Acta Orthop. Belg., 2021, **87 e-supplement** 1, 14-19

ORIGINAL STUDY

Clinical and radiographic results of total hip arthroplasty after a minimum follow-up period of 5 years after insertion of a TriLock bone preservation stem

Masanori Tsubosaka, Shinya Hayashi, Shingo Hashimoto, Koji Takayama, Ryosuke Kuroda, Tomoyuki Matsumoto

From the Department of Orthopaedic Surgery, Kobe University Graduate School of Medicine, Hyogo, Japan

The TriLock bone preservation stem (BPS) is a device that allows proximal fixation of the implant in total hip arthroplasty (THA). The purpose of this study was to evaluate the mid-term clinical and radiographic results of the TriLock BPS and investigate the differences in the results as a function of medullary cavity shape.

This study analyzed 76 consecutive patients (62 women and 14 men) who underwent THA using the TriLock BPS between April 2012 and September 2013. The minimum clinical and radiographic follow-up period for patients was 5 years (mean, 5.6 years). The radiographic results and Harris Hip Scores (HHS) were evaluated across the three Dorr femoral bone classifications.

The postoperative HHSs were significantly higher than the preoperative HHSs (p<0.05). There were no significant differences with respect to the three Dorr types based on preoperative and postoperative HHS scores. Stress shielding was observed in 66 hips. Spot welds and cortical hypertrophy were observed in various zones of 31 and 18 hips, respectively. There was no significant difference in the occurrence of stress shielding, spot welds, or cortical hypertrophy among the three Dorr types. There were no complications across all cases during the follow-up period.

Mid-term clinical results were good regardless of the medullary cavity shape. Furthermore, the occurrence of stress shielding, spot welds, and cortical hypertrophy was not significantly different among the three Dorr types. Therefore, the TriLcok BPS is a surgical option, regardless of the type of medullary cavity shape, for primary THA.

Keywords : total hip arthroplasty ; TriLock BPS ; mid-term clinical results ; Dorr types.

INTRODUCTION

Total hip arthroplasty (THA) was established by Sir John Charnley in the 1960s *(3)*. Since then, the development of the THA procedure and implant has been researched worldwide *(4)*. Cementless femoral stems have been used for primary THA for more than 2 decades *(18)*. In addition, cementless stems with various shapes and fixed concepts have been developed, therefore it is necessary to understand the characteristics of each stem *(14)*. Cementless

■ Masanori Tsubosaka, MD,.
■ Shinya Hayashi, MD, PhD,
■ Shingo Hashimoto, MD, PhD,
■ Koji Takayama, MD, PhD,
■ Ryosuke Kuroda, MD, PhD,
■ Tomoyuki Matsumoto, MD, PhD.
Department of Orthopaedic Surgery, Kobe University Graduate School of Medicine, Kobe, Hyogo, Japan.
Correspondence : Shinya Hayashi, Department of Orthopaedic Surgery, Kobe University Graduate School of Medicine, 7-5-2, Kusunoki-chou, Chuo-ku, Kobe, Hyogo, 650-0017, Japan. Phone: 81-78-382-5985. Fax: 81-78-351-6944.
Email : s11793290@yahoo.co.jp

Conflicts of interest: none

stem designs include tapered wedge, cylindrical, and anatomic varieties. Interestingly, there have been reports that postoperative clinical results depended on type of cylindrical stem design *(7)*, as well as the anatomic stem design also having varying degrees of success *(11)*. In contrast, the tapered wedge stem design has shown successful clinical results with a reported 10 to 15-year survivorship of 95% to 100% *(20)*. Dorr et al. classified the proximal femoral conformation into types A, B, and C, according to the thickness of the cortical bone and shape of the medullary canal *(5)*. They reported that type C femurs showed increased numbers of cells, reduced cell activity, and structural changes. These characteristics indicated that type C femurs might be a less favorable environment for biological fixation of cementless implants. A report has been published that states cementless femoral components might be suitable for use in young patients with femurs of types A and B *(15)*. The bone quality of these young patients allows for greater security in surgical manipulation and better initial stabilization for cementless femoral implants, with the theoretical advantage of better osseointegration.

