Hip replacement with a type 2B cementless short stem: Results of 2 to 5 years of follow-up

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ABSTRACT

Objectives: We aimed to determine 2- to 5-year stem survivorship rate, intraoperative fractures, subsidence and thigh pain rate in a consecutive, independent, one-surgeon series of surgical patients in whom a type 2B short stem was implanted. **Materials and Methods:** We reviewed the first 100 type 2B consecutive femoral short stems implanted in 84 patients with a mean age of 47 years old. Indications included age younger than 55 years (85 hips) or participation in impact sports in patients aged 56 to 60 years old (15 hips). Initial diagnosis was osteoarthritis in 82% of the cases. Median follow-up was 42 months. **Results:** Stem survivorship rate was 99% after 2 to 5 years followed by stem revision for any aseptic reason, and 98% when infection played a part. Mean Harris Hip Score improved significantly from 55 to 96 at final follow-up ($p = 0.02$). There was one lateral cortex perforation, and three intra-operative calcar partial fractures (3%), only one of them required cerclage wiring and delayed weight-bearing. None of the patients presented with thigh pain at final follow-up. Only one case subsided 4 mm, but then stabilized. The risk of revision was 1% after 2 to 5 years (95% CI 93.1-99.8%). **Conclusions:** We achieved promising short-term results with this device in this single-surgeon, non-consecutive series—including the learning curve period—using a type 2B short stem in young active patients in whom bone preservation was warranted.

Key words: Total hip arthroplasty; cementless short stem; hip osteoarthritis.

Level of evidence: IV

Reemplazo total de cadera con un tallo corto no cementado tipo 2B: resultados a los 2-5 años de seguimiento

RESUMEN

Objetivo: Determinar los resultados clínicos, la supervivencia y la incidencia de fractura periprotésica intraoperatoria con un tallo corto tipo 2B de fijación cervicometafisaria. **Materiales y Métodos:** Se analizaron prospectivamente los primeros 100 tallos (84 pacientes) MiniHip™ (Corin, Cirencester, Reino Unido) colocados, en forma consecutiva, por un mismo cirujano. La edad promedio fue de 47 años. La indicación para un tallo corto fue: edad <55 años (85 casos) o la participación previa en deportes de impacto en pacientes de entre 56 y 60 años (15 casos). El diagnóstico inicial fue artrosis primaria de cadera en el 82% de los casos. El seguimiento promedio fue de 42 meses. **Resultados:** El puntaje en la escala de Harris modificada mejoró de 55 a 96 al final del seguimiento ($p = 0{,}02$) y ningún paciente refirió dolor de muslo en el posoperatorio. La supervivencia del tallo fue del 99% (IC95% 93,1-99,8). Un caso presentó una perforación de la cortical lateral intraoperatoria, tratado con revisión con un tallo no cementado convencional. Un paciente tuvo una infección aguda, que fue tratada con desbridamiento, retención de componentes y antibióticos, con resultado favorable a los 48 meses de la cirugía. Se produjeron 3 fracturas incompletas del calcar intraoperatorias (3%). **Conclusiones:** Se obtuvieron resultados excelentes en esta serie de pacientes jóvenes y activos operados por un mismo cirujano con un tallo corto tipo 2B, a los 2-5 años de seguimiento, con un 1% de falla por falsa vía femoral intraoperatoria.

Palabras clave: Artroplastia; tallo corto no cementado; artrosis de cadera.

Nivel de Evidencia: IV

Received on May 12, 2018. Accepted after evaluation on November 18, 2018 • MARTÍN BUTTARO, MD • martin.buttaro@hospitalitaliano.org.ar

How to cite this paper: Buttaro M, Nally F, Salcedo R, Slullitel PA, Oñativia JI, Comba F, Piccaluga F. Hip replacement with a type 2B cementless short stem: Results of 2 to 5 years of follow-up. *Rev Asoc Argent Ortop Traumatol* 2019;84(2):112-121. http://dx.doi.org/10.15417/issn.1852-7434.2019.84.2.856

INTRODUCTION

Cementless femoral fixation is one of the main options for hip replacement in young patients. Although short stem designs are not new,[1] increasingly less invasive approaches have recently resurfaced. Currently, there are multiple short stem options on the market.[2,3] This reflects an evolution of the current market towards bone and soft-tissue preservation in hip replacements.

Considering that not all short stems are the same, Khanuja *et al.*[2] classified most of the available designs. Type 2B are those oval shaped with vertical grooves that resist torsion. These designs are intended to preserve part of the femoral neck, allow immediate stability on the three planes of motion and an all-around contact between the prosthesis and the bone. These stems have been designed to be in a certain direction towards the lateral cortex in order to achieve primary stability and allow consistent weight-bearing.

