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Stay Short or Go Long in Revision Total Hip Arthroplasty With Paprosky Type II Femoral Defects: A Comparative Study With the Use of an Uncemented Distal Fixating Modular Stem and a Primary Monobloc Conical Stem With 5-Year Follow-Up

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ABSTRACT

Background: In the revisions for Paprosky type II femoral defects, diaphyseal fixating femoral stems are commonly used. To preserve bone stock, the use of a shorter primary conical stem could be an adequate alternative. The objective of this study is to compare the results of a primary conical stem to the more commonly used diaphyseal fixating modular revision stem in revision total hip arthroplasty surgery with Paprosky type II femoral defects.

Methods: A total of 59 consecutive patients with Paprosky type II femoral defects from our prospective revision registry were included. Thirty patients who received a long distal fixating modular stem (Revision Stem, Lima Corporate) and 29 patients who received a primary conical short stem (Wagner Cone, Zimmer) were prospectively followed. Minimal follow-up time was 2 years for subsidence and patient-reported outcome measures and 5 years for complications, reoperation, and revision. We compared subsidence, perioperative complications, reoperations, femoral component survival, Oxford Hip Score, EuroQol 5 Dimension, visual analog scale (VAS) for pain at rest, and VAS for pain during activity between stems.

Results: Both groups were comparable regarding demographic, clinical, and surgery-related characteristics. We found more perioperative complications and stem revisions with the modular revision stem than with the primary conical stem. There were no statistical differences in subsidence, EuroQol 5 Dimension, Oxford Hip Score, and VAS for pain at rest or during activity between both stems.

Conclusion: In revision total hip arthroplasty with Paprosky type II femoral defects, uncemented primary monobloc conical femoral stems showed the same clinical result as distal fixating modular stems with fewer complications and fewer stem revisions.

Primary total hip arthroplasty (THA) is one of the most performed and successful procedures worldwide. The number of patients undergoing primary THA is increasing. As a result, the demand for hip revision is increasing [1–5]. Revision THA has a huge economical and clinical burden and demands specialized treatment [6,7].

Revision surgery can be challenging, especially in cases with more severe bone loss. The Paprosky femoral bone loss classification (Fig. 1) is a well-known scale to appreciate bone loss and to plan revision surgery [8,9]. In cases with more severe bone defects, long modular stems are typically used [10]. Also, in Paprosky I-IIIA, good results are obtained by using a modular distal fixating femoral component [11–13]. The main advantages of these stems are the possibility to fill the diaphysis and to bridge femoral defects where the distal fixation ensures axial and rotational fixation [14–16] and they are adjustable in leg length, offset, and version

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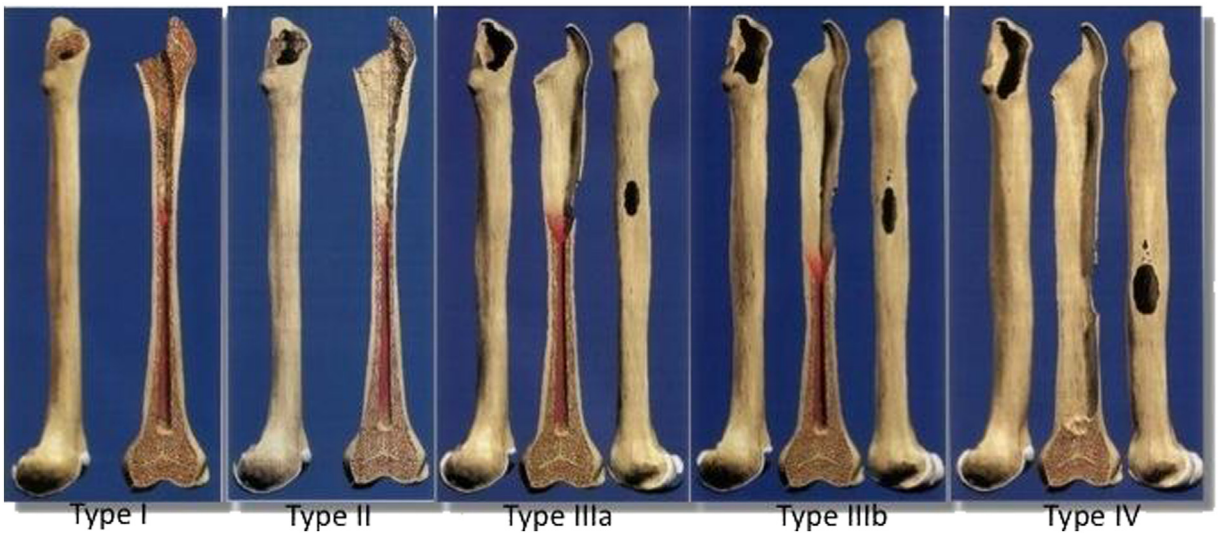

