Minimum ten-year outcome of a triple-tapered femoral stem implanted with line-to-line cementing technique

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Abstract

Background

A triple-tapered polished femoral stem was implanted with line-to-line cementing technique. The purpose of this study was to determine the survivorship, loosening rate, stem subsidence, radiologic changes and clinical outcomes in the minimum ten-year follow-up.

Methods

This was a retrospective study done in three institutes. Finally, 118 hips in 97 patients could be followed-up at the mean follow-up period of 126.9 months. The survivorship, radiological and clinical outcomes were investigated.

Results

Radiologically, 107 hips (90.7%) were categorized to Barrack cementing grade A, and 108 stems (91.5%) were inserted in neutral position. All hips were not loose and were not revised due to aseptic loosening. Survival with revision for any reason as the endpoint was 100% after 10 years. At the last follow-up, the mean subsidence was 0.41 mm, and the subsidence was less than 1 mm in 110 hips (93.2%).

JOA hip score improved from 42.7 ± 9.2 points preoperatively to 92.9 ± 6.8 points at the last follow-up. No patient complained thigh pain.

Conclusions

Line-to-line cementing technique with use of a triple-tapered polished stem was effective to achieve good cementation quality and centralization of the stem. The subsidence was small, and the minimum ten-year results were excellent without any failures related to the stem.

Trial registration: Retrospectively registered

Keywords: Total hip arthroplasty, Triple-tapered polished femoral stem, Line-to-line cementing technique, Subsidence

Background

Since the cement fixation system of femoral stems for total hip arthroplasty (THA) was established in the 1960s, a variety of different concepts have been applied to the development of the femoral stems. In these concepts, main topics are stem design and cement mantle thickness.

In terms of stem design, cemented femoral stems can be broadly divided into two designs that achieve fixation as a composite beam and those that function as a taper-slip device [1]. Recent studies of polished tapered cemented stems have reported superior long-term clinical outcomes from the systematic review [2], and significant survival advantages in the registry data [3]. Originally, double-tapered polished stems, such as the Exeter stem and the CPT stem, were developed. Their long-term good clinical results have been previously reported [4-6], while the bone loss in the calcar region around double-tapered stem was concerning [7]. A triple-tapered cemented stem was designed with the intention of loading the proximal femur, thereby reducing proximal bone loss [8]. Buckland et al. [9] measured bone mineral density (BMD) around a triple-tapered stem. The marked loss in BMD occurred in zone 1 and 7 within 9 months postoperatively, while zones 6 and 7 showed a recovery in BMD between 9 and 24 months postoperatively, and zones 1 and 3 showed more

55 delayed recovery in BMD at 18 months.

56 The second topic of cemented stem is cement mantle thickness. It is still unclear
57 whether thickening the cement mantle leads to better outcomes. Many studies have
58 reported good outcomes for a cement mantle thickness of at least 2mm [10-13], while
59 a favorable outcome with a thin cement mantle was also reported as 'French paradox'
60 [14, 15]. Line-to-line cementing technique means preparation of the femoral canal
61 using the largest possible broach and implantation of a stem with the same
62 dimensions as the broach. It is reported that line-to-line cementing technique in
63 human cadaver femora resulted in a mean thickness of cement of 3.1 mm, and the
64 cement was directly supported by cortical bone or cortical bone with less than 1 mm
65 of cancellous bone interposed in over 90% of thin cement mantle areas [16]. This
66 technique also can achieve the pressurization of the cement into cancellous bone
67 during insertion of the implant [17]. These results indicate that both polished
68 tapered stem design and line-to-line cementing technique might bring about
69 successful long-term outcomes.

70 The purpose of this study was to determine the survivorship, loosening rate, stem
71 subsidence, radiologic changes and clinical outcomes in the minimum ten-year
72 follow-up of a triple-tapered polished stem implanted with line-to-line cementing

technique. These results were compared with those of the other polished tapered stems.

Materials and Methods

The research protocol of this retrospective study was in compliance with the Helsinki Declaration. The institutional review board of Osaka Saiseikai Nakatsu Hospital approved this study. Informed consent was obtained from all patients who participated in this study.