Most of the complications related to this type of short stems are intraoperative femoral fractures, which incidence varies between 0% and 13.3% in published series (average 2.6%), and thigh pain in 2% of cases. Average survivorship of this short stem type has been reported, in 93% of 651 cases with the collum femoris-preserving (CFP) design (ESKA Implants, Lübeck, Germany), at 5 years on average, taking into account aseptic loosening as the final point of analysis.[4-10]

Kendoff *et al.*[11] and other authors[12-24] have reported a 99% stem survivorship rate in 1394 cases with an average follow-up of 6 years using the CFP design (Waldemar Link GmbH, Hamburg, Germany). There are few reports published on the results achieved with the MiniHip™ stem (Corin, Cirencester, UK):[3,25] a single series of patients operated on by a surgical team independent of the designers.[25]

The aim of this study was to determine short-term prosthesis survivorship, incidence of intraoperative femoral fractures, subsidence and thigh pain rate in an independent consecutive series of the first 100 young and active patients who received the MiniHip™ stem. Surgeries were performed by the same surgeon.

MATERIALS AND METHODS

From November 2010 to December 2013, 84 patients (100 hips) were treated with type 2B short stem hip replacement. These cases included the surgeon's learning curve, since they were the first procedures, and patient follow-up was performed prospectively. Sixteen patients were operated on sequentially, on both sides, on the same day. The average age was 47 years (range 17-58); 75 were men and 25 were women. In this series, the indications for a short stem were as follows: young patients with a maximum age of 55 years (85 cases) and patients between 56 and 60 years old who had practiced impact sports in the past (15 cases).

The sports or activities defined as impact sports were: running, football, taekwondo, squash and aerobic gymnastics trainers. During this period, we used another type of conventional cementless implant in six patients aged <55 years old whose health insurance did not cover the use of a short stem, two patients with osteosynthesis materials in the proximal femur, two cases of osteonecrosis with involvement of femoral metaphysis and neck, two cases with a history of contralateral surgery with a conventional stem and one case of severe growth dysplasia that required a subtrochanteric shortening osteotomy. The same surgeon performed the 280 primary hip replacements in patients over 55 years old.

In only two cases, in which a short stem placement was planned, the anatomical conditions of the proximal femur led the surgeon to place a conventional hydroxyapatite-coated rod with metaphyseal-shaft fixation (MetaFix™, Corin, Cirencester, UK).

The average body mass index of the group was 27 (range 22-37). The primary diagnosis was primary osteoarthritis (82 cases), growth dysplasia (6 cases), osteonecrosis (8 cases), idiopathic chondrolysis of the hip (2 cases), sequelae of Perthes disease (1 case) and pigmented vellonodular synovitis (1 case).

All patients were implanted with a cementless Trinity™ cup (Corin, Cirencester, UK) with a MiniHip™ short stem. This design is characterized by a short stem without a titanium collar (Ti-6Al-4V), coated with a double layer of hydroxyapatite, which partially preserves the femoral neck, and has a polished distal end. It was approved by the Food and Drug Administration in 2010 and has been used in Europe since 2006.

There are 9 size options with a 130º metaphyseal-neck angle, and its vertical grooves are designed to resist torsion (Figure 1).

Figure 1. MiniHip™. Short cementless stem, without titanium collar (Ti-6Al-4V), coated with a double hydroxyapatite layer and a polished distal end.

Preoperative planning was performed according to conventional analog methods.[26,27] Cutting of the femoral neck was carefully planned depending on the surgical approach to avoid excessive elongation of the operated leg and to determine hip lateralization. In cases of increased lateralization, a more vertical neck cut was performed and, in cases of decreased lateralization, a more horizontal one, as is well described by Teoh *et al*[3].

All patients were operated on by the same surgeon, using hypotensive epidural anesthesia, in a laminar flow operating room, through a minimally invasive posterolateral approach. After surgical dislocation of the hip, the femoral neck was cut depending on preoperative planning. Next, acetabular preparation and implantation of the Trinity™ cup were carried out. The external diameter of the cup was 54 mm on average (range 48-60). In 95 cases, 1 to 3 screws were used according to the quality of the fixation after placement. In 5 cases, no screws were placed. The entry point into the femur was calculated 4 mm lateral to the center of the femoral neck. In order to avoid a new cortical perforation, from the sixth case on, a step was added to the original surgical approach using a curved vascular clamp in the direction of the femoral canal. Upon observing bone marrow residues from the femoral canal, the first drill bit was placed.

Next, the proximal femoral bone was compacted with progressively sized drill bits until rotational stability was obtained, considering that this stem is designed to be in contact with cancellous bone and with neck and metaphyseal cortex. After obtaining a stable implant on the three planes, the definitive prosthesis was placed together with the head component.

The chosen loading surface was ceramics: fourth generation Delta® ceramics (Biolox, Ceramtec AG, Plochingen, Germany) in 96 cases and Delta® ceramics on highly-cross-linked-polyethylene in four patients whose health insurance did not cover the other type of implant. The femoral head diameter depended on the external diameter of the cup: 36 mm (51 cases), 40 mm (34 cases), 32 mm (14 cases) and 28 mm (1 case).

