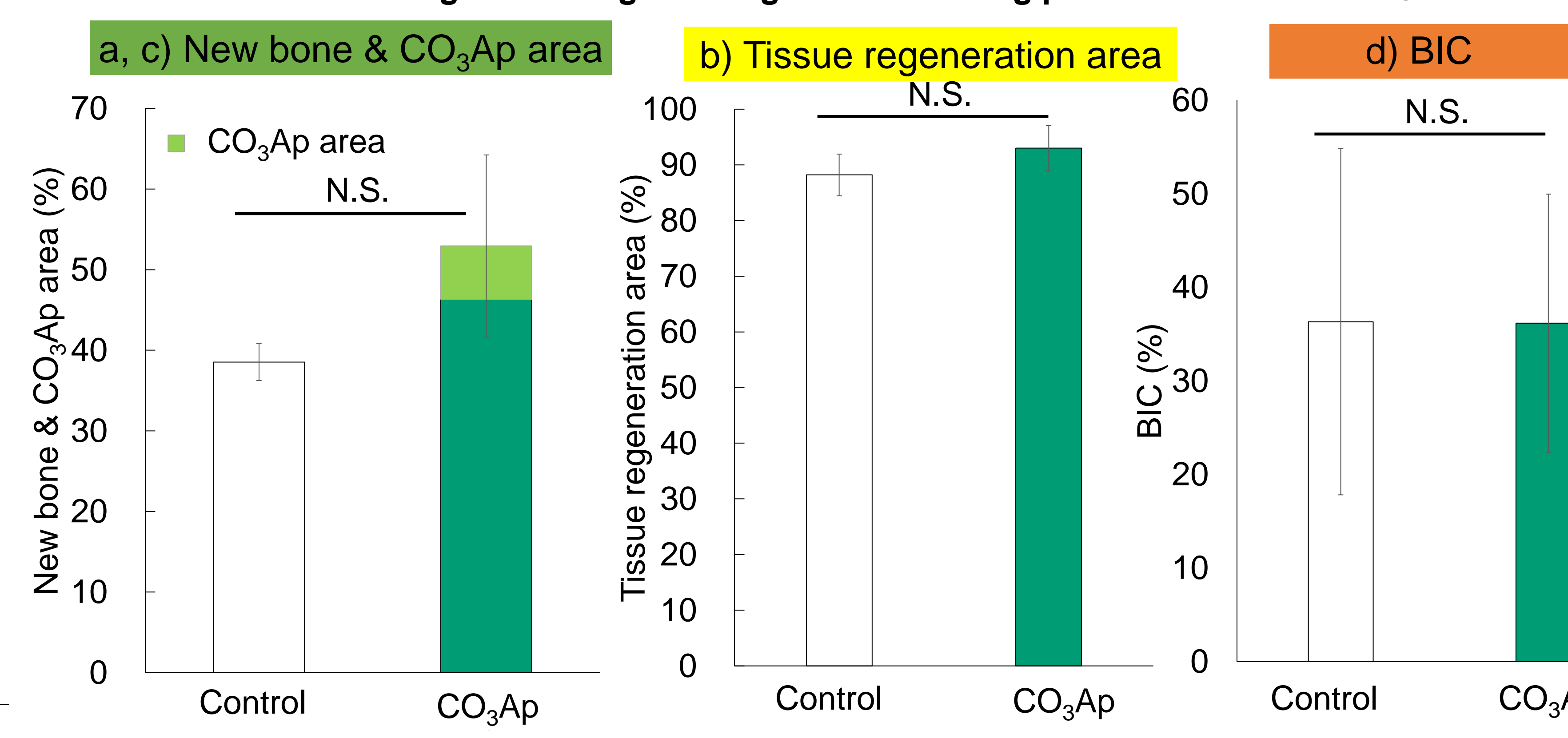
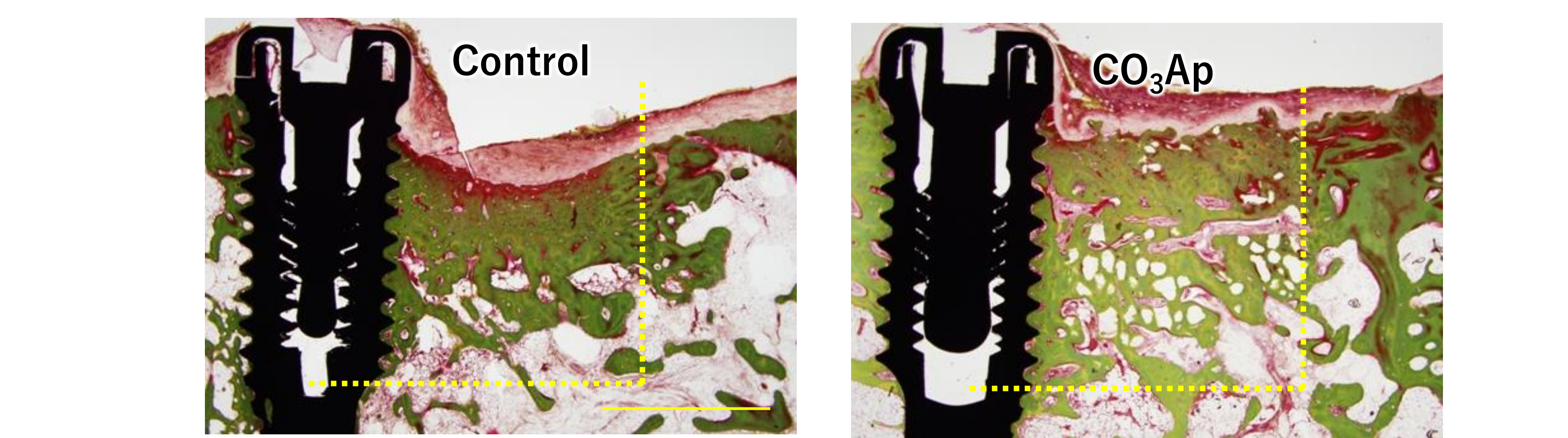


Fig 9. Histological image after a healing period of 12 weeks Bar : 2 mm



The result of histological evaluation, new bone area after 12 weeks of healing period at histological evaluation was 46% at CO₃Ap, which was higher than the control 39%. The remaining granules area was 7% at CO₃Ap. The tissue regeneration area in CO₃Ap group was higher than that of the control group. It is considered that CO₃Ap was covered with newly formed bone, and trabecular structure like surrounding bone was regenerated as the CO₃Ap was resorbed. These results suggest that CO₃Ap is gradually resorbed and completely replaced with newly formed bone and surrounding tissue. CO₃Ap promotes faster bone healing at 1-wall defect dog model as a severe model.