Revision of total hip arthroplasty using the Kerboul and KT plates

Tomonori Baba · Katsuo Shitoto

Received: 28 November 2008 / Accepted: 10 April 2009 / Published online: 7 May 2009
© Springer-Verlag 2009

Abstract We reviewed 42 hips which had undergone revision THA between 1995 and 2005 (the Kerboul plate in 24 hips, and the KT plate in 18 hips). Patients were followed-up for a mean of 7.5 years (range 3–13). In the Kerboul plate group, the five- and ten-year survival rates were 89.9% and 79.4%, respectively. In the KT plate group, the five-year survival rate was 87.5%. The Kerboul and KT plates are placed as close as possible to the original acetabular position and used in combination with a bone graft for bone defects. In Japan, for patients with large bone defects, femoral heads with good quality which have been resected due to osteoarthritis are difficult to prepare as bone grafts. Therefore, use of the KT plate can reduce the bone graft volume to a certain extent by high placement, which was effective in our cases.

Introduction

Total hip arthroplasty (THA) has produced clinically excellent results. With advances in hip prostheses, the number of patients undergoing THA has been increasing annually, as has the number undergoing revision. In general, the survival rate after revision THA is lower than that of primary THA. This is due to difficulties in the removal of bone cement and the prosthesis, the filling of extensive bone defects, and determination of the implant position [1–3]. For long-term maintenance of the function of the hip prosthesis after revision THA, it is desirable that

the prosthesis be placed as close as possible to the original acetabular position, but this causes larger bone defects [4]. In such cases, we have performed acetabular reconstruction using a Kerboul plate [5] or a KT plate [6] in combination with an allograft.

The Kerboul acetabular reinforcement device facilitates restoration of the hip's centre of rotation. It consists of four branched hemispheric crosses. Its shape results from the orthogonal crossing of two hemispheric plates. The vertical plate ends distally with a hook that must be inserted under the inferior margin of the acetabulum and proximally with a rounded plate for iliac screw fixation above the acetabulum. The horizontal plate is asymmetrical; thus, its anterior branch is shorter than the posterior which generates a ten degree anteversion of the opening plane of the device (Fig. 1a). The KT plate is a modified Kerboul acetabular reinforcement device with a similar shape. It was developed by Tanaka with the permission of Kerboul. Types of this device vary in their offset and vertical plate lengths (Fig. 1b, c).

The purpose of this study was to examine the midterm results of revision THA using Kerboul and KT acetabular reinforcement devices.

Material and methods

Patients

We reviewed 39 patients (42 hips) who had undergone revision THA between 1995 and 2005. The Kerboul acetabular reinforcement device was used in 24 hips (1995–2004), and the KT plate in 18 hips (2001–2005). The 39 patients consisted of 15 males and 24 females, and three patients underwent bilateral THA. After excluding two patients with Kerboul plates who were

T. Baba (✉) · K. Shitoto
Department of Orthopedic Surgery,
Juntendo University Urayasu Hospital,
2-1-1 Tomioka, Urayasu,
Chiba, Japan
e-mail: baba@juntendo-urayasu.jp

Fig. 1 **a** Kerboul plate. **b** KT plate for placement in the original position. **c** KT plate for high placement

lost to follow-up, 37 patients (40 joints) were enrolled as the subjects. Thirty-five patients underwent revision of the acetabular component only. The previous operations included 33 cementless THA and seven cemented THA cases. The mean age at primary hip arthroplasty was 56.6 years (range 44–65). The mean age at revision was 68.2 years (range 58–74), and the mean time to revision was 11 years (range 6–23). Patients were followed-up for a mean of 7.5 years (range 3–13). The initial diagnoses were osteoarthritis secondary to acetabular dysplasia in 30 hips, ankylosing spondylitis in four hips, rheumatoid arthritis in five hips, and osteonecrosis of the femoral head in one hip. Revision surgery was undertaken for aseptic loosening in 39 hips and for infection in one hip. The mean number of previous operations was 1.2 (range 1–4). Acetabular defects were classified according to the system of grading of the American Academy of Orthopedic Surgeons [7]. For cases using the Kerboul plate, type I defects involved five hips, type II defects involved six hips, and type III defects involved 11 hips. For cases using the KT plate, type II defects involved six hips, type III defects involved 11 hips, and a type IV defect was present in one hip.

