

Functional outcome after successful internal fixation versus salvage arthroplasty of patients with a femoral neck fracture

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Abstract

Objectives: To determine patient independency, health-related and disease-specific quality of life (QOL), gait pattern, and muscle strength in patients after salvage arthroplasty for failed internal fixation of a femoral neck fracture.

Design: Secondary cohort study to a randomized controlled trial.

Setting: Multicenter trial in the Netherlands, including 14 academic and non-academic hospitals

Patients: Patients after salvage arthroplasty for failed internal fixation of a femoral neck fracture were studied. A comparison was made with patients who healed uneventfully after internal fixation.

Intervention: None (observatory study)

Main outcome measurements: Patient characteristics, SF-12, and WOMAC scores were collected. Gait parameters were measured using plantar pressure measurement. Maximum isometric forces of the hip muscles were measured using a handheld dynamometer. Differences between the fractured and contralateral leg were calculated. Groups were compared using univariate analysis.

Results: Of 248 internal fixation patients (median age 72 years), salvage arthroplasty was performed in 68 patients (27%). Salvage arthroplasty patients had a significantly lower WOMAC score (median 73 versus 90, $P=0.016$) than patients who healed uneventfully after internal fixation. Health-related QOL (SF-12) and patient independency did not differ significantly between the groups. Gait analysis showed a significantly impaired progression of the center of pressure in the salvage surgery patients (median ratio -8.9 versus 0.4, $P=0.013$) and a significant greater loss of abduction strength (median -25.4 versus -20.4 N, $P=0.025$).

Conclusion: Despite a similar level of dependency and QOL, salvage arthroplasty patients have inferior functional outcome than patients who heal after internal fixation of a femoral neck fracture.

Level of evidence: III

Introduction

The optimal surgical treatment of femoral neck fractures remains unclear.¹⁻⁵ Treatment options are internal fixation, arthroplasty, and in specific cases conservative treatment. Revision surgery rates of approximately 35% have been reported after internal fixation failure.^{1, 3-5} It has been argued that salvage arthroplasty is a safe procedure if internal fixation fails, and that surgical outcome of salvage arthroplasty is satisfactory.⁶⁻⁸ However, little is known about the functional outcome after salvage arthroplasty for failed internal fixation of a femoral neck fracture. Few studies have focused on functional outcome, and have only recorded general function such as walking ability and pain or general health-related quality of life scores.⁸⁻¹² To the best of our knowledge, a disease-specific functional score was used only in two studies.^{10, 13} Objective functional outcome parameters such as muscle strength or gait are not available, even though they are important factors influencing walking ability and quality of life. Gait analysis may add information to the results from functional outcome scores like the Western Ontario McMaster Osteoarthritis Index (WOMAC).¹⁴ Its value has been proven in clinical studies of other surgical interventions, such as hip arthroplasty for degenerative osteoarthritis.¹⁵

The aim of this study was to determine traditional outcome parameters such as patient independency and health-related quality of life (QOL) as well as disease-specific QOL, gait pattern, and muscle strength in patients after salvage arthroplasty for failed internal fixation of patients with a femoral neck fracture. The study was performed as a secondary cohort study to the Dutch sample of an international randomized controlled trial, the FAITH trial. Results of salvage arthroplasty patients were compared with those of patients that did not receive a salvage arthroplasty. We hypothesized that patients after salvage arthroplasty would have worse functional outcome and QOL than patients that did not receive a salvage arthroplasty.

Patients and Methods

Population

This study (clinical trial registration number, NL32419.078.10) was a secondary cohort study to the Dutch sample of an international randomized controlled trial, the FAITH trial (Fixation using Alternative Implants for the Treatment of Hip fractures, NCT00761813). The primary objective of the FAITH trial was to assess the impact of internal fixation implants (sliding hip screw versus multiple cancellous screws) on rates of revision surgery at two years in elderly patients with femoral neck fractures. In the Netherlands 14 hospitals participated and randomized 250 patients between February 2008 and August 2009. These patients were adults aged >50 years, who were ambulatory and not cognitively impaired pre-fracture. Patients had an undisplaced fracture or a displaced fracture (in ASA 1-2 patients, aged 50-80 years, with a fracture that could be reduced closed).¹⁶ Surgeries were performed or supervised by a senior surgeon. All patients were allowed weight bearing as tolerated after initial surgery.¹⁷

In the current study, all Dutch FAITH patients who received a salvage arthroplasty (for any reason, *e.g.*, avascular necrosis, non-union, internal fixation break-out, or persisting pain) were compared with patients who healed after internal fixation (control group). The decision to plan a re-operation was left to the discretion of the treating surgeon. Surgeons used their preferred approach and type of prosthesis, which therefore varied (both unipolar and bipolar). In a sub-study gait pattern and muscle strength were measured. Patients were included in the gait analysis at least one year after their initial internal fixation surgery.