The average implanted femoral stem size was 4 (range 1-9) (Figure 2). The average operating time was 58 minutes (range 35-85). Cefazolin was administered as a prophylactic antibiotic agent for 24 hours, except in two patients who received an alternative antibiotic due to a confirmed allergy to betalactam antibiotics. Thromboembolic prophylaxis was administered with rivaroxaban (Xarelto®, Bayer Schering Pharma AG, Wuppertal, Germany) to 30 patients with intermediate risk of deep vein thrombosis, and aspirin 325 mg/day PO to 54 low-risk patients; both anticoagulants were prescribed during the first 3 weeks after surgery.[28]

The protocol for postoperative rehabilitation consisted of early weight-bearing depending on pain tolerance, 24 hours after surgery, with the use of two canes, for 15 days, and then progression to one cane until the 21st day after surgery. Patients operated on both hips on the same day continued to use some kind of support until the fourth week after surgery. No-contact or impact sports were allowed until the third month after surgery, and could be resumed on the sixth month after surgery.

Patients were followed-up, prospectively, at 2 and 6 weeks, 3 and 6 months after surgery and then once a year. The modified Harris preoperative and postoperative functional scale was used.[29] Demographic and radiographic data were collected and analyzed by two hip surgeons in training at our Center. Bone fixation of the stem was determined by comparing the initial postoperative X-rays with those of the last follow-up using the Engh score.[30] The location of radiolucent lines was evaluated according to the seven areas described by Gruen *et al.* on AP X-rays of both hips.[14] Stem subsidence was evaluated by comparing the immediate postoperative X-rays with those of the last follow-up using the Alma Medical Imaging System (Alma, Barcelona, Spain).

At the last follow-up visit, the type of sports played by the patient and the number of weekly hours were recorded, as well as the presence of thigh pain. Implant survivorship was calculated using the Kaplan-Meier method with 95% confidence intervals (CI).[31]

RESULTS

Stem survivorship was 99% (95% CI 93.1-99.8%) in an average follow-up of 42 months (range 24-64) for any aseptic reason and 98% when infection played a part (Figure 2).

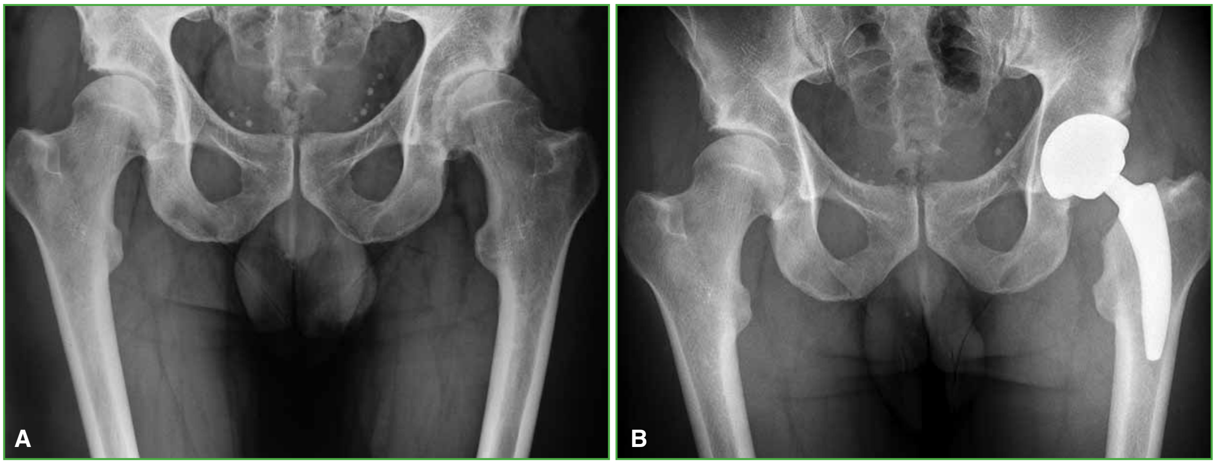

Figure 2. A. Preoperative AP X-ray of both hips. Case 28, a 52-year-old patient with primary osteoarthritis of the left hip. **B.** AP X-ray of both hips. Left hip replacement with a MiniHip™ stem, 4 years after surgery.

None of the patients were lost to follow-up. The most serious complication occurred in case 6: perforation of the lateral cortex (Figure 3A), which was treated on the same day by changing the short stem to a conventional hydroxyapatite-coated stem with metaphyseal-shaft fixation (MetaFix™) (Figure 3B). There were three partial intraoperative calcar fractures (3%), of which only one required wire cerclage and partial weight-bearing during 30 days after surgery. There was a 4-mm subsidence, which stabilized 45 days after surgery without treatment due to the absence of symptoms (Figure 4).

