Force Characterization and Rigidity Analysis of a Monolithic Cochlear Prosthesis Actuator

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Cochlear implants continue to be used in the treatment of profound deafness. Because of the tonotopic nature of the cochlea, more controlled insertion is perhaps the most important factor affecting device performance. The implant stiffness, and therefore the scala tympani (ST) wall contact force, contributes to insertion difficulties. Attempts to correlate the implant carrier structural properties and the intracochlear contact forces during insertion are limited. Researchers in the Michigan Center for Wireless Integrated Microsystems are developing perimodiolar-shaped silicon and parylene-based thin film cochlear electrode arrays and backing devices for a more controllable implantation. We report a method developed for measuring the thin film actuated electrode array rigidity to quantify the ST and modiolus wall contact forces during and after insertion. The method used a pneumatically actuated polyethylene terephthalate (PET) monolithic electrode actuator using pressurized air (0–200 kPa) for actuation. The prototype actuators consisted of PET tubes with an ID of 365 μm and a wall thickness of 58 μm. Force calculations using cantilever beam bending theory were performed to estimate the tube bending forces as a function of internal pressure and therefore variable structural stiffness. Based on estimations, a method was developed to measure such small forces avoiding the use of commercially available, relatively insensitive load cells. A fixture was fabricated incorporating two brass microcantilevers (reference and deflection arms) sensitive to sub-mN forces applied by the actuator on the deflection arm of the cantilevers. Microcantilver deflection data, captured by an interferometric microscope, was used to calculate the actuator force and eventually the reaction force acting on the actuator. The implant actuation forces ranged from 0–0.76 mN over an actuation pressure range of 0–140 kPa, from nearly straight to the relaxed perimodiolar post-implantation shape. For estimating the implant rigidity (EI), the actuator stiffness and the actuation pressure was correlated. The actuator stiffness at different actuation pressures was obtained both theoretically (using beam bending theory and PET tube structural properties) and experimentally (using the derived unconstrained actuator deflections at measured actuator forces). The theoretical and experimental stiffness values ranged from 3.6E-08 to 5.34E-07 N/μm and 2.5E-08 to 7.8E-06 N/μm respectively over the working pressure range. The calculated rigidity constant (EI) of the best prototype insertion tool from the experimental stiffness measurement was 6.71E06 Nμm^2. The insertion tool-ST wall contact forces were calculated, using the estimated rigidity, in a hypothetical insertion situation. Force calculations assumed that the implant is equipped with actuator deflection feedback sensors and the actuator's stiffness remains constant over its entire length for a given operating pressure. A contact force of 1.19 mN was found acting on the cochlear ST wall when the insertion tool hits the wall and deflects by 200 μm at an actuation pressure of 140 kPa.

The Development of a Novel Adaptive Seating System for Children with Neuromuscular Disorders

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Adaptive seating has been defined as the customized prescription and application of sitting support devices based on therapeutic principles. It is recognized that for children with neuromuscular disorders that result in poor postural control, a comfortable adaptive seating system that provides them with the support needed to maintain a sitting position can be essential for raising their overall level of well being. These systems are also used to try and prevent or to slow the progression of skeletal deformities. However, problems with current adaptive seating systems do exist. After extensive research into these problems we developed a novel adaptive seating system which aims to improve on current designs. It includes a number of innovative features including

• Active dynamic supports: The backrest and headrest are mounted on gas springs, allowing them to move in order to accommodate the user's task induced movement or abnormal muscle tone. The forces applied to and the position of the supports are monitored and used to control motors attached to the gas springs. This means that the user can, when required, be returned to their original position in a controlled but still dynamic manner. The "floating" nature of these supports, especially the backrest, is also intended to allow for some growth of the user.

• Novel backrest shape: In an attempt to positively influence abnormal hip extensor tone, the user's trunk is given a predominantly lateral rather than posterior type of support. Preliminary results suggest that this approach could have some beneficial effects in terms of reducing abnormal hip extensor tone.

• Multi-planar tilting seat base: Tilting of the base in the saggital and coronal planes can be actuated manually or pre-programmed to do so automatically at set intervals. This aims to improve user comfort and prevent the development of pressure sores and could also be used to accommodate deformities such as pelvic obliquities.

Through these features the novel system has the potential to provide improved comfort, support and functionality for the users and to reduce the burden place on those who care for them.