From February 2009 to October 2010, consecutive 186 hips in 162 patients underwent THA with a femoral stem (Trilliance, B.Braun Aesculap, Tuttlingen, Germany) fixed with line-to-line cementing technique. This stem was made of CoCr with a highly polished surface (Ra 0.01 mm) and a quadrangular section (Fig. 1). Twelve patients died, 14 patients could not visit due to the comorbid disorders, 18 patients could not visit due to long distance to the institutes, and 21 patients were lost to follow-up. Finally, 118 hips in 97 patients could be followed-up at longer than ten years postoperatively (Fig. 2). The patients demographics, diagnosis, and surgical approaches were shown in Table 1. No patient received prior surgery to the hip. A type of cup and bearing materials were chosen according to the surgeons' preference (Table 2). The heads used were 22, 26, 28 and 32 mm in diameter. Femoral

canal was prepared using the largest possible broach, and bone plug or polyethylene cement plug was placed at 1 cm distal to the stem tip. After pulse lavage, vacuum mixed bone cement was introduced in a retrograde fashion. The femoral stem was inserted without a distal centralizer.

Clinical and radiological evaluation was undertaken preoperatively and at 3 weeks (baseline radiograph) and every year. At each follow-up visit, the patients had a physical examination by the operating surgeons and the functional results were evaluated using Japanese Orthopaedic Association hip score (JOA hip score, full mark=100) [18]. Anteroposterior radiograph of the pelvis with the patient supine position was obtained, and all the radiographs were examined independently by the three authors. The cementing technique was assessed using the grading of Barrack et al. [19]. The alignment of the stem was referenced from the axial alignment of the femur, and the alignment was assumed to be neutral within 3 degrees from co-linearity. On the final radiographs, the presence and evolution of radiolucent lines and cortical thickening in any of the seven zones described by Gruen et al. [20] was evaluated. Loosening of the femoral component was defined according to the criteria of Harris et al. [21] which included subsidence of the stem greater than 3 mm, fracture of the cement mantle, and a complete radiolucent line greater than 2 mm or

a radiolucent line in zone 1 greater than 2 mm in width. Periprosthetic cystic or scalloped lesions larger than 2 mm in diameter which had not been present on the immediate post-operative radiograph were defined as osteolysis. Subsidence of the stem was measured on magnified images calibrated using the known size of the femoral head. The radiological landmarks were the greater trochanter, the proximolateral cement mantle and the shoulder of the prosthesis, as described by the Exeter group [22].

All data were collected and analyzed using the Microsoft Excel Software (Microsoft Corporation, Redmond, WA). Kaplan-Meier survival analyses (EZR, Saitama Medical Center, Jichi Medical University, Saitama, Japan) were used to evaluate the cumulative stem survivorship and performed for any reasons, and aseptic loosening.

Results

According to the Barrack cementing grade, 107 hips were categorized to grade A, 11 hips were categorized to grade B. Stem was inserted in neutral position in 108 hips, in valgus in 7 hips, and in varus in 3 hips. Radiolucent lines and osteolysis were not observed in any hips. All hips were not loose and were not revised due to any reasons (Fig. 3). Cortical thickening was observed in one hip at zones 3 and 5. Fracture of the cement mantle was not observed. No post-operative complication occurred, such

127 as deep venous thrombosis, and heterotopic ossification.

128 Survival with stem revision for any reasons as the endpoint was 100%. At the last

129 follow-up, the mean subsidence was 0.41 mm (0 mm to 1.9 mm). In most of the hips,

130 the subsidence was less than 1 mm (Table 3).

131 JOA hip score improved from 42.7 ± 9.2 points preoperatively to 92.9 ± 6.8 points at

132 the last follow-up. No patient complained thigh pain.

133 ## Discussion

134 In this study, survival with revision for any reasons as the endpoint was 100%. The

135 most widely used polished tapered femoral component, Exeter stem, showed that the

136 survival rate for all-cause revision of the stem was 96.8%, and that for aseptic

137 loosening as the endpoint was 100% at 13.5 years [5]. From the report of C-stem,

138 there were no revision for stem loosening but two stems was revised for fracture at

139 a mean follow-up of 13 years [23]. CMK stem, implanted with line-to-line cementing

140 technique, marked the cumulative survival rate with revision of either component

141 for any reason as endpoint of 90.5% at 17 years [15]. Our long-term results would be

142 comparable to those of polished tapered stems.