Fig. 1. Paprosky classification of femoral bone loss. Type I: minimal metaphyseal bone loss. Type II: extensive metaphyseal bone loss and minimal diaphyseal bone loss. Type IIIA: extensive metaphyseal and diaphyseal bone loss but $\geq$ 4 cm intact diaphyseal bone. Type IIIB: extensive metaphyseal and diaphyseal bone loss and <4 cm intact diaphyseal bone. Type IV: extensive metaphyseal and diaphyseal bone loss and nonsupportive isthmus.
Della Valle CJ, Paprosky WG. Classification and an algorithmic approach to the reconstruction of femoral deficiency in revision total hip arthroplasty. J Bone Joint Surg Am. 2003; 85:1–6.

[17]. Disadvantages are the risks of corrosion and stem fracture [18,19], intraoperative fractures [20], higher cost [21], thigh pain, and proximal stress shielding [16,22–24]. Because of these disadvantages, the suitability or value of these stems in the lower Paprosky bone defects can be questioned. Because there is no decisive scientific evidence for the traditionally used adage of 'bypassing of the femoral defect with 2 cortical diameters' [25], 'as proximal as possible and as distal as necessary' is gaining attention [26,27].

Initially, the use of primary uncemented stems in femoral revisions had limited success because of high re-revision rates [28,29]. Considering the potential advantages of sparing the bone for further revision, lower complexity of surgery with reduced risk for complications, and lower product cost, the use of primary stems in revision THA has gained new interest in recent years [30]. We evaluated prospective data to gain more insights in the outcome of primary stems in revision THA. We compared the results of a primary conical stem (PCS) to the more commonly used diaphyseal fixating modular revision stem (MRS) in revision THA in Paprosky type II femoral defects.

Materials and Methods

Patients

We selected all patients from the prospective revision registry in our high-volume revision clinic who had revision THA between January 1, 2013, and December 31, 2016, with Paprosky type II femoral defects and were treated by using an uncemented MRS or a PCS and had a minimal follow-up of 60 months for retrospective analysis of the prospectively collected data. Preoperative and postoperative patient-reported outcome measures (PROMs) and clinical and radiological evaluations had to be available for comparison. Total revisions (femoral and acetabular) were not excluded. We identified 59 patients eligible for this study. Our study was granted a waiver by the Arnhem-Nijmegen Ethical Review Board.

Surgery

All patients were treated in the Sint Maartenskliniek, Ubbergen, The Netherlands by a specialized surgical team between January 2013 and December 2016.Thirty patients were treated by using an MRS (Revision Stem, Lima Corporate), and 29 were treated by using a PCS (Wagner Cone, Zimmer). The MRS is a modular grit-blasted femoral prosthesis with a Wagner philosophy with fins for rotational stability. The MRS has a distal stem length of minimum 140 millimeters (mm) and maximum 200 mm with a diameter of 14-26 mm. The proximal body can be 50-110 mm. Together the length of the total construct is 190-310 mm from the tip to the center of rotation.

The PCS is a grit-blasted, primary length, conical, titanium monobloc femoral prosthesis with longitudinal ribs for initial rotational stability. The PCS has a stem length of 115 mm with a diameter of 13 mm to 127.6 mm with a diameter of 24 mm. In our facility, larger custom-made diameters were available up to 27 mm. Three patients received a lager diameter. One 25 mm, one 26 mm, and one 27 mm stems were used. Both stems were believed to have equivalent performance and were used without predetermined standards. A posterolateral approach was used in all cases. Indications for revision surgery were aseptic loosening in 29 cases, malposition in 3 cases, infection in 24 cases, sequelae after periprosthetic fracture in 1 case, instability in 1 case, and polyethylene wear in 1 case. Six interface tissue cultures were taken for microbiological evaluation in all cases.

