Fixation of an Anatomically Designed Cementless Stem in Total Hip Arthroplasty

Abstract

Purpose

Objectives: The Anatomic Fiber Metal plus stem (Zimmer) is one of the anatomically designed, cementless stems that achieves stable fixation by using metaphyseal fit. The press-fit and outcomes of total hip arthroplasty (THA) using this stem have been reported to be good for primary osteoarthritis in Caucasian patients. However, there are few reports available on the outcomes of THA using this stem in Japanese patients. Therefore, in this study, we evaluated the outcomes of cementless THA using this stem and the possible effects of the quality of metaphyseal fit on outcomes in a Japanese population.

Methods

Participants: The cementless THA total hip arthroplasty using with this stem was performed for 155 hips. One hundred and thirty-seven hips of 122 patients were followed up after for 5 to 16 (mean, 9.7) years and entered enrolled into the study. Main outcome measures: The metaphyseal fit was defined as good or poor from examination of anteroposterior radiographs after surgery. We studied the fixation of the stem and bone reaction on an anteroposterior radiograph at the final follow-up.

Results: Twelve hips had revision; six for acetabular components and six for acetabular liners. No stems were revised. The biological fixation of the stem was bone ingrown fixation for 136 hips and unstable for one hip. The metaphyseal fit was good for 83 hips and poor for 54 hips. No differences were observed for stem fixation and bone reaction between the two classifications.

Conclusions: The fixation of the Anatomic Fiber Metal plus stem was stable at a mean follow-up of 9.7 years independently from metaphyseal fit. This stem, therefore, represents a long-term option for THA total hip arthroplasty.

1. Introduction

For a large variety of femoral component designs have been developed for cementless total hip arthroplasty (THA), a large variety of femoral component designs have been developed. The Anatomic Fiber Metal plus stem (Zimmer, Indiana, USA) is one such design of the anatomically designed femoral components to be inserted without cement (Figure 1). This concept of this stem was to achieve stable fixation by metaphyseal fit and fill [1, 2]. It has a configuration that matches the medullar canal of a normal femur, and a circumferential fiber-mesh coating on the proximal one-third. The neck of the stem has an anteverision of 12° (twelve degrees).

INSERT FIGURE 1 HERE

The press-fit and outcomes of THA using this stem were reported to be good for the primary osteoarthritis in selected Caucasian patients [1]. However, there are a few reports available regarding the outcomes of THA using this stem in Japanese patients [13]. The majority of the hips with osteoarthritis are Dysplastic hips in Japanese patients represent the majority of
cases of hip osteoarthritis worldwide. Therefore, the postoperative results of this population may be different from those of Caucasian patients.

With this in mind, we studied the outcomes of cementless total hip arthroplasty (THA) using the Anatomic Fiber Metal plus stem in Japanese patients and the possible effects of the metaphyseal fit and fill design on patient outcomes.

2. Methods

Study Population

The cementless total hip arthroplasty (THA) using the Anatomic Fiber Metal plus stem was performed for 155 hips of 139 patients between February 1994 and August 2003 at our hospital. Eighteen hips of 17 patients were excluded for the following reasons: six patients (seven hips) had died during follow-up, eight patients could not be contacted, and the remaining three patients were confirmed to have no revision and to have no hip pain, but did not visit our clinic. As a result, 137 hips of 122 patients were followed for more than five years and entered into the study of clinical and radiographic outcomes.

The average follow-up period of the study group was 9.7 (5–16) years, and the average age at the time of surgery was 62 (33–80) years old. The diagnosis was osteoarthritis for 117 hips, osteonecrosis of the femoral head for 18 hips, and rapidly destructive coxarthrosis for two hips.

Choice of stem

The indication of the usage of the Anatomic Fiber Metal plus stem was different according to the periods of the surgery. This stem had been used principally for all hips between February 1994 and May 1999 (defined as the non-selection period). Between June 1999 and August 2003 (defined as the selection period), we had used this stem as a first choice, but selected other stems (straight-taper type or modular type) when the Anatomic Fiber Metal plus stem did not fit to the shape of medullar canal in an anteroposterior (AP) radiograph. During this period, we used the Anatomic Fiber Metal plus stem; these cases accounted for 48% of all THA cases. Of the 155 hips inserted with this stem included in the present study, 62 hips were operated on in the non-selection period, and 93 hips were operated on in the selection period.

The acetabular components were cementless spherical cups: HGP-II (Zimmer) for 22 hips and Trilogy (Zimmer) for 115 hips. The modular head was made of cobalt chromium alloy. The polyethylene of the acetabular liner was conventional for 51 hips and cross-linked for 76 hips.

