Degradation behavior of hyaluronic acid-gelatin scaffolds intended for intestine tissue engineering

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Abstract:
Intestinal tissue engineering is an emerging field due to a growing demand for intestinal lengthening and replacement procedures secondary to massive resections of the bowel. Damaged segments of intestinal tissue require surgical interventions, which can lead to malnutrition eventually resulting in high mortality and morbidity rates. There is also a clinical demand for generating physiologically functional intestinal replacement. The challenge in tissue engineering functional intestinal replacement lies in the anatomic complexity of this tubular organ. In this way the regeneration and degradation behavior of scaffolds play a crucial role.

1. Fabrication of intestine scaffolds:
In this study, the development of three-dimensional (3D) scaffolds with highly porous structure has been demonstrated. Gelatin/collagen hybrid scaffolds in corporation with Hyaluronic acid (HA) were prepared by freeze-drying their blending solutions and subsequent chemical cross-linking by using genipin. It was found that the porous structure of scaffolds can be tailored by varying the ratios of HA to gelatin/collagen, the degradation rate increased with the increase of HA content in hybrid scaffolds, and cross-linking the scaffolds with genipin improved the degradation resistance of the scaffold in culture media. The combined results of the physicochemical and biological studies suggested that the developed gelatin/collagen HA hybrid scaffolds exhibit good potential and biocompatibility for tissue engineering applications.

Fig. 1. SEM images of porous scaffolds before incubation in PBS.

2. Pore diameter distribution of the scaffolds:
Fig. 2 shows the diameter distribution of scaffolds. For instance, the average pore size was 224 ± 209 µm for GCHA1 scaffold (Fig. 1A), but it decreased to 194 ± 71 µm for GCHA2 scaffold (Fig. 1C) which have a HA content of 5%. When the content of HA increased to 15% and 25% the pore size increased to 256 ± 90 for GCHA3 and 415 ± 159 for GCHA4 scaffold, respectively (Fig. 1 D, E). As illustrated in Fig. 4, the GCHA1 and GCHA2 scaffolds showed a percentage weight loss of 51% and 53% after degradation for 28 days, while for GCHA3 and GCHA4 there is a remarkable weight loss in the last week. It is noted that the highest weight loss percentage of scaffolds occurred during the last week of in vitro degradation by increasing the content of HA. This degradation behavior might be due to both saturation and pH change of the degradation solution over time, which inhibits the subsequent dissolving of HA from scaffolds.

3. Degradation behavior of the scaffolds in PBS solution:
Fig. 3 shows SEM micrographs of various scaffolds after 4 weeks of incubation in PBS. Although the scaffolds still remained the porous structure after 4 weeks, the breakdown of the pore walls became aggravated as the HA content increased from 1% to 25%. However, in the GCHA3, 4 scaffolds (Fig. 3 B, D) the porous structure became destroyed.

As illustrated in Fig. 4, the GCHA1 and GCHA2 scaffolds showed a percentage weight loss of 51% and 53% after degradation for 28 days, while for GCHA3 and GCHA4 there is a remarkable weight loss in the last week. It is noted that the highest weight loss percentage of scaffolds occurred during the last week of in vitro degradation by increasing the content of HA. This degradation behavior might be due to both saturation and pH change of the degradation solution over time, which inhibits the subsequent dissolving of HA from scaffolds.

4. Summary:
In this study, gelatin/collagen-based scaffolds have been successfully prepared. The effect of further addition of HA into the structure of the scaffolds has been evaluated in terms of microstructure and degradation behavior of the final scaffolds. According to the obtained results, the addition of HA in the scaffold matrix caused a slight increase in the pore diameter of the scaffolds. In addition, by addition of HA the degradation rate of the scaffolds became lower, and after three weeks it was a significant decrease in the mass loss of the scaffolds in PBS solution.

References: