Minimum Two-Year Results of Total Hip Arthroplasty Using a Short Tapered-Wedge Stem

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Abstract

Background: The short-stem design concept has several advantages, including preservation of the proximal femur, reduction of stress shielding, and less invasiveness. We evaluated the clinical and radiological outcomes of total hip arthroplasty (THA) using a short tapered-wedge stem after a follow-up period of at least 2 years.

Methods: We retrospectively evaluated 70 hips of 63 patients who had undergone cementless THA using the Initia stem (Kyocera, Kyoto, Japan) with a short tapered-wedge stem design from February 2017 to April 2019 and had a minimum follow-up period of 2 years. We evaluated the clinical and radiological results associated with the morphology of the proximal femur, which was classified as Dorr type A, B, or C.

Results: The mean Harris hip score (HHS) and Japanese Orthopaedic Association (JOA) hip score significantly improved postoperatively. No hips had a postoperative radiolucent line of ≥2 mm or stem subsidence of ≥2 mm. The survival rate was 100% for at least 2 years. Intraoperative femoral fracture occurred in two hips (2.8%). Grade 1 and 2 stress shielding was detected in 26 hips (37.1%) and 30 hips (42.9%), respectively. Spot welds were detected in Gruen zones 2 and 6 in 13 hips (18.6%) and 24 hips (34.3%), respectively. There were no significant differences in the valgus angle of the stem, intraoperative femoral fracture, or postoperative HHS and JOA hip scores among patients with Dorr type A, B, and C femurs.

Conclusions: The short-term results of THA using a short tapered-wedge stem were good with respect to fixation and clinical outcomes. However, long-term follow-up studies are warranted to confirm these results.

Key words: short tapered-wedge stem, cementless, total hip arthroplasty, Dorr classification

Introduction

Total hip arthroplasty (THA) is considered one of the most successful procedures in orthopedic surgery [1]. Historically, THA was mainly performed in older patients, but its use in younger patients has increased during the past decade [2]. However, young patients have a higher risk of requiring revision than do elderly patients [3]. Therefore, short-stem prostheses have been developed to preserve the bone stock of the proximal femur with the aim of facilitating future revisions[4]. This short-stem design concept has several other advantages, including reduced stress shielding, less invasiveness, and facilitation of soft tissue-sparing procedures [5),6)].

The use of short stems began in the early 1980s [7]. Various short-stem shapes are now being manufactured, and the models can be classified into four types [8]: femoral neck only, calcar loading type, lateral flare calcar loading type, and shortened tapered type. Several clinical studies have been conducted to assess the outcomes of various short-stem prostheses. Previous studies on short-stem prostheses in young and elderly patients have revealed excellent clinical results and fixation during short- and mid-term follow-ups [9]. However, there are only a few reports of the clinical results of the short tapered-wedge

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stem shape and no reports on the Initia stem (Kyocera, Kyoto, Japan) with a short cementless tapered-wedge stem. The Initia stem is a tapered, titanium, porous, plasma-sprayed device, and the coating on the distal 10-mm length of the sprayed area increases gradationally from distal (0.2 mm) to proximal (0.5 mm); this is expected to prevent stress concentration (Fig. 1).

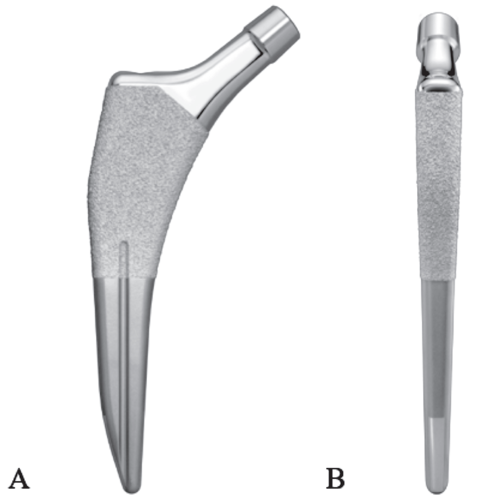

Fig. 1. Stem design. (A) Anterior view. (B) Lateral view. The Initia stem with a short tapered-wedge stem design allows for bone preservation and gradual load transfer from proximal to distal. The stem is also suitable for minimally invasive procedures because of its laterally reduced design, thin shape, and short length. This figure was provided by Kyocera Corporation, Kyoto, Japan.

