

World Journal of *Orthopedics*

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ORIGINAL ARTICLE**Case Control Study**

- 206 Role of shoulder gradient in the pathogenesis of rotator cuff tears
Sobhani Eraghi A, Hajializade M, Shekarchizadeh E, Abdollahi Kordkandi S

Retrospective Cohort Study

- 213 Day case *vs* inpatient total shoulder arthroplasty: A retrospective cohort study and cost-effectiveness analysis
Borakati A, Ali A, Nagaraj C, Gadikoppula S, Kurer M

Retrospective Study

- 222 Analysis of orthopedic surgical procedures in children with cerebral palsy
Rehbein I, Teske V, Pagano I, Cúneo A, Pérez ME, von Heideken J
- 232 Total hip replacement using MINIMA® short stem: A short-term follow-up study
Drosos GI, Tottas S, Kougioumtzis I, Tilkeridis K, Chatzipapas C, Ververidis A

Prospective Study

- 243 Kitesurf injury trauma evaluation study: A prospective cohort study evaluating kitesurf injuries
van Bergen CJ, Weber RI, Kraal T, Kerkhoffs GM, Haverkamp D

ABOUT COVER

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Retrospective Study

Total hip replacement using MINIMA® short stem: A short-term follow-up study

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Patients were not required to give informed consent to the study because the analysis used anonymous clinical data that were obtained after each patient agreed to treatment by written consent.

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Abstract**BACKGROUND**

Total hip replacement has become one of the most successful orthopaedic procedures. The length of the femoral stem constitutes one of the most important geometrical and mechanical features of the prosthesis. Several different implants are currently available but data are limited concerning the clinical results for some of these implants.

AIM

To report the short-term clinical and radiological results of a novel squared section, tapered design – with four conicity – short stem in total hip replacement.

METHODS

This is a retrospective study of a prospectively collected data using of MINIMA® short stem in 61 consecutive patients with at least 1 year follow-up. The collected data included patients' demographics, type of arthritis, bone morphology, perioperative data, clinical results using Harris Hip Score, EuroQol (EQ-5D), pain score and satisfaction rate, complications and radiological results.

RESULTS

Total 61 patients were included in our study with a mean age of 56 years of age (range 25-73 years). The majority of them (68.6%) were women, thirty seven patients (56.9%) were less than 60 years of age and almost half of patients (45.1%) suffered from secondary osteoarthritis (hip dysplasia, osteonecrosis, etc.). The mean time of follow-up examination was 33.4 mo (2.8 years) with a range of 12-57 months (1-4.8 years). In 35 patients (56.9%) the follow-up examination was more than 3 years. No major complications such as revision, periprosthetic fracture, dislocation or infection were presented. Re-admission 90 d postoperatively or later was deemed unnecessary for any reason regarding the operation. Respectively, the mean pain score, mean Harris hip score, and mean EQ-5D were

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improved from 6.3, 58.7 and 77.3 preoperatively to 0.1, 95.1, and 79.8 postoperatively. The Satisfaction rate at the final follow-up was 9.9 (SD 0.3, range 8.0-10.0). All stems were classified as stable bone ingrowth and no radiolucent lines were revealed in any of the modified Gruens' zone at the postoperative X-rays. Stem subsidence was within acceptable limits and the incidence of distal cortical hypertrophy was relatively low.

CONCLUSION

The clinical and radiological results concerning the MINIMA® short stem are excellent according to this first report of this specific design of the short femoral stems. Because of the small number of cases and short-term follow-up of this study, a longer follow up time and more patients' enrollment is required.

Key words: Total hip replacement; Total hip arthroplasty; Short-stem; Hip prostheses; Femoral components; MINIMA® stem

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Core tip: Total hip replacement has become one of the most successful orthopaedic procedures. The length of the femoral stem constitutes one of the most important geometrical and mechanical features of the prosthesis. Several different implants are currently available but data are limited concerning the clinical results for some of these implants. Our objective is to report the short-term results of a novel squared section, tapered design –with four conicity- short stem. According to our findings the clinical and radiological results were excellent in the short-term follow-up using the MINIMA® short stem in total hip replacement.

