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Experimental Research of Canine Mandibular Defect Construction with the Controlled Meshy Titanium Alloy Scaffold Fabricated by Electron Beam Melting Combined with BMSCs-Encapsulating Chitosan Hydrogel

Authors : Wang Hong, Liu Chang Kui, Zhao Bing Jing, Hu Min

Abstract : Objection We observed the repairment effection of canine mandibular defect with meshy Ti6Al4V scaffold fabricated by electron beam melting (EBM) combined with bone marrow mesenchymal stem cells (BMMSCs) encapsulated in chitosan hydrogel. Method Meshy titanium scaffolds were prepared by EBM of commercial Ti6Al4V power. The length of scaffolds was 24 mm, the width was 5 mm and height was 8mm. The pore size and porosity were evaluated by scanning electron microscopy (SEM). Chitosan /Bio-Oss hydrogel was prepared by chitosan, β- sodium glycerophosphate and Bio-Oss power. BMMSCs were harvested from canine iliac crests. BMMSCs were seeded in titanium scaffolds and encapsulated in Chitosan /Bio-Oss hydrogel. The validity of BMMSCs was evaluated by cell count kit-8 (CCK-8). The osteogenic differentiation ability was evaluated by alkaline phosphatase (ALP) activity and gene expression of OC, OPN and CoI. Combination were performed by injecting BMMSCs/ Chitosan /Bio-Oss hydrogel into the meshy Ti6Al4V scaffolds and solidified. 24 mm long box-shaped bone defects were made at the mid-portion of mandible of adult beagles. The defects were randomly filled with BMMSCs/ Chitosan/Bio-Oss + titanium, Chitosan /Bio-Oss+titanium, titanium alone. Autogenous iliac crests graft as control group in 3 beagles. Radionuclide bone imaging was used to monitor the new bone tissue at 2, 4, 8 and 12 weeks after surgery. CT examination was made on the surgery day and 4 weeks, 12 weeks and 24 weeks after surgery. The animals were sacrificed in 4, 12 and 24 weeks after surgery. The bone formation were evaluated by histology and micro-CT. Results: The pores of the scaffolds was interconnected, the pore size was about 1 mm, the average porosity was about 76%. The pore size of the hydrogel was 50-200μm and the average porosity was approximately 90%. The hydrogel were solidified under the condition of 37℃in 10 minutes. The validity and the osteogenic differentiation ability of BMSCs were not affected by titanium scaffolds and hydrogel. Radionuclide bone imaging shown an increasing tendency of the revascularization and bone regeneration was observed in all the groups at 2, 4, 8 weeks after operation, and there were no changes at 12weeks.The tendency was more obvious in the BMMSCs/ Chitosan/Bio-Oss +titanium group and autogenous group. CT, Micro-CT and histology shown that new bone formed increasingly with the time extend. There were more new bone regenerated in BMMSCs/ Chitosan /Bio-Oss + titanium group and autogenous group than the other two groups. At 24 weeks, the autogenous group was achieved bone union. The BMSCs/ Chitosan /Bio-Oss group was seen extensive new bone formed around the scaffolds and more new bone inside of the central pores of scaffolds than Chitosan /Bio-Oss + titanium group and titanium group. The difference was significantly. Conclusion: The titanium scaffolds fabricated by EBM had controlled porous structure, good bone conduction and biocompatibility. Chitosan /Bio-Oss hydrogel had injectable plasticity, thermosensitive property and good biocompatibility. The meshy Ti6Al4V scaffold produced by EBM combined BMSCs encapsulated in chitosan hydrogel had good capacity on mandibular bone defect repair.

Keywords : mandibular reconstruction, tissue engineering, electron beam melting, titanium alloy
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