In the present retrospective study, we reviewed the clinical and radiological performance of the Initia stem with a short cementless tapered-wedge stem design used for primary THA after a follow-up period of at least 2 years.

Materials and methods

Patients

From February 2017 to April 2019, the same surgeon performed primary THA on 87 consecutive hips of 79 patients at our hospital via the anterolateral approach in the supine position. The Initia stem with a short cementless tapered-wedge stem design was used for femoral reconstruction in all 87 hips. We excluded 17 hips of 16 patients who underwent THA because their follow-up period was less than 2 years. Finally, we included 70 hips of 63 patients in this study. The patients comprised 48 female patients (55 hips) and 15 male patients (15 hips).

The primary diagnoses of the hips that underwent THA were osteoarthritis secondary to developmental dysplasia of the hip (41 hips), osteonecrosis of the femoral head (12 hips), primary osteoarthritis (11 hips), post-traumatic osteoarthritis (1 hip), rheumatoid arthritis (1 hip), osteoarthritis secondary to septic arthritis of the hip (1 hip), subchondral insufficiency fracture of the femoral head (1 hip), rapidly destructive coxarthrosis (1 hip), and femoral neck fracture (1 hip).

Clinical outcomes

The functional outcomes of the hip joint were evaluated using the Harris hip score (HHS) and the Japanese Orthopaedic Association (JOA) hip score preoperatively and at the final follow-up [10),11)]. Patients who underwent stem revision for aseptic loosening were also identified.

Radiographic analysis

Radiographic evaluation included assessment of the valgus angle of the stem, morphology of the proximal femur, stem stability, stem subsidence, stress shielding, spot welds, radiolucent lines, progressive migration, and osteolysis. The angle between the femoral axis and lateral sideline of the stem was defined as the valgus angle of the stem and was measured on anteroposterior pelvic radiographs [12)]. The morphology of the proximal femur was classified as Dorr type A, B, or C [13)]. Stem stability was evaluated as either stable or unstable according to the criteria established by Engh et al.[14)] "Stable" was defined as no subsidence, no progressive migration, and no formation of a radiolucent line of <2 mm in width around the stem[14)]. "Unstable" was defined as progressive subsidence or migration and formation of a radiolucent line of ≥2 mm in width around the stem. Stem subsidence of ≥2 mm as shown on postoperative radiographs was defined as positive subsidence [15)]. Stress shielding was categorized into four degrees according to the criteria established by Engh et al. [14)]: grade 1, only the most proximal medial edge of the cut femoral neck was slightly rounded off; grade 2, the proximal medial femoral neck was rounded off and the medial cortical density was lost; grade 3, more extensive resorption of the cortical bone was present, typically involving both the medial and anterior cortical regions; and grade 4, cortical resorption extended into the diaphysis.

All hips were reviewed for the development of spot welds using the Gruen zone classification [16)].

Statistical analysis

Tukey's honestly significant difference test was used to compare the following data among Dorr types A, B, and C: age at surgery, height, weight, body mass index (BMI), valgus angle of the stem, postoperative HHS, and postoperative JOA hip score. Statistical analyses were performed using SPSS ver. 20.0 (IBM Corp., Armonk, NY, USA). Statistical significance was indicated by a p-value of <0.05. A survival analysis was performed according to the Kaplan–Meier method using the endpoint of stem revision for aseptic loosening.

