Continuous Monitoring of the Migration of Cemented Cup Fixed with Impaction Bone Grafting with Different Bone/HA ratio

+1Kishida, S; 2Ida, S; 3Ohashi, H; 4Yamazawa, T; 5Tanabe, Y

1Chiba University, Chiba, Japan, 2Matsudo City Hospital, Chiba, Japan, 3Saiseikai Nakatsu Hospital, Osaka, Japan, 4Niigata University, Niigata, Japan

shnjksd@faculty.chiba-u.jp

Introduction

One of the greatest problems of revision hip arthroplasty (THA) is dealing with lost bone stock. Good results have been obtained with impaction grafting of allograft bone. However, there have been problems of infection, reproducibility, antigenicity, stability, availability of bone, and cost. Thus, alternatives to allograft have been sought. Hydroxypatite (HA) granules are commercially available and the mechanical properties are promised. By mixing of HA granules into bone chips, the volume and the mechanical strength of allografts might be supplemented. We investigated the initial mechanical stability of cemented cup fixed with impaction grafting. The unique point of our study was that the migration of the cup was continuously traced by a high-speed camera during cyclic loading and following load releasing period. The migration of the cup was evaluated in reference to the bone/HA ratio of the grafted materials.

Materials and Methods

A hemisphere defect of 60mm in diameter was made in composite test blocks (Sawbone). Bone chips were obtained from femoral heads of femoral neck fracture and hip osteoarthritis. The size of the bone chips varied from 6 to 10 mm. The size of HA granules (Neobone, Covalent Materials Ltd., porosity: 75%) varied from 2.0 to 5.0 mm. We tested 4 different bone/HA ratio; 100%/0% (HA 0%), 75%/25% (HA 25%), 50%/50% (HA 50%) and 0%/100% (HA 100%). Twenty grams of grafted materials were impacted by an impactor, and finally a weight of 550g was dropped from the height of 160mm 20 times, then a polyethylene cup was fixed with bone cement (Fig. 1). The specimen was mounted on the Biaxial material testing machine (858 Mini Bionix III). A dynamic load of 150 N to 1500 N with a frequency of 1 Hz was applied for 30 minutes, followed by a dynamic load of 300 N to 3000 N for 30 minutes (stage 1). After the load releasing for 15 minutes, a dynamic load of 300 N to 3000 N with a frequency of 1 Hz was applied for 60 minutes twice (stage 2 and 3). Between stage 2 and 3, the loads were released for 15 minutes.

The high-speed photography camera (motion analysis microscope, Keyence Co. Ltd) captures 15 images per second. The migration of the cup was calculated in each stage.

To investigate the fracture or deformity of bone chips and HA granules, the size of grafted materials was measured before and after loading.

Results

Figure 2 shows the migration of the cup at the start of 150N loading, the end of 1500N, the start of 3000N, and the end of 3000N in stage 1 and at the start of 3000N and the end of 3000N in stage 2. The amount of migration was small with increase of HA ratio. However, the gradient of cup migration increased with increase of HA ratio at the end of stage 3 (r = 0.62) (Fig. 3).

The size of HA granules in HA100 after loading was smaller than that before loading (Fig. 4).

![Fig. 1 Grafted materials with 4 different bone/HA ratio were impacted.](image1)

![Fig. 2 Migration of the cup at each loading point in stage 1 and 2](image2)

![Fig. 3 Gradient of cup migration at the end of stage 3](image3)

![Fig. 4 Size distribution of grafted materials before loading (MCB; mercerized cancellous bone, HA) and after loading (HA0, HA25, HA50, HA100)](image4)

Discussion

In this study, we continuously traced the migration of the cup fixed with impaction bone grafting with different bone/HA ratio using a high-speed camera. In HA100, the migration was small in stage 1 and 2, while the migration became greater in stage 3. Focusing on the size of HA granules, the size was smaller after loading. These results indicated that the fracture of HA granules occurred during cyclic loading and the stability of the cup decreased with time. By adding bone chips, the initial stability was slightly decreased, while the long-term migration of the cup was small. The limitation of this in vitro study was that the effects of new bone formation into the grafted bone could not be assessed. In terms of initial mechanical stability of the cup fixed with impaction bone grafting, we recommend to add HA granules into bone chips with the ratio of between 25 and 50%.

Significance

In this study revealed that the fracture of HA granules occurred during cyclic loading and the stability of the cup decreased with time. We recommend adding HA granules into bone chips with the ratio of between 25 and 50%.