Assessments

Baseline parameters were collected for both groups. These parameters were age, gender, surgery side, American Society of Anesthesiologists, body mass index, previous surgical approach, previous stem fixation, full or partial revision, and indication for revision. All patients had a standard preoperative workup according to our hip reconstruction unit protocol with successive pelvic x-rays, computed tomography scan, and laboratory tests. If there was any suspicion for infection, an aspiration was added to the workup.

If the result of this aspiration was positive, a one-stage or two-stage revision was planned. There were 19 one-stage and 11 two-stage revisions in the MRS group and 22 one-stage and 7 two-stage revisions in the PCS group.

All patients received questionnaires and radiological evaluation. The questionnaires consisted of the Oxford Hip Score (OHS) [31] and the EuroQol 5 Dimension (EQ-5D) [32]. Also, a visual analog scale for pain (VAS) at rest and during activity was reported. These measures were collected preoperatively and at 3, 12, and 24 months postoperatively. The OHS was validated for the Dutch population [33].

Outpatient monitoring consisted of patient satisfaction, assessment of complications, pain, limitations, and x-rays. The radiologic evaluation was done using a standardized pelvic anteroposterior x-ray to evaluate prosthesis position, prosthesis integrity, or other abnormalities. Osseointegration or subsidence was measured with the method of Engh [34]; a line was drawn along the lateral longitudinal axis of the femoral prosthesis with 2 perpendicular lines, one at the level of the tip of the greater trochanter and one at the level of the shoulder of the prosthesis. The difference between these horizontal lines on the postoperative radiographs was compared with this distance after 4 months, 1 year, and 2 years. All distances were measured independent of each other by an experienced orthopedic surgeon and specialized radiologist, and a measurement difference of maximum 0.5 mm was considered acceptable. Subsidence of 10 mm or under 10 mm but with clinical complaints as dislocation or impingement was considered abnormal. Implant complications were collected, and complications restricted to the acetabular side were noted separately. Postoperative weight bearing as tolerated was advised except for patients with a bone impaction grafting technique on the acetabular side in case this was performed with a full revision. These patients were restricted to 50% weight bearing for 6 weeks. All patients received a minimum of 4 weeks of low-molecular-weight heparin for thrombosis prevention. Outpatient controls were planned after 6 weeks and 4 months and every year postoperatively including radiological examinations. In case of missing values for subsidence or PROMs, for example, because of a stem revision, these cases were excluded for only that specific analysis.

Complications and Failure

For a complete overview of complications, health care professionals at all our locations review the complications of all patients that day and note them in our electronic patient record system. For the patients with the MRS and PCS, complications are derived from this electronic patient database.

Reoperation was defined as every surgery on the hip regardless of the indication. Every reoperation was evaluated by a team of hip revision specialists. Cases with revision of the implanted femoral component at the end of follow-up were considered as failure. Partial exchange of the femoral head in the situation of treatment of an acute infection with debridement, antibiotics, and implant retention was not considered as failure. Failure rates were compared between the MRS and PCS.

Data Analysis

Statistical analysis was performed with descriptive statistics to analyze the data using R, version 3.5.1 (R Foundation for Statistical Computing). Subsidence was compared between groups at each time point using Wilcoxon signed rank tests. Linear mixed models were used to compare OHS, EQ-5D, and VAS pain at rest and during activity between groups over time. Models were constructed with time (3 levels) and group (2 levels) as fixed factors and patient ID as a random factor. $P < .05$ was considered to be statistically significant.

Results

Baseline Comparison

No significant differences in gender, age, body mass index, surgery side, classification according to the American Society of

Table 1
Baseline.