The TriLock stem has been in clinical use since 2009 in the United States and its short-stemmed [TriLock Bone Preservation Stem (BPS)] variant has been used in Europe since 2010 *(20)*. The conventional TriLock stem has been in use since 1981 in the United States as a cementless stem, with excellent clinical results *(2)*. This TriLock system is based on cementless stems, with a straight, collarless, cobalt-chrome Muller design, which was popular in the 1980s and 1990s *(19)*. The TriLock BPS has been reduced in size and shape compared to the conventional stem variant. The TriLock BPS is classified as short stems with a tapered wedge design and a proximal porous coating, which allows proximal fixation of the implant. Several reports indicated good clinical results following THA performed using a femoral component of the TriLock BPS *(1,16)*. However, there are few reports on comparing clinical and radiographic results in accordance with femoral shape. Therefore, the purpose of this study was to evaluate the mid-term clinical and radiographic results of the TriLock BPS, and the difference in the results according to medullary cavity shape. We hypothesized that the TriLock BPS could achieve good clinical and radiographic results regardless of medullary cavity shape.

MATERIALS AND METHODS

This study analyzed 83 consecutive patients (65 women and 18 men) who underwent THA with the TriLock BPS (Depuy, Warsaw, IN) between April 2012 and September 2013. Seven patients were lost during the follow-up period, therefore a total of 76 patients (62 women and 14 men) were included in this study. The follow-up rate was 91.6%. The minimum clinical and radiographic follow-up of patients was 5 years (mean, 5.6 years ; range, 5.0-6.2 years). The preoperative diagnosis of the 76 patients who underwent hip surgery included osteoarthritis (64 patients), rheumatoid arthritis (2 patients), and osteonecrosis (10 patients). The mean age of the patients at the time of surgery was 65.3 ± 10.4 years. The mean heights, weights, and body mass indexes were 154.9 ± 8.1 cm, 56.8 ± 11.4 kg, and 23.6 ± 3.8 kg/m^2, respectively. Pinnacle acetabular cup, and a 36 mm, 32 mm or 28 mm diameter (3.9% of patients, 40.8% of patients and 55.3% of patients, respectively) Delta ceramic head system (DePuy, Warsaw, IN) were used in this study. All surgeries were minimally invasive, using the anterolateral approach in the supine position. One day after surgery, physical therapy was initiated, and all patients were encouraged to be fully weight bearing.

The physical or radiographic examination follow-ups were conducted 3, 6, and 12 months post THA, and subsequently, once a year. The anteroposterior radiographs at the final follow-up were evaluated by an orthopaedic surgeon, specialized in hip joints, with 20 years of experience, who had no relationship to the present study. Femoral osteopenia resulting from stress shielding was graded according to the system described by Engh et al. *(7)*. By using the Dorr classification for proximal femoral shape *(6)*, 9 patients were identified as having a Dorr type A femur (funnel shaped) ; 55 patients, a Dorr type B femur (intermediate) ; and 12, a Dorr type C femur (cylindrical). Other parameters were also evaluated including the incidence of spot welds *(8)* (endosteal new bone formation on the prosthesis), cortical hypertrophy, the ratio of canal filling *(9)*, and the Canal-Flare index (CFI) *(13)*. The ratio of canal filling was defined as the ratio of the width of the stem over the width of the femoral canal at the following 3 sections : (a) proximal (10 mm above the lesser trochanter), (b) middle (the lesser trochanter), and (c) distal (60 mm below the lesser trochanter). The Harris Hip Score (HSS) *(10)* was investigated preoperatively and then postoperatively at the last clinical evaluation follow-up. We also evaluated the presence or absence of complications such as dislocation, infection, and need for revision.