Surgery

Thirty-three hips were revised via a transgluteal approach, and seven hips were revised via a lateral approach with trochanteric osteotomy. Acetabular preparation followed removal of the loosened implant. If necessary, we reamed the acetabular cavity after excision of the soft tissue membrane. Bone grafting was performed by either collection of the ipsilateral iliac bone during surgery or the use of

an auto- or allogeneic femoral head. Since 2000, femoral head auto- and allografts harvested under sterile conditions and stored at -80°C have been available. In 13 joints involving an iliac bone autograft, a morsellised graft was employed in 12 joints in the Kerboul plate group and a bulk graft in one in the KT plate group. In all 13 joints, bioactive granules (A-W glass ceramic [8] or hydroxyapatite granules [9, 10]) were used in combination with the graft. The other 27 joints involving a femoral head auto- or allograft consisted of 12 joints using a morsellised graft and 15 using a bulk graft. Bioactive granules (A-W glass ceramic or hydroxyapatite granules) were used in combination with the graft in 23 joints. In nine joints in the Kerboul plate group, a morsellised graft was used in four joints and a bulk graft in five. In 18 joints in the KT plate group, a morsellised graft was employed in eight joints and a bulk graft in ten. Appropriately-sized Kerboul and KT plates for defects were chosen and implanted. The inferior hook was placed under the inferior acetabular margin. When there were bone defects remaining between the rounded plate and the lateral edge of the acetabulum, such defects were reconstructed with cortical bone from the freeze-dried femoral neck. The number of screws placed in the upper flange was two in five, three in 26 plates, and four in nine plates. The cup was cemented directly onto the plate and graft.

Assessment

The postoperative rehabilitation schedule included the initiation of partial weight-bearing after four weeks and full weight-bearing after eight weeks. All patients were followed-up by clinical and radiographic evaluation on an

outpatient basis at intervals of one to three months until one year after the operation and at intervals of six months thereafter. For clinical assessment, the hip function was evaluated according to the scoring system of Merled'Aubigné and Postel [11]. The preoperative and final follow-up hip scores were compared to assess hip function. A postoperative anteroposterior radiograph of the pelvis, including both hips two weeks after surgery, served as a baseline for comparison with follow-up radiographs. The postoperative plate placement angle (angle between the line connecting the tear drops and that connecting the lower end of the upper flange of the plate and the lower end of the hook) was defined as the abduction angle and was measured. For the high-placement type of KT plate, a line resulting from the parallel translation of the line connecting the tear drops to the high-placement site was used as a reference line. The angle between the reference line and the line connecting the intersection of the plate and reference line with the lower end of the upper flange was defined as the abduction angle.

Survival analysis was performed using the Kaplan-Meier method, using loosening of the acetabular component as an end point. Radiological loosening was defined as any of the following three criteria: (1) screw or inferior hook breakage or loosening, (2) the presence of a change >3 mm in implant position, as recorded by horizontal and vertical migration, or an alteration $>3^\circ$ in the abduction angle of the acetabular device, and (3) the presence of a radiolucent line >3 mm in all three zones, as defined by DeLee and Chanley [12].

Statistical analysis

The preoperative and final follow-up Merled'Aubigné and Postel hip scores and the abduction angle of the acetabular device were compared using Student's *t*-test. A *p*-value <0.05 was considered significant.

Results

Clinical evaluation

The Merled'Aubigné and Postel hip score was 10.8 ± 1.8 (Kerboull plate group, 10.9 ± 1.8 ; KT plate group, 10.8 ± 1.9) before the operation but significantly improved to 15.4 ± 1.4 (Kerboull plate group, 15.3 ± 2.0 ; KT plate group, 15.5 ± 0.7) at the time of the final evaluation ($p < 0.001$). In particular, the pain score was 3.4 ± 0.9 (Kerboull plate group, 3.2 ± 1.0 ; KT plate group, 3.7 ± 0.5) before the operation but markedly improved to 5.9 ± 1.4 (Kerboull plate group, 5.8 ± 0.4 ; KT plate group, 5.9 ± 0.3) at the final evaluation. No significant difference was observed between the Kerboull and KT plate groups.

