Comparison of resistive and optical strain measurement for early fracture detection

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To increase learning success in surgical training, physical simulators are supplemented by measurement technology to generate and record objective feedback and error detection. An opportunity to detect fractures following hip stem implantation early can be measurement of occurring strains on bone surface.
This strains can be determined while using strain gauges, digital image correlation (DIC) or photoelasticity. In this research strain gauges and DIC were compared regarding their suitability as strain measurement tools for use in physical simulators.
Therefore a testing method was described to replicate the implantation of a hip stem. Testing devices modelled on a realistic prosthesis were pressed into prepared porcine femora in a two-step procedure with a material testing machine. The local strains occurring on bone surface were determined using an optical measurement system for DIC and strain gauges.
The initial fracutres in the testet femora are located medial-anterior in most cases (73,6 %). With increasing indentation depth of the test device the strains on bone surface increase. Comparing the local strains determind by DIC and strain gauges consistencies in curves are noticeable. Maximal determind strains before fracturing amount to 0,69 % with strain gauges and 0,71 % with DIC. In the range of the fracture gap strain gradients are determind by using DIC. However the detected surfaces are of low quality caused by gaps and motion artefacts.
The results show strains on bone surfaces for early fracture detection are measurable with strain gauges and DIC. Variations are due to non linearities of strain gauges on high strains and partially losses of surface information for DIC caused by motion artefacts and fracture gap. Therefore DIC is assessed as less suitable compared to strain gauges. Furthermore strain gauges have greater level of integration and economic efficiency, so they are preferred for the use in surgical training simulators.

Recognition of tenogenic differentiation using convolutional neural network

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Introduction

Methodologies to asses stem cell differentiation in the culturing state are needed for regenerative medicine and tissue engineering techniques. In recent years, convolutional neural networks (CNNs), a class of deep neural networks, have made impressive advancements in image-based classification, recognition and detection tasks. CNNs have been introduced as a non-invasive cell characterization method by learning features directly from image data of unlabeled cells. Furthermore, this approach serves as a rapid and inexpensive methodology with high performance compared to traditional techniques that require complex laboratory procedures including antibody staining and gene expression analysis.

Methods

Here, we studied the potential of the CNN approach to recognize stem cell differentiation based on cell morphology utilizing phase-contrast microscopy images.We have examined the differentiation potential of bone marrow mesenchymal stem cells (BMSCs) into tenocytes, with the treatment of bone morphogenetic protein-12 (BMP-12). After treatment, the phase-contrast images of cells were obtained directly from cell culture flasks to train CNN and the differentiated phenotype of stem cells was characterized by immunostaining.

Results

CNN was able to classify the cells into three groups including non-stem cells (chondrocytes), stem cells (BMSCs) and differentiated stem cells (tenocytes) based on their morphology with 92.2 % accuracy.

Conclusion

The presented study revealed that CNN performed faster and non-invasive cell classification task compared to traditional methodologies.

Comparison of Results from a Spasticity Assessment of the Ankle Joint using the Tardieu Scale and EMG Activity Recorded Simultaneously in Stroke Patients

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Introduction

Spasticity arises in over 30% of stroke patients. Transcutaneous Spinal Cord Stimulation (tSCS) has proven to alleviate spasticity in SCI patients but the influence of tSCS on the spinal cord circuitry is unknown. In the presented work we firstly explore the correlation of ankle joint flexibility and muscle activity in the lower limb muscles and secondly, the effects of tSCS on ankle joint flexibility in stroke patients.

Methods

Data was collected on four stroke patients (mean age 65.5 ± 7.6 years) with spastic hemiplegia in four phases (A1, B1, A2, B2) of alternating baseline (A) and intervention (B) with an 18 to 24 weeks washout period in between B1 and A2. The intervention consisted of a 30-minute home application of tSCS daily for three weeks. The Tardieu Scale test and a simultaneous EMG recording from the tibialis anterior (TA) and triceps surae (TS) muscles were included in each session. Muscle reaction and ankle joint flexibility are examined.

Results

An evident correlation between the flexibility of the ankle joint and the EMG muscle activity is observed. An increase in flexibility after the treatment was consistently experienced, with the exception of phase 1 for subject 6. On the other hand, a direct correlation between increase in flexibility and decrease in EMG activity is not observed. The RMS of the EMG activity recorded during the Tardieu test is evenly distributed and does not show any tendency to increase or decrease after treatment.

Conclusion

Our results suggest that the tSCS treatment does improve the quality of muscle reaction but does not necessarily decrease the EMG muscle activity concurrently. Also substantial correlation between muscle activity and flexibility and that tSCS can be helpful in improving the range of motion of joints in individuals with spasticity.

Dynamics of intermuscular coupling in unilateral transfemoral amputees

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Introduction

Patients with an unilateral transfemoral amputation present an impaired control of balance due to the loss of sensory feedback, a reduced base of support and an increased joint stiffness. In this work, we compared the dynamics of intermuscular coupling during quiet standing between amputees and able-bodied participants.