All values are expressed as mean ± standard deviation. Data analyses were performed using a statistical software package (Statview 5.0 ; Abacus Concepts Inc, Berkeley, CA). The Shapiro-Wilk test (SPSS Statistics 21 ; IBM Japan, Tokyo, Japan) was performed to analyze normally distributed data. Correlations between the preoperative and postoperative HHS were analyzed using paired t-tests, and correlations between CFI and postoperative HHS were analyzed using simple regression analysis. Furthermore, we evaluated the occurrence of stress shielding, spot welds, and cortical hypertrophy among the 3 Dorr types using a multiple comparison. The number of occurrences of stress shielding, spot welds, and cortical hypertrophy were also evaluated between Dorr types A and B, types A and C, and types B and C using Fisher's exact test. The ratio of canal filling to HHS was also evaluated among the 3 Dorr types by using one-way analysis of variance. P values of <0.05 were considered to be statistically significant.

This study has been approved by the IRB of the authors' affiliated institutions, and informed consent for participation was obtained from all participants.

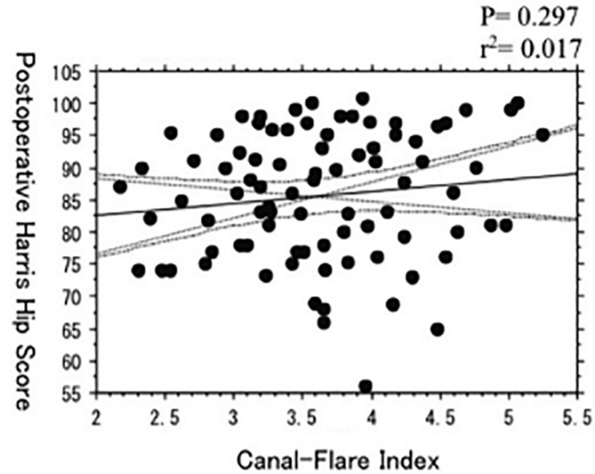

Fig. 1. — Correlations between the canal-flare index (CFI) and postoperative Harris hip score (HHS) at the last follow-up. No significant correlation was found between CFI and postoperative HHS.

RESULTS

The preoperative and postoperative HHS at the last follow-up were 53.6 ± 14.8 and 91.0 ± 9.4, respectively, in Dorr type A, 50.0 ± 8.8 and 87.3 ± 8.8, respectively, in Dorr type B, and 58.5 ± 12.8 and 92.7 ± 6.5, respectively, in Dorr type C. The postoperative HHSs for all three types were significantly higher than the preoperative HHSs ($p<0.05$). However, no significant differences were found among the 3 Dorr types in preoperative HHS and postoperative HHS (Table 1). The mean CFI was 3.7 ± 0.8. No significant correlation was found between CFI and postoperative HHS (Fig. 1). The ratio of canal filling at the proximal, middle, and distal sections were showed in Table 2. The ratios of canal fillings at the proximal section were significantly higher in Dorr type C than in both

Table 1. Preoperative and postoperative Harris hip score (HHS) at the last follow-up

	Dorr type A (9 hips)	Dorr type B (55 hips)	Dorr type C (12 hips)	P value type A vs B	P value type A vs C	P value type B vs C
Preoperative HHS	**53.6 ± 14.8**	**50.0 ± 9.4**	**58.5 ± 12.8**	**0.513**	**0.501**	**0.091**
Postoperative HHS	**91.0 ± 9.4**	**87.3 ± 8.8**	**92.7 ± 6.5**	**0.257**	**0.662**	**0.055**
P-value	**<0.001**	**<0.001**	**<0.001**			

