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Original research

Aseptic Revision of Total Hip Arthroplasty With a Single Modular Femoral Stem and a Modified Extended Trochanteric Osteotomy—Treatment Assessment With the Forgotten Joint Score-12

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ABSTRACT

Background: Aseptic loosening is among the most common reasons for revision total hip arthroplasty (RTHA). Modular revision stems implanted through an extended trochanteric osteotomy (ETO) promise good results, but patient-reported outcome measures (PROMs) are rarely conveyed. This study used the Forgotten Joint Score-12 (FJS-12) to assess patient-reported outcome in patients who had undergone RTHA for aseptic stem loosening using a modified ETO approach with a tapered, fluted modular stem.
Material and methods: A single-center analysis of aseptic RTHA was performed (2007–2019). Clinical results (range of motion, walking ability, function), radiographic results (ETO healing, stem subsidence), and PROMs (FJS-12, Harris Hip Score, European Quality of Life 5D Score) were assessed. Minimum follow-up duration was 1 year. Complications including revisions were recorded.
Results: Primary outcome parameters were assessed on 72 patients (mean age 73.3 years, mean body mass index 27.6kg/m^2). Additional PROMs were collected by phone interviews from 41 patients (mean follow-up 5.7 years). In 76%, leg length was restored, and a normal gait was achieved. After 1 year, the ETO was healed in 93%; subsidence occurred in 8.3% of cases. The mean FJS-12 at the final follow-up was 85.6 ± 23.6, and the respective Harris Hip Score and European Quality of Life 5D Score averaged 87 ± 17.8 and 72.9 ± 15.9. Complication and revision rates were 33.3% and 13.9%, respectively.
Conclusion: Aseptic RTHA as presented here resulted in excellent PROMs in the medium term. FJS-12 score averaged 85.6 with a mean follow-up of 5.7 years. Treatment using a modular implant and a modified ETO was associated with good clinical and radiographic outcomes. Complication and revision rates were 33.3% and 13.9%, respectively.

Introduction

The numbers of primary total hip arthroplasties (THAs) have steadily increased in recent decades, but despite improvements in implant design and surgical technique, the number of patients requiring revision procedures has equally increased [1,2]. Apart from periprosthetic fractures, dislocation, and infection, aseptic loosening is 1 of the most common reasons for revising THAs and accounts for approximately 17% of all revision procedures [3].

Patients undergoing revision THA (RTHA) primarily expect improvement in their quality of life, a reduction of pain, and possibly increased activity [4,5]. However, compared with primary hip arthroplasty, worse postoperative outcomes have consistently been reported for revision procedures [6,7]. Various patient-reported outcome measures (PROMs) such as the Harris Hip Score (HHS), the European Quality of Life 5D Score (EQ-5D), or the Western Ontario and McMaster Universities Arthritis Index [8] are frequently used to evaluate postoperative outcomes but lack discriminatory power in well-performing patients due to ceiling effects.

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In addition, studies investigating the postoperative outcome following RTHA commonly lack consistency: Surgical techniques often vary within the study populations [9], different implants are used [10], and several indications are included [11,12].

The Forgotten Joint Score-12 (FJS-12) is a validated PROM for evaluating knee and hip arthroplasty outcomes [13,14], but had not yet been applied to an RTHA patient population.

Compared to other outcome assessment tools like Western Ontario and McMaster Universities Arthritis Index, EQ-5D, or Oxford hip score [15], FJS-12 has shown improved responsiveness, suggesting that joint awareness may be a more discerning measure of patient outcome than traditional PROMs. Its excellent accuracy in determining a successful outcome after primary THA [16] suggests its potential value in revision cases.

The aims of the study were (1) to report the clinical, radiographic, and PROM data of a homogeneous group of RTHA due to aseptic loosening and (2) to apply for the first time the FJS-12 as a PROM instrument in revision cases.

