EVALUATION OF BONE INGROWTH OF TITANIUM FIBER MESH WITH HYDROGEN PEROXIDE SOLUTION

Kim, T; Suzuki, M; Tamai, H; Watanabe, E; Ohtsuki, C; Osaka, A; Moriya, H
Department of Orthopedic Surgery, School of Medicine, Chiba University, Chiba-city, Japan.
1-8-1 Inohana, Chuou-ku, Chiba-city, 260-8677 Japan, 81-43-226-2117, uhi3116@uichi.hosp.chibamedu.ac.jp

INTRODUCTION
Fixation of arthroplasty implants to the bone is one of the most significant factors in obtaining satisfactory clinical outcomes in procedures such as total knee arthroplasty. Titanium and titanium alloys have excellent mechanical properties and biocompatibility. However, because they are encapsulated in fibrous tissue, they cannot directly bond to living body. Several attempts have already been made to devise methods to providing titanium with bioactivity, including hydroxyapatite coating. It is difficult to control the composition of such bioactive coatings, however, and equally hard to derive strong bonds with the substrates. This study concerns enhancing the bone bonding with titanium alloys, via treatment with a hydrogen peroxide solution containing tantalum chloride. We evaluate the bonding in terms of bone ingrowth and bonding strength of titanium fiber mesh surfaces alloy, and compare the results for hydrogen peroxide solution treated specimens and non.

MATERIALS AND METHODS
Implant
The implants were cubic titanium rods (Ti-6Al-4V), 7.6mm x 7.6mm x 20.0mm, consisting of a titanium fiber mesh surfaces. The fiber mesh surface of the rod had an average pore size of 250 micrometers to a depth of 1.0 millimeters. The rods were immersed in the hydrogen peroxid solution (30 vol%) containing tantalum chloride in concentration of 5 mmol/d at 60°C for 24 hours. The treated rod were washed with deionized and distilled water, and denoted as H2O2/Ta-Ti. The same titanium alloy rod without surface treatment was used as control.

Operative Technique
With use of a sterile technique, the implants were inserted bilaterally into the distal aspect of the femur of 18 beagle dogs. Each dog received one implant that was treated hydrogen peroxide solution and one that was not.

Histological Study
The nine dogs in the histological study group were sacrificed at five, eight weeks postoperatively. The specimens were fixed in ethanol, and embedded in methylmethacrylate.200-micrometer cross section from the specimen were mounted on slides and then polished to a thickness of fifty micrometers. Histomorphometric measurements were made with NIH imaging, to determine the bone ingrowth area of the fiber mesh surfaces. Bone ingrowth was measured in intervals of 500 micrometers and then averaged.

Mechanical Testing
The strength of the implant-bone-interface was evaluated with a pull-out test. The nine dogs were sacrificed at three, five, eight weeks postoperatively; the distal aspect of each femur was removed. Shearing force between implant and bone was measured by a pull-out test (Shimazu Autograph AGS-10KN) with a loading rate of 0.5mm/min.

RESULTS
Formation of bone on both the treated and the untreated implants increased with time. Bone ingrowth was consistently greater in the hydrogen peroxide solution coated implants, compared with the uncoated implants, and was significantly higher at five and eight weeks (Figure 1). With the coated implants, new bone was formed in the bottom of the interface. The shearing force of the hydrogen peroxide solution coated implants was higher than the control implants each weeks, and was significantly higher at three and five weeks (Figure 2).

DISCUSSION
The results indicate that titanium alloy treated with the hydrogen peroxide solution containing tantalum chloride can bond more tightly to bone than untreated titanium alloy. In this study, untreated tantalum metal induced few areas of direct bone implant apposition interface between bone and titanium alloy. Surface treatment with hydrogen peroxide solution containing tantalum chloride can provide apatite formation on titanium metal due to the formation of a high mount of Ti-OH group. The coexistence of tantalum ion or tantalum gel helps to induce apatite formation because tantalum hydrogel can also induce apatite formation. Previous reports demonstrated that HA coating alloy had more bone ingrowth than uncoated alloy. In HA coating, however, it is difficult to coat such surfaces uniformly and pore obstruction is likely to occur. This method has the advantage that it simply provides titanium metal with bone bonding ability, and is simple and economical compared with the HA coating technique.