Variable	PCS (N = 29)	MRS (N = 30)	Overall (N = 59)	Test Statistic	df	*P* value
Gender				$X^2 = 0.14$	1	0.712
Male	12 (41.4%)	10 (33.3%)	22 (37.3%)			
Female	17 (58.6%)	20 (66.7%)	37 (62.7%)			
Age at surgery				t = −1.82	57	0.074
Mean (SD)	62.8 (11.1)	68.0 (10.8)	65.5 (11.2)			
BMI				t = −0.30	56	0.765
Mean (SD)	26.9 (5.32)	27.3 (4.95)	27.1 (5.09)			
Surgery side				$X^2 = 0.18$	1	0.667
Left	10 (34.5%)	13 (43.3%)	23 (39.0%)			
Right	19 (65.5%)	17 (56.7%)	36 (61.0%)			
Type of revision				$X^2 = 0.04$	1	0.844
Femur only	8 (27.6%)	10 (33.3%)	18 (30.5%)			
Full revision	21 (72.4%)	20 (66.7%)	41 (69.5%)			
Previous approach				$X^2 = 1.27$	2	0.531
Anterior	1 (3.4%)	0 (0%)	1 (1.7%)			
Lateral	6 (20.7%)	5 (16.7%)	11 (18.6%)			
Posterior	22 (75.9%)	25 (83.3%)	47 (79.7%)			
ASA				$X^2 = 0.4.04$	2	0.132
1	7 (24.1%)	2 (6.7%)	9 (15.3%)			
2	18 (62.1%)	25 (83.3%)	43 (72.9%)			
3	4 (13.8%)	3 (10.0%)	7 (11.9%)			
1 or 2 stage						
1-stage procedure	22 (75.9%)	19 (63.3%)	41 (69.5%)	$X^2 = 0.58$	1	0.336
2-stage procedure	7 (24.1%)	11 (36.7%)	18 (30.5%)			
Previous stem fixation				$X^2 = 0.27$	1	0.602
Cemented	6 (20.7%)	9 (30.0%)	15 (25.4%)			
Uncemented	23 (79.3%)	21 (70.0%)	44 (74.6%)			

PCS, primary conical stem; MRS, modular revision stem; BMI, body mass index; ASA, American Society of Anesthesiologists; df, degrees of freedom.

Table 2
Indication for Revision.

Indication	PCS (N = 29)	MRS (N = 30)	Test Statistic	df	*P*
Indication overall	29	30	$X^2 = 3.52$	5	0.620
Aseptic loosening	11	15			
Infection	10	11			
Malposition	4	2			
Wear	2	1			
Instability	1	1			
Fracture sequelae	0	1			

PCS, primary conical stem; MRS, modular revision stem; df, degrees of freedom.

Anesthesiologists, previous surgical approach, previous stem fixation, and full or partial revision were found (Table 1). The reason for revision was not different between groups (Table 2). Aseptic loosening was the most common indication, closely followed by infection.

Perioperative Complications and Implant Failure

The overall stem complication rate in the PCS group was 9 of 29 (31.0%), and in the MRS group, it was 13 of 30 (43.3%) (Table 3). There was one revision in the PCS group within a year due to subsidence caused by undersizing of the femoral component. In the MRS group, there were five revisions. Two stems were revised because of a failure in the connection between the distal stem and proximal body. Subsidence was the reason for revision of 2 femoral components. And one revision was performed because of recurring dislocations without evident subsidence. Only the acetabular component was revised with a good result and no further need for intervention. We did not qualify the latter case as failure of the femoral component. One trochanter major fracture was observed with the MRS, and 2 late diaphyseal fractures were observed in the PCS group. All were treated without a stem revision. The failure rate of the femoral component for the PCS was 3% (1/29) and for the MRS was 13% (4/30).

Patient-Reported Outcome Measures

No significant differences between groups were found regarding OHS, EQ-5D, VAS pain at rest, and VAS pain during activity. All PROMs showed improvements over time (Figs. 2-5). Changes in scores over time did not differ significantly between the PCS and MRS (Table 4).

Subsidence

Subsidence was the reason for repeat revision in one case in the PCS and in two MRS cases. After exclusion of these cases, there was no difference in subsidence at 4 months (PCS median 1.6 with interquartile range [IQR] 2.3 versus MRS median 1.4 with IQR 9.2, $P = .698$), at 12 months (PCS median 2.1 with IQR 3.1 versus MRS median 5.1 with IQR 9.4, $P = .235$), and at 24 months (PCS median 2.5 with IQR 1.7 versus MRS median 2.0 with IQR 9.7, $P = .826$) between groups (Fig. 6).

Table 3
Complications With the Femoral Stem.

Complication	PCS (N = 29)	MRS (N = 30)
Intraoperative fracture/perforation	0	1
UPC	1	1
Dislocation	1	1
Infection perioperative	1	1
Leg length discrepancy	2	3
Subsidence >10 mm revision	1	2
Late fracture	2	0
Revision stem	1	4
subsidence	1	2
connection failure	0	2
Total complications	9	13

PCS, primary conical stem; MRS, modular revision stem; UPC, unexpected positive culture.

