Scottish Executive Health Department Chief Scientist Office

FOCUS ON RESEARCH

Assessment of the Osteogenic Nature of Commercial Bone Substitutes Using a Novel Bioreactor

Researchers
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Aim

1. To determine whether currently available bone substitutes differ in their ability to support bone growth
2. To ascertain whether deformations engendered under physiological levels of mechanical loading (exercise) alters the bone forming (osteogenic) potential of bone substitutes
3. To establish whether our findings regarding the relationship between scaffold material properties, deformation and bone growth may be used to design an improved geometric scaffold for use in the clinic.

Project Outline/Methodology

Bone substitutes are used to aid the repair of bone and to fill gaps caused by disease or trauma. To work well, these substitutes should not only support new bone infiltration (osteoconduction) but also encourage new bone formation (osteoinduction) at the repair site. Six different commercial bone substitutes were tested under physiological loading (exercise) conditions using a unique biological testing device (a bioreactor). These included samples made from calcium phosphate, collagen, and a synthetic polymer. The substitutes were seeded with human bone-forming osteoblast cells and then placed in individual chambers in the bioreactor. Substitutes were exposed to a daily "exercise" routine which consisted of imparting set strains or loads to the samples in a waveform corresponding to physiological jumping. Samples were then assessed according to initial cell adhesion, viability, and new bone formation (mineralisation) of the substitute.

Key Results

Deformations (Strains) caused by loading (exercise) had a clear impact on mineralisation of the bone substitute: samples that were exposed to daily loading for 2 weeks were mineralised while the non-loaded samples were not mineralised. The degree and type of mineralisation was dependent on the substitute material. The collagen scaffold was associated with the most mineralisation, followed by the calcium phosphate substitute. The synthetic polymer did not show any mineralisation after 14 days.

Mineralisation occurred on the surface of the calcium phosphate substitute and in contrast, within the collagen material itself.

Conclusions

Physiological loading enhances bone formation on some but not all commercial bone substitutes.

What does this study add to the field?

These preliminary studies are the first to compare the load-engendered bone forming potential of commercially available bone substitutes directly and to demonstrate differences in this regard.

Implications for Practice or Policy

The knowledge gained in these studies points to the likely benefit of some bone substitutes over others in a clinical setting. The efficient healing / repair of bones in our expanding elderly population represents a key healthcare policy target.

Where to next?

Having identified clear differences in exercise induced bone forming potential between bone substitutes, we are currently planning a study to determine whether our results predict the outcome in a group of patients. If so, this would inform surgeons as to the best type of bone substitute for a given application.

After further validation of these preliminary studies has been undertaken, knowledge gained from this work will be used to develop a new scaffold for use in bone repair and tissue engineering of human bone.

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