Material and methods

This is a retrospective single-center analysis performed at a tertiary trauma center in Switzerland. Ethics approval was obtained from the local ethics committee. Participants provided written informed consent for inclusion in the study. One hundred eight patients who had undergone RTHA for aseptic stem loosening between January 2007 and January 2019 were reviewed. *Patients with a cementless, modular titanium revision stem (Revitan; Zimmer, Warsaw, IN) were considered for this study*. This procedure was performed through a modified extended trochanteric osteotomy (mETO) approach according to our inclusion criteria. The surgical technique has been outlined in a previous publication [17].

Concomitant acetabular component and/or liner exchange were included. A minimum clinical and radiographic follow-up of 1 year was needed for study inclusion. Data collection was performed through electronic and nonelectronic chart reviews obtained preoperatively, as well as at 2 and 12 months postoperatively. Demographic data included age at surgery, sex, body mass index, affected side, American Society of Anesthesiology score and comorbidities (including osteoporosis). Surgical data considered were time, number and fixation of previous arthroplasties, length of surgery, concomitant procedures (liner and/or cup exchange), intraoperative blood loss, length of hospital stay, and complications.

Primary outcome parameters were clinical, radiographic, and PROM (*FJS-12, HHS, EQ-5D*). Secondary outcome measures included complications, reoperation, and implant survival rates.

Clinical outcome focused on walking ability (including the use of walking devices, limping, Trendelenburg sign), hip function (range of motion, straight leg raise test), and leg length discrepancy.

Radiographic outcome parameters were radiographic union (ie, presence of callus bridging the osteotomy on orthogonal views), heterotopic bone formation/heterotopic ossifications according to Brooker et al. [18], trochanter fragment migration, and the presence of stem subsidence (Fig. 1). The presence of radiolucencies was defined as progressive radiolucent changes in the bone implant interface according to Gruen et al. [19] and was determined chronologically on all postoperative radiographs (Fig. 2). All other radiographic outcome parameters were evaluated on radiographs taken 1 year following surgery.

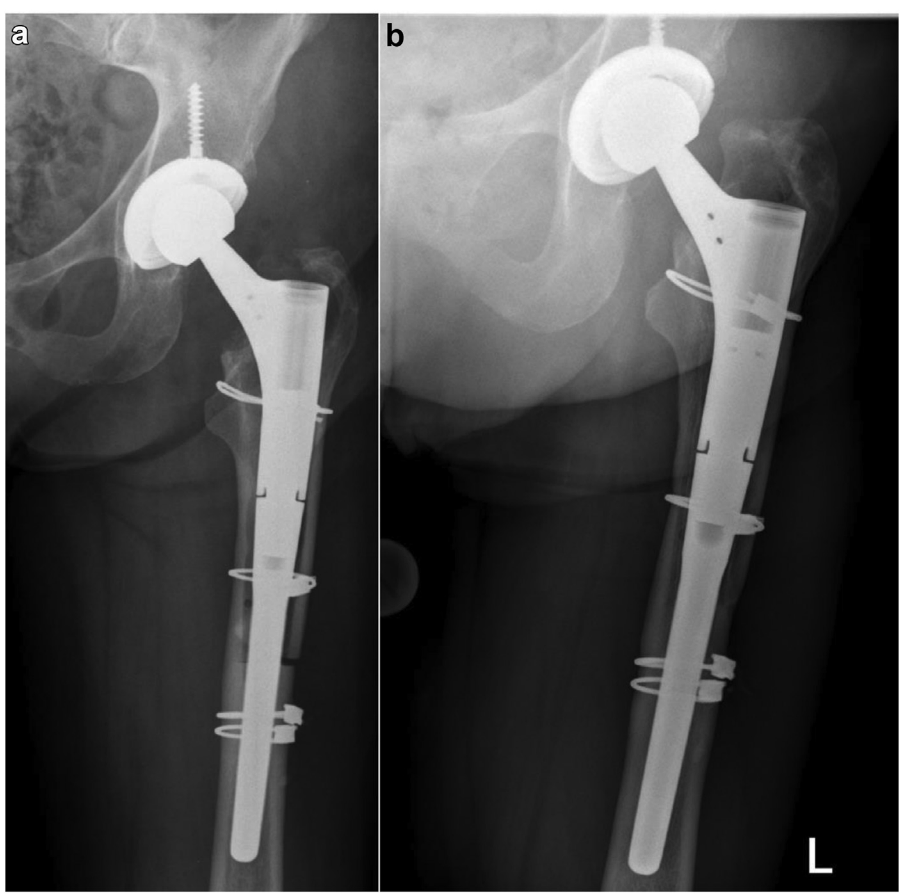

Figure 1. Radiographs taken postoperatively (a) and at a follow-up visit (b) showing stem subsidence.

