Total hip replacement arthroplasty with Mallory-Head system—minimum ten-year follow-up results

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Abstract

Purpose The purpose of this study was to assess the clinical and radiographic results of a total hip arthroplasty with the double tapered Mallory-Head system.

Methods The clinical and radiographic results of a consecutive series of 81 total hip replacements in 75 patients were reviewed 10–15 years (average 11.4 years) postoperatively. The patients' underlying conditions were avascular necrosis in 46 hips (57 %), osteoarthritis in 12 hips (15 %), RA in nine hips (11 %), and others. Clinical results were evaluated based on the modified Harris hip score and modified Merle d'Aubigné-Postel score. A radiographic analysis was performed.

Results The average modified Harris hip score improved from a preoperative score of 56 points to a postoperative 92 points. The average modified Merle d'Aubigné-Postel score was 15 points at the latest follow up, and 55 hips (68 %) were classified as the clinical grades of excellent or good results. One acetabular component was revised because of loosening, and one was revised for recurrent dislocation.

Conclusion The clinical and radiological evaluations of the total hip replacements using the Mallory-Head system showed good results.

Introduction

The cementless femoral stem of the artificial hip joint can be categorised according to its shape as the columnar shape, anatomical shape and tapered shape, and its durability has been reported to be good in the follow-up observations longer than ten years [1–3]. Cobalt chrome was used as material for early cementless arthroplasties. However, bone resorption in the proximal femoral area became problematic, and thus titanium (TiAl₆V₄) alloy is presently used as the major material. The elasticity coefficient of titanium is lower than cobalt chrome, resulting in the improvement of the stress shielding, allowing the prosthesis to survive for a long time. However, pain in the femoral area, the phenomenon of stress shielding, and limited range of movement due to the shape of the neck area have been pointed out to be problems in uncemented implants. The cause of osteolysis was thought to be cement, however, the incidence of osteolysis was reported to be high in the early cementless prostheses, hence, recently it has been considered to be due to reactions to polyethylene and to the extension of the effective joint space of the non-circular proximal coated stem [4]. We examined the mid/long-term clinical and radiological outcomes of hip replacement arthroplasty with the Mallory-Head® system (Biomet, Warsaw, IN, USA), which is one of the second generation cementless femoral stems, circular porous-coated and distal tapered.

Materials

Research subjects

Among 89 patients (98 hip joints) who received total hip replacement arthroplasty using the Mallory-Head system from March 1996 to February 2000, there were 75 patients

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(81 hip joints) available for follow-up observation for longer than ten years. The femoral stem used in our study was of forged titanium alloy with the double tapered structure providing four-point fixation by fins in the anteroposterior and lateral side and contact of the medial side with the bone. In addition, 1/3 of the proximal area (proximal 1/3) was porous coated with titanium plasma spray (average porosity, 43.6 %; coating thickness range, 635–889 μm) the middle area was roughly textured (30 mesh-grit blasted), and the distal 1/3 was a smooth surface. The design objective was to preferentially load proximally with gradual diminution of load from proximal to distal. As the stem grows thicker it simultaneously grows longer. For acetabular fixation, the Mallory-Head Radial Acetabular Shell (Biomet, Warsaw, IN, USA) with porous coated titanium alloy and polyethylene liners (Ring Loc Acetabular Liner, Biomet, Warsaw, IN, USA) were used, and fixed with two titanium cancellous bone screws. For the femoral head, cobalt chrome alloy metal heads were used. All arthroplasties were performed by a single surgeon (J.H.S) using the posterolateral approach. The average follow-up period was 11.4 years (10–15 years) and the follow-up rate was 84.2 %. There were 39 male patients (52 %) and 36 female (48 %), and the age at the time of surgery was 59.4 years (36–64 years). The diagnosis prior to surgery, was avascular necrosis of femoral head in 46 cases (57 %), degenerative arthritis in 12 cases (15 %), rheumatoid arthritis in nine cases (11 %), and trauma in nine cases (11 %).

Research methods

Clinical evaluation

Clinical evaluation was performed by the modified Harris hip score [5] and the modified Merle d'Aubigné-Postel Score [6] prior to surgery, three months and six months after surgery, and annually thereafter. For thigh pain, the presence or absence of pain was assessed at each visit by the visual analogue scale (VAS) from 1 point to 10 points.