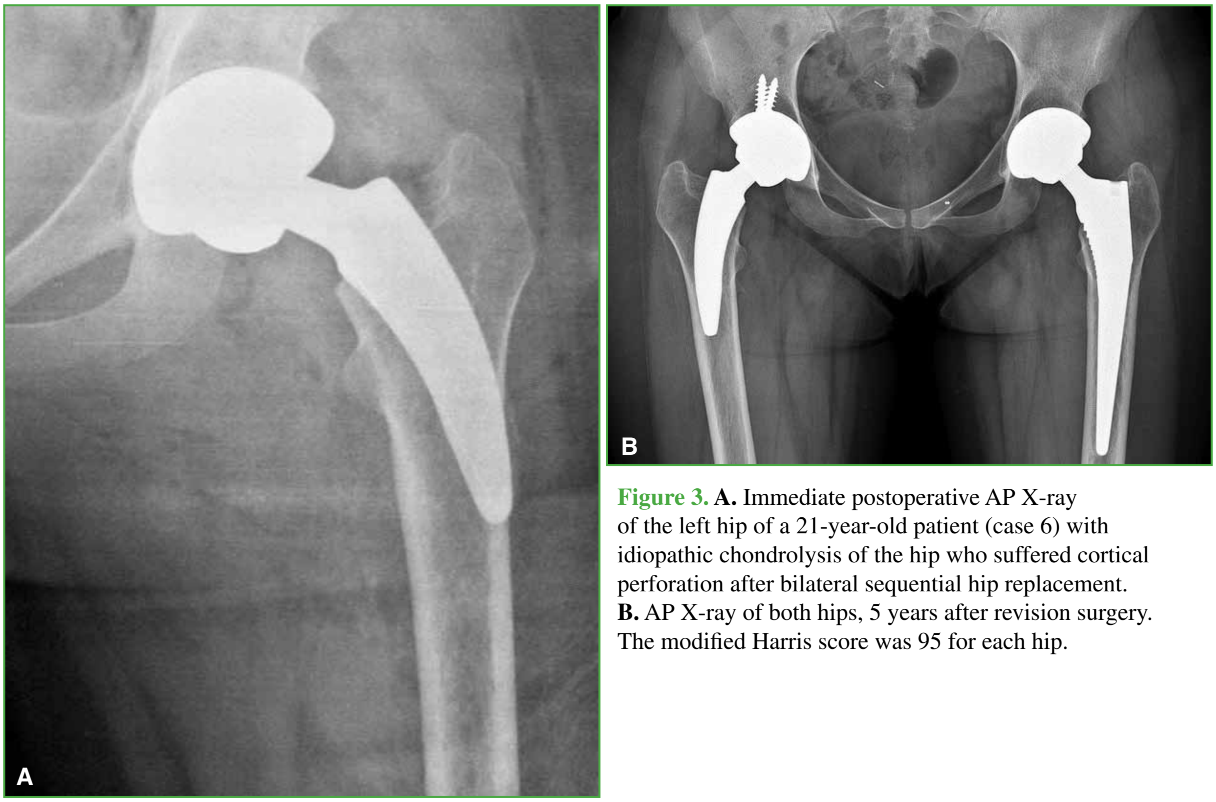

Figure 3. A. Immediate postoperative AP X-ray of the left hip of a 21-year-old patient (case 6) with idiopathic chondrolysis of the hip who suffered cortical perforation after bilateral sequential hip replacement. **B.** AP X-ray of both hips, 5 years after revision surgery. The modified Harris score was 95 for each hip.

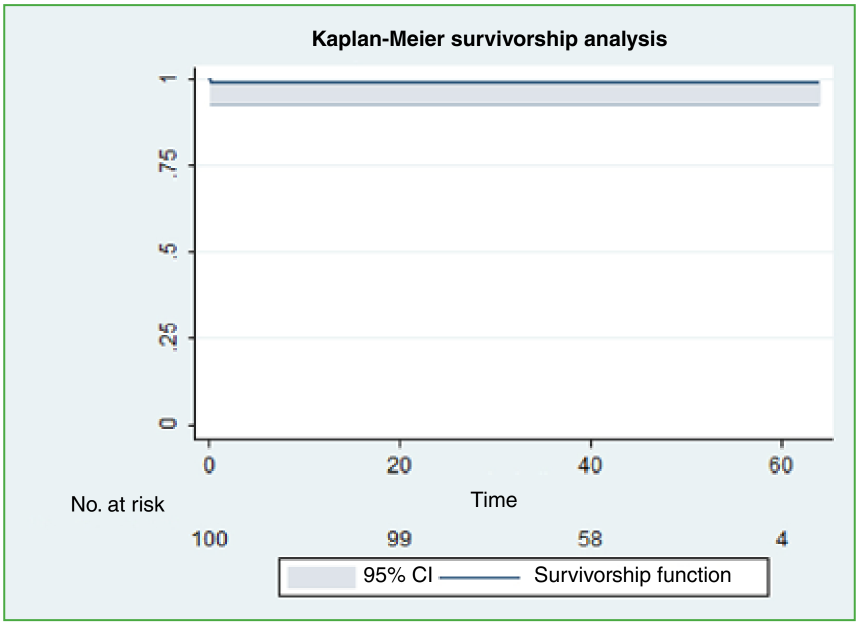

Figure 4. Kaplan-Meier survival analysis considering the revision of the stem for any cause as an end-point.