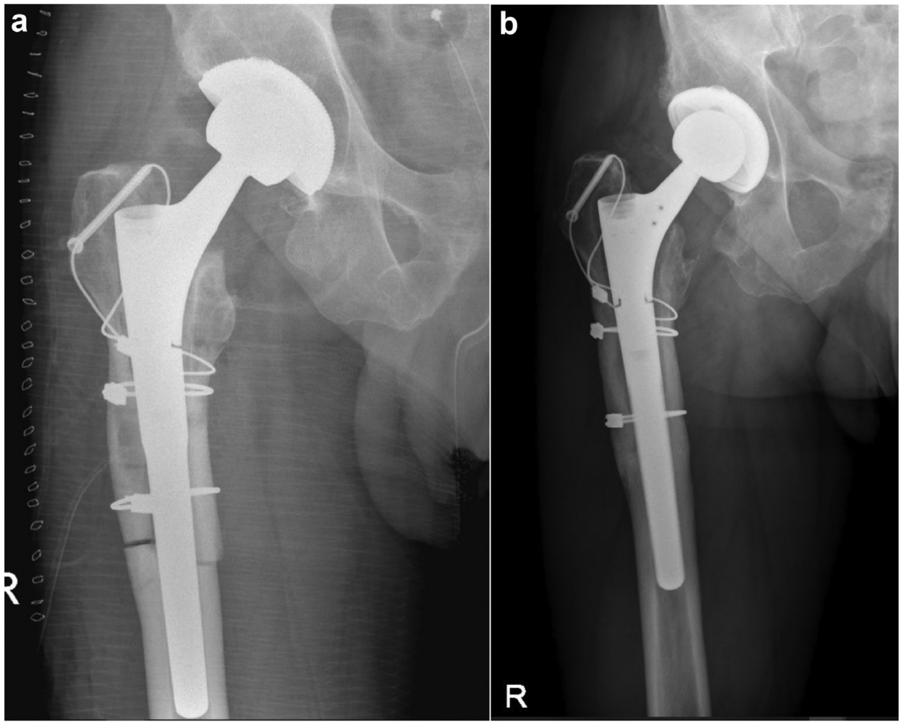

Figure 2. Presence of radiolucencies: radiographs taken postoperatively (a) and at a follow-up visit (b) showing radiolucent lines in zones 1 and 7 according to the study by Gruen et al. [19].

Postoperative standing radiographs served as the baseline. Fixed landmarks (eg, the modular junction of the implant, cerclage cables, or the tip of greater trochanter) were used as reference points for the radiographic measurements. A 25-mm radiographic marker routinely used for prosthetic templating served for size calibration. Subsidence was defined as a change in stem insertion length >4 mm [20]; it was graded as mild (5-10 mm) or severe (>10 mm). All radiographic measurements were made independently by 2 orthopedic surgeons (in double) who were not involved in the procedure. Inter-rater reliability was assessed comparing the independent results of the 2 raters.

PROMs included the FJS-12, HHS, and EQ-5D *that were assessed preoperatively and at 2 and 12 months postoperatively*. In addition, a phone interview with all patients treated within the given period was conducted by a trained study nurse in December 2020 for medium-term PROMs, including FJS-12, HHS, EQ-5D, and overall patient satisfaction (7-point Likert scale).

Statistical analysis

All statistical analyses were performed using R (R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/). Descriptive statistics included means, standard deviations, ranges, and proportions. Comparative statistics included Chi-square test (where appropriate Fisher exact test was applied alternatively). Multivariate regression analysis was performed to determine factors influencing subsidence. The confidence level for rejecting null hypotheses was set at 95% (*P* value <.05).