Radiographic evaluation

To evaluate the plate placement site, the postoperative plate abduction angle was measured and compared. The mean abduction angle was $45.7 \pm 4.5^\circ$ in the KT plate group but $57.0 \pm 11.5^\circ$ in the Kerboull plate group, showing a significant difference ($p < 0.05$). The placement angle was almost optimal in the KT plate group but acute in the Kerboull plate group.

Survival rate

The survival rate was analysed by the Kaplan-Meier method. In all cases of both Kerboull and KT plate groups, the five-year survival rate was 89.3%, and the ten-year survival rate was 80.6% (Fig. 2a). In the Kerboull plate group, the five-year and ten-year survival rates were 89.9% and 79.4%, respectively. In the KT plate group, the five-year survival rate was 87.5% (Fig. 2b). The survival rate was similar between the two plate groups, although direct comparison could not be made since we had yet to obtain the ten-year survival rate in the KT plate group. Loosening

Fig. 2 Survival curve for the cross plates. **a** Survival curve for the combination of the Kerboull and KT plates. **b** Survival curves for the Kerboull and KT plates

Fig. 3 In the presence of large bone defects in the acetabular bed. **a** When a Kerboull plate is placed at an abduction angle of 45° , the morphology does not fit the acetabulum. **b** When the plate is placed to avoid interference with acetabular bed bone by the plate dome, the abduction angle is small, resulting in a marked increase in the graft bone volume. **c** When the plate is placed so that the upper flange is forcibly brought into contact with the acetabular margin, the placement angle becomes acute, and the hook tends to come out of the obturator foramen. **d** When the KT plate type for placement in the original position is used, the plate can be placed at the optimal site. **e** When the high-placement type is used, the area of the upper flange in contact with the acetabulum becomes large, and the graft bone volume for the weight-bearing zone becomes small

was observed in a total of five joints (four in the Kerboull plate group and one in the KT plate group), and two of the five joints had rheumatoid arthritis. In two cases, the position of the hook was inaccurate, and the plate abduction angle was markedly acute. In these cases, if the plate had been placed at an abduction angle of 45° , recommended by Kerboull et al., the plate-bone defect relationship would have been classified as Kawanabe stage 4 [13], in which there is no contact

between the upper flange and acetabulum. We tried to bring the upper flange into contact with the acetabulum, which resulted in a poor placement angle. Hook fracture was observed in two cases, which also showed screw backout but not screw breakage. Four cases showing loosening had undergone grafting using only morsellised bone.

Complications developed in four cases. Recurrent dislocation was observed in one case in which the inner

Fig. 4 A case of large bone defects in which there is no contact between the upper flange and acetabular bed bone even using the KT high-placement type. This problem can be solved by fixation at the acetabulum via a bulk graft

Fig. 5 A case of rheumatoid arthritis in which a Kerboul plate was used. **a** Postoperative radiograph. **b** Hook breakage, screw backout, and acetabular base destruction were observed after five years

cup migrated after three years and revision surgery was performed. Pseudarthrosis was observed in one case in which the lateral approach with trochanteric osteotomy had been used, but since there were no clinical symptoms, the course was observed without re-fixation. Iliac bone fracture was observed in two cases (one during the operation, one postoperative) in which central migration of the acetabular cup was severe and dislocation was impossible; therefore, the posterior wall of the acetabulum was resected before dislocation, but a fissure occurred in the anterosuperior area of the acetabulum during reduction of the dislocation, also resulting in fracture of the iliac crest, and reduction and internal fixation were performed using the plate. The patient with postoperative fracture was 49 years old but had received steroid therapy due to rheumatoid arthritis for a long period, thus osteoporosis as an underlying disease was suspected. Since the fracture developed from the iliac bone to the acetabulum four years after the operation,

osteosynthesis was performed using a plate and screw. As this patient underwent revision in the lateral position, ipsilateral iliac bone was collected for acetabular reconstruction. When there are sizable bone defects, collection of a large amount of bone causes much stress in the bone defect area and the area around the bone collection site, which is associated with a high risk of iliac bone fracture during and after surgery. A system for the use of frozen femoral heads was established after the development of a fracture in this patient, and since then, autografts have not been used. When autografts are employed, bone collection from the unaffected side is performed.