Table 2. — The ratio of canal filling at proximal, middle and distal sections

	Dorr type A (9 hips)	Dorr type B (55 hips)	Dorr type C (12 hips)	P value type A vs B	P value type A vs C	P value type B vs C
Proximal section	73.4 ± 6.6	75.1 ± 8.7	82.6 ± 4.7	0.566	0.017	0.010
Middle section	89.0 ± 7.1	88.9 ± 9.8	91.4 ± 7.2	0.966	0.587	0.444
Distal section	75.6 ± 9.3	78.6 ± 11.0	83.5 ± 8.9	0.443	0.116	0.194

Table 3. — The number of occurrences of stress shielding

					Chi-squared test		
Engh's classification	Dorr type-A (9 hips)	Dorr type-B (55 hips)	Dorr type-C (12 hips)	Multiple comparison P value	P value Type-A vs -B	P value Type-A vs -C	P value Type-B vs -C
Grade 1	3	21	4	1.000	1.000	1.000	1.000
Grade 2	4	26	4	0.709	1.000	0.673	0.525
Grade 3	0	3	1	0.734	1.000	1.000	0.555
Grade 4	0	0	0	-	-	-	-
Total	7	50	9	0.134	0.253	1.000	0.147

Table 4a. — The number of occurrences of spot welds.

					Chi-squared test		
Gruen's classification	Dorr type-A (9 hips)	Dorr type-B (55 hips)	Dorr type-C (12 hips)	Multiple comparison P value	P value Type-A vs -B	P value Type-A vs -C	P value Type-B vs -C
Zone 1	0	2	0	1.000	1.000	-	1.000
Zone 2	0	9	2	0.578	0.337	0.486	1.000
Zone 3	0	3	0	1.000	1.000	-	1.000
Zone 4	0	3	0	1.000	1.000	-	1.000
Zone 5	0	0	0	-	-	-	-
Zone 6	1	8	3	0.595	1.000	0.603	0.400
Zone 7	0	0	0	-	-	-	-
Total	1	25	5	0.175	0.071	0.125	1.000

Table 4b. — The number of occurrences of cortical hypertrophy

					Chi-squared test		
Gruen's classification	Dorr type-A (9 hips)	Dorr type-B (55 hips)	Dorr type-C (12 hips)	Multiple comparison P value	P value Type-A vs -B	P value Type-A vs -C	P value Type-B vs -C
Zone 1	0	0	0	-	-	-	-
Zone 2	0	2	1	0.611	1.000	1.000	0.452
Zone 3	2	9	1	0.683	0.666	0.553	0.676
Zone 4	0	1	0	1.000	1.000	-	1.000
Zone 5	1	1	0	0.247	0.263	0.237	1.000
Zone 6	0	1	0	1.000	1.000	-	1.000
Zone 7	0	0	0	-	-	-	-
Total	3	14	2	0.2504	0.2134	0.9298	0.1789

Dorr types A and B (Table 2). Stress shielding was observed in 66 hips, with first-grade shielding in 28 hips, second-grade shielding in 34 hips, third-grade shielding in 4 hips, and fourth-grade shielding in 0 hips (Table 3). Spot welds were seen in various zones of 31 hips, and cortical hypertrophy was observed in

18 hips (Table 4A, 4B). No significant differences were found among the Dorr types in the number of occurrences of stress shielding and cortical hypertrophy. No complications of dislocation, infection, and aseptic loosening occurred in any of the cases during the follow-up period.

DISCUSSION

Several reports have demonstrated that severe stress shielding was found in Dorr type C after THA with a cementless femoral stem *(12,21)*. We hypothesized that the TriLock BPS could achieve good clinical and radiographic results, regardless of the medullary cavity shape. The most important finding in this study is that mid-term clinical results with the tapered wedge femoral component were not significantly different across the Dorr types even in Dorr type C, which supported our hypothesis. Furthermore, no significant difference was found between the CFI and postoperative HHS. This might indicate that the size of the femoral medullary canal did not influence the clinical results after THA with insertion of the TriLock BPS.

