Alveolar Bone Augmentation Using a Resorbable Silica-Calcium Phosphate Nano Composite

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Statement of Purpose: Supracrestal or vertical bone augmentation presents the greatest challenge in terms of regenerating bone. Small and moderate size defects (≤ 3 mm and 4-6 mm) have been successfully treated however in larger defects adequate vertical bone gain was not consistently reached[1]. The objective of the present research work is to employ silica–calcium phosphate nano composite (SCPC50) granules for the management of severe alveolar ridge atrophy. The effect of SCPC50 loaded with low dose of rhBMP2 on alveolar ridge augmentation in critical size bone defect in dog is reported. New bone formation is correlated to BMP2 release kinetics and the bioactivity properties of SCPC.

Methods: The study was conducted on 12 healthy mongrel dogs, of about 18-24 months of age, and weighs 9-14 Kg. They were kept under the same nutritional and environmental conditions in the experimental animal house at the Faculty of Veterinary Medicine, Alexandria University. Premolar teeth were extracted and two saddle-type defects per jaw quadrant were made (12mm mesiodistally x7 mm apicocoronally). The defects were randomly assigned for the following groups: **Group I**: 8 defects in 4 dogs, each received porous granules (250-425 µm) of silica–calcium phosphate nanocomposite SCPC50 (in mol%, 40.68% CaO, 20.34% P2O5, 19.49% Na2O and 19.49% SiO2) loaded with 10 mg rh(BMP-2), **Group II:** 8 defects in 4 dogs received SCPC50 granules alone, **Group III**: 8 defects did not receive any graft. The defects were covered by collagen membrane the flap was sutured. All dogs received the same dose of Penicillin antibiotic after surgery (25 mg/kg body weight I.M. every 8 hrs for 5 days). Animals were sacrificed at 8 and 16 weeks interval surgical sites were dissected out and fixed in 10% neutral buffered formalin, decalcified and stained with H&E and Gomori trichrome stains. Morphometric evaluation of the total surface area of the formed bone, the increase in bone height and total defect fill were assessed for each specimen using the (Image J 1.46) program. To determine the rhBMP2 release kinetics in vitro, SCPC50-BMP2 were immersed in 5mL phosphate-buffered saline (PBS; pH 7.4) containing 1% BSA at 37°C. At various time periods (1, 2, 4, 8 and 12 hrs, and 1, 2, 4, 8, 12, 16, 18 and 21 days) 1mL of the immersion solution was exchanged with 1mL of fresh PBS. Concentrations of released BMP2 were quantified with a Quantikine ELISA kit (R&D Systems, Inc.). Statistical analysis was performed using one-way (ANOVA) and Tukey's post-hoc test.

Results: bone defects grafted with SCPC50 showed no adverse reactions both clinically and histologically. The percent new bone formation in defects grafted with SCPC50-rhBMP2 (Group I) was significantly higher than that in defects grafted with control SCPC50 (Group II) at 8 and 16 weeks ($p<0.001$ and 0.01 respectively) (Fig. 1).

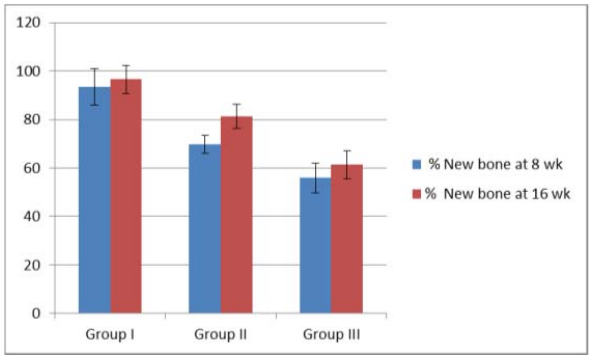

Fig. 1: New bone formation in defects grafted with SCPC50-rhBMP2 (Group I), SCPC50 (Group II) and control ungrafted (Group III) after 8 and 16 weeks.

Moreover, the percent new bone formation in Group II defects was significantly higher than that in Group III (control ungrafted defects) at both 8 weeks and 16 weeks $p<0.001$. Bone height in defects grafted with SCPC50-rhBMP2 (Group I) was significantly higher than those grafted with control SCPC50 (Group II) at 8 and 16 weeks ($p=0.009$ and 0.019 respectively). Moreover, the bone height for defects of Group I was significantly higher than that for control ungrafted defects ($p<0.001$ for 8 weeks and $p<0.007$ at 16 weeks). Bone height in defects grafted with SCPC50 was higher than that in control ungrafted defects however; the difference was not statistically significant. During the first 24hrs, there was a burst release of 6.63 + 2ng BMP2 from the SCPC50-BMP2, followed by a sustained release profile of 4.6 + 3.34pg BMP2/ml/hr in 24-504hrs (21 days).

Conclusions: SCPC-rhBMP-2 hybrid showed significant enhancement of alveolar ridge augmentation in critical size mandibular, full thickness, saddle-type defects as indicated by the increased vertical bone height and bone volume. The dose of BMP-2 used in the study was an optimal does as indicated by the absence of excessive bone formation or fluid-filled voids. The superior bone-healing effect of SCPC50 loaded with a lower dose of rhBMP-2 indicates that the nano pores of SCPC50 provided protection for the rhBMP2 molecules during the long term sustained release inside the bony defect. The synergistic effects of bioactive SCPC50 and rhBMP2 stimulate early cell differentiation and new bone formation. Results of the study suggest that SCPC50 is an effective grafting material and can be used for preserving the alveolar ridge after tooth extraction.

References:

1. Wang HL, Al-Shammari K. HVC ridge deficiency classification: A therapeutically oriented classification. Int J Periodontics Restorative Dent 2002; 22: 335-43.