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INTRODUCTION

Total hip replacement (THR) is considered as one of the most successful procedures in orthopaedic surgery^[1,2]. The length of the femoral stem is one of the most important geometrical and mechanical characteristics of the prosthesis. Nevertheless, there is no clear scientific evidence concerning the ideal stem length and no consensus regarding the definition of the standard or conventional stems as well as the short stems (SS)^[3]. Many authors met the conclusion that SS are those with a length of less than 120 mm^[4], while other definitions have also been proposed^[5].

The use of SS started more than 30 years ago^[5,6]. Clinical studies, meta-analysis as well as comparative studies have shown survival rate similar to conventional stems but for most SS the available data is controversial regarding short or medium term results^[7-9]. Several different implants have been currently available^[10], classified in different categories^[5,11]. Yet, the existing literature regarding clinical results is limited to some of these implants.

Our aim is to report the short-term results of a novel squared section, tapered design –with four conicity- short stem. To the best of our knowledge, this is the first report concerning the clinical use of this particular SS.

MATERIALS AND METHODS

This is a report of a prospectively collected data of 61 consecutive patients undergone THR using the MINIMA® short stem (Lima Corporate, Udine, Italy) (Figure 1) with a minimum follow-up time of 1 year. The study was approved by Ethics committee/Scientific Council of our hospital (SC6/Item 109/28-09-2017).

Operations were performed under either general or spinal anesthesia (chosen by the attending anesthesiologists), using a lateral approach (modified Hardinge). Peri-



Figure 1 The MINIMA® short stem.

operative antibiotic prophylaxis with a second generation cephalosporin (cefoxitin sodium) for 24 h and anticoagulation protocol with low-weight molecular heparin were applied. The appropriate size and orientation of the femoral component were ensured with fluoroscopy after the trial reduction in all cases (Figure 2).

All patients' data including demographics, American Society of Anesthesiology physical status classification system^[12], Charlson index^[13], diagnosis (arthritis type), hip dysplasia according to Hartophylakidis classification^[14] femoral morphology according to Dorr's classification^[15], perioperative data including operation time, blood loss, and transfusion rate, length of stay, 90-d re-admissions and complications, were collected prospectively.

The standard postoperative follow-up protocol (at 6 wk, 3 mo, 6 mo, 1 year and every year thereafter) was the same for all patients.

Complications were categorized according to Parvizi *et al*^[16] as systemic (major or minor) and local (major or local).

Clinical results were assessed using Harris hip score^[17], EuroQol (EQ-5D) 0-100 scale^[18], pain score and satisfaction rate using the VAS/NRS scale^[19] (Table 1).

Implants

The MINIMA® short stem (Lima Corporate, Udine, Italy) is a cementless, squared section, tapered design stem. It is available in 12 sizes and its length varies between 82 mm and 118 mm. This is a type 3 -standard neck osteotomy, trochanteric sparing-stem^[11].

Two different uncemented acetabular components were used (1) a Porous Titanium coating - Titanium plasma spray (SPH-Contact® cup, Lima Corp. Udine, Italy); and (2) a Porous Titanium with HA coating (Delta-PF® cup, Lima Corp. Udine, Italy).

Radiological study

Radiological results were assessed using digital radiographs and a standard system^[20]. The modified seven zones of Gruen in anteroposterior and seven zones in lateral radiograph view were evaluated in order to discover any potential (1) radiolucent lines; (2) reactive lines; and (3) cortical hypertrophy^[21] (Figure 3).

The femoral stem fixation was classified as stable bone ingrowth, stable fibrous fixation or unstable fibrous fixation^[22]. Femoral stem subsidence was measured as the distance between the summit of the lesser trochanter and bottom edge of the stem at 6 wk postoperatively in comparison to the latest follow-up imaging^[23].

Leg length discrepancy was measured as the difference between the distances from the inter-teardrop line and the summit of the lesser trochanter of both hips.

Ectopic ossification was probed, according to the classification of Brooker^[24].

Proximal femoral stress shielding and bone resorption were investigated, as described by Engh CA^[25,26].

