



Volume stability of hydroxyapatite and β -tricalcium phosphate biphasic bone graft material in maxillary sinus floor elevation: a radiographic study using 3D cone beam computed tomography

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Introduction

To improve bone volume to support dental implants, internal augmentation of the maxillary sinus such as sinus floor elevation(SFE) was widely accepted as a routine method. Graft materials for the SFE should be something that can achieve rapid new bone formation with long-term volume stability. Biphasic calcium phosphate(BCP), as a kind of synthetic material, has been widely used as a bone substitute. A mixture of hydroxyapatite(HA) and β -tricalcium phosphate(β -TCP) has been the popular combination of BCP. Oss-pol®, one of numerous graft materials for SFE, is a biphasic material composed of HA and β -TCP. 3D CBCT offers a reliable technique for 3D visualization of the changes in the volume of new bone formation after SFE. For the evaluation and to obtain more accurate volume change of the augmented site over the time, volumetric analysis of 3D object matching function in OnDemand3D software was used.

Material & Methods

Patients

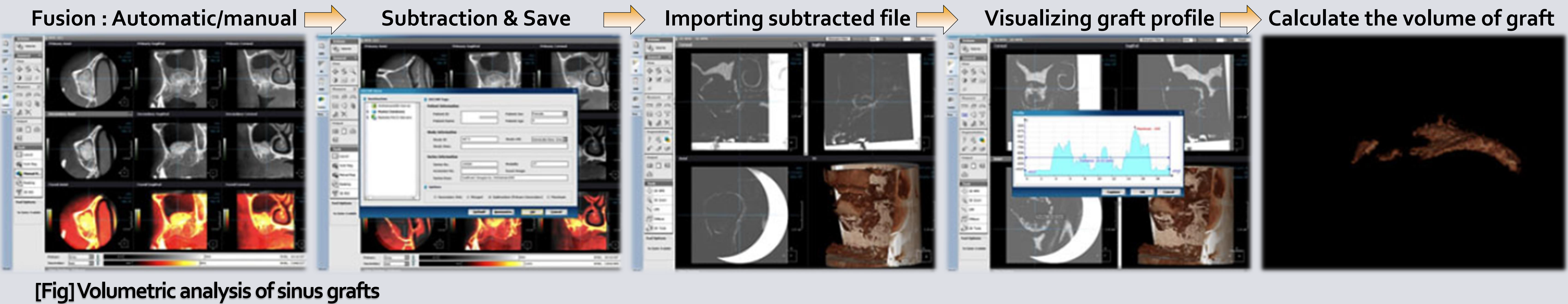
- Prospective study on maxillary SFE–lateral window technique from 2009 to 2011
- 15 patients (8 male & 7 female, mean age 50.1 yrs old)
- 1 was edentulous & 14 patients partially edentulous
- Mean residual bone height was $2.2 \pm 0.47\text{mm}$ (range : 1.2 ~ 3 mm)
- No history of systemic disease, smoking habits, and sinus pathology on radiographs

Surgical Procedure

- Sinus floor augmentation was carried out in staged surgical approach.
- Lateral window technique as described by Kent & Block (1989) was used
- 1.0–2.5 cc Oss-pol® with platelet-rich fibrin (PRF) was packed loosely into the maxillary sinus, and the grafted site was covered with a collagen membrane.
- Various volume of materials were grafted depending on the size of defect to be filled

Radiographic examination & Volumetric analysis

- CBCT taking for 5 times; pre-op.(T₀), 1 week(T₁) of post-op., first month(T₂), third month(T₃) and sixth month(T₄).
- OnDemand3D(Cybermed Inc.) was used for analysis
- An experienced radiologist measured the volumes for 3 times in a new randomized test.
- Augmented material was only included in the measurement if the radiodensity was between 250 and 3071 HU
- The volume of each images of the block was calculated automatically.

