

Three finned press-fit cup: Does its initial fixation strength provide an adequate stability? Clinical midterm results of 685 implants

Rocco Romeo, Aniello Omar Gonnella, Giuseppe Mancusi, Michele Trabace

Department of Orthopaedic and Trauma, AOR San Carlo Hospital, Potito Petrone Street, 85100 Potenza, Italy

Address for correspondence:

Dr. Rocco Romeo,
Ospedale San Carlo, Via Potito Petrone, 85100 Potenza, Italy.
E-mail: rivgio@libero.it


ABSTRACT

Introduction: One of the major causes of loosening of cementless acetabular cup implants is insufficient initial stability. A technical proposal to decrease the risk of suboptimal first stability is a circumferential finned design of the cup. This design aims to improve periacetabular bone contact and prevent rotational micromotion of the cup when optimal press-fit cannot be obtained. **Materials and Methods:** We retrospectively reviewed a group of 712 consecutive patients who underwent total hip arthroplasty from June 2006 to June 2014. In all patients, a titanium cup, characterized by three anti-rotational circumferential fins at the superior pole, was implanted. **Results:** Five hundred and ninety-two patients, for a total of 685 hips, were evaluated at a mean follow-up of 58 months (range 12–96 months). At 1-year follow-up, the average score increased to 82.90 (range 100–70) and at the final follow-up (58 months, range 12–96 months), it was 80.12 (range 100–66). In 22 cases (3%), screws to obtain a secure primary stability of the cup were used. Nineteen complications (2.6%) needing revision surgery were observed. Survivorship at 10 years was 98.7% (95% confidence interval [CI], 98.7–99.7%) with revision for aseptic cup loosening as an endpoint and 96.7% (95% CI, 98.3–95.1%) with revision for all causes of revision as the second endpoint. **Discussion:** In our group of patients, we did not observe the cases of very early cup loosening. The only two-cup revision, do to loosening of osteolysis, was observed 26 and 32 months before surgery. **Conclusion:** Our very low rate of additional screws represents an indirect sign of finned cup first stability. Three-finned cup design clinically confirmed to improve initial cup stability.

Keywords: Arthroplasty, cup, finned

Introduction

One of the major causes of loosening of cementless acetabular cup implants is insufficient initial stability. Mechanical fixation at the cup

Access this article online	
Quick response code	Website: www.joas.in
	DOI: 10.4103/2319-2585.193752

bone interface is achieved by oversizing the cup.^[1-4] In fact, press-fit first fixation involves pressure bonding by differences in elasticity between the bone and the metal cup. If the acetabular bone is very sclerotic and hard, or if the hemispherical dome created by reaming is smaller than necessary, it is difficult for the acetabular cup to contact the bottom of the bone bed since its pole cannot reach the predetermined depth. Conversely, if the hemispherical dome created by reaming is larger than necessary, especially in older patients with osteoporosis, initial press-fit fixation cannot be expected to gain sufficient cup stability.^[5] In both cases, initial instability can predispose to an early micromotion and subsequent failure.

A technical proposal to decrease the risk of suboptimal first stability is a circumferential finned design of the cup. This design aims to improve periacetabular bone contact and prevent rotational micromotion of the cup when optimal press-fit cannot be obtained.

This is an open access article distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as the author is credited and the new creations are licensed under the identical terms.

For reprints contact: reprints@medknow.com

How to cite this article: Romeo R, Gonnella AO, Mancusi G, Trabace M. Three finned press-fit cup: Does its initial fixation strength provide an adequate stability? Clinical midterm results of 685 implants. J Orthop Allied Sci 2016;4:54-7.

The purpose of this study was to evaluate the clinical influence of a three-finned cup on initial implant stability.

Materials and Methods

We retrospectively reviewed a group of 712 consecutive patients who underwent total hip arthroplasty from June 2006 to June 2014, 420 were female and 292 were male. The average age at the time of surgery was 62 years (range from 38 to 86 years). The preoperative diagnosis was: Primary osteoarthritis in 591 cases (83 bilateral), avascular necrosis of the femoral head in 66 cases (4 bilateral), rheumatoid arthritis in 32 cases (8 bilateral), traumatic osteoarthritis in 12 cases, and other causes in 11 cases.

Patients were all operated in the prone position with Hardinge approach. In all patients, a total cementless implant with the use of PCL stem and FIN II cup (Gruppo Bioimpianti, Peschiera Borromeo, MI, Italy) was implanted.