Eighty-seven percent (66/76) of patients were confirmed to have had stress shielding in their last postoperative radiograph in the current study. The TriLock BPS is classified as a short stem with tapered wedge design and a proximal porous coating, which allows proximal fixation of the implant at the metaphyseal part of the femur. The use of a short stem such as the TriLock BPS has allowed for greater conservation of the proximal femoral structures, providing higher resistance to torsional forces and a better endurance to varus-valgus stress *(17)*. The higher torsional force leading to proper mechanical loading in the proximal femur may be one of the reasons why the occurrence of stress shielding was not different across the Dorr types. Forty-one percent (31/76) of patients were confirmed to have had spot welds of which 75% were found in zones 2 and 6. Spot welds were defined as new cancellous bone formation between the femoral prosthesis and the endosteal surface of the femur, as seen on radiographs during the early phase after surgery *(8)*. Tapered wedge femoral stems are wedge-shaped in the medial-lateral plane to allow press-fit fixation in the proximal metaphyseal canal of the femur, which is essential for achieving initial stability and optimized mechanical loading on the femur, thereby lowering the risk of proximal stress shielding and periprosthetic bone loss *(14)*. This concept of tapered wedge stems is called metaphyseal fit without distal fill, and from the site of occurrence with stress shielding and spot welds, it was understood that the TriLock BPS was properly inserted as the concept.

The ratio of canal fillings at the proximal section were significantly higher in Dorr type C than in both Dorr types A and B. In patients with a Dorr type C bone, the femoral canal is wide, and the cortices are thin. So, if the femur was same size, the stem that could be inserted was larger in Dorr type C than both Dorr types A and B. As a result, ratios of canal filling at the proximal section in Dorr type C were higher. There was no significant difference in the ratio of canal fillings at the middle section, which was the fixation site of the stems with tapered wedge design. This indicated that the TriLock BPS is a surgical option regardless of the type of medullary cavity shape.

The present study has some limitations. First, this study included only TriLock BPS, so the findings related to other proximal fixed tapered cementless stems may be different. Second, the sample size of this study was relatively small, with respect to the evaluation of the clinical and radiographic outcomes. Further study with a larger sample size is needed and a longer follow-up will be required.

CONCLUSIONS

We evaluated the mid-term clinical and radiographic results of the TriLock BPS and the difference in the results across the various medullary cavity shapes. Mid-term clinical results were good regardless of the medullary cavity shape. Furthermore, the number of occurrences of stress shielding, spot welds, and cortical hypertrophy was not significantly different among the three Dorr types. Therefore, the TriLcok BPS use is a surgical option, regardless of the type of medullary cavity shape, for primary THA .

