Fixation of Anatomically Designed Cementless Stems in Total Hip Arthroplasty

Abstract

**Objectives**: The Anatomic Fiber Metal plus stem (Zimmer) is an anatomically designed, cementless stem that achieves stable fixation 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. **Participants**: Cementless THA with this stem was performed on 155 hips. One hundred and thirty-seven hips of 122 patients were followed up after 5–16 (mean 9.7) years and enrolled in the study. **Main outcome measures:** Metaphyseal fit was classified as good or poor from examination of postoperative anteroposterior radiographs. We studied the fixation of the stem and bone on an anteroposterior radiograph at the final follow-up. **Results**: Twelve hips required 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 1 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**: Fixation of the Anatomic Fiber Metal plus stems is independent of metaphyseal fit. This stem, therefore, represents a long-term option for THA.

1. Introduction

Various femoral component designs have been developed for cementless total hip arthroplasty (THA). The Anatomic Fiber Metal plus stem (Zimmer, Indiana, USA) is one such design (Figure [1](https://www.hindawi.com/journals/aorth/2012/912058/fig1/)). This stem achieves stable fixation by metaphyseal fit. [[1](https://www.hindawi.com/journals/aorth/2012/912058/#B1), [2](https://www.hindawi.com/journals/aorth/2012/912058/#B2)] It has a configuration that matches the medullar canal of a normal femur and a circumferential fiber-mesh coating on the proximal third. The neck of the stem has an anteversion of 12°.

**INSERT FIGURE 1 HERE**

The press-fit and outcomes of THA using this stem are good for primary osteoarthritis in Caucasian patients. [[1](https://www.hindawi.com/journals/aorth/2012/912058/#B1)] However, reports on the outcomes of THA using this stem in Japanese patients are limited. Dysplastic hips in Japanese patients represent the majority of cases of hip osteoarthritis worldwide. [[3](https://www.hindawi.com/journals/aorth/2012/912058/#B3)] The postoperative results of this population may differ from those of Caucasian patients.

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

2. Methods

*Study Population*

Cementless 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 three patients were confirmed via telephone to have no revision and no hip pain, but did not visit our clinic. As a result, 137 hips of 122 patients were monitored for at least 5 years and evaluated for 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. The diagnosis was osteoarthritis for 117 hips, osteonecrosis of the femoral head for 18 hips and rapidly destructive coxarthrosis for 2 hips.

*Choice of stem*

Indication for the use of the Anatomic Fiber Metal plus stem differed according to the periods of the surgery. This stem had been used 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 the shape of the medullar canal in the anteroposterior (AP) radiograph. These cases accounted for 48 % of all THA cases. Of the 155 hips included in the present study, 62 hips were operated on in the non-selection period, and 93 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 crosslinked 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](https://www.hindawi.com/journals/aorth/2012/912058/fig2/)). The metaphyseal fit was considered 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 considered 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.

**INSERT FIGURE 2 HERE**

*Analysis of Biological Fixation*

We studied the fixation of the components and the 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 Engh et al.’s method. [[4](https://www.hindawi.com/journals/aorth/2012/912058/#B4)] Unstable fixation was defined as loosening of the stem. A subsidence of more than 4 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](https://www.hindawi.com/journals/aorth/2012/912058/#B5)] around the cup or a change of more than 4° in the inclination angle. The stress shielding was classified into 4° according to Engh et al.’s method [[4](https://www.hindawi.com/journals/aorth/2012/912058/#B4)] Radiolucent line, spot welds, and osteolysis were evaluated in the seven zones of Gruen et al. [[6](https://www.hindawi.com/journals/aorth/2012/912058/#B6)] from AP radiographs.