Discussion

We compared a PCS and an MRS in revision THA with Paprosky type II femoral defects. We found only one study comparing primary and modular revision stems in revision THA. In this study, the authors retrospectively identified ten patients who had had a revision with a Corail (DePuy Synthes, Warsaw, IN) primary stem and matched them on demographic variables and the reason for revision to a similar cohort of ten patients who underwent a revision with another revision stem [21]. They found no difference in PROMs and higher cost in the modular revision group. Our study has the advantage that the data were obtained prospectively with a higher number of patients in a more homologous group regarding femoral defects and the type of stem used for the revision. Moreover, this study reports on PROMs and surgical outcome. Our study shows fewer perioperative complications, lower failure rate, and no clinically relevant differences in subsidence and PROMs at a mean follow-up of 5 years with the use of a PCS in revision THA with Paprosky type II femoral defects in comparison to an MRS.

One of the disadvantages of an MRS is the risk of intraoperative fractures. Huang and Huddleston describe 11% of intraoperative fractures in 70 and 150 Paprosky I-IIIA revisions [13,35]. Fractures with the use of a diaphyseal fixating stem are often more distally located [20,36] but also can substantially be located at the site of the greater trochanter [13]. In our MRS cohort, we only had one fracture located at the greater trochanter. Because it was observed 6 weeks postoperatively, we cannot clearly state what the cause of this fracture was. There were no intraoperative fractures in the PCS group, only one small shaft perforation due to the removal of cement.

Other revision-related complications occurring using the MRS were neuropraxia of the sciatic nerve with a temporary drop foot which fully recovered over time. Of 3 patients with leg length discrepancy of maximum 1 cm, two were treated with an insole and one did not want additional treatment. One complication was a periprosthetic joint infection (PJI), and one was unexpected positive cultures. In the PCS group, these were one early PJI and one late PJI, one unexpected positive cultures, one dislocation, and 2 tendon-myogenic complaints of the abductor muscle, and they were treated with corticosteroid injections and exercises. There were 2 leg length discrepancies comparable to the leg length discrepancy of the MRS of maximum 1 cm, and they were treated with insoles. These complications are not unexpected and are frequently seen in revision THA and are within the normal outcome of (revision) hip arthroplasty [37–41].

In our 59 patients, the survival of the MRS is 86.7% (26/30) and of the PCS is 96.5% (28/29) at 5 years. For the PCS, this is comparable to the findings of Katakam (93.3% at 33.6 months) [42] and Cavagnaro (95.6% in 4.7 years) [30]. For the MRS, the survival is lower than Kang (97.6%) [43] and Huang (94.4%) [35] reported. The stem survival of the MRS would be 93.3% if the revisions for disconnection of the modular stem were excluded.

At 4 and 24 months, the subsidence was 1.6 and 2.5 mm with the use of the PCS and 1.4 and 2.0 mm with the MRS. The MRS results are comparable with Kang and Park [43,44]. In our MRS cohort, we had subsidence in 2 of 30 patients (6.6%) with the need for revision. Both had initial good fixation, and no fracture or infection was seen at the time of revision. The results for the PCS are also in accordance

