COLLAGEN-HYDROXYAPATITE MEMBRANES FOR GUIDED BONE REGENERATION

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Purpose of Study

Guided bone regeneration (GBR) is currently regarded as an important strategy for the successful reconstruction of defective hard tissues. Many researches have been made to develop the GBR membranes by means of hybridizing resolvable polymers and calcium phosphates [1]. In this study, we fabricated collagen-apatite membranes by a modified biomimetic process (co-precipitation and filtration technique). The potential of the hybrid membranes, particularly the mechanical properties and biological stability was addressed in comparison with pure collagen membrane.

Materials and Methods

As starting materials, $Ca(OH)_2$, H_3PO_4 and type I collagen were used. The precipitation method was modified from the biomimetic method by coprecipitation [2]. The precipitates were filtrated using laboratory designed equipments and freeze-dried. As a reference, a pure collagen membrane is made similarly. To enhance the chemical stability, all the membranes were cross-linked with EDC-NHS solution for 24 h. For uniform thickness the membranes were warm-pressed and sterilized. Thermal analysis was carried out on the samples to calculate the mineral amount. Phase and morphology of the membranes were evaluated using XRD and SEM. Mechanical properties of the samples prepared in a rectangular form were evaluated using Instron. Enzymatic stability of the membranes was assessed with collagenase medium prepared at different concentrations for different times.

Results and Discussion

The XRD and FTIR analyses of the collagen-apatite membranes showed a typical structural evolution of apatite and collagen, as previously observed [2]. Based on thermal analysis, the mineral amount obtained was slightly lower than that initially added: 18 and 35% respectively for the initial 20 and 40% apatite. The freeze-dried membranes had a porous and layered structure at all compositions. Moreover, the internal structure was constituted of long collagen fibers and precipitated apatite nanoparticles. Of particular note, the hybrid membranes exhibited significantly higher ultimate tensile stress (UTS) than the pure collagen membrane (Fig. 1). The strength of hybrid membrane with 40wt% apatite was three times higher than that of pure collagen. Moreover, elastic modulus (E) of the hybrid membrane was also improved significantly when compared to that of pure collagen. From the results, apatite nanocrystallines are considered to reinforce effectively the matrix of collagen. The degree of swelling of the hybrid membrane was also reduced significantly when compared to that of pure collagen membrane, suggesting the hybrid membrane decreased the volume change in solution. More importantly, the hybrid membranes had improved enzymatic stability than the collagen (Fig. 2). When considering that one of the main problems of collagen in practical use as GBR membrane is its fast degradation prior to cell recruitment and reconstruction of bony tissues, this reduced degradation of the hybrid membrane suggested high potential for use in GBR applications. Further in vivo animal study on the hybrid membranes is currently underway.

Materials	Collagen	20wt%HA	40wt%HA
Tensile strength (MPa)	0.44 ±0.14	1.55 ±0.34	2.37 ±1.01
Elastic modulus (MPa)	9.10 ±3.88	41.80 ±7.43	82.57 ±16.41

Figure 1. Mechanical properties of hybrid membranes

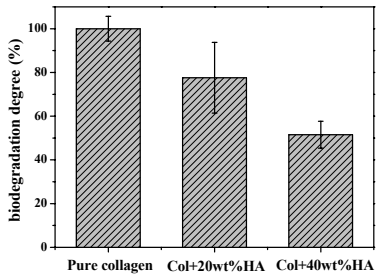

Figure 2. Enzymatic stability hybrid membranes

Conclusion

Hybrid membranes constituted of collagen and apatite mineral were successfully fabricated via modified co-precipitation and filtration processes. The mechanical, physical and biological properties of the hybrid membranes were systematically observed in comparison with those of pure collagen. Results provided significant improvements particularly in the tensile strength and chemical stability by the hybridization. Present finding suggested the potential usefulness of the collagen-apatite membrane in GBR fields.

References

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