There were no cases of thigh pain or dislocation. The Harris average functional score improved significantly from 55 before surgery to 95 (range 82-100) at the last follow-up ($p < 0.05$).[28] At the last follow-up, 24 patients ran more than 5 km/week, 18 swam 1 or 2 times/week, 12 cycled more than 2 h/week, 8 practiced golf without restriction, 6 played non-competitive football, 6 practiced martial arts, 2 played basketball and 1 resumed squash. The average weekly sports activity was 6 hours, and 20 patients practiced more than one sport at the last follow-up. Return to sports activity occurred, on average, at 4.4 months (range 3-7).

In all cases, osseointegration was confirmed using the Engh score[30]. None of the stems showed radiolucent lines. Average limb discrepancy was 1.7 mm (range -4.7/+7 mm). Average femoral lateralization increased 4.6 mm (range -4/+7 mm). Six patients presented bone remodeling of the femoral neck and 3 presented hypertrophy. One suffered a deep acute infection that was successfully treated with debridement, component retention and antibiotics.

DISCUSSION

The revision rate in this consecutive series of patients operated on by the same surgeon, which included the learning curve period, was 1%. The Kaplan-Meier analysis for cumulative failure showed a stem survivorship of 99% at an average of 42 months due to aseptic failure and 98% when infection played a part.[31]

Currently, there are multiple short stem designs with different results reported (Table). A systematic literature review including 19 studies with different designs with a follow-up of less than 5 years has shown an adequate stem survivorship.[32]

Table. Results of the different publications comparing different type 2B short stems in primary hip surgery

Author	Year	Stem design	Number of hips	Average follow-up (months)	Survivorship due to aseptic failure
Ender[4]	2006	CUT	67	60	89%
Ender[5]	2006	CUT	56	60	88%
Ender[6]	2007	CUT	123	60	87%
Rudert[32]	2007	CUT	49	37	96%
Steens[34]	2010	CUT	99	78	98%
Nieuwenhuijse[25]	2012	CUT	39	60	95%
Pipino[29]	2004	CFP	353	42	99%
Rohrl[30]	2006	CFP	26	24	100%
Gill[10]	2008	CFP	75	43	100%
Pons[31]	2010	CFP	138	38	99%
Briem[1]	2011	CFP	155	74	99%
Nowak[26]	2011	CFP	49	82	98%
Kress[20]	2012	CFP	38	84	97%
Molfetta[22]	2011	CFP	153	42	99%
Ghera[9]	2013	CFP	126	66	100%
Kendoff[16]	2013	CFP	149	132	97%
Jerosch[14]	2013	MiniHip™	181	36	98%
Teoh[36]	2016	MiniHip™	275	37	99%
This study	2016	MiniHip™	100	42	99%

Despite advances in prosthetic design and surgical approaches, anatomical reconstruction of the hip continues to be a considerable challenge. When an anatomical reconstruction of the hip is not achieved, the results are unsatisfactory.[33] Discrepancies in length and lateralization lead to disorders in adjacent joints, such as the knee or the lumbosacral spine, and represent one of the main reasons of medical malpractice litigations in the United States.[13,26,34,35]

Stem manufacturers mentioned on this paper have published 250 consecutive cases with the MiniHip™ stem in four surgical centers, and reported a change in lateralization of 0.28 cm after surgery and a small decrease of -0.51° in the neck-shaft angle. The length of the operated leg increased 0.09 cm in this series.[25] However, a detailed clinical analysis focused on implant survivorship and associated complications was not included.