Methods

Ten unilateral transfemoral amputees (age: 55.50 ± 11.35 yr.) and ten able-bodied age-matched controls (age: 52.30 ± 10.26 yr.) were recruited. All participants provided a written informed consent (ethical approval N° 230/18). EMG signals were recorded from the Tibialis anterior (TA), Gastrocnemius (GA), Erector spinae (ES), and Obliquus externus (OE) muscles during three 30-s trials of quiet standing with eyes open (EO) and eyes closed (EC). The EMG signals were filtered (1-500 Hz and 50 Hz) and rectified. The wavelet coherence between EMG signals of each muscle pair was then computed. The coherence values were averaged for the 5-20 Hz frequency band. The entropic half-life (EnHL) was then computed on these time series. The EnHL values were averaged across trials for both conditions. A mixed ANOVA was implemented for statistical analysis.

Results

At the 5-20 Hz frequency band, a more regular coupling (higher EnHL) was observed for the OE-ES muscle pair with EO. Removing vison reduced the regularity of the ES-TA coupling.

Conclusion

In this study, we investigated the dynamics of the coupling between muscles involved in the control of balance in transfemoral amputees and able-bodied controls. The 5-20 Hz frequency is associated with subcortical and spinal inputs, including the reticulospinal tract that has previously been associated with unconscious balance control. The differences observed in intermuscular coupling may reflect the loss of somatosensory feedback in amputees.

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Explanted Human Skin Acts as a Serious Alternative to Skin Mimicking Phantom Materials for Electrical Evaluations of AIMDs

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Introduction

Powering of active implantable medical devices requires an appropriate transcutaneous energy coupling, e.g. inductive, capacitive or ultrasonic. Both strategies are strongly dependent on the skin properties. Often, skin mimicking phantom materials are used for the in vitro evaluation of modern coupling methods. We propose to use explanted human skin instead, since it represents the complex electrical properties more accurate.

Methods

We compared the frequency dependent electrical properties of skin mimicking phantom materials and explanted human skin. Healthy human skin was taken from the abdomen of patients in a tissue reduction surgery. Experiments were performed after within 4 h after tissue explantation to minimize alterations. This study was approved by the ethical commission of the University Medical Center Freiburg (EK-Freiburg450/17). The design and performance of the study is in accordance with the Declaration of Helsinki. Signed informed consent was obtained from all participants.

Results

Despite the interruption of blood flow in the skin samples, the electrical properties were closer to literature containing regions of α- and β-dispersion. This behavior was not present in phantom materials although conductance and permittivity could be adapted.

Conclusion

For the evaluation of transcutaneous energy coupling, explanted human skin is a promising alternative to artificial phantom materials. Complex electrical behavior in a wide frequency was represented more accurate, whereas phantom material can be adjusted to a small frequency range only. In addition, evaluations of explanted human skin offer the possibility of reducing animal trials according to the 3R-concept (replacement, reduction, refinement). Explanted human skin is also the preferred alternative to skin samples taken from any animal, since it is closer to the final application. Further it is excess material and therefore the better option from an ethical point of view.

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Micro-Riveted Interconnections for Flexible Electrode Arrays

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Introduction

Electrical neuromodulation has become increasingly important as therapeutic approach for the treatment of various neural disorders and dysfunctions. The development of small and flexible neural interfaces is necessary to selectively target nerve structures for modulating pathological neural signals. A challenging task during fabrication is to ensure a reliable contact to the macroscopic measurement system. This work provides a comparison of different contacting approaches in terms of mechanical stability, electrical characteristics, process complexity and reproducibility.

Methods

In this study a micro-machined flexible microelectrode array is contacted to a customized printed circuit board (PCB) by either gluing with isotropic conductive adhesive (ICA) or by gold stud bumping (GSB). The electrical impedance spectrum of over 100 electrodes is measured before and after contacting the PCB by the respective method.
In addition, the shape, size and mechanical stability of the gold studs are evaluated by confocal light microscopy and shear force testing.

Results

Within the parameter study, a direct dependence of the ball stud properties on the applied ultrasonic force, power and time can be observed. Increasing each of the mentioned parameters results in a larger bump diameter and a higher measured shear force.
Comparing the two described methods in terms of reproducibility and impedance characteristics, contacts which are bonded by GSB have a significantly lower electrical impedance at 1 kHz than glued contacts (65 kΩ compared to 145 kΩ, both measured with electrodes of 30 µm in diameter). Furthermore, 100 % of the electrodes contacted by GSB show a reliable electrical contact while the yield of functional electrodes contacted by ICA is only 80 %.

Conclusion

GSB has proved to be a suitable method to electrically connect flexible neural interfaces to rigid adapters. In comparison to ICA, GSB excels in terms of reproducibility and electrical properties, while being less time consuming in processing.