Acetabular component evaluation included (1) the presence of radiolucent lines at the bone-prosthesis interface according to DeLee *et al*^[27], 1976; and (2) the cup stability according to Manley *et al*^[28] criteria.

Manual measurements were performed using IMPAX software (Version 6.3, Agfa IMPAX, AGFA-Gevaert N.V, Mortsel, Belgium). The implanted acetabular shell was used for calibration.

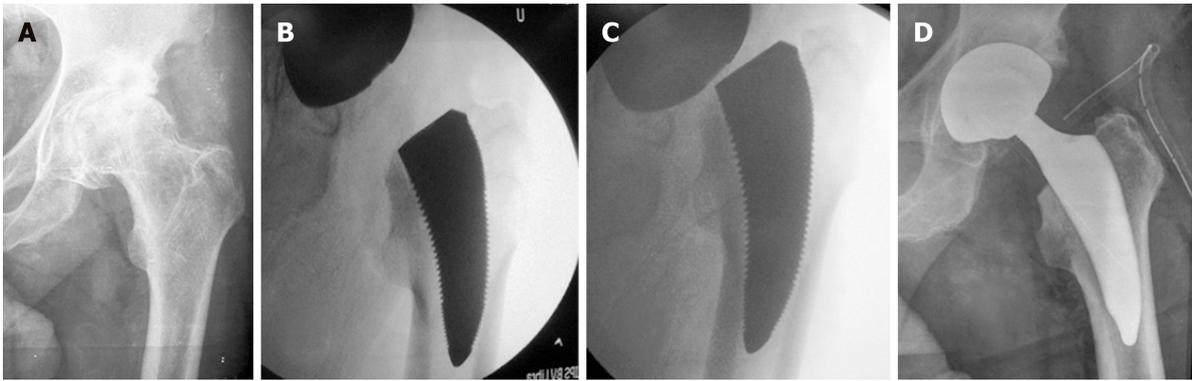


Figure 2 The appropriate size and orientation of the femoral component were ensured with fluoroscopy after the trial reduction in all cases. A: Pre-operative radiograph; B: Intra-operative fluoroscopy after the trial reduction showing a varus and undersizing rasp; C: Correct orientation and sizing; D: Immediate postoperative radiograph.

RESULTS

Sixty one patients were included in this study, with a mean age of 56 years of age (range 25-73 years). Thirty seven of our patients (56.9%) were less than 60 years of age and 42 (68.6%) of the patients were women (Table 1). About half of the patients suffered from primary osteoarthritis (n : 33%-54.9%), and the rest of them from secondary osteoarthritis (osteonecrosis, hip dysplasia or other deformities) (Figure 4 and Figure 5), while in 6 patients (9.8%) a previous operation had been performed (femoral osteotomy, vascularized fibular graft, internal fixation for hip fracture) (Figure 5, Figure 6, and Table 2).

The mean time of follow-up was of 33.4 mo (2.8 years) with a range of 12-57 mo (1-4.8 years). In 35 (56.9%) of our patients the follow-up was more than 3 years (Table 1).

Apart from a deep vein thrombosis in one patient at 6 weeks postoperatively, no other complications such as revision, infection, hip dislocation, peri-prosthetic fracture were appeared. Anterior thigh pain was not reported by any of our patients.

Respectively, the mean Pain score, mean HHS, and mean EQ-5D were improved from 6.3, 58.7 and 77.3 preoperatively to 0.1, 95.1, and 79.8 postoperatively (Table 1). The Satisfaction rate at the final follow-up was 9.9 (SD 0.3, range 8.0-10.0).

No patient was re-admitted during the first 90-d nor later for any reason related to the operation.

Radiological findings

Femoral stem: The femoral stem was classified as stable bone ingrowth in all patients^[22]. No radiolucent lines were observed in any of the modified seven zones of Gruen in anteroosterior and lateral views^[21]. Cortical hypertrophy was observed in 4 patients (6.6%) (Figure 7). In 2 patients reactive lines were observed in zones 3, 4 and 5 (Figure 8). The calculated mean stem subsidence was 1.8 mm (SD 0.9, range 0.0-3.9 mm).

