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In Vitro Evaluation of a Chitosan-Based Adhesive to Treat Bone Fractures

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Abstract : Complex fractures located in articular surfaces are challenging to treat and their reduction with conventional treatments could compromise the functionality of the affected limb. An adhesive material to treat those fractures is desirable for orthopedic surgeons. This adhesive must be biocompatible and have a high adhesion to bone surface in an aqueous environment. The proposed adhesive is based on chitosan, given its adhesive and biocompatibility properties. Chitosan is mixed with calcium carbonate and hydroxyapatite, which contribute to structural support and a gel like behavior, and glutaraldehyde is used as a cross-linking agent to keep the adhesive mechanical performance in aqueous environment. This work aims to evaluate the rheological, adhesion strength and biocompatibility properties of the proposed adhesive using in vitro tests. The gelification process of the adhesive was monitored by oscillatory rheometry in an ARG-2 TA Instruments rheometer, using a parallel plate geometry of 22 mm and a gap of 1 mm. Time sweep experiments were conducted at 1 Hz frequency, 1% strain and 37°C from 0 to 2400 s. Adhesion strength is measured using a butt joint test with bovine cancellous bone fragments as substrates. The test is conducted at 5 min, 20min and 24 hours after curing the adhesive under water at 37°C. Biocompatibility is evaluated by a cytotoxicity test in a fibroblast cell culture using MTT assay and SEM. Rheological results concluded that the average gelification time of the adhesive is 820±107 s, also it reaches storage modulus magnitudes up to 106 Pa; The adhesive show solid-like behavior. Butt joint test showed 28.6 ± 9.2 kPa of tensile bond strength for the adhesive cured for 24 hours. Also there was no significant difference in adhesion strength between 20 minutes and 24 hours. MTT showed 70 ± 23 % of active cells at sixth day of culture, this percentage is estimated respect to a positive control (only cells with culture medium and bovine serum). High vacuum SEM observation permitted to localize and study the morphology of fibroblasts presented in the adhesive. All captured fibroblasts presented in SEM typical flatted structure with filopodia growth attached to adhesive surface. This project reports an adhesive based on chitosan that is biocompatible due to high active cells presented in MTT test and these results were correlated using SEM. Also, it has adhesion properties in conditions that model the clinical application, and the adhesion strength do not decrease between 5 minutes and 24 hours.

Keywords : bioadhesive, bone adhesive, calcium carbonate, chitosan, hydroxyapatite, glutaraldehyde
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