REGENERATION OF SKELETAL TISSUES ON JOINT

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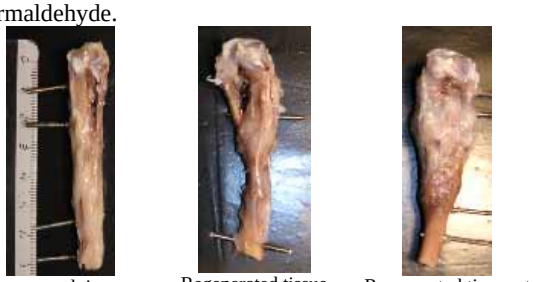
INTRODUCTION

The study concerns the regeneration of skeletal tissues (bone, cartilage, tendon, and ligament). It is possible to initiate, in vivo as well as in vitro, mesenchymal tissue regeneration, involving progenitor cells. This process recapitulates some cellular event of embryonic skeletal formation. If progenitor proliferation and differentiation pathways can be controlled, it is conceivable that a functional joint may be regenerated. The goal of this study is to analyse the mechanical factors regulating locally mesenchymal cell proliferation and differentiation pathways towards functional skeletal tissues production. This work is a first step to analyse undifferentiated cells as far as bone regenerated.

Experimental studies in vivo and in vitro are developed. This combined approach associating mechanical and biological analyse of the cellular events provides a powerful tool in understanding the regulation mechanisms of functional tissue engineering in vivo and in vitro.

METHODS

Our in vivo experimental studies were coupled together with in vitro experimental studies to be used in numerical modelling. Very few authors have studied the mesenchymal tissue [1, 2] because it is very difficult to analyse this soft tissue before its maturity. A process of skeletal tissue regeneration was initiated by a vascularized periosteal flap transfer in New Zealand white rabbit. Time between the initiation of the regeneration process and the first explants are 7, 14 and 21 days (Figure 1). Fresh samples were preserved in the formaldehyde.



Regenerated tissue at 7 days | Regenerated tissue at 14 days | Regenerated tissue at 21 days

Figure 1: Regenerated tissue

We developed an experimental INSTRON device which was used to analyse the mechanical properties of bones and ligaments [3 and 4]. This device is adapted to analyse the behaviour of the regenerated tissues. Samples were attached by a cable. They were tested with tensile tests as far as failure in order to characterize their mechanical properties and include them in a numerical finite element model. The displacement of the lower traverse beam was measured using an LVDT sensor (Linear Variable Differential Transformer), attached to the machine frame. The tensile load was measured by a strain gauge sensor with an uncertainty of measurement of 1% on the upper traverse beam.

RESULTS AND DISCUSSION

From these results, the mechanical properties of compact bone were deduced where failure occurred. Force-displacement curve obtained for a 14 days sample (Figure 1) was divided into four parts.

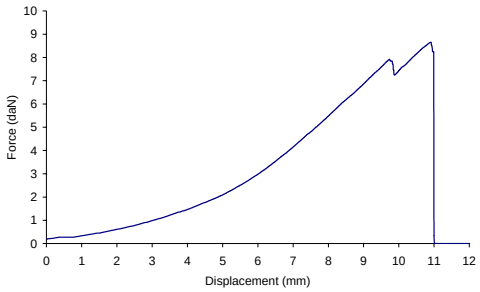


Figure 1

The first part of the curve corresponds to the setting in tension of the cables. On the second part of the curve the behaviour is linear elastic. On the third part, one could observe that the behaviour became non-linear, showing that the material was damaged ductile. In the final stage failure occurred. The damaging part of the bone behaviour is divided in two picks. The first one represents the failure of a first fibre networks constituted by a soft material comparable to a cartilage. The second one represents the failure of second fibre networks which is more mineralised.

CONCLUSIONS

This study is a first step to analyze precisely the tissue regenerated by immature cells. The second step is to regenerate joint cartilaginous tissue because of the weak potential of spontaneous repairing of these tissues. The perspectives of this work concern the development of engineer processes tissue allowing the production of cartilage implants, and of biomaterials of joint resurfacing.

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