INTRODUCTION
Complications in external fixation including pin track infection arise primarily from mechanical instability in the bone-screw interface (1). To solve the problem, Moroni et al (2) proposed plasma-sprayed hydroxyapatite as a suitable coating material to improve the bone-pin fixation and lessen these problems. Recently, Sogo et al (3) combined infusion fluids containing calcium and phosphate and obtained a calcium phosphate (CaP) precipitate on a hydroxyapatite plate. We think that CaP can be coated on titanium screws with a titanium oxide layer using the solutions, and hypothesize that the CaP-coated screw can improve fixation strength with bone. This study has been conducted to clarify the characteristics of the CaP coating on the screws and compare the fixation strength between CaP-coated screws and uncoated ones.

MATERIALS & METHODS
CaP coating on titanium screws with a titanium oxide layer
Five clinically available infusion fluids were combined; a calcium containing solution (8.17 ml, CaCl₂: 4.5 mM) compounded with Ringer’s solution (Otsuka Pharmaceutical Co., Ltd., Japan) and Conelyte®-Ca (Otsuka Pharmaceutical Co., Ltd., Japan), a phosphorus containing solution (0.92 ml, PO₄³⁻: 20 mM) compounded with Klinisalz® B (KOBAYASHI Pharmaceutical Co., Ltd., Japan) and Conelyte®-P (Otsuka Pharmaceutical Co., Ltd., Japan) and an alkalizer: Bifi® (0.91 ml, NaHCO₃: 166 mM) (AJINOMOTO PHARMA Co., Ltd., Japan). We used AO titanium cancellous screws from the company SYNTHES® (USA (# 407-030, 4.0 mm in diameter, 30 mm in length). Originally, the screws (Otsuka Pharmaceutical Co., Ltd., Japan), a phosphorus containing (KOBAYASHI Pharmaceutical Co., Ltd., Japan) and Conclyte®-P (Otsuka Pharmaceutical Co., Ltd., Japan) and an alkalizer: Bifi® (0.91 ml, NaHCO₃: 166 mM) (AJINOMOTO PHARMA Co., Ltd., Japan). We used AO titanium cancellous screws from the company SYNTHES® (USA (# 407-030, 4.0 mm in diameter, 30 mm in length). Originally, the screws were observed by a scanning electron microscope (SEM) equipped with an energy dispersive electron probe X-ray analyzer (EDX). The precipitates on the coated screw surfaces were observed with X-ray diffraction (XRD) patterns.
Surgical procedure for the animal experiments
Twenty skeletally mature male Japanese white rabbits weighing approximately 3.0 kg were used for this study. The coated screws were implanted in both proximal tibial metaphyses of ten rabbits, and ten other rabbits were operated as a sham control. Small (10mm) incisions were made in the skin at the medial proximal tibia. Then, tunnels 2.5 mm in diameter were drilled at both tibial metaphyses. The holes were tapped with individual taps for each screw, and the screws were manually inserted. After the implantation, the skin was tied with 3-0 nonabsorbable sutures bilateral the screw (Fig. 1). Then, all the animals were sacrificed 4 weeks after the operations and checked osteomyelitis using X-ray views.
Biomechanical analysis
A torque measuring device was used to measure the torque required to extract screws. The control group was fixed in 10 % neutral buffered formalin, undecalcified and decalcified sections. The specimens were cut perpendicularly to the tibial longitudinal axis and parallel to the screw hole. All specimens were H&E stained.

RESULTS
Characterization of the coated CaP
DISCUSSION
In this study, we coated titanium screws with a titanium oxide layer with a 300 nm thick apatite layer 300 nm thick was formed on the screw after the immersion in the supersaturated calcium phosphate solution prepared by mixing the infusion fluids. The apatite layer was nearly invisible to the naked eye (Fig. 2). In SEM, the precipitate morphologically identical to apatite formed a layer on the screw surface (Fig. 2). Calcium and phosphate were detected on the screw surface by EDX. The XRD patterns showed the presence of low-crystalline apatite on the coated screw- a broad peak ascribed to bone-like apatite was observed.

Biomechanical results for the animal experiments
We analyzed the extraction torque of the nineteen screws in the CaP coated group and the eighteen screws in the uncoated group (except for the osteomyelitis specimen). The extraction torque was 0.24 ± 0.07 newton-meters in the coated group, 0.18 ± 0.06 newton-meters in the uncoated group. It was significantly higher in the coated group than in the uncoated group (p = 0.0132).

Histological results
A greater amount of new bone was observed around the CaP-coated screw (Fig. 3a) than around the uncoated screw (Fig. 3b). In both the undecalcified and decalcified sections.

REFERENCES

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