Results

Overall, 108 patients who had been treated between January 2007 and January 2019 for aseptic stem loosening at our institution were identified. Thirty-six patients were subsequently excluded for different reasons, including 5 deaths that occurred within the first year following surgery. Among these, 1 (aged 59) died from metastatic cancer disease at 11 months postoperatively, and 3 patients (aged 69 to 85) died following infectious diseases unrelated to the procedure; 1 patient died within the first year from acute myocardial infarction at the age of 90 years. Six patients were excluded due to subsequent surgical interventions to the affected limb, unrelated to the index procedure, within the first year. Seventy-two patients had had a minimum follow-up time of 1 year (mean follow-up: 22.1 months) and were assessed for primary and secondary outcome parameters (Fig. 3).

Baseline demographics and surgical data are listed in detail in Table 1. Means, ranges, and standard deviations of clinical and radiographic outcome parameters are shown in Table 2. Inter-rater reliability was 0.93.

In December 2020, 41 patients were available for midterm PROM assessment by telephone. The remaining patients were either deceased, declined to participate, or were unable to participate PROM assessment or could not be contacted. The mean follow-up time for these patients was 5.7 ± 3.7 years (range 1.4-13.1 years). PROMs increased steadily over time (Table 3). The development of FJS-12 over time is shown in Figure 4.

No intraoperative complications were documented. Postoperatively, a total of 26 complications occurred in 24 (33.3%) patients. Details are presented in Table 4. Subsidence was noted in 6 patients. However, no stems required revision as they all stabilized over time. In a multivariate regression analysis (which considered stem thickness, stem length, the distance of the osteotomy to the distal end of the prosthesis, number of cable wires, and the healing of the ETO), no factor was found to predict or influence stem subsidence. Ten patients underwent revision surgery. Details on the revision procedures are presented in Table 4. Taking into account all