Radiological evaluation

Formation of new bone in the lateral side of femur (spot weld), distal cortex hypertrophy observed on periodical X-rays, cases in which subtrochanteric diaphysis mineralisation was intact although metaphyseal bone loss had progressed in the proximal femur on serial postoperative X-rays (proximal stress shielding), radiolucency in the vicinity of the femoral stem, and the presence or absence of osteolysis was examined according to the seven zones of Gruen's classification were recorded [7]. Regarding acetabular cups, socket migration and the presence or absence of the breakage of screws were assessed. The presence or absence of

osteolysis in the vicinity of acetabular cup was recorded according to the DeLee's three zones classification [8]. The erosion level (linear wear rate) of polyethylene was measured using the Livermore's method [9].

Results

Clinical results

The modified Harris hip score was increased from an average 56 points prior to surgery (36–80 points) to 92 points (63–119 points) at the last follow-up observation. The modified Merle d'Aubigné-Postel score at the last follow-up observation was an average 15 points, and it was higher than good grade in 55 cases (68 %). The thigh pain was present in three cases (3.7 %), and their VAS classification was 3 points, 6 points, and 8 points.

Radiological results

In radiological examination, new bone formation (the presence of spot welds of endosteal new bone contacting the porous surfaces) in the femur was observed in 62 cases (76.5 %) and distal cortical hypertrophy (Fig. 1) in 25 cases (30.8 %), observed primarily in the Gruen zones 3 and 5. There were no cases in which this hypertrophy was observed in Gruen zone 2 or 6. All cases showed periosteal and endosteal hypertrophy, mainly ballooning out on the medial cortex. The phenomenon of proximal stress shielding was seen in cases in which overall bone contrast on radiographs was decreased in 28 cases (34.6 %) primarily in Gruen's zone 1 and 7. Among them, bone contrast decrease combined with cortical thinning was observed in the radiographs of ten cases (12.3 %). Radiolucency in the vicinity of the femoral stem occurred in two cases (2.4 %). Osteolysis was seen as a local decrease of the contrast of the endosteum and was observed in three cases (3.7 %) in zones 1, 3, and 6 of Gruen's classification (Table 1). Regarding acetabular cups, acetabular cup revision was performed in two cases (2.4 %). The cause of one case was the osteolysis phenomenon in the pelvic area of zone 1 according to the DeLee's classification, and the cause of the other case was recurrent dislocation. Breakage of screws or socket migration was not observed, and re-arthroplasty due to osteolysis was only one case (1.2 %) (Fig. 2). The erosion level of polyethylene according to the Livermore's method was 0.28 mm/year. The result of Kaplan-Meier survival rate (standard error 0.2; 95 % confidence interval: upper 11.0; lower 10.1) showed that 10.6 years survival rate is 95.06 %.

Fig. 1 Radiograph of Mallory-Head stems at follow-up after 10 years shows bilateral cortical hypertrophy

Discussion

The first generation femoral stems of the cementless hip arthroplasties include Anatomic Medullary Locking (AML) (DePuy/Johnson & Johnson, Warsaw, IN, USA) which are a broad range multiporous coated shape for the fixation of the distal area, the PCA femoral stem (Howmedica, Rutherford, NJ, USA) which achieved fit and fill by the insertion into the femoral stem and the proximal area and the anatomic femoral stem (Zimmer, Warsaw, IN, USA). However, due to the characteristic of designs, shortcomings such as pain in the femur, the stress shielding phenomenon in the distal femur, osteolysis, dissociation, and difficulties in removal the femoral stem during revision were reported [10]. To resolve the problems of the first generation femoral stems, the stem was redesigned to fit firmly into the femoral proximal area by the concept of the tapered shape design, and maintain the hoop stress continuously to avoid stem subsidence. Regarding pain in the femur, a high incidence of 20–33 % in the first generation cementless femoral stems was reported. Occasionally, the pain was very severe, and thus revision for the prosthesis to achieve stable fixation was required in some cases [11–13]. Bourne et al. [14] reported

Fig. 2 Radiographs show revision of cup after identifying loosening of cup because of the pelvic osteolysis. **a** Pelvic osteolysis at ten years after operation. **b** After revision of cup

in a study comparing the PCA femoral stem using the sintered bead techniques with the Mallory-Head femoral stem using the plasma spray techniques that the incidence of femoral pain in the group using PCA was 23 % at two years and cases using the Mallory-Head femoral stem was 3 % at two years. It was explained that the Mallory-Head femoral stem mediated effects by reducing firm connection due to the long antero-posterior diameter of the femoral stem and the tapered shape. In our study, femoral pain developed in three cases (3.7 %). Although special differences were not detected in cases which developed pain, it is considered that the major cause of pain was malalignment or associated spinal disease. New bone formation in the vicinity of the multiporous surface (spot weld) was observed in 62 cases (76.5 %), which shows stable fixation by osseous integration due to the stable weight bearing on the proximal multiporous surface [15]. Distal cortical hypertrophy is caused by the stress transduction phenomenon between the femoral stem and cortical bones. Ritter et al. [1] reported that it develops due to the abnormal stress distribution during femoral weight bearing, it is not