143 Line-to-line cementing technique has some advantages. It can achieve the

144 pressurization of the cement into cancellous bone during insertion of the implant.

While grade A cementation quality described by Barack was recognized in 49.6% and 73.6% when using the Exeter stems [5, 24], grade A was achieved in 90.7% in our study. Other advantage is centralization of the stem. Scheerlinck et al. reported line-to-line stems without a distal centralizer were better aligned than undersized stems fitted with a centralizer [17]. Cortical point contact during stem insertion may improve alignment of the stem into the proximal medullary cavity. In our study, 91.5% was inserted in neutral position, and the CMK stem that was also implanted with line-to-line cementing technique, was in a neutral position in 80.5% [15]. In contrast, 65.3% was inserted within 2 degrees of varus or valgus in the Exeter stem [24], and 61.7% was in a neutral position in the C-stem [25].

The mean subsidence was 0.41 mm at the mean follow-up period of 126.9 months. It was reported that the mean subsidence of Exeter stem was 1.2 mm at a minimum of 10-year follow-up [5]. The subsidence of C-stem AMT was reported to be 1.28 mm at two years [26]. A hollow polymethyl-methacrylate centralizer was placed on the tip of these stems. The use of centralizer and thick cement mantle might allow these stems for subsidence. Subsidence remains a fundamental principle of the design of taper-slip stem, which produces tensile hoop forces in the cement and compressive stress at the cement-bone interface. On the other hand, the mean subsidence was

163 0.63 mm in CMK stem, that had no centralizer and was implanted with line-to-line
164 cementing technique [15].
165 Cortical thickening was observed in one hip (0.8%) in our study. The rate of cortical
166 thickening was reported from 0.5% to 40.2% [4, 15, 27]. The rate of cortical
167 thickening was lower compared to those reported results. Cortical hypertrophy
168 might reflect the mechanical conditions around cemented femoral components,
169 however, this was not matched to poor outcome, and its clinical relevance is still
170 unclear.
171 The first limitation of the study is the uncontrolled retrospective study, and there
172 was no control group. Thus, the results were compared with those of the other
173 polished tapered stems. The Exeter stem and the CPT stem were double-tapered
174 stem, and the C-stem was triple-tapered stem. These stems were fixed using distal
175 centralizer with keeping cement mantle. The CMK stem was also double-tapered
176 stem and the line-to-line cementing technique was applied. Secondary, the follow-up
177 period was not enough to compare our results with reported long-term results. For
178 predicting the long-term survival of this femoral stem, we have to continue to
179 investigate the clinical and radiological outcomes.
180 In conclusion, line-to-line cementing technique with use of a triple-tapered polished

stem was effective to achieve good cementation quality and centralization of the stem. The subsidence was smaller than that of well-established polished tapered stems. The minimum ten-year results were excellent without any failures related to the stem. Further follow-up is needed to compare with results with longer-term follow-up.

Declarations

Abbreviations

THA: Total hip arthroplasty, BMD: Bone mineral density, JOA hip score: Japanese Orthopaedic Association hip score

Ethics approval and consent participate

The research protocol of this retrospective study was in compliance with the Helsinki Declaration. The institutional review board of Osaka Saiseikai Nakatsu Hospital approved this study. Informed consent was obtained from all patients who participated in this study.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and anlysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare no conflicts of interest associated with this manuscript.

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Authors' contribution

HO designed the work, acquired and analysed the data, and was a major contributor in writing the manuscript. SI and IM acquired and analysed the data, and substantively revised the manuscript. All authors read and approved the final manuscript.

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Figure legends

Fig. 1 Three views of a triple-tapered polished cemented stem, Trilliance

Fig. 2 The flowchart of patients in this study

Fig. 3 Post-operative anteroposterior radiographs of 62-year-old woman with dysplastic hip osteoarthritis showing (a) well-aligned stem cemented with line-to-line technique, (b) follow-up at 10 years without measurable subsidence of the stem