Exclusion criteria were:

- Primary conversion to arthroplasty
- Not capable of walking several meters independently
- Lower limb abnormalities that could be expected to influence gait pattern

- Previous internal fixation or arthroplasty of the contralateral (control) hip.

Salvage surgery patients in the gait analysis were compared with a control sample of patients from the Dutch FAITH population who did not have salvage arthroplasty, but healed after internal fixation. Gait pattern and muscle strength in the control group had been measured in a previously published study, using the same selection criteria and study protocol.¹⁸ The study was approved by the Medical Research Ethics Committee (MEC-2010-164).

Data and measurements

Patient and fracture characteristics at the time of the fracture, and surgical characteristics, rehabilitation data, Western Ontario McMaster Osteoarthritis Index (WOMAC) and Short Form-12 (SF-12) scores at two years follow-up were available from the FAITH trial.^{19, 20} SF-12 scores were converted to a norm-based score and compared with general population norms of the United States (1998), as weighing factors for the Dutch population were not available.

Measurements of gait pattern and muscle strength were performed during a single visit to the outpatient clinic, following the same protocol applied previously.¹⁸ Gait analysis was performed using a pressure plate (Footscan[®], RSscan International, Olen, Belgium; 2.0 x 0.4m, 125 Hz). Patients were instructed to walk barefoot across the pressure plate at their usual, preferred speed, starting several steps before and ending several steps after the pressure plate. Five measurements were performed per patient. The combination of at least three gait measurements that were most representative for each patient were selected based upon the coefficient of variation, and used for analysis. The following temporospatial gait parameters were analyzed: gait velocity, duration of stance phase, single and double support phase, step length, foot axis, and progression of the center of pressure in the walking direction (COP ΔY). Data of the fractured leg were compared with the contralateral side. The difference was computed using the formula: $\text{Parameter}_{\text{fractured leg}} - \text{Parameter}_{\text{contralateral leg}}$.

The maximum isometric forces of the hip muscles were measured using a handheld dynamometer (MicroFET[®], Biometrics BV, Almere, the Netherlands). Flexion, extension, abduction, and adduction strength were measured in a supine position. The means of triplicate measurements were calculated, and the differences between the affected extremity and control side were computed.

Finally, leg length was measured during the visit, using a direct tape measure method. The distance between the anterior superior iliac spine and the medial malleolus was measured twice. The average value was used for analysis. This strategy has an acceptable validity and reliability.²¹ Patients were also asked if they felt they had a leg length discrepancy. If so, patients completed a Visual Analog Scale (VAS) to indicate how much they felt hampered due to the discrepancy. The VAS ranged from zero (free of complaints) to ten (very much hampered). Use of a heel lift to correct a leg length discrepancy was also recorded. Finally, patient satisfaction with their gait pattern was measured using a VAS, ranging from zero (extremely dissatisfied) to ten (completely satisfied).

Data analysis

Analyses were performed using SPSS (version 16.0, SPSS Inc., Chicago, IL, USA). Because this was an explorative cohort study in a restricted sample of patients, statistical analysis was confined to univariate comparison of patients who received salvage arthroplasty with patients who healed after internal fixation (control group). For continuous variables the Mann-Whitney U-test was used, and the Chi-squared test or Fisher's exact test for categorical variables. Results with $P < 0.05$ (two-sided test) were regarded as statistically significant. Continuous variables, which were all non-parametric, are presented as medians with interquartile ranges. Categorical variables are presented as numbers and percentages.

Results

Patient, fracture, and treatment characteristics

Of the initial group of 250 randomized patients, two patients could not be followed; one patient turned out not to have a femoral neck fracture and one patient withdrew consent immediately after randomization. Patient, fracture, and treatment characteristics of the remaining 248 patients are shown in Table 1. The study group had a median age of 72 years (P₂₅-P₇₅ 62-78). Patients were relatively healthy and independent pre-fracture. Prior to the fracture only 3% of the patients were institutionalized and 13% used an aid for mobilization. Thirteen percent had severe comorbidities (ASA3). The median follow-up was 26 months (P₂₅-P₇₅ 25-28) after the initial surgery.

Salvage arthroplasty was performed in 68 patients (27%), of whom 45 (66%) received a total hip arthroplasty. Patients who received a salvage total hip arthroplasty were significantly younger than patients who received a salvage hemiarthroplasty (median age 70 versus 76 years, P=0.035). The total hip arthroplasty patients were also more independent in their functioning pre-fracture (0% versus 17% living institutionalised, P=0.011, 9% versus 30% use of walking aid, P=0.036)

Of the 180 patients who healed after internal fixation 38 patients (21%) had their implant removed during the follow-up, mainly because of painful hardware. Taking all revision surgeries into account, there was a significantly shorter time between last surgery and final follow-up in the salvage arthroplasty patients than in the patients who healed after internal fixation (median 21 versus 25 months, P<0.001).

