Study on swelling behaviour of HANP/PVA composites with adding PLGA for alveolar ridge preservation

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Abstract

Objective: The aim of this study was to compare the swelling behaviour of HANP/PVA and HANP/PLGA/PVA composites.

Material and Methods: This study was divided into 2 groups, HANP/PVA and HANP/PLGA/PVA composites which prepared by freeze drying methods. HANP 20% (w/w) was combined with PLGA 20% (w/w) and dissolved in PVA solution at 50°C. Swelling behaviour was obtained by measured initial weight (Wi) and the weight of composites after immersing in PBS pH 7.4; 37°C for 7 days (Ws). Statistical analysis based on Independent T-test ($p < 0.05$).

Results: The initial weight (Wi) of HANP/PVA and HANP/PLGA/PVA

composites are 467 ± 4.73 and 292 ± 9.52 . The swollen weight (Ws) of HANP/PVA and HANP/PLGA/PVA composites are 897 ± 26.61 and 860 ± 32.36 . Furthermore, the water retention of HANP/PVA composite is 92.07% ($p < 0.05$) and HANP/PLGA/PVA composite is 194.52% ($p < 0.05$).

Conclusion: The addition of PLGA enhance swelling behaviour of HANP/PVA composites. The strong interaction between HANP and PVA decrease the swelling re. HANP is inert in nature, but the combination of HANP/PLGA/PVA can be a good substitute for alveolar preservation.

Keywords: Swelling behaviour, HANP, PVA, PLGA, Alveolar ridge preservation

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Introduction

Alveolar bone resorption can be occurred in several physiological and pathological process, e.g. post tooth extraction, periodontitis, etc.¹ The incident of bone resorption made worst if the patients have systemic disease e.g., diabetes mellitus.^{1,2} When alveolar bone resorption is occurred, it cannot regenerate in normal physiological processes, so requires other intervention such as bone graft. Bone resorption after tooth extraction treatment is physiological and progressive process, especially in the first 6 month.^{3,4} Furthermore, alveolar bone resorption may compromise dental implant, removable and fixed denture treatment with risk destroyed anatomical structure.²⁻⁴ Therefore, alveolar ridge preservation is one methods to avoid aggressive bone loss after tooth extraction treatment.⁵

Biocomposite based on polymers and ceramics have been developed for biomedical application, especially for bone repair and reconstruction.⁶ Several polymers which widely used for this purpose are Polylactic co-glycolic acid (PLGA) and Poly Vinyl Alcohol (PVA) because of their biocompatibility and biodegradability properties. PLGA is one of the best biodegradable materials, drug carrier and can be degrade to non-toxic products.⁷ PVA has great biocompatibility, physicochemical characteristic and has been used for biomedical application. PVA has better mechanical stability than other polymers which has been demonstrated

in previous studies.⁸

Hydroxyapatite Nanoparticles (HANP) is natural bioceramic extracted from many sources, e.g. scales of fish. HANP shows dimensional stability, improve composite density, and fracture toughness.⁹ Furthermore, HANP has better osteoconductivity, biocompatibility, and biodegradability if combine with other materials to be composites. As in study, HANP/PVA composites has slight microporosity and it should combines with another material to improve the microstructure of HANP/PVA composites.¹⁰ The aim of our study was to evaluate the effect of adding PLGA on swelling behaviour of HANP/PVA composites, measuring for 7 days.

Material and Methods

HANP (~60 nmBATAN, Indonesia), PVA (fully hydrolysed, Mw 73.000, Merck, USA), PLGA (50:50, acid terminated, PolysciTech, USA), PBS (Merck, USA).

Preparation HANP/PVA/PLGA composites

At first, PVA was dissolved in distilled water at 50°C for 2 hours by magnetic stirrer. In other tube. HANP 20% (w/w) was added in PVA solution at room temperature, then PLGA 20% (w/w) was added and stirred until the solution homogenous. The PVA/HANP/ PLGA solution was distributed into 48 well plate. The well plates were placed within a deep freezer at -80°C for 24 h.

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Swelling behaviour

In this study, swelling behaviour was investigated according a method describes earlier. All of the composites were fully immersed in PBS solution (pH 7.4) for seven days. The swelling percentage of the samples were calculated by the equation:

$$\text{Water retention (\%)} = \frac{W_s - W_i}{W_i} \times 100$$

Where W_s is the weight of sampels after swelling and W_i is an initial weight conditions ($n=3$). The values were expressed as percentage.

Figure 1 Swelling HANP/PVA and HANP/PVA/PLGA after 7 days

Results

Swelling studies indicated that the HANP/PVA composites which is added PLGA absorb water more than that of initial weight after 7 days. There is slight difference between adding PLGA or not in after 24 h in PBS. The HANP/ PVA/ PLGA composites raises gradually the swelling percentage after soaked 1d, 3d and 7d in PBS. The HANP/PVA composites without PLGA also raises until day-7 but not as great as HANP/ PVA/ PLGA composites [figure 1](#).

Discussion

Besides structural stability, the swelling behaviour is one of the critical for their practical use in tissue engineering especially for alveolar ridge presevation.^{11,12} Swelling of composites allows absorption of body fluid and transfer of cell nutrients and metabolites inside the scaffold.¹² Swelling behaviour is depending with the porosity and the natural

of materials which contained in the composites.¹² To assess the swelling behavior of the composites or scaffolds, the samples should be soaked in culture media (DMEM, AMEM), PBS or SBF for several days up to three weeks.¹³ In our study, all of the composites were soaked in PBS for seven days and there is slight apparent size/shape change for all the scaffold. HANP enhances apatite like structur formation by supporting chemical interaction on formability of HANP/PVA composites.⁸ The freeze dried composite in this study showed high swelling ability. This observation shows that addition PLGA has a beneficial effect. The incorporation of PLGA in composites may increase the swelling capability because PLGA can increase the porosity of scaffold. With adding PLGA, the swelling increase which is attributed to hydrophilic functional groups.^{7,14} Furthermore, PLGA may increase the swelling percentage may be credited to the disturbace of hydroxyl group of HANP and PVA molecules. Swelling behaviour of composites or scaffolds is helpful for stable implantation and helps to fill a specific tissue defect.¹⁵ Furthermore, the swelling of HANP composites in an aqueous environment is an important property because swelling behaviour increase porosity and surface area to support cell attachment and tissue regeneration, thus maximizing the internal surface area of composites for cell infusion and attachment.^{8,15} Swelling is desirable and the resultant increase in pore size facilitates cell attachment and growth. The swelling behaviour was evaluate quantitatively which is defined as the weight difference between wet and dry states of a sample divided by the dry weight of the samples. This ratio reveals how materials absorb aqueous media with respect to its dry state.

Conclusion

The addition of PLGA increase the swelling behaviour of the composites. HANP is inert in nature, so the combination of HANP/PVA/PLGA can be a good substitute for tissue engineering. Therefore, still need further research to be conducted for optimizing the composites. Swelling in physiological must be controlled cause it may weakening and rapid.

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Conflict of Interest

The authors report no conflict of interest.

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