Fig. 1

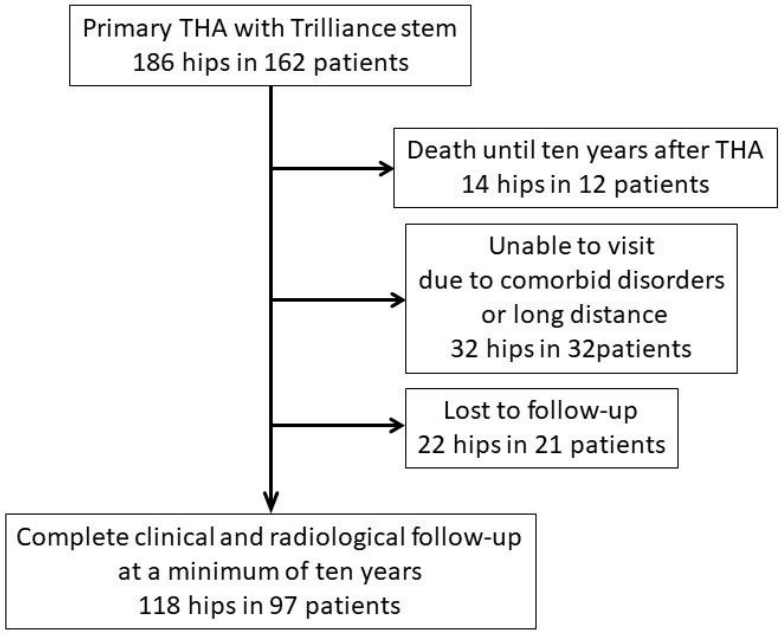
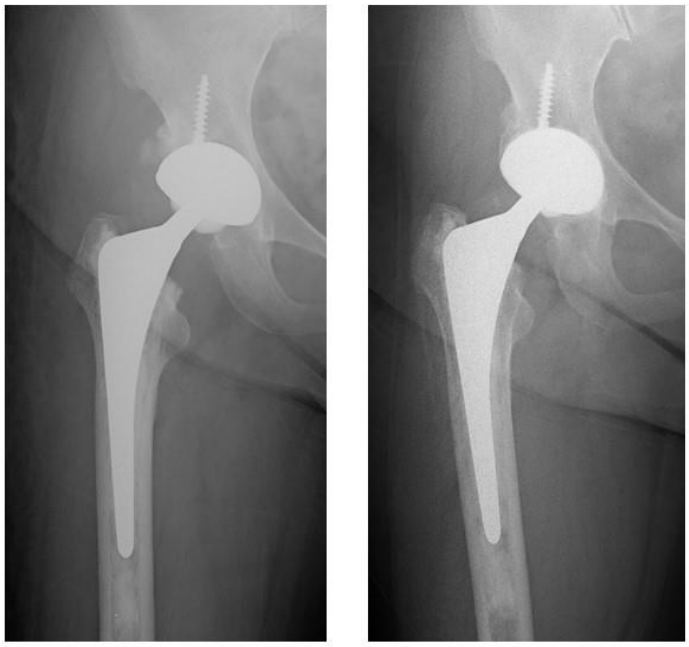

Primary THA with Trilliance stem
186 hips in 162 patients
Death until ten years after THA
14 hips in 12 patients
Unable to visit
due to comorbid disorders
or long distance
32 hips in 32patients
Lost to follow-up
22 hips in 21 patients
Complete clinical and radiological follow-up
at a minimum of ten years
118 hips in 97 patients

Fig. 2



(a) (b)

Fig. 3

Table 1 Patient demographics, diagnosis, and surgical approaches

Demographics	
Number of hips	118 hips
Age at operation (mean ± SD, range)	61.0 ± 10.0 (20-84) years
Sex	
Males	18 hips
Females	100
Follow-up period (mean ± SD, range)	126.9 ± 5.7 (120-139) months
Diagnosis	
Osteoarthritis	104 hips
Idiopathic osteonecrosis of femoral head	9
Rheumatoid arthritis	2
Rapidly destructive coxarthritis	2
Miscellaneous	1
Approaches	
Direct anterior approach	97 hips
Direct lateral approach	20
Transtrochanteric approach	1

SD: standard deviation

Table 2 Cups and types of articulation used in this study

Cup	
Plasmacup	68 hips
Contemporary	5
Triad HA	2
Trident	43

Articulation	
Ceramic / Ceramic	68 hips
Metal / Polyethylene	50

Table 3 Number of hips in every 1 mm for subsidence

Subsidence	
0 mm	28 hips (23.7%)
1 mm >S	82 hips (69.5%)
2 mm > S≧ 1 mm	8 hips (6.8%)

S: subsidence