The FIN titanium cup, hemispherical and titanium plasma spray coated, is characterized by three anti-rotational circumferential fins at the superior pole, and three holes for the use of acetabular screws. The straight titanium stem, tapered at the tip, is characterized by a trapezoidal cross section and a titanium plasma spray coating in the metaphyseal area. The implants were characterized by a ceramic-ceramic coupling in 655 cases (92%) and by a ceramic-polyethylene coupling in 57 cases (8%). For the most of the implants have been used heads (ceramic) of 32 mm (462 cases, 65%) and 36 mm (249 cases, 35%), only in one case was performed an implant with the use of a 28 mm head coupled to a 44 mm cup. The surgeon decided to use appropriate screws to improve the primary stability of the cup only in cases in which intraoperative text after implant left some doubt about the total absence of micromotion at bone cup interface.

According to the department, internal protocol patients were clinically and radiographically evaluated at 3, 6, 12 months and then every 12 months, once considered not critical. At each follow-up, patients were evaluated clinically using the Harris Hip Score (HHS)^[6] and radiologically to detect any radiolucent lines, heterotopic ossification, subsidence or migration of the prosthetic components, acetabular erosion or protrusion acetabuli.

Kaplan–Meier survivorship analysis^[7] was performed with revision for both cup aseptic loosening and revision for all causes as end points.

Results

Of 712 implants, 27 implants (two patients with bilateral hip arthroplasty and 23 patients with single hip arthroplasty) were lost at first follow-up after surgery for reasons not related to the surgical treatment. Five hundred and ninety-two patients, for a total of 685 hips, were instead evaluated at a mean follow-up of 58 months (range 12–96 months).

Regarding clinical evaluation, the preoperative average HHS was 44.12 (range 32–56), at 3 months after surgery was 84.22 (66–100). At 1 year, the average score increased to 82.90 (range 100–70) and at the final follow-up (58 months, range 12–96 months), it was 80.12 (range 100–66).

In 22 cases (3%), it was necessary to resort to the use of appropriate screws to obtain a secure primary stability of the cup.

Nineteen complications (2.6%) needing revision surgery were observed: Two cases of rupture of the ceramic insert in the 2nd year after surgery, three cases of intraoperative trochanteric fracture for a technical error, four cases of septic arthritis, two dislocation in the first 4 weeks postsurgery, and eight cases of aseptic loosening (4 stems, 4 acetabular cups).

The reported results regarding radiographic assessment underlined, in most cases, a good integration of both prosthesis components. In two cases, treated with acetabular screws for the implant fixation, the breakage of a screw occurred without any variation of the osseointegration. In nine cases, the stem, even if implanted in a correct position, showed radiolucent lines in the Gruen *et al.*^[8] zone 1 and zone 7; in all cases, an undersizing of the stem was observed. In four cases, there observed a progressive stem subsidence and all were submitted to a revision surgery due to thing pain after 11, 14, 16, and 18 months, respectively. In two cases, the distal migration of the stem was symptomatic for 4 and 7 months, respectively. Both resulted osseointegrated and asymptomatic at 12 months from the surgery without the need of a revision. In the remaining asymptomatic three cases, there has been a reduction of the radiolucent lines at 24 months after surgery without subsidence. One year radiological follow-up revealed 14 (6.8%) cases of Brooker Grade I heterotopic calcifications, eight cases (3.9%) of Brooker Grade II heterotopic calcifications, and two cases (0.9%) of Brooker Grade III heterotopic calcifications.^[9]

Radiolucent lines were noted in 29 cups at the final follow-up; 13 occurred in zone 1, 18 in zone 2, and 7 in zone 3. Osteolysis involved zone 1 in 7 hips and zone 2 in 11. Four out of them were submitted to a revision surgery before 26, 43, 77, and 98 months, respectively, because they were symptomatic while the others did not show any signs of increased radiolucent and remained asymptomatic.

Survivorship at 10 years was 98.7% (95% confidence interval [CI], 98.7–99.7%) with revision for aseptic cup loosening as an endpoint and 96.7% (95% CI, 98.3–95.1%) with revision for all causes of revision as the second endpoint.

Discussion

The aim of our study was to evaluate the clinical influence of a three-finned design on initial implant cup stability. For this reason, we retrospectively evaluated the results of 685 hips at a mean follow-up of 58 months (range 12–96 months).