Table 1 Comparison of results of operations using Mallory-Head total hip replacement system

Results	This study	Bourne et al. [14]	Gosens et al. [28]	Mallory et al. [29]	Mulliken et al. [30]	Park et al. [31]
Number of cases	81	307	63	120	172	76
Endosteal spot weld (%)	76.5	14	49.5	87.5	9	71
Distal cortical hypertrophy (%)	30.8	50	46	12.3	53	9.7
Stress shielding (%)	34.6	50				67.1
Femoral osteolysis (%)	3.7	6.2	0	32.4	58	10.5
Thigh pain (%)	3.7	3	3	3.4	5	4.4
Survival rate (%)	95.1	90	91.3	97.5	96.5	97.4

directly associated with pain or dissociation, and femoral hypertrophy develops most readily in women using stainless wires. It has been reported that the incidence of the femoral cortical hypertrophy of the HGP femoral stem was 30 %, the AML femoral stem was 19 %, and the PCA femoral stem was 14 % [16–19]. In our study, 25 cases (30.8 %) developed, primarily in the Gruen zones 3 and 5. It is speculated that the tapered design did not match the shape of the femoral endosteum, and thus weight and stress transduction was focussed on special areas. The proximal stress shielding phenomenon was frequently seen in prosthesis with a large surface area and high intensity based on the concept of the early distal stress fixation. Heekin et al. [20] reported 63 % stress shield phenomenon in the PCA femoral stem. In our study, such phenomena occurred in 28 cases (34.6 %), which is thought to be due to the focus on the distal area of the multiporous coated areas because of the characteristic tapered shape, although new bone was formed in the proximal multiporous coated area. Radiolucency in the vicinity of the femoral stem shows that endosteal growth was not achieved. In our study, it was observed in two cases (2.4 %). Nonetheless, bone growth in the proximal multiporous surface was sufficient and thus it could not mediate effects of the stability of artificial prosthesis. Osteolysis occurred primarily in the non-circular coated prosthesis among the first generation femoral stems. Clohisy and Harris [21] reported osteolysis in 52 % of the first generation Harris-Galante femoral stems, and in other non-circular femoral stems, distal femoral osteolysis was reported in approximately 10 % of cases [21–23]. Schmalzried et al. [24] introduced the concept of the effective joint space in which abrasion particles could migrate to the distal area due to the pressure within the articular cavity through the path of least resistance. Bobyn et al. [25] have proven that in animal experiments, abrasion particles migrated better on the non-porous coated surface than the porous coated surface. Emerson et al. [26] reported that the femoral stem surrounded by circular multiporous layers closed the joint space and thus prevented the migration of abrasion particles to the femur. In our study, similarly, the incidence of osteolysis was three cases (3.7 %), probably due to the blocking effects of the invasion of particles inducing osteolysis to the distal area due to the proximal multiporous circular coating and the physical compression fixation of the tapered femoral stem. Osteolysis in the pelvic area is a major interest in hip replacement arthroplasty. Santavirta et al. [27] have reported that among cementless joint replacement arthroplasty patients, granulomatosis developed in a wide area of the vicinity of the acetabular cup in five cases, and because of the consequent pain, revision was performed in all cases. Histological tests revealed this to be due to plastic particles of the acetabular cup liner. The thin polyethylene and the wide diameter of femoral head could be considered as the

cause of osteolysis in the vicinity of the acetabulum. Whether the residual screw holes act as the migration pathway of particles is still controversial. In our study, the incidence of osteolysis in the pelvic area occurred in one case (1.2 %), and the incidence was lower than the abrasion level of polyethylene, which could be because new bone formation in the vicinity of the acetabular cup was sufficient, and thus either it blocked polyethylene abrasion particles effectively, or it may be dependent on the different level of the inflammation response of individuals.

Conclusion

In a longer than ten-year follow-up observation of the Mallory-Head artificial joint using the proximal multiporous coated system, clinical and radiological results were determined to be excellent based on stable osseous integration, low revision rate, and thigh pain.

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