INVESTIGATION OF OSTEOCLAST RESPONSE TO DIFFERENT FORMS OF Ti-20MO SUBSTRATES

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Keyword(s): In vitro biocompatibility, Ti-20wt%Mo substrates, Bone implant, Osteoblasts

Abstract
Due to bone trauma, tumor, deformity, and degeneration and also an increasingly aging population, there is a high demand for orthopaedic implants. In this study, foetal murine calvarial Osteoblasts (OB) were cultured on five different forms of Ti-20Mo (in wt.%) alloy for 7 days: coarse-grained β-(Ti-20Mo), nanostructured β-(Ti-20Mo) (NS1), nanostructured Ti-20Mo alloy with a mixed structure of α and β (NS2), and nanostructured Ti-20Mo alloy (β+α) with two different types of surface porous structures (NP1: 40-50 nm pores and NP2: 300-400 nm pores), benchmarked against as-cast Grade 2 commercially pure Ti (CP-Ti). The surface topographies were analyzed using atomic force microscopy and scanning electron microscopy. The cellular adhesion, numbers of cells and cellular morphology were evaluated for both the OB and BAEC based on the observations obtained from confocal microscope imaging. It was observed that the OB behaved differently on different titanium substrate topographies. These results revealed that the surface characteristics of titanium (Ti) substrates are important factors that affect osseointegration.

References

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EXPLORING THE “STARTREACT” PARADIGM IN POSTURAL RESPONSES OF YOUNG HEALTHY PARTICIPANTS

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Introduction
Pedunculopontine nucleus (PPN) deep brain stimulation (DBS) for Parkinson’s Disease (PD) provides encouraging benefit to gait and posture difficulties [1]. Therapeutic mechanisms of PPN DBS on postural instability are poorly understood, and can be elucidated using the “StartReact” paradigm [2], where reaction times (RT) are sped up by a startling auditory stimulus (SAS) [3]. Startle pathways involve brainstem structures thought to influence gait and posture [4]. Using a novel instrumented pull test, and an elbow flexion task as a control condition, our study aims to investigate the interaction of a SAS on postural responses by determining potential differences in postural RT to a SAS.

Methods
After giving informed consent, five males and four females (22-35 years), performed 35 ballistic elbow flexion and 35 pull test trials each. In the pull test, an examiner pulled the participant backwards using a force-gauge harness. An auditory cue randomised at 90 dB (normal) or 116 dB (SAS) was synchronised with initiation of each pull by automated force thresh-holding. RT to maximum elbow flexion and RT to pulls were measured using surface electromyography of biceps brachii and tibialis anterior respectively. Differences in RT between normal cue and a SAS were calculated for each task using independent t-tests.

Results
Elbow flexion RT (106±30.7 ms) (Mean±SD) to a SAS were faster ($p < 0.01$) than normal stimulus (127±46.0 ms). Postural RT (126±65.8 ms) to a SAS did not differ ($p = 0.922$) from normal stimulus (127±61.9 ms).

Discussion
“StartReact” was found in elbow flexion but not in a postural response. This suggests postural responses elicited by a backward perturbation triggers automatic reflex RT that cannot be further accelerated by a SAS. This response could be diminished in PD patients experiencing postural instability and restored by PPN DBS. We will explore this interaction in future studies.

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Functional connectivity assessment of language areas in CI users using fNIRS

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Keywords: cochlear implant users, low frequency fluctuations, functional connectivity, functional near-infrared spectroscopy.

Abstract
Understanding functional re-organization of the brain after cochlear implantation plays an important role when investigating the performance on speech understanding of cochlear implant (CI) users during rehabilitation. Functional near-infrared spectroscopy (fNIRS) - likely to be a suitable neuroimaging modality for CI users - offers ways to measure brain hemodynamics. With the hypothesis to detect functional connectivity differences between normal-hearing listeners (NH) and CI user as well as differences among CI users, we conducted a resting state functional connectivity study of the low frequency fluctuations (LFFs) < 0.1 Hz. Head motions, low frequency drifts, heartbeat, respiration, and unwanted physiological noise arising from blood flow regulation processes are the main sources of contamination in fNIRS signals that mask the underlying neural activation patterns during rest. Efficient removal of these nuisance effects is a pre-requisite to determine meaningful functional connectivity maps. A pre-processing strategy for recovering resting state functional connectivity networks from fNIRS data is presented and tested on two different population groups: NH vs CI. Comparing 4 NH listeners and 5 CI users, we observed a consistent lower inter-hemispheric connectivity across CI users.

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THE FORMATION OF HUMAN CAPILLARY NETWORKS FROM THE INJECTION OF HUMAN MICROVASCULAR ENDOTHELIAL CELL SPHEROIDS INTO A MURINE TISSUE ENGINEERING CHAMBER AND DERMAL POCKET WOUNDS

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Keyword(s): Biomedical Engineering

Abstract

BACKGROUND: The rapid formation of vascular networks is vital for the survival of three dimensional tissue engineered constructs after implantation and for effective wound healing. Here we describe the implantation of human microvascular endothelial cells as multicellular spheroids to rapidly form vascular networks into a murine tissue engineering chamber and murine dermal pocket wounds. Multicellular spheroids may avoid anoikis, a programmed cell death caused by the loss of cell-cell and/or cell-matrix interactions.