Proximal femoral stress shielding and bone resorption were graded radiologically as grade 1 in all patients^[25].

The mean leg length discrepancy was 1.7 mm (SD 5.4) with a wide range (from -17 to 19 mm) due to the relatively high prevalence of patients with a secondary osteoarthritis (45.1%), -dysplastic hips, bilateral in most cases.

Acetabular component: No radiolucent lines were observed in any zones according to DeLee *et al*^[27] (1976). All cups were classified as stable according to Manley *et al*^[28] (1998) criteria.

DISCUSSION

According to the findings of the present study the clinical and radiological results were excellent in the short-term follow-up using the MINIMA® short stem in THR. Despite the short follow-up time and the small number of cases, no revision for any cause was performed, no radiological signs for loosening or impending loosening were observed, no periprosthetic fractures were presented and clinical scores and patients' satisfaction were excellent.

Comparing our results to those of the existing literature, it is difficult to draw safe

Table 1 Demographics and clinical data

Characters	Values
Number of patients ¹	61
Gender female ²	42 (68.6%)
Gender male ²	19 (31.4%)
Age (yr) ³	56 ± 11.1 (25-73)
BMI ³	31.2 ± 4.9 (22.8-50.0)
ASA ³	1.8 ± 0.6 (1.0-3.0)
Charlson index ³	1.2 ± 0.5 (0.0-3.0)
LOS (d) ³	3.3 ± 1.1 (2.0-8.0)
Operating time (min) ³	89.9 ± 17.2 (60.0-120.0)
Blood loss (mL) ³	1.154 ± 0.213 (0.735-1.631)
Transfusion rate ²	2 (3.9%)
Follow-up (mo) ³	33.4 ± 15.8 (12-57)
Follow-up (yr) ³	2.8 ± 1.3 (1-4.8)
Follow-up more than 3 yr ²	35 (56.9%)
Pain pre-operative ³	6.3 ± 1.9 (2.8-8.0)
Pain final follow-up ³	0.1 ± 0.4 (0.0-2.0)
HHS pre-operative ³	58.7 ± 13.5 (33.0-78.0)
HHS final follow-up ³	95.1 ± 4.9 (83.0-100.0)
EQ-5D pre-operative ³	77.3 ± 16.7 (50.0-95.0)
EQ-5D final follow-up ³	79.6 ± 12.1 (50.0-100.0)
Satisfaction final follow-up ³	9.9 ± 0.3 (8.0-10.0)
Complications	
Deep vein thrombosis ²	1

¹The values are given as raw numbers.

²The values are given as raw numbers with the percentages in parentheses.

³The values are given as the mean ± SD and the range in parentheses. BMI: Bone mass index; ASA: American Society of Anesthesiologists score; LOS: Length of stay, HHS: Harris hip score; EQ-5D: EuroQol.

conclusion, because there are no other report concerning the use of this particular stem in THR. A recent review of the literature has shown that the calculated overall median revision rate is comparable to those of conventional stems of National Registries, but the survival rate of SS depends on the type of the stem^[9]. The best results have been reported for type 2 stems followed by the type 3 stems, while the revision rate for type 1 has been disappointing. The MINIMA® short stem belongs to the type 3 category – a standard femoral neck osteotomy stem.

Furthermore, the available comparative studies and a subsequent meta-analysis have shown no significant differences between SS and conventional stems in the short-term follow-up^[6].

However, the available clinical results (either observational or comparative studies) are limited to some of the several different implants that have been currently used.

Despite their theoretical advantages and the reported encouraging results the use of SS has not gained yet a wide acceptance among the orthopaedic surgeons.

Short stem advantages

The advantages of using short stems in THR's include (1) the removal of less bone in the proximal femur; (2) a subsequent "easier" stem revision as less bone is expected to be "violated"; (3) less bone remodeling or bone mineral changes of the proximal femur (proximal stress-shielding); and (4) less anterior thigh pain. Finally, another important benefit of short stems is that enables surgeons to overcome the problem of the proximal-distal mismatch due to Dorr type A femur, femoral shape or femoral deformity.