Press-fit cups have become the gold standard for primary hip replacement;^[10-12] its adequate initial stability is an essential precondition for the osseointegration.^[13,14] Press-fit fixation can potentially generate gaps between the cup and the acetabular bone. Gap formation or micromotion between the cup and acetabulum would likely worsen long-term outcomes. Pilliar *et al.*^[14] reported that implant displacement $\geq 150 \mu\text{m}$ will prevent bone formation within porous-surfaced implants and will allow attachment via well-organized fibrous connective tissue. Carlsson *et al.*^[15] reported that a gap $\geq 0.35 \text{ mm}$ at the insertion between the bone and implant will prevent direct cortical bone apposition on the implant.

A technical solution to avoid an early micromotion between cup and bone is represented by additional screws fixation. Additional screw fixation is effective under good press-fit conditions, but it shows little impact on whole-cup stability. When adequate press-fit fixation cannot be achieved, cup stability decreases considerably and depends on the strength of screw fixation, which is influenced by the length and position of the screws.^[16]

However, supplemental screw fixation has a risk of vascular injury as well as particulate wear debris from the backside of the cup. Krieg *et al.*^[17] reported the rate of polyethylene backside volumetric change to be 2.8% of the rate of volumetric articular wear. Moreover, migrated acetabular components showed significantly higher rates of backside volumetric change plus screw head indentations compared with components without migration. Hwang^[18] reported a case of massive retroperitoneal hemorrhage due to perforation of the external iliac vein by a drill tip passing through the anterosuperior quadrant of the acetabulum during cementless hip replacement.

These limitations of screw fixation have encouraged the search for alternative cup designs for acetabular initial stability. A proposed alternative solution is to use an acetabular cup design with fins located on the shell rim.

Baleani *et al.*^[19] investigated the effect of fins on the initial cup stability. Three designs were studied with none, 2, and 12 fins, respectively. The addition of fins on the cup rim increases *in vitro* both axial and frontal (and anterior-posterior for the asymmetric geometry) initial stability in all investigated cases, especially in cases of a poor press-fit with a good substrate. This preclinical investigation suggests that the use of a finned cup may be beneficial in all cases in which press-fit of the cup cannot be assured.

Huber *et al.*^[16] examined the fixation characteristics of a six-finned acetabular cup in both primary and revision arthroplasty in comparison with two other cup designs without fins. In this experimental *in vitro* study, the finned press-fit cup evaluated in this study is significantly more resistant to cyclic and asymmetric edge loading both in the normal acetabulum and in acetabula with moderate to severe dorsocranial rim defects than the cup designs without fins.

Ries *et al.*^[20] in their photoelastic model evaluating periacetabular stresses at the time of implantation of four different cup designs, found that a finned cups had lower peripheral than dome stresses and that the fins appeared to separate the periacetabulum into quadrants that reduced the peripheral stress. The authors speculated that the fins, rather than the peripheral press-fit, would provide initial cup stability.

Furthermore, migration and clinical results of the implant were prospectively assessed in 67 patients after hip arthroplasty with a press-fit finned cup. At 2 years after surgery, none of the implants needed revision and HHS increased from 39.7 to 92.2. In contrast to the beneficial clinical outcome, 17 of 44 patients showed increased total migration of 1 mm.

In our group of patients, we did not observe the cases of very early cup loosening. The only two-cup revision, due to loosening for osteolysis, was observed 26 and 32 months before surgery. Three-finned cup design clinically confirmed to improve initial cup stability. Furthermore, a very low rate (0.3%) of additional screws was performed. Since there is no evidence for the inappropriateness of the use of a screw, it is also unclear whether the use of a screw is advantageous, its use should be minimized.^[5] For this reason, we used an additional screw only in cases in which surgeon was not confident about the total absence of micromotion at bone cup interface. Our very low rate of additional screws represents an indirect sign of finned cup first stability.

Two cases of revision for all reasons appear in contrast with published data in the Australian Orthopaedic Association National Joint Replacement Registry (AOANJRR) where cumulative percent revision at 5 years follow-up is reported in the amount of 5.1.^[21] However, must be considered that Australian register data are referred to all reasons of revision, including dislocation, technical error, and loosening of polyethylene. Furthermore, our experience is not comparable with AOANJRR experience. Implanted stem is not the same, in our experience PCL stem confirmed good mid results (0.1 revision rate at 4.8 years follow up), AOANJRR reported a mixing of components from different manufacturers and fin cup is ever mixed with a modular neck stem with the obvious same cumulative percent revision of 5.1 at 5 years follow-up.^[22] In the light of our experience, we suppose a different manufacturer modular neck stem with high revision rate conditioning Fin cup mid results to explain the discrepancy between AOANJRR revision rate and our results.

Our study has a number of limitations. First, there is not a control group. A double-blind study comparing the primary stability between a finned and without fin acetabular cup designs is necessary to conclude for a clinical advantage of finned design. Additional limitation includes the retrospective nature of the study.