Discussion

Kerboul et al. reported a 13-year survival rate of 92.1% using a Kerboul plate in combination with a bulk graft [5], while Tanaka et al., who used a KT plate in combination

Fig. 6 A patient with a history of four operations in whom a KT plate was used. **a** Postoperative radiography. **b** Hook breakage and screw backout were observed after five years

with hydroxyapatite granules, reported a survival rate of 100% after a mean follow-up of five years and four months [6]. However, another study involving a Kerboul plate in combination with a morsellised graft showed aseptic loosening in six of 35 cases after a mean follow-up of four years and 11 months [14]. Thus, the results of previous studies have been inconsistent. Kawanabe et al. [13] focussed on the bone quality of the bone graft and reported that the results were better using a Kerboul plate in combination with a bulk graft than a morsellised graft when the acetabular bone defect was large (ten-year survival rate: 53% in the morsellised graft group, 82% in the bulk graft group). In our cases, the survival rate six years after the operation was also higher in the bulk graft group (88.9%) than in the morsellised graft group (77.9%).

The principles for the placement of the Kerboul or KT plate are as follows: (1) the hook is placed at the superior margin of the obturator foramen, (2) the plate is positioned so as to achieve an abduction angle of 45°, (3) the plate should not be bent or stretched, and (4) the position of the upper facet should not be shifted anteriorly or posteriorly. When the acetabulum with a large bone defect is reconstructed using a Kerboul plate based on these principles, the contact area between the upper facet and acetabular margin is small, or there is no contact. Depending on the superior margin of the obturator foramen, the dome portion of the plate interferes with the bone bed, resulting in a decrease in the abduction angle (Fig. 3a, b). Therefore, the bone graft volume for not only the weight-bearing zone but also the upper facet-acetabulum space becomes great. If the upper facet is forcibly brought into contact with the acetabular margin, the placement angle becomes acute, and the hook tends to come out of the superior margin of the obturator foramen (Fig. 3c). If the size is increased so that the plate can come into contact with both the acetabular margin and obturator foramen, the anteroposterior axis does not fit, and plate bending is not recommended in terms of strength. Since the angle between the upper facet and hook in the KT plate, even the type placed in the original acetabular position, is less acute than that in the Kerboul plate, the KT plate can be placed even in the presence of large bone defects (Fig. 3d). When the high-placement type is used, the area of the upper facet in contact with the acetabulum is large, and therefore, the bone graft volume for the weight-bearing zone can be small (Fig. 3e). In cases showing large bone defects treated using a Kerboul plate in this study, the upper facet was brought into contact with the acetabular margin as much as possible, resulting in a sharp abduction angle ($57.0 \pm 11.5^\circ$). After the change to the KT plate, the high-placement type was used in the presence of bone defects, and the contact area between the palette and acetabulum increased. However, even in the absence of contact between the palette and the bone bed at

the acetabular margin, the bulk graft was frequently used, allowing reconstruction even in cases showing very large bone defects (Fig. 4). In addition, the screw for the KT plate is more effective than the A-O type screw for the Kerboul plate in terms of the fixation force, allowing firm fixation via the bulk graft even in the absence of contact between the upper facet and bone bed. Due to these advantages, favourable results were obtained using the KT plate.