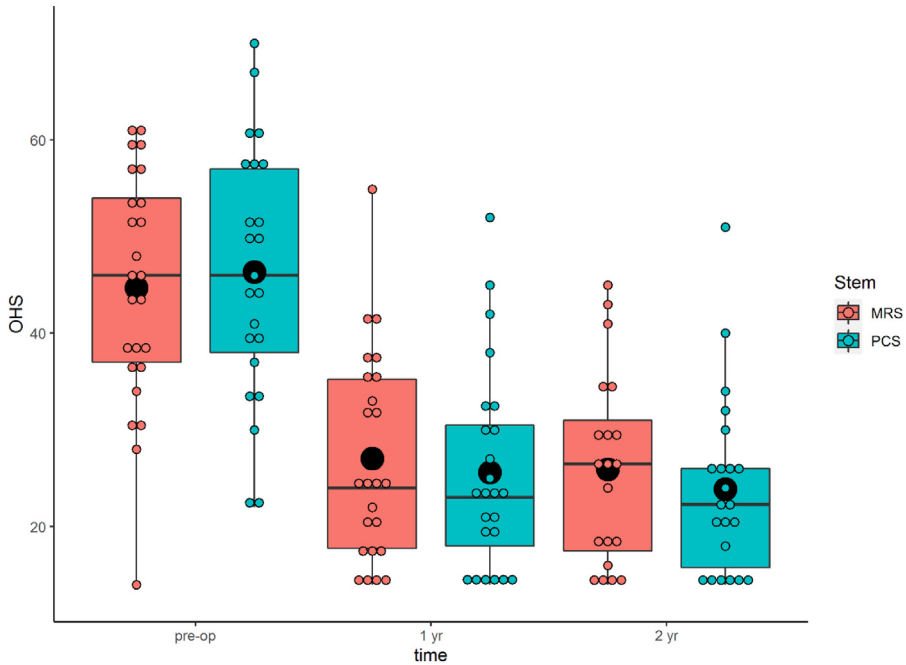

Fig. 2. Oxford Hip Score. Boxplot of the OHS. OHS, Oxford Hip Score; MRS, modular revision stem; PCS, primary conical stem. All dots are individual data points. The black circle is the mean of the individual data points.

with other publications [42,45]. In our PCS group, one prosthesis was revised within a year because subsidence of 14 mm due to under sizing.

We found a substantial improvement in PROMs, EQ-5D, and VAS with the use of the MRS and the PCS. This is generally the case in revision THA with modular or primary stems [30,45–52].

In the past, primary uncemented and cemented primary stems were used in revision THA with moderate results [29,53,54]. More recent decent results have been published with survival of 95.6% at a mean follow-up of 4.7 years [30]. We believe that lower-grade femoral defects can be treated with a primary implant in selected cases. In our 29 patients who were revised using a PCS, all defects were Paprosky type II femoral defects, so we agree that Paprosky (I and) II femora with enough metaphyseal bone and 4 cm of distal fit are revisable with these stems [27,44,48,55–57]. We cannot support the criterion that the medullary canal should not exceed eighteen mm [55]. All our patients, except one, in the PCS group and half of the patients in the MRS group had bigger diameters with no

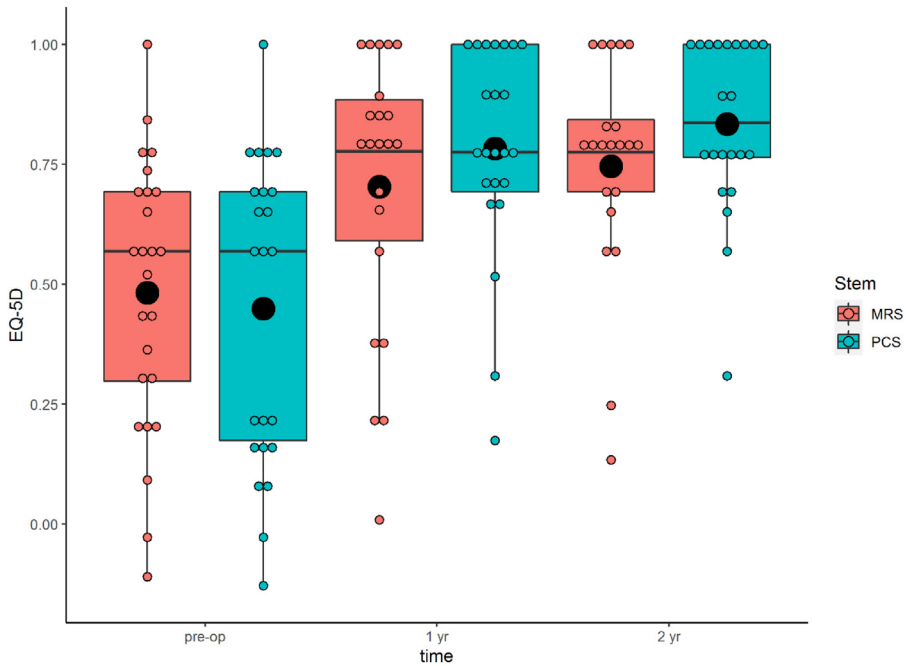

Fig. 3. EuroQol-5D. Boxplot of the EQ-5D. EQ-5D, EuroQol-5D. All dots are individual data points. The black circle is the mean of the individual data points.