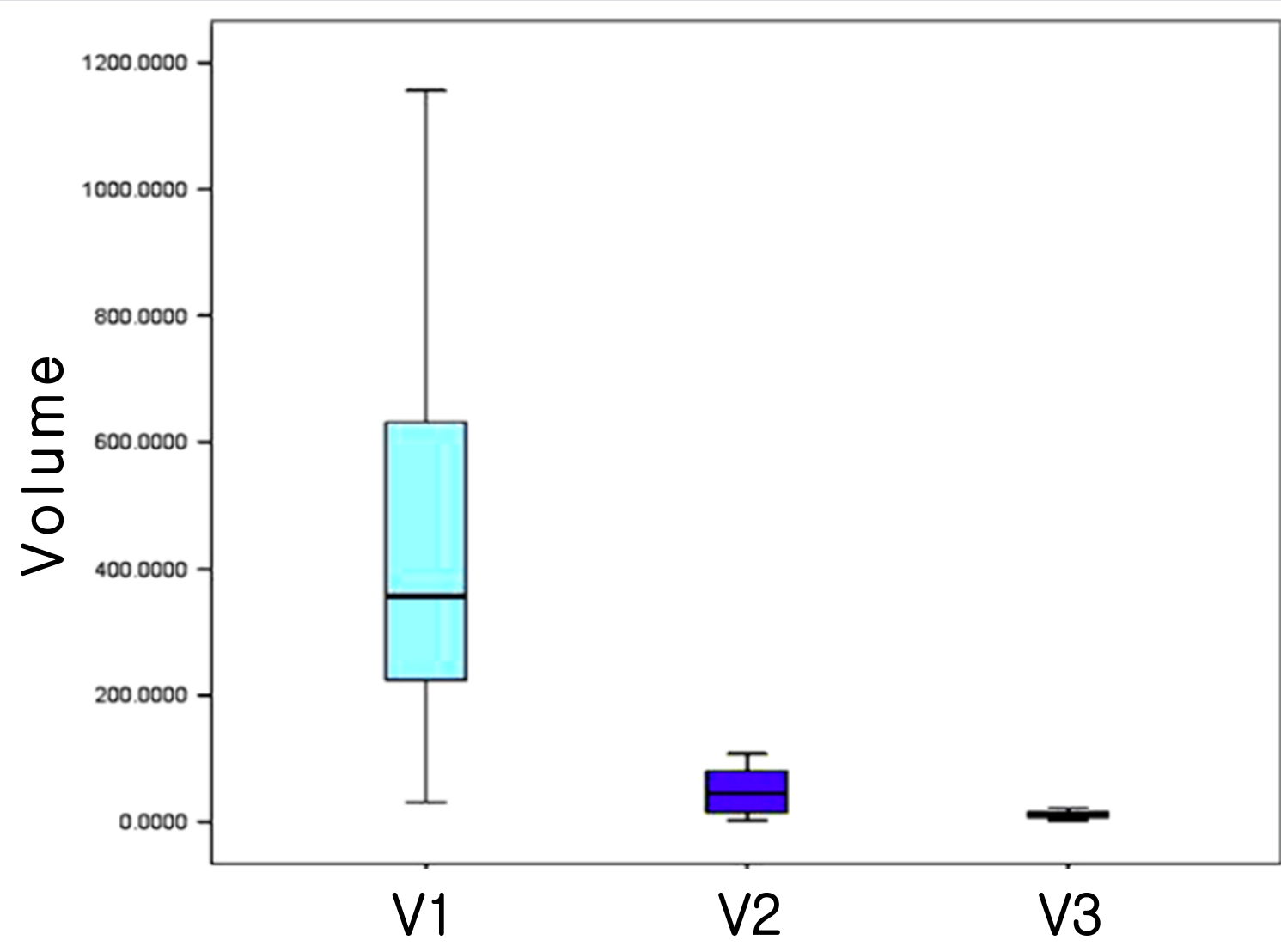
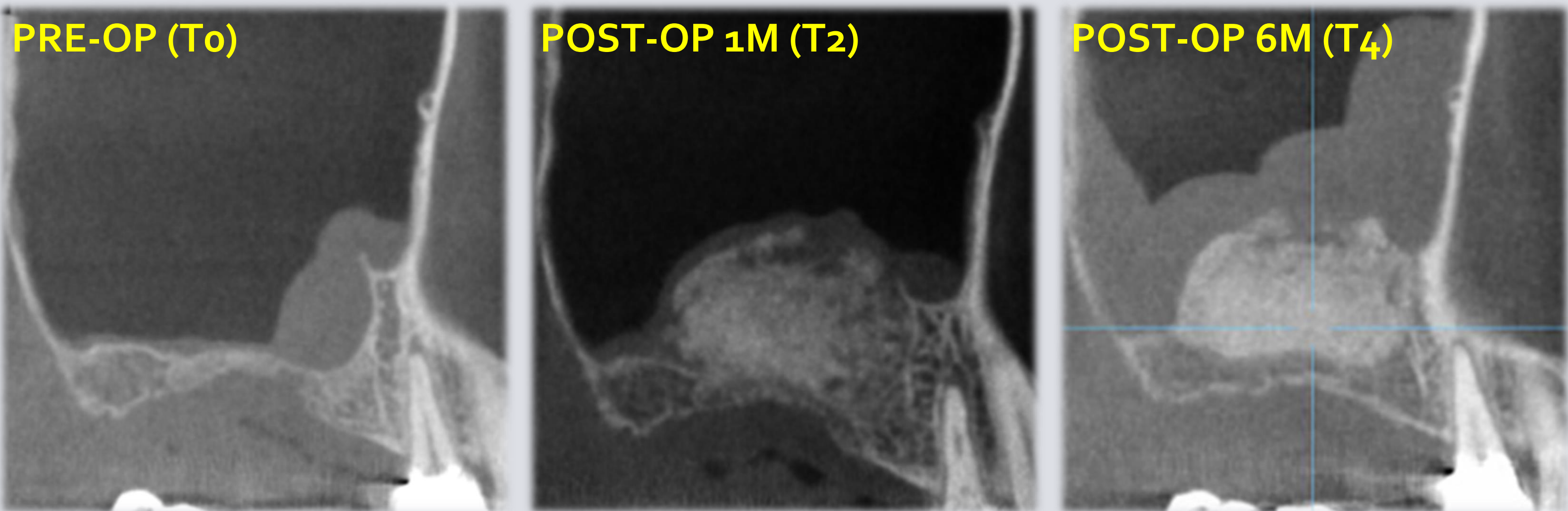


