Friction Reduction in Metal on Metal Hip Joint

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In the world, approximately 800,000 total hip replacements are implanted, while, at least 50,000 hip replacements are performed in the United Kingdom each year. Orthopaedic surgeons have traditionally delayed joint replacement surgery in patients younger than 60 due to its limited survivorship time and biological effect inside the human body. The highest percentage (71%) hip joint failure was caused by aseptic loosening of the femoral and acetabular components and the war rate and debris are the accepted causes of that aseptic loosening. The wear particles, either ion or stable form, can react with proteins and change the pH value of albumin solutions inside the human body, causing damage to the DNA resulting in genotoxicity. There has been a great deal of research into the materials, dimension of the prosthesis, surface roughness, and lubrication effect by surface coating. But it is very rare to apply surface texture technique to a metallic prosthesis bearing surface although it has proven very successful in many engineering applications including automobile industry due to secondary lubrication effect and hydrodynamic effect. A TE 77 high frequency friction simulator has been used for the experiment where specimens were manufactured with 50 mm diameters and 50 μm clearance. A dynamic loading was applied synchronized with Hip CD 98 while the temperature was controlled at 37°C. The output data including friction coefficient, friction force and contact pot were recorded in connected computer via COMPEND 2000 software. The surfaces were inspected after and before test under scanning electronic microscopy. The plateau honed surfaces were produced on the moving specimens with controlled load, speed and various grade of emery paper using a specially designed tool. The friction coefficient was recorded 0.035 for the honing surface which was made by 30 kg laod and 60 emery paper, 0.04 for the honing surface profile made by 30 kg load and 150 emery paper and 0.06 for plane surface after one million cycles. The rest of surfaces profiled surface were broken down before one million cycles. That made a conclusion that plateau honing surface made with 30 kg load and 60 emery paper was best surface texture profile (45° honed angle, 40 ± 10 μm width and 35 ± 10 μm depth honing) for the metal on metal hip prosthesis. The comparison experiment was continue for plane surface and plateau honing surface of 60 emery paper and 30 kg load up to one and half millions cycles. It was found that the friction coefficient (0.03) was further reduced 0.005 after one and half million cycles for plateau honing surface but it was increased nearly double (0.065) for plane surface. The static friction coefficient was also reduced 38% in case of that plateau honing surface. The contact pot profile which is an indicator of fluid film thickness was noticed higher in plateau honing surface. This was evidence that the lubrication distribution was better in plateau honed surface which should provide longer life of joint, reduce wear and improves acceptability of metal on metal hip joints.

Vibrotactile Balance Rehabilitation Gait Assist Device

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Visual, vibrotactile, and auditory cues have proven successful in numerous applications to supplement or in some cases completely replace missing sensory information. Sensory substitution using vibrotactile stimulation has been effective in improving postural stability during stationary tasks and tasks involving perturbed stance. The challenge increases, however, when designing a wearable device that provides meaningful information during a dynamic task such as walking. Techniques that directly apply the feedback strategies effective in stance (trunk tilt) to walking have largely proven ineffective (excluding heel-to-toe walking, which is essentially a series of standing balance tasks). We have demonstrated a device for correcting vestibulopathic gait using a novel feedback methodology that was co-developed with physical therapists specializing in balance rehabilitation. The device supplies vibrotactile cues based on factors during walking that are considered important by physical therapists, including gait velocity, stride length, and gaze. The device consists of three independent units, each consisting of an inertial measurement unit (IMU), vibrotactile display, and microprocessor. Head tilt (which approximates eye gaze), trunk tilt, stride length, and velocity are estimated by the IMUs and displayed to the patient in the form of vibrotactile cues on the head, trunk, and tibia, respectively. Algorithms were developed to estimate stride length and gait velocity in real time from measured heel-strike and toe-off events. Feedback of the head pitch angle is provided continuously to the subject, while gait velocity and stride length feedback are provided during heel strike events only. Preliminary results demonstrate that healthy subjects can interpret this feedback to correct their head pitch and adjust their stride length and gait velocity.