Analysis of Metaphyseal Fit
We evaluated the metaphyseal fit on the postoperative AP radiograph and divided all hips into two groups (Figure 2). The metaphyseal fit was defined as good if the medial side of the stem was in contact with the endosteum of the medial femoral cortex through the area of proximal fiber-mesh coating. The metaphyseal fit was defined as poor if the medial side of the stem was not in contact with the endosteum of the medial femoral cortex at any point in the area of proximal fiber-mesh coating. In the poor metaphyseal fit cases, we calculated the canal-filling ratio (CFR) at the distal end of the lesser trochanter and at the distal end of the stem to evaluate the stem size.

Analysis of Biological Fixation

We studied the fixation of the components and bone reaction on an AP radiograph at the final follow-up. The biological fixation of the stem was classified into bone ingrown fixation, stable fibrous fixation, or unstable fixation according to the methods of Engh et al. [4]. Unstable fixation was defined as loosening of the stem. The subsidence of the stem more than four mm was considered significant. Loosening was defined as the acetabular component having a clear zone of more than 1 mm in all of the three zones of DeLee and Charnley [5] around the cup or a change of inclination angle of more than 4° degrees was defined as loosening. The stress shielding was classified into 4° four degrees according to the method of Engh et al. [4]. Radiolucent line, spot welds, and osteolysis were evaluated in the seven zones of Gruen et al. [6] in AP radiographs.

The function of the hip was evaluated using the Japanese Orthopedic Association (JOA) hip score [7], with a full total score of 100 points (pain, 40; gait, 20; range of motion, 20; and activity of daily living, 20 points).

Statistical Analysis

We studied the revision rates and survival rates of all 155 hips using the Kaplan-Meier methods. The Chi-squared test or Fisher’s Exact test was used for categorical data, and the Mann-Whitney U test was used for numerical data. P-values less than 0.05 were considered significant.

Ethics Statement

This study was approved by the ethics committee of our institute and was performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

3. Results

Twelve hips—including one hip with late infection—had undergone revision. The mean duration between THA (total hip arthroplasty) and revision was nine (1–16) years. No stem was revised.
Six hips had undergone revision of acetabular components; and the remaining six hips had undergone revision of the acetabular liners. Conventional polyethylene liners had been used for all 12 hips, conventional polyethylene liners had been used. Out of the six acetabular revisions, three cups were well fixed; and the other three had no bony fixation. Well-fixed three cups were all HGP-II cups. Cross-linked polyethylene liners were not available for HGP-II cups, hence, and so we revised these cups to use cross-linked polyethylene liners. The reasons for liner revision were as follows: liner wear for three hips, late infection for one, dislocation for one, and dislodge of liner for one. For one hip whereof liner revision was carried out, a bone graft was performed to for osteolysis at the zone 1 of the femur.

The average JOA score of the study group was x points before surgery and x points at the final follow-up. One hundred and three hips (75%) showed more than 80 points at the follow-up with three hips; cases had reporting thigh pain being reported in three cases.

The biological fixation of the stem was classified as bone ingrown fixation for 136 hips (Figure-3) and unstable for one. The hip with unstable stem was occurred in the right hip of a 45-year-old woman who had received bilateral THA for rapidly destructive coxarthrosis. The metaphyseal fit had been classified as poor on the postoperative AP radiograph (Figure-4). The stem had been undersized: the CFR had been was 0.63 at the distal end of the lesser trochanter and was 0.59 at the distal end of the stem. The follow-up radiographs showed no subsidence of the stem at three months after surgery, but subsidence of 5 mm at four years after surgery. The final follow-up radiographs at 6.1 years after surgery showed stem loosening with subsidence of 16 mm. She-The patient had died due to unrelated pulmonary disease not related to the hip before revision was performed.

INSERT FIGURES 3 AND 4 HERE

Tw o hips showed subsidence. One hip was in the patientis described above, and the hip had sustained a femoral neck fracture during surgery. The stem had subsided 30 mm at six months after surgery, but showed no additional subsidence. At 7.5 years after surgery, the radiographs showed bone ingrown fixation. The 104-year survival rate was 94 (86–97) % when any surgery or revision for any reason was defined as the end-point and was 99 (95–99.9) % when loosening or revision of the stem was defined as the end-point.

Radiolucent lines of more than one mm were found at zones 1, 2, 5, and 6 of one hip with stem loosening (Figure-4(b)). Radiolucent lines of less than one mm were found at zone 2 of six hips, at zone 3 of 19 hips, at zone 4 of 106 hips (most frequent), at zone 5 of 46 hips, at zone 6 of 2 hips, and at zone 7 of one hip. No hip showed radiolucent lines of less than one mm at in more than four zones. Spot welds were found at zone 6 of 108 hips. No spot welds were found at any other zones. Osteolysis was found at the greater trochanter in 18 hips (13%) and at zone 1 in 13 hips. No osteolysis was found at any other zone. Stress shielding was grade I for 133 hips and grade II for four hips.