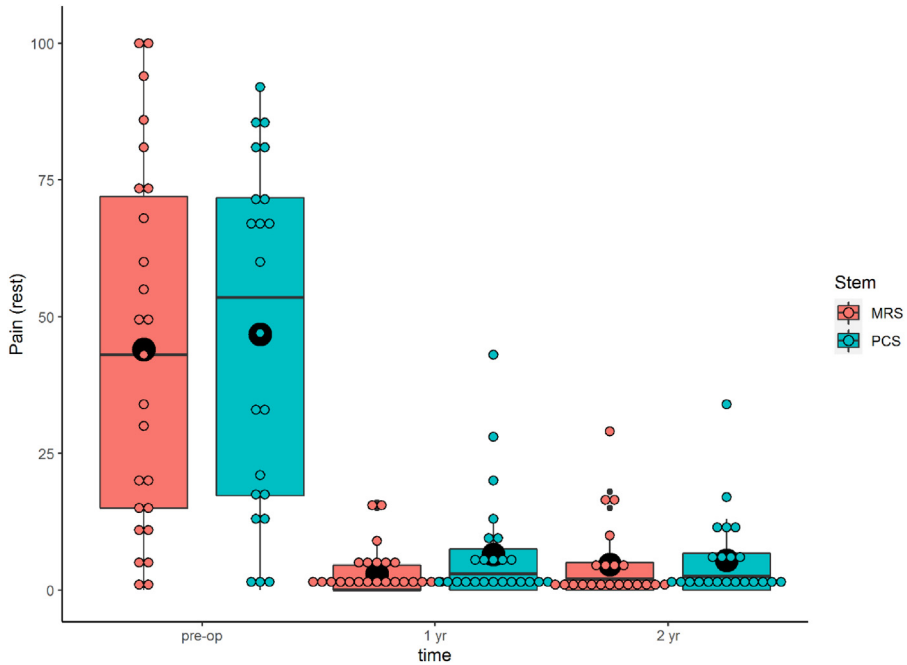

Fig. 4. Pain at rest. Boxplot of the VAS (0-100) for pain at rest. VAS, visual analog scale. All dots are individual data points. The black circle is the mean of the individual data points.

evident negative consequences. Furthermore, because of the limited bone defects, it is suggested that in 52% of 'simple' revisions, it is not mandatory to bypass the distal tip or cement mantle of the previous stem [55]. In our cohort, only one femoral stem was long enough for bypassing. In 27 patients, this yielded adequate results when the PCS was used to revise a previous primary stem. In 2 cases, where the PCS was used to revise a longer revision stem, 2 fractures occurred with minimal trauma at more than one and one and a half years after revision distal to the PCS, although the proximal femur and diaphysis had adequate bone for implantation of a well-fixed primary implant and no subsidence was seen in the first year. Because of these cases, we advise against the use of a primary stem if the explanted stem is a revision stem because of the probability of diaphyseal weakening.

The results of a revision with a primary stem of a previously uncemented stem are expected to be better than those of a cemented stem [30]. We found no differences in our outcome, but we had only 6 cemented and 23 uncemented femoral stems for