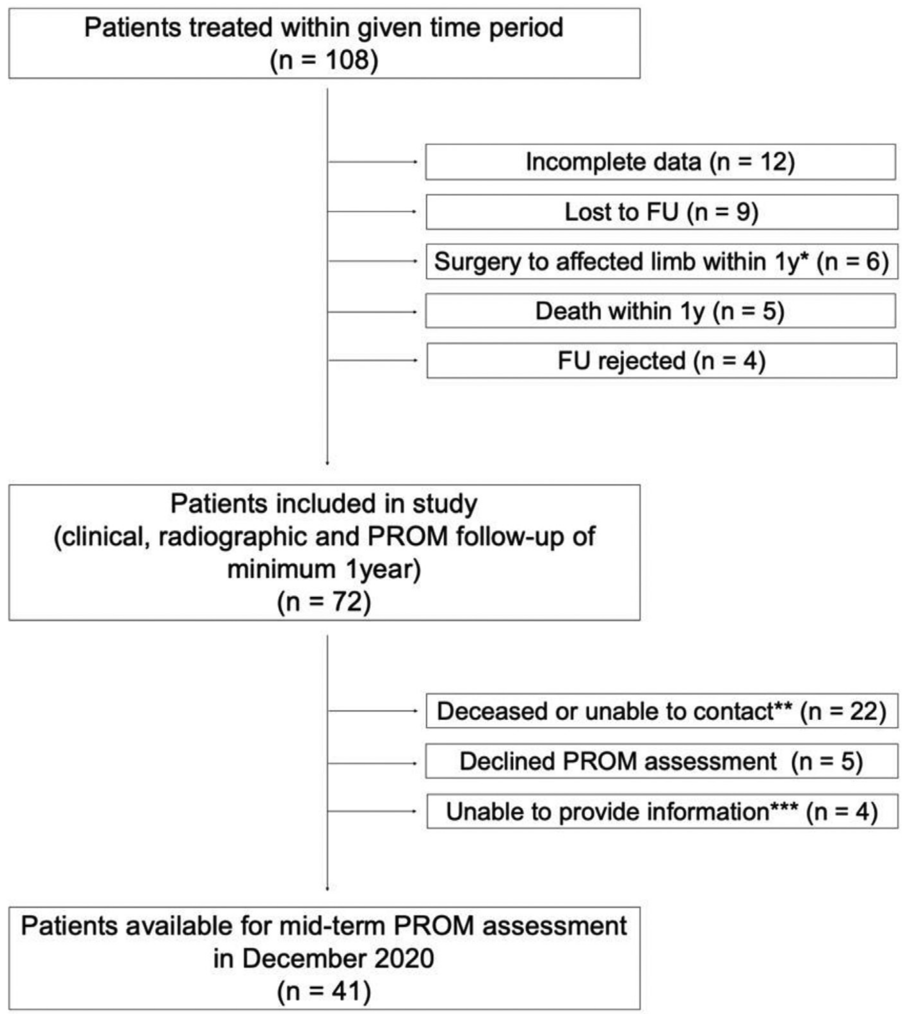

Figure 3. Patients' flowchart. *Unrelated to index procedure, **invalid contact details, ***due to cognitive impairment/dementia. FU, follow-up.

revisions for any reason, the overall 10-year implant survival rate was 82% (Kaplan-Meier survival analysis).

Discussion

The present study is the first to assess joint awareness with FJS-12 in patients undergoing RTHA for aseptic stem loosening. The FJS-12 has been successfully applied to an RTHA patient population. Treatment success is often judged by threshold values defining the *patient acceptable symptom state* [16]. In primary THA treatment, success has been associated with achieving an FJS-12 threshold of 73.96 at 1 year postoperatively [16]. In the present study, FJS-12 was significantly lower at this time point (mean FJS-12 at 1 year: 65.4 ± 29.0) but comparable at the time of the last FU [21]. However, one must bear in mind that the score was set for primary THA; values for RTHA are not available.

The satisfactory FJS-12 values at the last FU are likely due to the different demographics with significantly older patients at revision surgery (mean age at revision surgery vs index surgery: 73.9 vs 55.8 years [21]). Age-specific differences are well known for normative values of PROMs [22,23]: values decrease with increasing age in most cases. However, a differential impact of age was found regarding joint awareness [22]. In a healthy sample of the US general population, the FJS-12 scored higher (better) with increasing age across all age groups [22]. This finding is consistent with the available literature, stating that older patient age was found to be a positive predictor of reduced joint awareness in the activities of daily living [23]. A possible explanation could be that joint awareness may decrease as activity levels naturally decrease with age. Furthermore, general health problems often overshadow minor joint-related impairments in an older population. The mean HHS was in line with the values reported in the literature for RTHA [24,25]. Overall, PROMs improved uniformly over time and were very satisfactory at a mean FU time of 5.7 years.

Besides PROMs, our series confirmed favorable clinical and radiographic outcomes and acceptable postoperative complication and revision rates: 23.6% of patients needed some kind of assistive walking device, and 45% of patients had a slight limp. In a cross-sectional analysis, the reported prevalence of using a mobility device ranged from 16% to 23% [26]; thus, the data of the present study provide a fairly realistic picture.

No significant morbidity related to mETO was observed. The union rate of 93% was comparable to the results in the literature [27–29]. In contrast to previous reports [27], the use of femoral cement *at the index procedure* could not be identified as a risk factor for nonunion.

Trochanteric migration is a potentially serious complication and might lead to the loss of the mechanical function of the hip abductors. In this series, mETO fragments were stabilized using 2-mm cerclage cables. Additionally, fixation of the greater trochanter was

Table 1
Patient demographics and surgery data.