REFERENCES

1. **Albers A, Aoude AA, Zukor DJ, Huk OL, Antoniou J, Tanzer M.** Favorable Results of a Short, Tapered, Highly Porous, Proximally Coated Cementless Femoral Stem at a Minimum 4-Year Follow-Up. *J Arthroplasty*. 2016 Apr ; 31(4) : 824-829.
2. **Burt CF, Garvin KL, Otterberg ET, Jardon OM.** A femoral component inserted without cement in total hip arthroplasty. A study of the Tri-Lock component with an average ten-year duration of follow-up. *J Bone Joint Surg Am*. 1998 Jul ; 80(7) : 952-960.
3. **Charnley J.** Low Friction Arthroplasty of the Hip. Berlin Heidelberg New York : Springer-Verlag ; 1979.
4. **Charnley J.** Arthroplasty of the hip. A new operation. *Lancet*. 1961 May 27 ; 1 (7187) : 1129-1132.
5. **Dorr LD, Faugere MC, Mackel AM, Gruen TA, Bognar B, Malluche HH.** Structural and cellular assessment of bone quality of proximal femur. *Bone*. May-Jun 1993 ; 14(3) : 231-242.
6. **Dorr LD.** Total hip replacement using APR system. *Tech Orthop*. 1986 ; 1 : 22-34.
7. **Engh CA, Bobyn JD, Glassman AH.** Porous-coated hip replacement. The factors governing bone ingrowth, stress shielding, and clinical results. *J Bone Joint Surg Br* .1987 Jan ; 69(1) : 45-55.
8. **Engh CA, Massin P, Suthers KE.** Roentgenographic assessment of the biologic fixation of porous-surfaced femoral components. *Clin Orthop Relat Res.* 1990 Aug ; (257) : 107-128.
9. **Grant TW, Lovro LR, Licini DJ, Warth LC, Ziemba-Davis M, Meneghini RM.** Cementless Tapered Wedge Femoral Stems Decrease Subsidence in Obese Patients Compared to Traditional Fit-and-Fill Stems. *J Arthroplasty.* 2017 Mar ; 32(3) : 891-897.
10. **Harris WH.** Traumatic arthritis of the hip after dislocation and acetabular fractures : treatment by mold arthroplasty. An end-result study using a new method of result evaluation. *J Bone Joint Surg Am.* 1969 Jun ; 51(4) : 737-755.
11. **Heekin RD, Callaghan JJ, Hopkinson WJ, Savory CG, Xenos JS.** The porous-coated anatomic total hip prosthesis, inserted without cement. Results after five to seven years in a prospective study. *J Bone Joint Surg Am.* 1993 Jan ; 75(1) : 77-91.
12. **Nishino T, Mishima H, Kawamura H, Shimizu Y, Miyakawa S, Ochiai N.** Follow-up results of 10-12 years after total hip arthroplasty using cementless tapered stem - frequency of severe stress shielding with synergy stem in Japanese patients. *J Arthroplasty.* 2013 Dec ; 28(10) : 1736-1740.
13. **Noble PC, Box GG, Kamaric E, Fink MJ, Alexander JW, Tullos HS.** The effect of aging on the shape of the proximal femur. *Clin Orthop Relat Res.* 1995 Jul ; (316) : 31-44.
14. **Khanuja HS, Vakil JJ, Goddard MS, Mont MA.** Cementless femoral fixation in total hip arthroplasty. *J Bone Joint Surg Am.* 2011 Mar ; 93(5) : 500-509.
15. **Lachiewicz PF.** Cement fixation of the femoral component in older patients. *Instr Course Lect.* 2008 ; 57 : 261-265.
16. **Sperati G, Ceri L.** Total hip arthroplasty using TRI-LOCK(R) DePuy bone preservation femoral stem : our experience. *Acta Biomed.* 2014 Sep 24 ; 85 Suppl 2 : 66-70.
17. **Patel RM, Smith MC, Woodward CC, Stulberg SD.** Stable fixation of short-stem femoral implants in patients 70 years and older. *Clin Orthop Relat Res.* 2012 Feb ; 470(2) : 442-449.
18. **Purtill JJ, Rothman RH, Hozack WJ, Sharkey PF.** Total hip arthroplasty using two different cementless tapered stems. *Clin Orthop Relat Res.* 2001 Dec ; (393) : 121-127.
19. **Swanson RL, Evarts CM.** Dual-lock total hip arthroplasty. A preliminary experience. *Clin Orthop Relat Res.* 1984 Dec ; (191) : 224-231.
20. **Teloken MA, Bissett G, Hozack WJ, Sharkey PF, Rothman RH.** Ten to fifteen-year follow-up after total hip arthroplasty with a tapered cobalt-chromium femoral component (tri-lock) inserted without cement. *J Bone Joint Surg Am*. 2002 Dec ; 84(12) : 2140-2144.
21. **Tsubosaka M, Hayashi S, Hashimoto S, Takayama K, Kuroda R, Matsumoto T.** Patients with a Dorr type C femoral bone require attention for using a Summit cementless stem : Results of total hip arthroplasty after a minimum follow-up period of 5 years after insertion of a Summit cementless stem. *J Orthop Sci.* 2018 Jul ; 23(4) : 671-675.