Introduction:
Recently, opening high tibial osteotomy (HTO) has become popular because of its several advantages. Good long-term results after opening HTO using hydroxyapatite as a bone filler were reported. However, if severe varus or valgus knee deformity were to occur, fixing a component in the tibia during total knee arthroplasty might be difficult. In contrast, most of the porous beta-tricalcium phosphate (TCP) can be resorbed within a few years. However, the TCP with 75% porosity which we have used, had a compressive strength of only 3 MPa, which is inadequate for weight-bearing sites until bone incorporation occurs. Initially during HTO, we implanted autogenous iliac bone on the medial side of the tibia to support compression and filled the remainder of the defect with TCP having 75% porosity. Compressive strength can be increased by reducing porosity. Thus, we have recently developed wedge-shaped beta-TCP with 60% porosity exclusively for opening HTO. This TCP has a compressive strength of 20 MPa, which is approximately seven-fold greater than that of TCP with 75% porosity. In this study, we report bone formation and TCP resorption in the TCP implanted sites.

Materials and methods:
Since May 2003, medial opening HTO using TCP with 60% and 75% porosity without autogenous bone graft was performed in 54 patients who had a mean age of 64 years. During opening HTO, the opened defect was fixed with a Puddu plate, after which TCP with 75% porosity was used to fill the defect, except the medial side where a wedge-shaped TCP block with 60% porosity was implanted in front and back of the plate (Fig. 1,2). The opening of 7.5mm, 10mm, and 12.5mm was performed in 1, 24, and 29 patients respectively. Four to five weeks after surgery, partial weight-bearing was allowed and total-weight bearing was allowed at 7 to 8 weeks. All patients were followed up at regular intervals in our outpatient clinic and underwent radiographic examination. Biopsy samples were obtained from the 60% porosity TCP implanted sites (Fig. 2D) after TCP had been completely or nearly completely replaced by bone radiologically (Fig.1C), and were used for histological analysis. The surface area of the remaining beta-TCP and of bone was measured using an image analyzer and was expressed as percentage to the newly formed bone.

Results:
The results obtained from 39 patients who had surgery at least 1 year before showed that no correction loss had been found and bone formation was noted in all cases. Complete or nearly complete replacement of both 60% and 75% porosity TCP by bone was obtained 27 to 37 months after surgery (Fig.1C), and 7 patients agreed to removal of fixation devise and biopsies. During removal surgery, the TCP implanted sites in front and back of the plate were completely replaced by bone macroscopically (Fig. 2D) in all 7 cases. Histological examination of biopsies showed that good lamellar bone formation was noted in all 7 patients and the residual TCP was noted in 3 patients (Fig. 1D). The percentage of beta- TCP to bone in 3 patients was only 0.26% to 2.25 %.

Discussion:
We have used this technique in 54 patients and have observed no correction loss or nonunion. Resorption of beta-TCP is affected by patient’s age. The mean age in this study was 64 years. However, good TCP resorption was found even in the aged patients such as shown in Fig.1 Resorption of beta-TCP is also affected by porosity. Thus, we estimated that beta-TCP with 60% porosity required more time than that of beta-TCP with 75% porosity. However, the results showed that resorption of TCP with 60% porosity occurred and did not require more time. We speculated that the mechanical stress may facilitate bone formation and TCP resorption in the medial site of the tibia.

Histological findings obtained from 7 patients showed that complete or nearly complete bone healing was achieved in all cases. Bone formation and TCP resorption were also found by MR images after removal of the plate and screws.

The surgical technique used in this study did not require fibula osteotomy and it may produce few problems when TKA is necessary in the future. Autologous iliac bone graft was used until April 2003. However, since May 2003, the use of beta-TCP block with 60% porosity, which was approximately 7 times stronger than that with 75% porosity in terms of compressive strength, allowed avoidance of autogenous bone grafting and shortening of the surgical time.