Recently, the ability to radiographically restore hip biomechanics using three different prosthetic systems has been reported.[36] By comparing a type 2B short stem, a conventional cementless stem, and a hip surface replacement, the authors have been able to determine that the rotation center was restored equivalently with the three systems. As for control of leg length, the short stem was superior to the other two systems, and the surface stem better controlled lateralization compared to the healthy contralateral hip. In our series, average limb discrepancy was 1.76 mm (range -4.7/+7 mm) and average femoral lateralization increased 4.56 mm (range -4/+7 mm), which is acceptable compared to those in other series in which the control of these parameters has been less predictable.[36,37] Unlike joint surface replacement, we believe that the learning curve with this design can be quickly overcome, giving patients the opportunity to preserve femoral bone stock, especially in young and active people. Likewise, Wedemeyer *et al.* described a strong correlation between preoperative planning and intraoperative measurements and a low correlation with lateralization, neck-shaft angle and correction of leg length using a type 2A short stem.[37]

Teoh *et al.* published a series of 275 patients who received the MiniHip™ stem with favorable results in a follow-up of 1-6 years. In this series, the complications were intraoperative calcar fractures (3%), a revision rate of 0.75%, and a 6.5% subsidence rate in the follow-up period.[3] Although said study includes a series of patients operated on by a single surgeon, age varied between 20 and 84 years, and they used different cup designs and combined different loading surfaces. The upper age limit in this series of patients may explain the high rate of subsidence.

Kim *et al.* published a high-quality scientific analysis that compares a group of patients operated on both sides, sequentially, with type 3 short stems on one side and conventional stems on the other side, followed-up prospectively for a minimum of 10 years.[38] However, the design of the short stem they used has been recalled from the market due to technical issues.[2] Using the Wright *et al.* classification, which offers recommendation levels based on the overall quality of the publications,[39] Khanuja *et al.* stated that there is not enough evidence to currently recommend routine use of type 3 stems.[2]

Our interest in short stems began in 2010, when the results of joint surface replacement started to be poorer due to the design that we used back then, in young and active patients, and also due to complications being reported, such as pseudo-tumors and adverse reactions derived from metallic debris.[7] After a detailed analysis of the short stems available in our country, we chose a system that was similar to the one we used for conventional cementless stems, with excellent results after a 20-year follow-up.[40] The hydroxyapatite-coated surface, as well as the loading surface, were exactly the same as those we used at the time. This chosen design was approved by the Food and Drug Administration and was popular in Germany, and was not only 42% shorter than a conventional cementless stem, but also, according to various publications, preserved part of the femoral neck.[41] The area of shaft fixation is compensated by the increase in the fixation area if part of the femoral neck is preserved. Contrary to joint surface replacement, the surgical approach used with this short stem is much simpler and similar to the implantation of a conventional stem. The only necessary change we have observed is the need for a more proximal femoral neck cut.

After the only femoral cortical perforation in case 6, we have not seen this complication in the following 344 cases operated on until today using a curved vascular clamp to enter the femoral canal.

There were 3 partial calcar fractures that did not require treatment, except for partial weight-bearing for 30 days, a complication that was also observed with other conventional cemented and cementless designs. Thus, we recommend that, whenever a short stem is implanted, a conventional stem is also available to use if anatomical conditions or intraoperative complications arise during surgery.

This study has several limitations. First, the lack of comparison with a group of patients with similar characteristics, operated on with a conventional design, and the short follow-up lead to a low estimation of survivorship analyzes. We are aware that a study on a new implant requires a longer follow-up period and a comparison with another design. Many implants seem to work properly in the short term; these findings are confirmed by retrospective series of few patients, and are adopted to later show that their results are poorer than those obtained with conventional implants. Second, the fact that not all patients <55 years were operated on with this same stem in this study, for anatomical or financial reasons, could be an indication bias, but, in the same way, there are femurs that cannot be reconstructed with a conventional cementless stem. Third, we only compared published results with type 2B stems and not with those of other types of short stems; the reason for this limited comparison is the large number of publications on short stems. As strengths of the study, we can mention the prospective follow-up and the fact that all patients were operated on by the same surgeon; this way, we could include the learning curve, which avoids experience bias.

In this consecutive series of young patients operated on by the same surgeon and with the same short stem design, the risk of revision was 1% at 2-5 years. We believe that the indication for this type of femoral implant is warranted in young and active patients, not with the intention of overcoming already-proven results with reliable conventional implants, but to reproduce them with a higher femoral bone stock preservation.

Conflicts of interests: the authors claim they do not have any conflict of interests.