In our series, no cases with stem revision were required, therefore we cannot confirm the "easiness" of revision. The future will show the benefit for our patients since 37 (56.9%) of these patients were less than 60 years of age and some or most of them are going to undergo a revision surgery in the future.

No cases with postoperative thigh pain were observed. The MINIMA® short stem was used in 11 (17.6%) patients with Dorr type A femur.

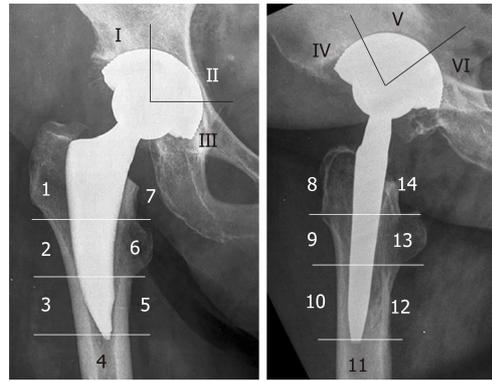


Figure 3 The modified Gruen zones.

Proximal bone remodeling or bone mineral changes were not estimated in our study. Bone remodeling seems to be less for short stems according to a recent literature review, although the results are not the same for all SS designs^[29]. Furthermore, according to a recent report based on data from the existing literature, the bone mineral changes around femoral stems (cemented, cementless, conventional and short stems) are not predictive for the level the satisfaction of long term clinical outcomes regarding total hip arthroplasty^[30]. Therefore, the authors suggested that studies with a follow up shorter than 5-10 years are perhaps clinically irrelevant^[30].

Short stem disadvantages

The three main concerns for short stems are (1) the possible stem malposition (and stem undersizing) due to lack of distal extension to guide position within the canal and subsequent stem subsidence; (2) possible inadequate early stability, stem micromotion and subsequent fibrous ingrowth instead of bone ingrowth; and (3) the long-term clinical results.

We believe that the routine use of intra-operative fluoroscopy guaranteed proper implant orientation and correct sizing in our series. This fact eliminated the influence of the surgical technique as a confounding factor in stems' survivorship.

As far as the early stem stability is a concern, our clinical impression is that it is provided by the design of this particular stem. Specifically, it is (1) the taper design - with four taper conicity- to avoid sinking; and (2) the squared section providing torsional stability.

The long-term results concerning the use of MINIMA® short stem cannot be predicted from the results of this study.

Stem subsidence (distal migration)

Roentgen stereophotogrammetric analysis is generally accepted as the most accurate method of femoral stem subsidence (distal migration), as well as Einzel-Bild-Roentgen-Analyse femoral component analysis, which also allows accurate measurement of femoral stem subsidence^[31-33]. The IMPAX software, which was used in the present study, has been used before^[34], although we are not aware of its accuracy in measuring the stems' distal migration.

Stem subsidence was within acceptable limits in our series. It was calculated more than 3 mm only in 3 patients, but no other radiological signs or symptoms of stem loosening were recorded.

Femoral stem subsidence is usually measured using as reference points the tip of the greater trochanter and the proximal end of the femoral stem^[35].

We noticed, that radiographic changes of the tip of the greater trochanter -heterotopic ossification- in 11 (17.6%) of our patients were presented. This fact made the measurement less reliable in some cases in our study. Therefore, we used as reference points the summit of the lesser trochanter and the bottom edge of the stem for measurement of the femoral stem subsidence^[23].

Distal cortical hypertrophy

The incidence of distal cortical hypertrophy varies among different studies. Despite the different hypotheses for its development and the excellent short-term clinical results, the exact cause or pathogenesis and the long-term clinical results in patients with this radiological finding remains unknown^[36].