Acetabular reconstruction is performed by the method in which the high placement of the acetabulum is permitted for a reduction in the bone graft volume or the method in which the acetabular component is placed in the original position. Dearborn et al. placed a cementless cup at the high hip centre for acetabular reconstruction and obtained good results [15]. However, when further loosening occurs, the degree of bone defects becomes serious. The Kerboul plate is placed as close as possible to the original acetabular position and used in combination with a bone graft for bone defects. Therefore, when further loosening occurs, and the plate is removed, the bone graft area becomes a new bed. In Japan, for patients with large bone defects, good quality femoral heads and resected for osteoarthritis are difficult to prepare as bone grafts. This is because osteoarthritis in Japan is frequently due to acetabular dysplasia, the resected femoral head is often transplanted to the acetabulum in the initial operation, and use of the bone bank system is difficult. If an adequate amount of bone graft of good quality is obtained, even the KT plate should be placed in the original position in principle. However, use of the KT plate can reduce the bone graft volume to a certain extent by high placement, which was very effective in our cases.

Regarding cases showing loosening, rheumatoid arthritis was observed in two and a history of four operations in one patient (Figs. 5 and 6). In these patients, bone quality of the host bone was poor, suggesting delayed bone union with the bone graft. The Kerboul and KT plates have a structure that does not cause direct loading on the acetabulum, but loosening occurred in these cases. Time until bone union in patients with rheumatoid arthritis is suggested to be about twice that in those with osteoarthritis [16]. In diseases associated with bone fragility, a delay in the full weight-bearing time should be considered in the future.

References

1. Amstutz HC, Ma SM, Jinnah RH et al (1982) Revision of aseptic loose total hip arthroplasties. *Clin Orthop* 170:21–23
2. Pellicci PM, Wilson PD Jr, Sledge CB et al (1982) Revision of total hip arthroplasty. *Clin Orthop* 170:34–41
3. Kavanagh BF, Ilstrup DM, Fitzgerald RH (1985) Revision of total hip arthroplasty. *J Bone Joint Surg Am* 67:517–526

4. Yoder SA, Brand RA, Pedersen DR et al (1988) Total hip acetabular component position affects component loosening rates. *Clin Orthop* 228:79–87
5. Kerboul M, Hamadouche M, Kerboul L (2000) The Kerboul acetabular reinforcement device in major acetabular reconstructions. *Clin Orthop* 378:155–168
6. Tanaka C, Shikata J, Ikenaga M et al (2003) Acetabular reconstruction using a Kerboul-type acetabular reinforcement granules. *J Arthroplasty* 18:719–725
7. D'Antonio JA, Capello WN, Borden LS et al (1989) Classification and management of acetabular abnormalities in total hip arthroplasty. *Clin Orthop* 243:126
8. Kokubo T, Shigematsu M, Nagashima Y et al (1982) Apatite- and wollastonite-containing glass-ceramics for prosthetic application. *Bull Inst Chem Res, Kyoto Univ* 60:260–268
9. Oonishi H, Yamamoto M, Ishimaru H et al (1989) The effect of hydroxyapatite coating on bone growth into porous titanium alloy implants. *J Bone Joint Surg Br* 71:213–216
10. Oonishi H (1991) Orthopaedic applications of hydroxyapatite. *Biomaterials* 12:171
11. Merled'Aubigné PM (1954) Functional result of hip arthroplasty with acrylic prosthesis. *J Bone Joint Surg Am* 36:451–475
12. DeLee JG, Chanley J (1976) Radiological demarcation of cemented socket in total hip replacement. *Clin Orthop* 121:20–32
13. Kawanabe K, Akiyama H, Onishi E et al (2007) Revision total hip replacement using the Kerboul acetabular reinforcement device with morsellised or bulk graft. *J Bone Joint Surg Br* 89:26–31
14. Lunn JV, Kearns SS, Quinlan W et al (2005) Impaction allografting and the Kerboul acetabular reinforcement device. *Acta Orthop* 76:296–302
15. Dearborn JT, Harris WH (1999) High placement of an acetabular component inserted without cement in a revision total hip arthroplasty. *J Bone Joint Surg Am* 81:469–480
16. Manabe T, Mori S, Iwata K et al (2005) Revision total hip arthroplasty with allograft. *Chubu Seikaisi* 17:163–166