Metaphyseal fit was good for 83 hips (61%) and poor for 54 hips (39%). In the 54 hips with poor metaphyseal fit, the mean CFR was (range, 0.59–0.92) at the distal end.
of the lesser trochanter and was \( k \) (0.59–0.98) at the distal end of the stem\[A35\]. The A CFR of below was less than 0.7 at for both levels in was only observed in one hip shown in Figure 4(a). Other hips with low CFR values at the distal end of the lesser trochanter showed good CFR at the distal stem (for example, like the hip of Figure 2(b). The percentage of hips with good metaphyseal fit was significantly higher in the selection period than in the non-selection period (69% versus 47%\[A39\]). In With regard to diagnosis diagnoses, the percentage of good fit was 59% for cases of osteoarthritis and 78% for cases of osteonecrosis. The hips with osteoarthritis showed a tendency of for a lower percentage of good metaphyseal fit; however, this trend was not found to be but no significant difference was found statistically significant \[A38\].

We studied possible The relationships between metaphyseal fit and outcomes of THA is presented in Table 1. The duration of follow-up showed no differences were observed between the good group and the poor fit group with regards to the duration of follow-up. There were no differences for in JOA score at the followup, stem fixation, the rate of positive radiolucent line in zone 4, spot welds in zone 6, osteolysis at the medial side of the greater trochanter, and or stress shielding between the two groups at follow-up.

**INSERT TABLE 1 HERE**

4. **Discussion**\[A39\]

Several studies \[1, 2, 8, 9\] have discussed the outcomes of THA using the Anatomic stem (Zimmer, Indiana, USA) in Caucasian patients reported that with low rates of stem revision due to loosening were reported low (from 0 to 2.6%). There were only two reports describe on the outcomes of this surgery in Japanese patients. Harada et al. \[10\] reported that five cups and no stems had been revised in 81 hips with a mean follow-up of 8.4 years. Nakoshi et al. \[11\] also reported that four cups and no stems had been revised in 20 hips with a mean follow-up of 12.8 years. In our study, no stems required had been revisioned and one stem showed loosening in out of 137 hips with a mean follow-up of 9.7 years\[A40\]. These results suggest that the biological fixation of this stem is good for 8 to 12 years after surgery not only in Japanese as well as Caucasian but also in Japanese patients.

There was only one previous study has that evaluated the metaphyseal fit or press-fit of the Anatomic stem. Ragab et al. \[1\] evaluated the press-fit of this stem in 97 hips using the methods of Callaghan et al. \[12\] and reported that the press-fit was excellent in 58 hips, good in 38 hips, and poor in one hip. These results suggest that the press-fit of this stem is good for the hips with primary osteoarthritis in Caucasian patients. However, direct comparisons to with our results are was not possible because we had did not use the evaluation methods of Callaghan et al. \[12\] for a number of reasons. In their methods, the press-fit was defined as excellent if the AP radiograph showed the stem to be in contact with the cortical bone at some point on both the medial and the lateral surface. The Anatomic stem has no lateral flare to contact with the endosteum of the lateral metaphyseal cortex around the innominate tubercle. Therefore, the assessments of the lateral side contact seemed to have new would be meaning less for in this stem. Additionally, we thought considered that stricter assessments should be employed were needed for the contact on the medial side. These are the reasons why we had not used the methods of
Callaghan et al. There were no other reports on the press-fit or metaphyseal fit of the Anatomic stem are currently available.

We discuss the reason for the fact that Our analysis revealed that the rate-occurrence of good metaphyseal fit was not high. The data of the design of the Anatomic stem was obtained from normal femora of cadavers. Kaneuji et al. [13] studied the three-dimensional morphology of the femur in 113 hips with osteoarthritis and 36 normal hips in Japanese individuals. In their study, the femoral canal was classified into three types, and the standard type accounted for 89% of the normal hips and only 42% of the hips with osteoarthritis. In our study, 117 hips out of 137 hips diagnosed as having osteoarthritis. The difference in femoral configuration between normal hip and osteoarthritic hips would be one of the reasons for the high incidence of poor metaphyseal fit. The use of an undersized stem like (Figure 4) can also cause poor metaphyseal fit. However, no other stems were undersized like this case and showed loosening. Therefore, we think conclude that the usage of undersized stems was not the main reason for poor metaphyseal fit.

The present study had several limitations that should be discussed. First, The metaphyseal fit was evaluated from AP radiographs. Three-dimensional analysis using CT scan would be more precise and is supposed to show lower rates of good fit. Second, because the mean follow-up of our study was 9.7 years, we cannot deny there may be possible effects of metaphyseal fit on outcomes after longer follow-up time periods that were not observed. These points require further study.

5. Conclusions

The good metaphyseal fit was observed in about 60% of cases, but the 10-year survival rate of the stem was 99%. The biological fixation of the Anatomic Fiber Metal plus stem was stable at a mean follow-up of 9.7 years independently of metaphyseal fit. This stem, therefore, represents a long-term option for total hip arthroplasty.