The function of the hip was evaluated using the Japanese Orthopedic Association (JOA) hip score [[7](https://www.hindawi.com/journals/aorth/2012/912058/#B7)] out of a 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—underwent revision. The mean duration between THA and revision was 9 (1–16) years. No stem was revised. Six hips underwent revision of acetabular components and the remaining six underwent revision of the acetabular liners. Conventional polyethylene liners were used for all 12 hips. Out of the six acetabular revisions, three cups were well fixed and the other three had no bony fixation. The well-fixed cups were all HGP-II cups. Crosslinked polyethylene liners were not available for HGP-II cups; hence, we revised these cups to use crosslinked polyethylene liners. The reasons for liner revision were as follows: liner wear for three hips, late infection for one hip, dislocation for one hip, and dislodge of liner for one hip. For one hip where liner revision was carried out, a bone graft was performed for osteolysis at 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 follow-up, with thigh pain being reporting in three cases.

The biological fixation of the stem was classified as bone ingrown fixation for 136 hips (Figure [3](https://www.hindawi.com/journals/aorth/2012/912058/fig3/)) and unstable for one hip. The unstable stem 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 (Figure [4](https://www.hindawi.com/journals/aorth/2012/912058/fig4/)). The stem had been undersized; the CFR was 0.63 at the distal end of the lesser trochanter and 0.59 at the distal end of the stem. The follow-up radiographs showed no subsidence of the stem at 3 months after surgery, but subsidence of 5 mm was noted 4 years after surgery. The final follow-up radiographs at 6.1 years after surgery showed stem loosening with subsidence of 16 mm. The patient died due to unrelated pulmonary disease before revision was performed.

**INSERT FIGURES 3 AND 4 HERE**

Two hips showed subsidence. One hip is described above, and the other had sustained a femoral neck fracture during surgery. The stem had subsided 30 mm at 6 months after surgery but showed no further subsidence. At 7.5 years after surgery, radiographs showed bone ingrown fixation. The 10-year survival rate was 94 (86–97) % when any surgery or revision for any reason was defined as the endpoint and 99 (95–99.9) % when loosening or revision of the stem was defined as the endpoint.

Radiolucent lines of more than 1 mm were found in zones 1, 2, 5, and 6 of one hip with stem loosening (Figure [4b](https://www.hindawi.com/journals/aorth/2012/912058/fig4/" \l "b" \t "_blank)). Radiolucent lines of less than 1 mm were found in zone 2 of 6 hips, zone 3 of 19 hips, zone 4 of 106 hips (most frequent), zone 5 of 46 hips, zone 6 of 2 hips, and zone 7 of 1 hip. No hip showed radiolucent lines of less than 1 mm in more than four zones. Spot welds were found in zone 6 of 108 hips. No spot welds were found in any other zones. Osteolysis was found at the medial side of the greater trochanter in 18 hips (13 %) and in zone 1 of 1 hip. No osteolysis was found in any other zone. Stress shielding was grade I for 133 hips, and grade II for 4 hips.

The 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 x (range, 0.59–0.92) at the distal end of the lesser trochanter and was x (0.59–0.98) at the distal end of the stem. A CFR below 0.7 for both levels was only observed in one hip (Figure [4a)](https://www.hindawi.com/journals/aorth/2012/912058/fig4/#a). Other hips with low CFR values at the distal end of the lesser trochanter showed good CFR at the distal stem (for example, Figure [2b)](https://www.hindawi.com/journals/aorth/2012/912058/fig2/#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 %, ). With regard to diagnoses, the percentage of good fit was 59% for cases of osteoarthritis and 78% for cases of osteonecrosis. Hips with osteoarthritis showed a tendency for a lower percentage of good metaphyseal fit; however, this trend was not found to be statistically significant (). The relationship between metaphyseal fit and outcomes of THA is presented in Table [1](https://www.hindawi.com/journals/aorth/2012/912058/tab1/). No differences were observed between the good and poor fit groups with regards to the duration of follow-up. There were no differences in JOA score, stem fixation, rate of positive radiolucent line in zone 4, spot welds in zone 6, osteolysis at the medial side of the greater trochanter, or stress shielding between the two groups at follow-up.