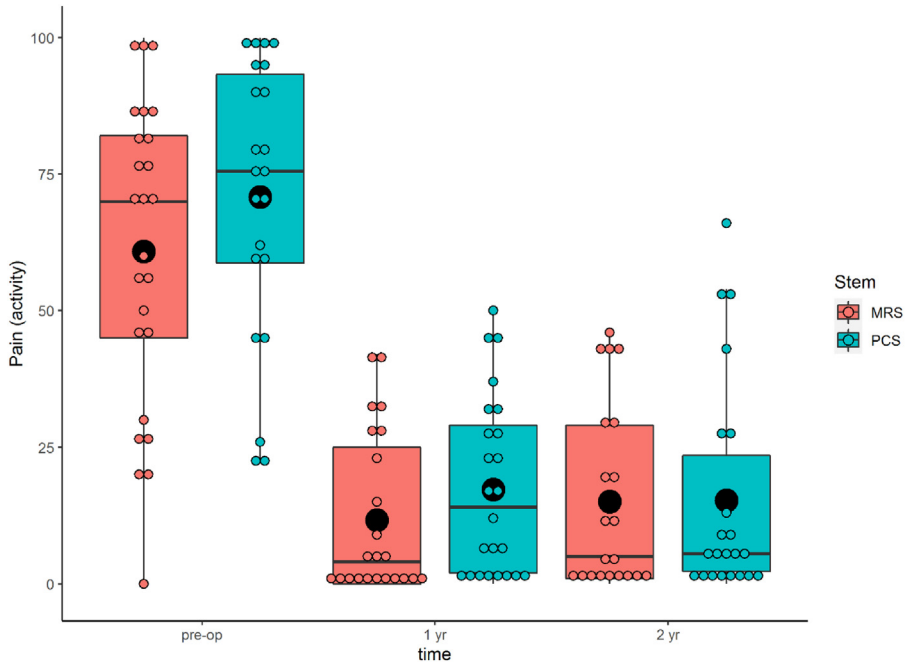

Fig. 5. Pain during activity. Boxplot of the VAS (0-100) for pain during activity. VAS, visual analog scale. All dots are individual data points. The black circle is the mean of the individual data points.

Table 4
Patient-Reported Outcome Measures.

PROM	Variable	df	F	*P* value
OHS	Stem	1	0.37	.543
	Time	2	50.06	<.001
	Stem × time	2	0.37	.693
EQ-5D	Stem	1	1.33	.251
	Time	2	20.96	<.001
	Stem × time	2	0.78	.461
VAS at rest	Stem	1	0.06	.810
	Time	2	62.15	<.001
	Stem × time	2	0.05	.947
VAS during activity	Stem	1	0.92	.338
	Time	2	89.88	<.001
	Stem × time	2	0.61	.548

OHS, Oxford Hip Score; VAS, visual analog scale; EQ5D, EuroQol-5D; df, degrees of freedom.

revision. We believe these numbers are too small to conclude in favor or against it. This is also the case for one-stage or two-stage procedures. In our cohort, 7 two-stage and 22 one-stage revisions were performed. Although we did not find any differences, our evidence is not strong enough to end the discussion if this will influence the outcome [44,45,55,57].

A number of limitations merit attention. First, we have selected only Paprosky type II femoral defects in order to compare a reasonable homogenous group. This limited our sample size to 30 patients in the MRS group and 29 in the PCS group. Large sample sizes will be needed for better comparisons of PROMs and clinical parameters. Second, this was an analysis of prospectively collected data. Randomization of patients with type II defects would be an additive for exclusion of the potential risk for bias by indication. Third, the revisions were performed by different surgeons. Although the surgeons are extensively trained and high-volume revision hip surgeons, with this variety, there is a possibility of bias, and preferably a single-surgeon design would have been better to minimalize confounding factors. Fourth, our follow-up was relatively short. However, it was comparable with other publications on the outcome and hip revision, and follow-up of 5 years would have brought most complications to light. Last, in our cohort, full and femur-only revisions are included. For a more detailed comparison, it would be better to have femur-only revisions, but in the clinical setting, this was not feasible.

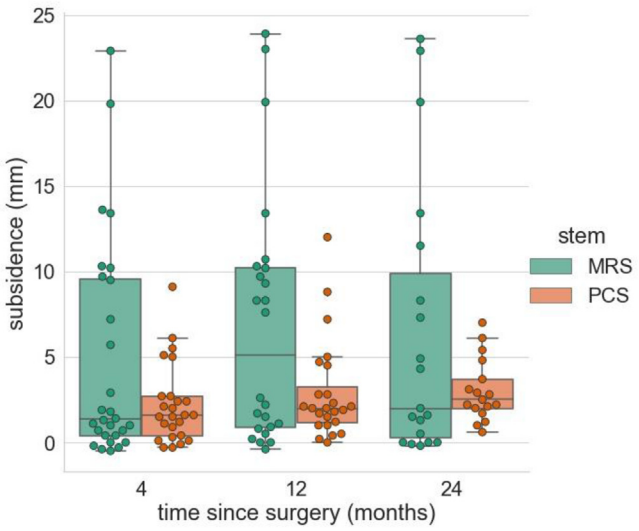

Fig. 6. Subsidence. Boxplot of the subsidence in mm (millimeters). All dots are individual data points.

Conclusion

For Paprosky type II femoral bone defects, a primary length conical stem was as good as a distal fixating MRS in terms of subsidence and PROMs. Because of a lower risk of perioperative complications and a lower failure rate, our results suggest that in revision THA for primary stems with Paprosky type II femoral defects, it is advisable to start with a primary (conical) stem and if no adequate reconstruction or fixation is achieved to choose for a longer distal fixating (modular) type.

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