METHOD: In vitro: Spheroids of 5,000, 10,000 and 20,000 cells were formed from human blood microvascular endothelial cells (hMEC) and human lymphatic microvascular endothelial cells (hLEC) and cultured in fibrin gel for three days to assess capillary-like sprout formation. In vivo: Spheroids of 5,000 cells were implanted into a mouse tissue engineering chamber that included the host epigastric vascular pedicle. After two weeks, the chambers were harvested and sectioned. Spheroids of 10,000 cells were injected into murine dermal pocket wounds. After one week, the wounds were harvested and sectioned. Immunohistochemical labelling of the chamber and wound sections with anti-human vimentin and anti-human CD31 was completed to assess human capillary formation.

RESULTS: In vitro: hMEC and hLEC spheroids sprouted capillary-like structures in vitro and displayed no significant differences in the average number of sprouts observed per plane between 5,000, 10,000 and 20,000 cell spheroids (hMEC: 9-11; hLEC: 11-18; n=3), nor in the average lengths of the sprouts (hMEC: 130-183 µm; hLEC: 169-213 µm; n=3). In vivo: Anti-human vimentin and anti-human CD31 positive capillaries containing mouse blood in the lumen were identified in spheroid injected chambers and wounds.

CONCLUSION: Human microvascular endothelial cells injected as multicellular spheroids into the mouse tissue engineering chamber and dermal pocket wounds form putative functional vascular networks and may potentially be used in other tissue engineering and wound healing applications.

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 UTILISING AMBULATORY EEG TO EXPLORE GAIT INITIATION FAILURE IN PARKINSON’S DISEASE

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Keyword(s): The Biomedical Engineering Workforce, Biomedical Engineering leading Health

Abstract

Gait Initiation Failure (GIF) is one of the most disabling gait disturbances of advanced Parkinson’s disease, described as the phenomenon where PD patients are unable to initiate the first step in order to start walking [3]. Failure to initiate the first step often precipitates falls; leading to an increased morbidity and subsequent nursing home placement. As such, this study utilized a novel ambulatory EEG technique to compare periods of GIF with periods of effective starts (GS) in a single PD patient during TUG tasks. Specifically, we set out to identify the brain activation pattern underlying GIF phenomenon.

134 samples data (62 GS and 72 GIF) collected from frontal, central, parietal and occipital regions were filtered and extracted into: theta, alpha, low beta and high beta band using FFT. Brain connectivity measurement was calculated by dDTF and mapped based on the peak of strength causal interactions originating at each pair electrodes.

In the investigation of PSD, the GIF episodes were associated with significant increases in the high frequency beta power (22-38Hz) in different areas of the brain, including the motor-frontal cortices. We proposed these changes of high beta oscillatory over central-frontal might reflected an inhibitory signal from the basal ganglia, which are likely to be associated with the inability to start walking during GIF in PD patients [2, 4]. In addition, effective connectivity analyses revealed that during GIF the motor cortices are “shut down” whilst the frontal regions try to overcome this connectivity loss. Frontal may be activating in an attempt to overcome GIF by communicating with other regions in order to break the GIF, getting primary motor regions to activate again [1].

The current finding demonstrated that GIF episodes might be associated with a “stopping” signal beta and affected more by the motor planning-execution in the center of the brain.

References


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ADVANCE MANUFACTURING OF AN OPTIMIZED AORTIC VALVE

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Keyword(s): Clinical Engineering, Biomedical Engineering leading Health.

Abstract

Aortic Valve Replacement (AVR) is the second most frequent cardiac operation after coronary artery bypass grafting[1] where Aortic Stenosis (AS) is accounted for the most prevalent cause of (AVR). Currently available prosthetic Heart Valves (PHV) are linked to the risk of thromboembolic and hemorrhagic complications, and bioprosthesis valves need to be replaced after 10–12 years in most patients due to its progressive tissue deterioration[2-4]. In contrast, Polymeric Valves (PVs) have superior biostability and durability and a good hydrodynamic performance. The design, material, and manufacturing process of PVs determine the functionality of the valve. In the last decade or so several valve designs were investigated and reported in literature [5, 6]. However, current designs still have number of drawbacks including high shear stress, poor stress distribution, and impaired flow dynamics. A tri-leaflet valve was designed to have superior hemodynamics and excellent mechanical integrity. The design was optimized in the series of Fluid Structure Interaction (FSI) to improve the durability of the valve[7]. Solution cast film of Bionate® Thermoplastic Polycarbonate urethane (PCU) with 5 mm thickness was used to construct the leaflets. Electron beam melting (EBM) technique was used to construct the mold to form the leaflets. The leaflets were shaped to the optimized geometry by pressing the Bionate film between the molds for two hours in 170C°. The leaflets attached to a 3D printed stent made from a composite polymers [8]. The fabricated valve was tested in a pulse duplicator device and the valve dynamics were validated against published data. It can be concluded that the optimized valve possessed high hemodynamic performance with no sign of damaging stress concentration found throughout the entire cardiac cycle, ensuring superior mechanical integrity. Furthermore, the manufacturing technique used to fabricate the valve showed a number of advantages over the current ones including high reproducibility, no thickness variations, and faster manufacturing time.

References


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