The incidence in our study was relatively low, since in 4 (6.6%) of our patients a cortical hypertrophy was observed in Gruen's modified ones 3 and 5. Nevertheless, a

Table 2 Arthritis type bone morphology and radiological findings

	n (%)
Arthritistype	
Primaryosteoarthritis	33 (54.9)
Dysplasia (type A) ¹	13 (21.6)
Low dislocation (type B) ¹	2 (3.9)
Osteonecrosis	7 (11.8)
Post traumaticarthritis	4 (5.9)
Other	1 (2.0)
Previous operation (osteotomy, Fracture fixation)	6 (9.8)
Proximal femoral morphology (Dorr type)	
A	11 (17.6)
B	48 (78.4)
C	2 (3.9)
Ectopic ossification (Brooker classification)	
All	11 (17.6)
Class 1	6 (9.8)
Class 2	5 (7.8)
Modified Gruen zones	
Radiolucent lines	0
Reactive lines (zones 3, 4, 5)	2 (3.3)
Cortical hypertrophy (zones 3, 5)	4 (6.6)
Subsidencein mm ²	1.8 ± 0.9 (0.0-3.9)
Leg length discrepancy in mm ²	1.7 ± 5.4 (-17-19)

¹Chartofylakidis classification.

²The values are given as the mean ± SD and the range in parentheses.

careful follow-up of these patients is required.

The main limitation of this study is the fact that it is a clinical and radiological report with a small number of cases and short-term follow-up. Future studies with large number of patients and longer follow-up time are required in order to ensure the safety and efficacy of using this particular short stem in THR patients.

Nevertheless the clinical and radiological results are excellent, without major complications and the follow-up in 56.9% of our patients is more than 3 years.

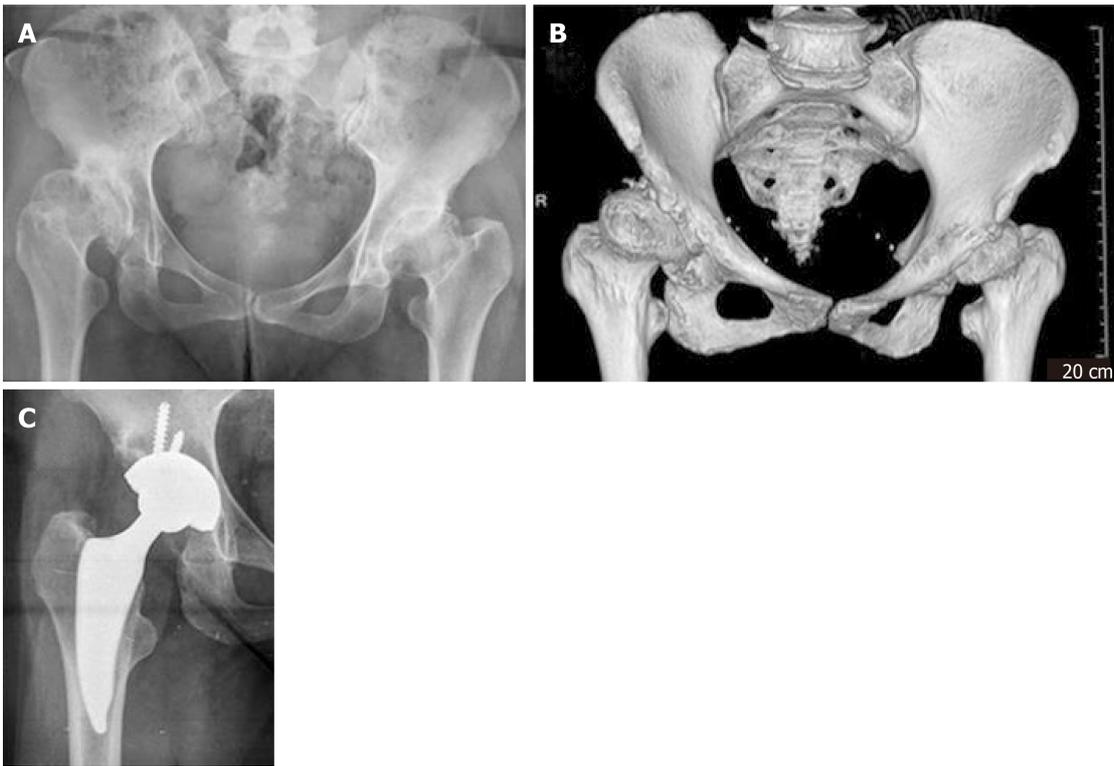


Figure 4 Hip dysplasia Hartophylakidis type II at the right side, and radiographs at 3 years postoperatively. A, B: Hip dysplasia Hartophylakidis type II at the right side; C: Radiographs at 3 years postoperatively.