N		72
Age at surgery (y)	Mean ± SD (range)	73.3 ± 9.0 (52-87)
Sex: female/male	N (%)	27 (37.5)/45 (62.5)
BMI (kg/m^2)	Mean ± SD (range)	27.6 ± 5.8 (19.1-47.3)
Affected side: right/left	N (%)	45 (62.5)/27 (37.5)
Osteoporosis: yes/no	N (%)	10 (13.9)/62 (86.1)
ASA score	N (%)	
1		8 (11.1)
2		33 (45.8)
3		27 (37.5)
4		4 (5.6)
Prior surgery		
Prior arthroplasties: 1/2/3/4	N (%)	58 (80.5)/10 (13.9)/2 (2.8)/2 (2.8)
Time from index procedure (y)	Mean ± SD (range)	11.3 ± 9.2
Fixation of revised implant: cemented/uncemented	N (%)	50 (69.4)/22 (30.6)
Type of procedure	N (%)	
Stem revision		37 (51.4)
Stem and inlay revision		15 (20.8)
Total prosthesis revision		20 (27.8)
Length of the procedure (min)	Mean ± SD (range)	
Overall		162.4 ± 45.9 (82-274)
Stem revision		146 ± 8.4
Stem and inlay revision		156.5 ± 30.9
Total prosthesis revision		200.5 ± 52.2
Surgeons	N	7
Intraoperative blood loss (mL)	Mean ± SD (range)	913.3 ± 830.3
Red blood cell transfusion: yes	N (%)	25 (34.7%)
Length of hospital stay (d)	Mean ± SD	14.4 ± 6.4

ASA, American Society of Anesthesiologists; BMI, body mass index.

Table 2
Clinical and radiological outcome.

Follow-up time (y)	Mean ± SD	
Use of a walking device	N (%)	
Steady gait without walking devices		55 (76.4)
Walking stick		6 (8.3)
Two canes/walker		11 (15.3)
Limping gait: yes/no	N (%)	33 (45.8)/39 (54.2)
Trendelenburg sign: positive/negative	N (%)	24 (33.3)/48 (66.7)
ROM (degree)	Mean ± SD	
Flexion/extension		101.5 ± 15.2/0.9 ± 3.5
Internal rotation/external rotation		14.2 ± 11/30.1 ± 10.9
Adduction/abduction		33.4 ± 15/41.1 ± 16.7
Raising straight leg: possible/impossible/NI	N (%)	43 (59.7)/1 (1.4)/28 (38.9)
Leg length discrepancy[a]	N (%)	
Balanced leg length		55 (76.4)
Shorter >0.5 cm/longer >0.5 cm		8 (11.1)/9 (12.5)
Osteotomy length (mm)	Mean ± SD	179.1 ± 28
Healing of mETO at 6-/12-mo follow-up	N (%)	42 (58.3)/67 (93.1)
Insertion length (mm)	Mean ± SD	89.6 ± 29.1
Stem subsidence	N (%)	
Overall		6 (8.3)
5-10 mm		5 (6.9)
>10 mm		1 (1.4)
Subsequent stem revision		0
Presence of radiolucencies (Gruen et al. [19])	N (%)	
None		69 (95.8)
Zone 1		2 (2.8)
Zones 1, 7, and 14		1 (1.4)
Heterotopic ossifications[b] (Brooker et al. [18])	N (%)	
Grade I		13 (18.6)
Grade II		8 (11.4)
Grade III		8 (11.4)
Grade IV		2 (2.9)

ROM, range of motion; NI, no information.
[a] Leg length differences of maximum ± 0.5 cm were considered as balanced leg length.
[b] No prophylaxis against heterotopic ossifications was applied.

Table 3
Patient-reported outcome measures.

Score		Preoperative, N = 72	2 Mo, N = 72	12 Mo, N = 72	Final FU,[b] N = 41
FJS-12	Mean ± SD (range)	30.1 ± 26.2 (2 to 90)	45.3 ± 27.5 (0 to 100)	65.4 ± 29.0 (8 to 100)	85.6 ± 23.6 (25 to 100)
HHS	Mean ± SD (range)	30 ± 26.2 (2 to 90)	66.1 ± 12.2 (43 to 84)	80.9 ± 14.8 (43 to 100)	87.0 ± 17.8 (30 to 100)
EQ-5D	Mean ± SD (range)	0.32 ± 0.36 (−0.44 to 1)	0.6 ± 0.19 (0.19 to 1)	0.75 ± 0.33 (0.33 to 0.88)	0.83 ± 0.21 (−0.13 to 1)
Patient satisfaction[a]	Mean ± SD (range)	NA	NA	NA	6.5 ± 1.8 (1 to 7)