**INSERT TABLE 1 HERE**

4. Discussion

Several studies [[1](https://www.hindawi.com/journals/aorth/2012/912058/#B1),[2](https://www.hindawi.com/journals/aorth/2012/912058/#B2),[8](https://www.hindawi.com/journals/aorth/2012/912058/#B8),[9](https://www.hindawi.com/journals/aorth/2012/912058/#B9)] have discussed the outcomes of THA using the Anatomic stem (Zimmer, Indiana, USA) in Caucasian patients, with low rates of stem revision due to loosening reported (from 0 to 2.6 %). Only two reports describe the outcomes of this surgery in Japanese patients. Harada et al. [[10](https://www.hindawi.com/journals/aorth/2012/912058/#B10)] reported that five cups and no stems had been revised out of 81 hips with a mean follow-up of 8.4 years. Nakoshi et al. [[11](https://www.hindawi.com/journals/aorth/2012/912058/#B11)] 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 revision and one stem showed loosening out of 137 hips with a mean follow-up of 9.7 years. These results suggest that the biological fixation of this stem is good for 8 to 12 years after surgery in Japanese as well as Caucasian patients.

Only one previous study has evaluated the metaphyseal fit or press-fit of the Anatomic stem. Ragab et al. [[1](https://www.hindawi.com/journals/aorth/2012/912058/#B1)] evaluated the press-fit of this stem in 97 hips using the methods of Callaghan et al. [[12](https://www.hindawi.com/journals/aorth/2012/912058/#B12)] and reported it to be excellent in 58 hips, good in 38 hips, and poor in 1 hip. These results suggest that the press-fit of this stem is appropriate for hips with primary osteoarthritis in Caucasian patients. However, direct comparison of these results with those of our study was not possible because we did not use the evaluation methods of Callaghan et al. [[12](https://www.hindawi.com/journals/aorth/2012/912058/#B12)] for a number of reasons. In their method, press-fit was considered 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 surfaces. The Anatomic stem has no lateral flare to maintain contact with the endosteum of the lateral metaphyseal cortex around the innominate tubercle. Therefore, assessments of the lateral side contact would be meaningless for this stem. Additionally, we considered that stricter assessments should be employed to evaluate contact on the medial side. No other reports on the press-fit or metaphyseal fit of the Anatomic stem are currently available.

Our analysis revealed that the occurrence of good metaphyseal fit was low. The Anatomic stem was designed using data obtained from normal femora of cadavers. Kaneuji et al. [[13](https://www.hindawi.com/journals/aorth/2012/912058/#B13)] studied the three-dimensional morphology of the femur in 113 hips with osteoarthritis and 36 normal hips in Japanese individuals. Their study classified the femoral canal into three types; the standard type accounted for 89 % of the normal hips but only 42 % of the hips with osteoarthritis. In our study, 117 hips out of 137 hips were diagnosed as having osteoarthritis. The difference in femoral configuration between normal and osteoarthritic hips could be one of the reasons for the high incidence of poor metaphyseal fit. The use of an undersized stem (Figure [4](https://www.hindawi.com/journals/aorth/2012/912058/fig4/)) can also result in poor metaphyseal fit. However, no other stems were undersized or showed loosening. Therefore, we conclude that the usage of undersized stems was not the main reason for poor metaphyseal fit.

The present study has several limitations. 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, there may be effects of metaphyseal fit that become apparent after longer periods, and we were unable to observe these. These points require further study.

5. Conclusions

Good metaphyseal fit was only 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 independent of metaphyseal fit. This stem, therefore, represents a long-term option for THA.

Source: [*Fixation of an Anatomically Designed Cementless Stem in Total Hip Arthroplasty*](https://www.hindawi.com/journals/aorth/2012/912058/) by Shigeru Nakamura, Noriyuki Arai, Takateru Kobayashi, and Takashi Matsushita, used under [CC-BY](https://creativecommons.org/licenses/by/3.0/)