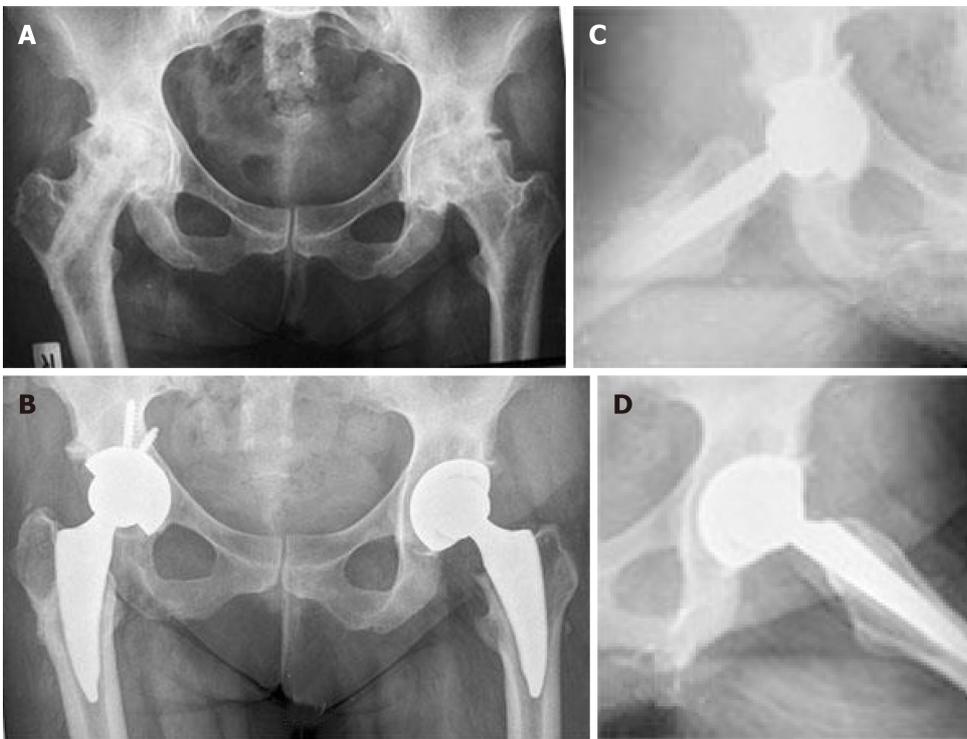


Figure 5 Bilateral osteonecrosis in a 24 years female patient suffered from lymphoma. A: Patient treated on the right side with a vascularized fibular graft; B: Postoperative radiographs 4 years postoperatively on the right side; C: 3 years on the left side; D: Lateral radiographs.

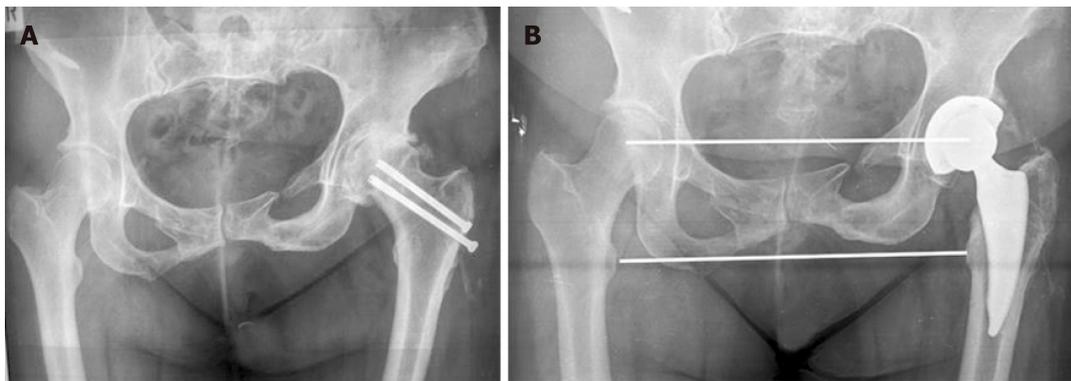


Figure 6 Ectopic ossification. A: Posttraumatic osteoarthritis; B: Radiographs at 4 years postoperatively.