FU, follow-up; NA, not assessed.
[a] Seven-point Likert scale.
[b] Assessment by telephone interview in December 2020 (N = 41).

performed by using a cerclage cable, by transtrochanteric cannulated screw in combination with a cerclage cable, or by osteosutures in case of severe trochanteric bone loss. The use of 2 or 3 adequately tensioned and appropriately locked cables has been recommended to provide sufficient stability in an uncomplicated osteotomy [30]. Hence, ETO fragment fixation was adequate in this respect. Trochanteric migration >10 mm was documented in 5/72 patients (6.9%); the incidence of substantial migration (>10 mm) reported in the literature is 4%-7% [29,31].

Stem subsidence (>5 mm) was noted in 8.3% of cases (Fig. 1a and b), consistent with the values reported in the literature [32,33]. Using the Revitan shaft, subsidence rates as low as 2.9% have been reported [33], whereas other studies found rates as high as 14.7% [34] and 24% [35]. However, the use of different thresholds might limit the comparability between these studies [34].

The overall complication rate in the present study was 33.3%, with 13.9% of patients undergoing revision surgery. Complication and revision rates were thereby higher than those reported in other studies [28]. Differences in defining complications and patient age could explain this. Furthermore, 3/10 revisions were necessary due to reasons unrelated to the index procedure (2 periprosthetic fractures following adequate trauma and 1 acetabular revision for loosening). Stem subsidence and trochanteric migration accounted for nearly 50% of all complications in the present series, and while the rate of these events was comparable to that in other studies, the overall complication rate was higher.

The 10-year survival rate of the implant (revision for any reason) was 82% and, therefore, in line with previous results. Fink et al. published survival rates of this specific implant with distal cone-in-cone fixation of 97.3% at 5 years and 95.7% at a mean of 7.5 years with stem-related further revision for any reason as the endpoint [33]. Schwarze et al. found survival rates of 90.4% at 5 years [32] but reported a reduced implant survival rate (83.4% after 5 years) when the revision stem replaced a cemented stem.

The strength of this study is the standardized nature of the intervention. This is the first study to assess joint awareness using the FJS-12 in a patient collective undergoing aseptic RTHA: A uniform patient population treated with a single implant for 1 specific