Results

For the analysis, 16 CT images in 15 patients were available.

The volumetric changes of grafted bone
A significant volumetric change (decreasing) is observed as time passed. Repeated-measures ANOVA shows significant influences of time on change of augmented bone.

A statistically significant difference was observed on V₁–V₂ (P = 0.001)* and V₁–V₃ (P = 0.002)*. There was no statistical difference on V₂–V₃(P = 1.000) (*P<0.05). 82.71% grafted BCP is maintained until post-op. 6 months (T₄), and the average volume loss is 203.73 mm³(about 0.20 cc).



Volumetric changes(mm ³)	V ₀ (ΔT_0-T_1)	V ₁ (ΔT_2-T_1)	V ₂ (ΔT_3-T_2)	V ₃ (ΔT_4-T_3)	V ₄ (ΔT_0-T_4)
Mean $\pm$ SD	1350.44 $\pm$ 562.56	426.15 $\pm$ 292.75	70.41 $\pm$ 84.48	14.67 $\pm$ 12.50	1117.04 $\pm$ 686.74

Discussion

The prospective analysis aimed to evaluate parameters that have a predictive value on the volume loss of HA-TCP biphasic graft after SFE by means of 3D volumetric analysis. Volumetric stability of sinus graft can represent an important factor for successful implant placement, which can be achieved by sufficient bone quantity as well as bone quality. In this study of 15 patients, BCP volume decreased with an average of 18% after 6 months of healing time. In comparison with other studies using autogenous or synthetic bone(Kirmeier et al. 2008, Jensen et al. 2012; Umanjec-Korac et al. 2013), we think that our result corroborates those from other studies. The volumetric stability of graft can be influenced by ratio of the mixture(Jensen et al. 2007 & 2009). 3D CT images enabled accurate measurements of volumetric changes and could also estimate bone density. However, the selection of the Region of Interest(ROI) in separate CBCT sections remain sensitive to distort. There are some limitations. First, most of the cases showed great mucosal thickening in T₁. It is possible to make an error due to the decreasing of the difference of densities between graft material and thickened mucosa. Also, the immediate post-op. swelling may be an influencing factor on initial graft volume change. Second, the volume can be changed according to the threshold. In this study, we could measure and visualize the initial and final volume of grafted site and the differences between each period easily through the subtraction methods of the OnDemand3D program. Most of resorption of graft materials was observed during the first 3 months after sinus augmentation. However, in many other studies, resorption of graft materials and repneumatization have been observed to occur, most noticeably within 2-3 years (Johansson et al. 2001; Kirmeier et al. 2008). Therefore, for the evaluation of long-term stability of Oss-pol®, additional study is required. Also, our study was limited by the small sample size used and the fact that multiple surgeons performed the sinus procedure.