Figure 7 Distal cortical hypertrophy at modified Gruen zones 3 and 5.

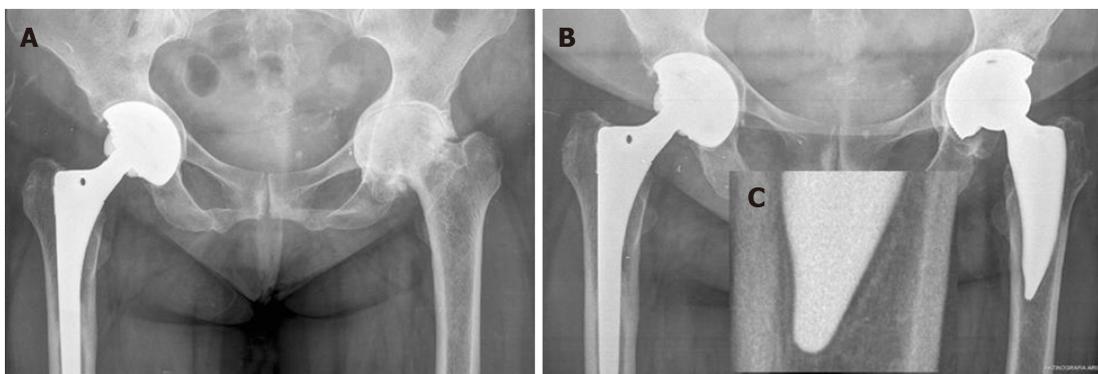


Figure 8 Reactive lines were observed in zones 3, 4 and 5. A: Preoperative radiographs showing "protrusion acetabuli" and Dorr type C proximal femur; B: Postoperative radiographs at two years; C: Reactive lines in zones 3, 4 and 5.

ARTICLE HIGHLIGHTS

Research background

Total hip replacement is considered as one of the most successful procedures in orthopedic surgery. The length of the femoral stem is one of the most important geometrical and mechanical characteristics of the prosthesis. The use of short stems started more than 30 years ago.

Research motivation

Clinical studies, meta-analysis as well as comparative studies have shown similar survival rate between conventional and short stems. However, for most short stems the available data is controversial regarding short or medium term results. Several different implants have been currently available, classified in different categories. Yet, the existing literature regarding clinical results is limited to some of these implants.

Research objectives

Our aim is to report the short-term clinical and radiological results of a novel squared section, tapered design –with four conicity- short stem in total hip replacement.

Research methods

This is a report of a prospectively collected data of 61 consecutive patients undergone total hip replacement using the MINIMA® short stem (Lima Corporate, Udine, Italy) with a minimum follow-up time of 1 year.

Research results

The mean time of follow-up was of 33.4 mo (2.8 years) with a range of 12-57 months (1-4.8 years). Apart from a deep vein thrombosis in one patient at 6 weeks postoperatively, no other complications such as revision, infection, hip dislocation, peri-prosthetic fracture were appeared. Additionally, the functional outcomes, pain score and satisfaction rate were significantly improved at the postoperative follow- up period. The femoral stem was classified as stable bone ingrowth in all patients. No radiolucent lines were observed in any of the modified seven zones of Gruen in anteroposterior and lateral views. Regarding the femoral component, no radiolucent lines were observed in any zones according to DeLee and Charnley.

Research conclusions

The clinical and radiological results of our study are considered as excellent, without major complications and the follow-up in 56.9% of our patients is more than 3 years.

Research perspectives

Further research based on well designed studies with longer follow-up examination need to be performed, in order to elucidate the efficacy of short stems.

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