Results

At the time of the procedure, the patients' mean age was 66.9 ± 13.1 years (range, 28–93 years), mean height was 154.9 ± 7.0 cm (range, 142.3–172.4 cm), mean weight was 55.5 ± 9.7 kg (range, 41.2–83.7 kg), and mean BMI was 23.1 ± 3.6 kg/m^2 (range, 17.1–34.1 kg/m^2). The mean postoperative follow-up period was 2.5 ± 0.5 years (range, 2–4 years) (Table 1).

The mean HHS improved from 59.9 ± 15.2 points (range, 21–88 points) preoperatively to 93.1 ± 6.4 points (range, 79–100 points) at the last follow-up. Similarly, the mean JOA hip score improved from 55.7 ± 15.2 points (range, 9–82 points) preoperatively to 89.0 ± 9.3 points (range, 50–100 points) at the last follow-up (Table 1). Subsidence, progressive migration, osteolysis, formation of a radiolucent line of ≥2 mm in width around the stem, or revision after the surgery were not observed in any hips. The Kaplan–Meier survival rate with the endpoint of aseptic loosening and stem revision was 100% at 2 years postoperatively.

Table 1. Characteristics of 70 hips in 63 patients who underwent primary total hip arthroplasty with the anterolateral approach in the supine position

Characteristic	All hips (n = 70)
Sex, male : female (no. of hips)	15 : 55
Age* (years)	66.9 ± 13.1 (28–93)
Height* (cm)	154.9 ± 7.0 (142.3–172.4)
Weight* (kg)	55.5 ± 9.7 (41.2–83.7)
BMI* (kg/m^2)	23.1 ± 3.6 (17.1–34.1)
Follow-up period* (years)	2.5 ± 0.5 (2–4)

*Data are expressed as mean ± standard deviation.
BMI, body mass index.

Intraoperative femoral fractures occurred in two hips (2.9%). These two hip fractures were located at the medial cortex of the femoral neck. Both fractures were treated via circumferential wiring and healed with no clinical or radiological evidence of complications.

The mean valgus angle of the stem was 3.6° ± 1.7° (range, −1.0° to 7.0°). Stress shielding was detected as follows: grade 1 in 26 hips (37.1%), grade 2 in 30 hips (42.9%), and grade 3 and 4 in 0 hips (0.0%). Spot welds around the femoral stem were identified at Gruen zone 1 in 0 hips (0.0%), zone 2 in 13 hips (18.6%), zone 3 in 5 hips (7.1%), zone 4 in 0 hips (0.0%), zone 5 in 4 hips (5.7%), zone 6 in 24 hips (34.3%), and zone 7 in 0 hips (0.0%).

There were no significant differences in the age at surgery (p = 0.68), height (p = 0.84), weight (p = 0.32), BMI (p = 0.44), valgus angle of the stem (p = 0.36), intraoperative femoral fracture (p = 0.67), postoperative HHS (p = 0.67), or postoperative JOA hip score (p = 0.86) among patients with Dorr type A, B, and C femurs (Table 2).

Discussion

In previous studies of THA using a short tapered-wedge stem (Taperloc Microplasty stem; Zimmer Biomet, Warsaw, IN, USA), the survival rate of stem revision and aseptic loosening was 99.6% and 100%, respectively, during a mean follow-up period of 2.2 years and 100% and

Table 2. Distribution and analysis of postoperative outcomes according to Dorr types

	Dorr A group n = 2 hips	Dorr B group n = 57 hips	Dorr C group n = 11 hips	P- value
Age at surgery* (years)	70.0 ± 19.8	65.6 ± 14.5	72.6 ± 10.1	0.68
Height* (cm)	155.5 ± 10.6	155.3 ± 7.5	153.0 ± 6.5	0.84
Weight* (kg)	61.6 ± 7.7	55.9 ± 10.0	52.6 ± 8.0	0.32
BMI* (kg/m^2)	25.4 ± 0.3	23.2 ± 3.7	22.5 ± 3.5	0.44
Stem valgus angle* (degree)	4.3 ± 0.2	3.3 ± 1.7	4.8 ± 1.5	0.36
Postoperative* HHS (points)	90.0 ± 1.4	93.5 ± 6.4	91.5 ± 6.6	0.67
Postoperative* JOA hip score (points)	86.0 ± 0	89.1 ± 9.7	88.7 ± 8.4	0.86

*Data are expressed as mean ± standard deviation.
BMI, body mass index; HHS, Harris Hip Score; JOA, Japanese Orthopaedic Association.