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REFERENCES

1. Pipino F, Molfetta L. Femoral neck preservation in total hip replacement. *Ital J OrthopTraumatol* 1993;19:5-12.
2. Khanuja HS, Banerjee S, Jain D, Pivec R, Mont MA. Short bone conserving stems in cementless hip arthroplasty. *J Bone Joint Surg Am* 2014;96(20):1742-52. https://journals.lww.com/jbjsjournal/Abstract/2014/10150/Short_Bone_Conserving_Stems_in_Cementless_Hip.10.aspx
3. Teoh KH, Lee PY, Woodnutt DJ. Our early experience of the Corin Minihip prosthesis. *Hip Int* 2016;16;26(3):265-9. https://doi.org/10.5301/hipint.5000343
4. Ender SA, Machner A, Pap G, Hubbe J, Grashoff H, Neumann HW. Cementless CUT femoral neck prosthesis: increased rate of aseptic loosening after 5 years. *Acta Orthop* 2007;78(5):616-21. https://doi.org/10.1080/17453670710014301
5. Ender SA, Machner A, Pap G, Grasshoff H, Neumann HW. The femoral neck prosthesis CUT. Three- to six-year results. *Orthopade* 2006;35(8):841-7. https://doi.org/10.1007/s00132-006-0986-y
6. Ender SA, Machner A, Hubbe J, Pap G, Neumann HW. Medium-term results of the cementless femoral neck prosthesis CUT. *Z Orthop Ihre Grenzgeb* 2006;144(5):477-83. https://doi.org/10.1055/s-2006-942265
7. Ng VY, Arnott L, McShane MA. Perspectives in managing an implant recall: revision of 94 Durom Metasul acetabular components. *J Bone Joint Surg Am* 2011;93:e100(1-5). https://doi.org/10.2106/JBJS.J.01311
8. Rudert M, Leichtle U, Leichtle C, Thomas W. Implantation technique for the CUT-type femoral neck endoprosthesis. *Oper Orthop Traumatol* 2007;19(5-6):458-72. https://doi.org/10.1007/s00064-007-1018-4
9. Steens W, Skripitz R, Schneeberger AG, Petzing I, Simon U, Goetze C. Cementless femoral neck prosthesis CUT—clinical and radiological results after 5 years. *Z Orthop Unfall* 2010;148(4):413-9. https://doi.org/10.1055/s-0030-1250150
10. Thomas W, Lucente L, Mantegna N, Grundei H. ESKA (CUT) endoprosthesis. *Orthopade* 2004;33(11):1243-8. https://doi.org/10.1007/s00132-004-0717-1
11. Kendoff DO, Citak M, Egidy CC, O'Loughlin PF, Gehrke T. Eleven-year results of the anatomic coated CFP stem in primary total hip arthroplasty. *J Arthroplasty* 2013;28(6):1047-51. https://doi.org/10.1016/j.arth.2012.10.013
12. Briem D, Schneider M, Bogner N, Botha N, Gebauer M, Gehrke T, et al. Mid-term results of 155 patients treated with a collum femoris preserving (CFP) short stem prosthesis. *Int Orthop* 2011;35(5):655-60. https://doi.org/10.1007/s00264-010-1020-x