Conclusion

The clinical and radiographic outcomes of this analysis, carried out on finned hip cup implant, have confirmed the extremely

valuable clinical influence of a three-finned design on initial implant cup stability.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

- Curtis MJ, Jinnah RH, Wilson VD, Hungerford DS. The initial stability of uncemented acetabular components. *J Bone Joint Surg Br* 1992;74:372-6.
- Adler E, Stuchin SA, Kummer FJ. Stability of press-fit acetabular cups. *J Arthroplasty* 1992;7:295-301.
- Kwong LM, O'Connor DO, Sedlacek RC, Krushell RJ, Maloney WJ, Harris WH. A quantitative *in vitro* assessment of fit and screw fixation on the stability of a cementless hemispherical acetabular component. *J Arthroplasty* 1994;9:163-70.
- Roth A, Winzer T, Sander K, Anders JO, Venbrocks RA. Press fit fixation of cementless cups: How much stability do we need indeed? *Arch Orthop Trauma Surg* 2006;126:77-81.
- Tabata T, Kaku N, Hara K, Tsumura H. Initial stability of cementless acetabular cups: Press-fit and screw fixation interaction – An *in vitro* biomechanical study. *Eur J Orthop Surg Traumatol* 2015;25:497-502.
- 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;51:737-55.
- Kaplan EL, Meier P. Nonparametric estimation from incomplete observations. *J Am Stat Assoc* 1958;53:457.
- Gruen TA, McNeice GM, Amstutz HC. "Modes of failure" of cemented stem-type femoral components: A radiographic analysis of loosening. *Clin Orthop* 1979;141:17-27.
- Brooker AF, Bowerman JW, Robinson RA, Riley LH Jr. Ectopic ossification following total hip replacement. Incidence and a method of classification. *J Bone Joint Surg Am* 1973;55:1629-32.
- Widmer KH, Zurfluh B, Morscher EW. Load transfer and fixation mode of press-fit acetabular sockets. *J Arthroplasty* 2002;17:926-35.
- Elke R, Berli B, Wagner A, Morscher EW. Acetabular revision in total hip replacement with a press-fit cup. *J Bone Joint Surg Br* 2003;85:1114-9.
- Pulido L, Rachala SR, Cabanela ME. Cementless acetabular revision: Past, present, and future. Revision total hip arthroplasty: The acetabular side using cementless implants. *Int Orthop* 2011;35:289-98.
- Bellini CM, Galbusera F, Ceroni RG, Raimondi MT. Loss mechanical contact of cementless acetabular prostheses due to post-operative weight bearing: A biomechanical model. *Med Eng Phys* 2007;29:175-81.
- Pilliar RM, Lee JM, Maniopoulos C. Observations on the effect of movement on bone ingrowth into porous-surfaced implants. *Clin Orthop Relat Res* 1986;208:108-13.
- Carlsson L, Röstlund T, Albrektsson B, Albrektsson T. Implant fixation improved by close fit. Cylindrical implant-bone interface studied in rabbits. *Acta Orthop Scand* 1988;59:272-5.
- Huber WO, Noble PC. Effect of design on the initial stability of press-fit cups in the presence of acetabular rim defects: Experimental evaluation of the effect of adding circumferential fins. *Int Orthop* 2014;38:725-31.
- Krieg AH, Speth BM, Ochsner PE. Backside volumetric change in the polyethylene of uncemented acetabular components. *J Bone Joint Surg Br* 2009;91:1037-43.
- Hwang SK. Vascular injury during total hip arthroplasty: The anatomy of the acetabulum. *Int Orthop* 1994;18:29-31.
- Baleani M, Fognani R, Toni A. Initial stability of a cementless acetabular cup design: Experimental investigation on the effect of adding fins to the rim of the cup. *Artif Organs* 2001;25:664-9.
- Ries MD, Salehi A, Shea J. Photoelastic analysis of stresses produced by different acetabular cups. *Clin Orthop Relat Res* 1999;369:165-74.
- Australian Orthopaedic Association National Joint Replacement Registry (AOANJRR); 2015. p. 203. <https://www.aoanjrr.sahmri.com/documents/10180/217745/Hip%20and%20Knee%20Arthroplasty>. [Accessed March 10, 2016]
- Australian Orthopaedic Association National Joint Replacement Registry (AOANJRR); 2015. p. 104 <https://www.aoanjrr.sahmri.com/documents/10180/217745/Hip%20and%20Knee%20Arthroplasty>. [Accessed March 10, 2016]