100%, respectively, during a mean follow-up period of 4.4 years [17),18)]. The excellent survival rates revealed in these studies are similar to those found in the present study, indicating that excellent survival rates can be obtained by THA using Initia stem.

Regarding clinical outcomes in the above-mentioned studies, Molli et al. [17)] reported that the mean HHS improved from 49.9 to 83.1 points during a mean follow-up period of 2.2 years, whereas Hayama et al. [18)] reported that the mean JOA score improved from 49 to 89 points during a mean follow-up period of 4.4 years. The good clinical outcomes revealed in these studies are similar to those found in the present study, indicating that good clinical outcomes can be obtained by THA using the Initia stem.

The incidence of intraoperative fractures when using a short stem reportedly ranges from 4.0% to 6.2% [19),20)]. The intraoperative fracture rate in the present study (2.9%) was similar to that reported in previous studies. Furthermore, the radiological outcomes in this study (no obvious stem subsidence or loosening) indicate that initial bone fixation was achieved in all cases. Therefore, with appropriate application, initial fixation can be achieved even with a tapered-wedge stem with reduced stem length.

The short tapered-wedge design depends mostly on tapered fixation in the proximal half of the plasma coating, with coating positions in Gruen zones 1/2 and 6/7. Previous studies on short tapered-wedge stems have revealed spot welds in Gruen zones 2 and 6 and Engh grade 1 and 2 stress shielding[18)]. The present study revealed similar results: spot welds were detected mainly in Gruen zones 2 and 6, while grade 1 and 2 stress shielding were observed in the atrophic regions of the femur around the stem. This may be attributed to the design of the Initia stem, in which plasma coating technology is applied from the proximal part to the center of the stem, as well as to the taper fixation at the center of the stem.

The morphology of the proximal femur differs according to age, race, sex, and lifestyle [21),22)]. Type C femurs are found predominantly in older women with a low body weight; the cortices in these women are thin because of loss of the medial and posterior cortices [22)]. These factors may detrimentally affect the immediate fixation and long-term survival of the prosthetic implant [22),23)]. One study of a standard tapered-wedge stem showed an excellent implant survival rate (100%) during a mean period of 40 months (range, 24–84 months), although the radiographic evaluation showed no subsidence in types A and B and subsidence of >2 mm 3,8% in type C respectively [24)]. In the present study, no hips showed subsidence of >2 mm in the postoperative radiographic evaluation, and the implant survival rate was excellent (100%) in Dorr types A, B, and C with good results. Therefore, we consider that the short tapered-wedge Initia stem is suitable for Dorr type A, B, and C femurs.

Our study has several limitations. First, we did not evaluate the interobserver variability of the radiological outcomes to confirm the measurements made by the single observer, which may have led to bias in interpreting the radiographs and caused underestimation or overestimation of the results. Second, the follow-up period was short. Third, morphological evaluation by the Dorr classification resulted in few type C femurs and especially few type A femurs. Future studies with more evaluators, larger patient populations, and longer follow-up periods are warranted to ensure the safety and efficacy of using a short tapered-wedge stem in patients undergoing THA.

Conclusions

The short-term results of this study revealed that THA using a short tapered-wedge stem resulted in good postoperative fixation and clinical outcomes. A short tapered-wedge stem may be used for any type of femoral morphology. Long-term follow-up studies are warranted to confirm these results.

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