13. Charles MN, Bourne RB, Davey JR, Greenwald AS, Morrey BF, Rorabeck CH. Soft-tissue balancing of the hip: the role of femoral offset restoration. *Instr Course Lect* 2005;54:131-41.
14. Gruen TA, McNeice GM, Amstutz HC. "Modes of failure" of cemented stem-type femoral components: a radiographic analysis of loosening. *Clin Orthop Relat Res* 1979;141:17-27. https://doi.org/10.1097/00003086-197906000-00002
15. Ghera S, Bisicchia S. The collum femoris preserving stem: early results. *Hip Int* 2013;23(1):27-32. https://doi.org/10.5301/HIP.2013.10718
16. Gill IR, Gill K, Jayasekera N, Miller J. Medium term results of the collum femoris preserving hydroxyapatite coated total hip replacement. *Hip Int* 2008;18(2):75-80. https://doi.org/10.1177/112070000801800202
17. Kress AM, Schmidt R, Nowak TE, Nowak M, Haeberle L, Forst R, et al. Stress-related femoral cortical and cancellous bone density loss after collum femoris preserving uncemented total hip arthroplasty: a prospective 7-year follow-up with quantitative computed tomography. *Arch Orthop Trauma Surg* 2012;132(8):1111-9. https://doi.org/10.1007/s00402-012-1537-0
18. Molfetta L, Capozzi M, Caldo D. Medium term follow up of the Biodynamic neck sparing prosthesis. *Hip Int* 2011;21(1):76-80. https://doi.org/10.5301/hip.2011.6296
19. Nowak M, Nowak TE, Schmidt R, Forst R, Kress AM, Mueller LA. Prospective study of a cementless total hip arthroplasty with a collum femoris preserving stem and a trabeculae oriented pressfit cup: minimun 6-year follow-up. *Arch Orthop Trauma Surg* 2011;131(4):549-55. https://doi.org/10.1007/s00402-010-1189-x
20. Pipino F, Molfetta L, Grandizio M. Preservation of the femoral neck in hip arthroplasty: results of a 13-17-year follow-up. *J Orthop Traumatol* 2000;1:31-9. https://doi.org/10.1007/s101950070026
21. Pipino F. CFP prosthetic stem in mini-invasive total hip arthroplasty. *J Orthop Traumatol* 2004;4(3):165-71. https://doi.org/10.1007/s10195-004-0065-2
22. Rohrl SM, Li MG, Pedersen E, Ullmark G, Nivbrant B. Migration pattern of a short femoral neck preserving stem. *Clin Orthop Relat Res* 2006;448(448):73-8. https://doi.org/10.1097/01.blo.0000224000.87517.4c
23. Nieuwenhuijse MJ, Valstar ER, Nelissen RG. 5-year clinical and radiostereometric analysis (RSA) follow-up of 39 CUT femoral neck total hip prostheses in young osteoarthritis patients. *Acta Orthop* 2012;83(4):334-41. https://doi.org/10.3109/17453674.2012.702392
24. Pons M. Learning curve and short-term results with a short-stem CFP system. *Hip Int* 2010;20(Suppl 7):S52-7. https://doi.org/10.5301/HIP.2010.4443
25. Jerosch J, Grasselli C, Kothny PC, Litzkow D, Hennecke T. Reproduction of the anatomy (offset, CCD, leg length) with a modern short stem hip design—a radiological study. *Z Orthop Unfall* 2012;150(1):20-6. https://doi.org/10.1055/s-0030-1270965
26. Lindgren JU, Rysavy J. Restoration of femoral offset during hip replacement: a radiographic cadaver study. *Acta Orthop Scand* 1992;63:407-10. https://doi.org/10.3109/17453679209154755
27. González Della Valle A, Slullitel G, Piccaluga F, Salvati EA. The precision and usefulness of preoperative planning for cemented and hybrid primary total hip arthroplasty. *J Arthroplasty* 2005;20(1):51-8. https://doi.org/10.1016/j.arth.2004.04.016
28. Salvati EA, Sharrock NE, Westrich G, Potter HG, Valle AG, Sculco TP. The 2007 ABJS Nicolas Andry Award: three decades of clinical, basic, and applied research on thromboembolic disease after THA: rationale and clinical results of a multimodal prophylaxis protocol. *Clin Orthop Relat Res* 2007;(459):246-54. https://doi.org/10.1097/BLO.0b013e31805b7681
29. 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. https://doi.org/10.2106/00004623-196951040-00012
30. Engh CA, Massin P, Suthers KE. Roentgenographic assessment of the biologic fixation of porous-surfaced femoral components. *Clin Orthop Relat Res* 1990;257:107-28. https://doi.org/10.1097/00003086-199008000-00022
31. Kaplan E, Meier P. Nonparametric estimation from incomplete observations. *J Am Stat Assoc* 1958;53:457-81. https://doi.org/10.1080/01621459.1958.10501452
32. Van Oldenrijk J, Molleman J, Klaver M, Poolman RW, Haverkamp D. Revision rate after short-stem total hip arthroplasty: a systematic review of 49 studies. *Acta Orthop* 2014;85(3):250-8. https://doi.org/10.3109/17453674.2014.908343
33. Hodge WA, Andriacchi TP, Galante JO. A relationship between stem orientation and function following total hip arthroplasty. *J Arthroplasty* 1991;6:229-35. https://doi.org/10.1016/s0883-5403(06)80169-5
34. Konyves A, Bannister GC. The importance of leg length discrepancy after total hip arthroplasty. *J Bone Joint Surg Br* 2005;87:155-7. https://doi.org/10.1302/0301-620X.87B2.14878

35. Steinberg B, Harris WH. The offset problem in total hip arthroplasty. *Contemp Orthop* 1992;24:556-62.
36. Nally FJ, Rossi LA, Diaz F, Stagnaro J, Slullitel PAI, Buttaro MA. Which prosthetic system restores hip biomechanics more effectively? Comparison among three systems. *Curr Orthop Prac* 2015;(26)4:382-6. https://doi.org/10.1097/BCO.0000000000000242
37. Wedemeyer C, Quitmann H, Xu J, Heep H, von Knoch M, Saxler G. Digital templating in total hip arthroplasty with the Mayo stem. *Arch Orthop Trauma Surg* 2008;128(10):1023-9. https://doi.org/10.1007/s00402-007-0494-5
38. Kim YH, Park JW, Kim JS. Ultrashort versus conventional anatomic cementless femoral stems in the same patients younger than 55 years. *Clin Orthop Relat Res* 2016;474(9):2008-17. https://doi.org/10.1007/s11999-016-4902-4
39. Wright JG, Einhorn TA, Heckman JD. Grades of recommendation. *J Bone Joint Surg Am* 2005;87(9):1909-10. https://doi.org/10.2106/JBJS.8709.edit
40. Vidalain JP. Twenty-year results of the cementless Corail stem. *Int Orthop* 2011;35:189-94. https://doi.org/10.1007/s00264-010-1117-2
41. Buttaro M, Martorell G, Quinteros M, Comba F, Zanotti G, Piccaluga F. Preservación ósea femoral con tallos cortos de fijación cervicometafisaria. Estudio radiográfico comparativo con tallos no cementados de fijación metafisaria. *Rev Asoc Argent Ortop Traumatol* 2015;79(4):232-6. http://www.scielo.org.ar/pdf/raaot/v79n4/v79n4a06.pdf