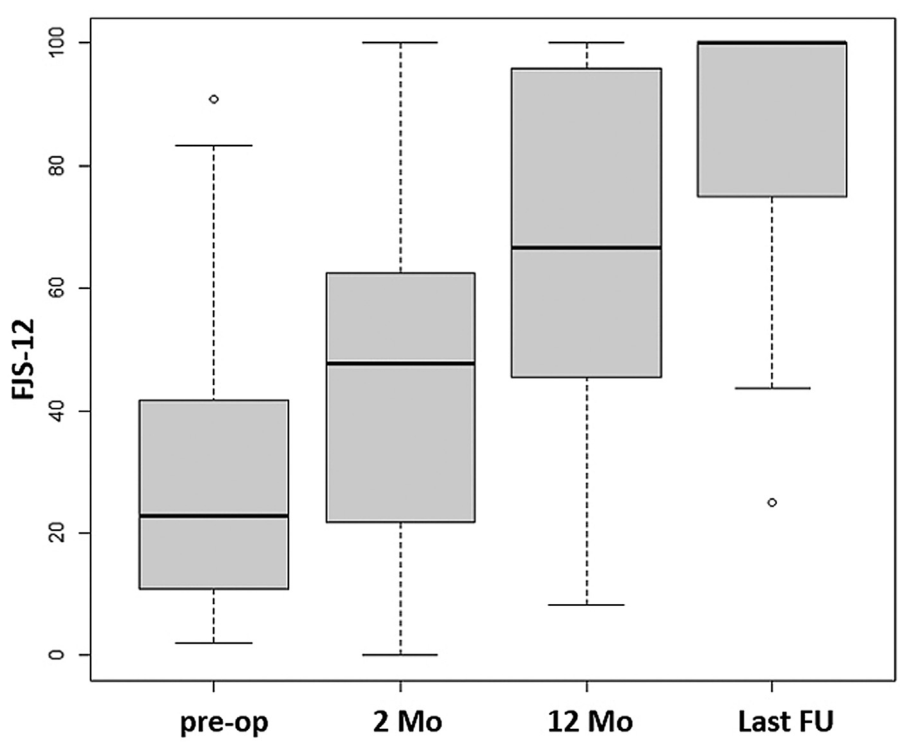

Figure 4. Development of FJS-12 over time: values are shown for the FJS-12: preoperatively, at 2 months postoperatively, 12 months postoperatively, and at the last FU. FU, follow-up.

Table 4
Postoperative complications and revision surgery.

Total number of patients suffering from complications	N (%)	24 (33.3)
Total postoperative complications		26
Stem subsidence		6
5-10 mm		5
>10 mm		1
Trochanteric migration (>10 mm)		5
Dislocation		5
Periprosthetic joint infection		3
Wound healing disorder/hematoma		2
Periprosthetic fracture		2
Acetabular loosening		1
Painful dislocated cable wire		1
Persistent peritrochanteric pain		1
Total number of patients undergoing revision surgery	N (%)	10 (13.9)
Total revision procedures		12
Head/inlay/shoulder exchange to increase stability		3
Debridement, head exchange + antibiotics		3
Stem revision due to periprosthetic fracture		2
Wound debridement + closure		1
Acetabular component revision		1
Cable wire revision		1
Trochanteric revision		1

indication was analyzed. This research thereby provides new information on the desirable outcome when dealing with this specific, but common, procedure. However, because of the narrow spectrum of indications for RTHA assessed here, the results are not necessarily applicable to other indications for RTHA.

This is a single-center study using a single modular implant for aseptic cases with a good short- to mid-term follow-up. However, there are several limitations of this study: First is the loss to follow-up. This is partly because our facility is a referral center with many patients being transferred for treatment to other centers who provide the aftercare locally. Second, the treatment group is generally old and frail (43% of patients were classified American Society of Anesthesiology score 3 or 4), and attending follow-up appointments is often a burden. Furthermore, it can be reasonably assumed that many of the patients with missing contact information have left their former homes and are now living in a retirement facility or a nursing home. As a result, we describe a comparatively smaller number of patients than most other series in the literature. There was a mismatch of the research population between clinical/radiographic assessment and PROM assessment, and heterogeneous observation points were used, potentially delivering a biased result.

The reliability of the clinical examination was not analyzed, but clinical outcome assessment was performed by trained medical staff. Radiographic measurements were performed on plain radiographs, and no advanced imaging was employed.

PROMs were assessed via telephone by a trained study nurse and not face-to-face. Telephone surveys have demonstrated higher PROM scores and greater improvement than in-person or online assessments in the past, which might affect our results [36]. However, telephone interviews offer clear advantages over self-administered questionnaires regarding completeness of data [37]. Current evidence does not favor 1 specific mode of PROM assessment over another, and no single mode of survey administration (postal, electronic, or by telephone), has been found to be superior to another [38]. In conclusion, it is fair to assume that the PROM assessment as reported here has produced valid and valuable data, bearing in mind a potential positive influence by this mode of assessment.

Finally, the study is limited by its retrospective design, with possible recall and selection bias.

Conclusion

RTHA for aseptic stem loosening using a cementless, tapered, modular titanium revision stem and an mETO approach resulted in excellent PROMs in the medium term (mean FU 5.7 years). Overall FJS-12 scores averaged 85.6 and are thereby comparable to the values published for primary THA. However, overall midterm complication (33.3%) and revision rates (13.9%) were comparatively high.

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Conflicts of interest

The authors declare that there are no conflicts of interest.
For full disclosure statements refer to https://doi.org/10.1016/j.artd.2022.03.004

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