Salvage arthroplasty was performed more frequently after a displaced fracture (Garden III-IV/AO 31-B2-3); 62% in the salvage arthroplasty group versus 35% in the healed after internal fixation group; P=0.001) or a Pauwels III fracture (52% versus 26%, P=<0.001).²² Of

all undisplaced fractures (Garden I-II/AO 31-B1) 20% failed, whereas 42% of all displaced fractures failed. Other characteristics were similar in both groups (Table 1).

Patient independency, health-related and disease-specific quality of life (QOL)

Health-related quality of life and patient independency did not differ significantly between the patients who healed after internal fixation and the salvage arthroplasty patients. There was no significant difference in SF-12 score, rates of institutionalization, the ability to walk independently, or the use of physical therapy at two years follow-up (Table 2). However, the salvage arthroplasty patients reported significantly lower median WOMAC scores at two years follow-up than the patients that healed after internal fixation (73 versus 90 points, $P=0.016$). This difference was mainly seen in the functional domain of the questionnaire, and to a lesser extent in the pain and stiffness domain. The salvage arthroplasty patients also reported a significant longer total use of physical therapy (median 26 weeks versus 11 weeks in the group healed after internal fixation; $P=0.002$). No significant differences in independency and QOL scores were found when comparing hemiarthroplasty patients with total hip arthroplasty patients in the salvage group.

Gait analysis, muscle strength and leg length discrepancy

Of the 68 salvage arthroplasty patients, 47 were eligible to study gait pattern and muscle strength, following the inclusion and exclusion criteria for this study (Figure 1). Nineteen patients gave informed consent. The patient characteristics of the 28 patients that did not want to participate (*i.e.*, age, ASA-score and pre-fracture use of aids) did not differ significantly from those in the included population. The included patients were compared with a control group of 77 patients who healed after internal fixation (Figure 1). Characteristics of these two

subgroups of 19 and 77 patients were similar as the characteristics summarized in Table 1 for the total groups.

The gait parameters did not differ statistically significantly between the groups, except for the progression of the center of pressure in the walking direction (COP ΔY ; Table 3). The COP is a parameter indicating the degree and direction of roll-off of the foot. The progression of the COP reflects the transfer of load from the left to the right limb and vice versa. The COP progression in the walking direction was significantly decreased for the fractured leg in the salvage arthroplasty patients, whereas an increase was noted in the patients who healed after internal fixation (median ratio -8.9 versus 0.4, $P=0.013$). Median gait velocity was 1.1 m/s in both groups. Patient scored their satisfaction with gait pattern a median of 7.4 on a VAS, which did not differ significantly between the groups.

Salvage arthroplasty patients had a significantly greater loss of abduction strength in the fractured leg than patients who healed after internal fixation did (median -25.4 versus -20.4 N, $P=0.025$; Table 3). Finally, the leg length discrepancy was less in the salvage arthroplasty patients than in patients who healed after internal fixation (median 0.0 versus 0.8 cm, $P=0.001$). Consequently, they used a heel lift less often (5% versus 30%, $P=0.036$).

Discussion

Salvage arthroplasty resulted in inferior disease-specific functional outcome scores (WOMAC) than successful internal fixation did. Twenty seven percent of patients required salvage arthroplasty after internal fixation of a femoral neck fracture. This is in line with previously published data, both for the percentage failure in displaced fractures (37%) and undisplaced fractures (19%).^{1, 4, 5} To the best of our knowledge, functional outcome of salvage surgery patients has never previously been compared with outcome of patients who healed uneventfully after internal fixation. However, Blomfeldt *et al.* showed a worse functional outcome of salvage arthroplasty after failed internal fixation compared with primary arthroplasty.¹⁰

The observed inferior disease-specific functional outcome scores did not lead to a difference in health-related quality of life. With a median SF-12 score of 93 points, salvage arthroplasty patients seemed to have a good health-related quality of life. This may reflect a good coping mechanism of the relatively young and healthy femoral neck fracture study population. It also demonstrates that functional outcome after hip surgery should be tested with a disease specific questionnaire, because generic questionnaires like the SF-12 may not be specific enough.

A more deviant gait pattern may contribute to the inferior functional outcome in patients after salvage arthroplasty. In our study group, salvage arthroplasty patients had a more impaired progression of the center of pressure in the fractured leg, indicating an impaired transfer of load underneath the affected limb. This could be the effect of impaired balance, or, as indicated by the univariate analysis, an overall impaired muscle strength of the hip abductor muscles in the affected limb.²³ None of the other individual gait parameters reached statistical significance when comparing the groups. Perhaps with increasing numbers,

more significant alterations in gait pattern may be measured in the salvage arthroplasty patients. Moreover, although the left-right differences in gait parameters seem small, research in patients after total hip arthroplasty for osteoarthritis has indicated that these subtle difference have clinical relevance.²⁴

Another contributing factor to the inferior functional outcome in patients after salvage arthroplasty is a greater loss of abductor muscle strength. The median loss of 25 N can be expected to have clinical relevance. This greater loss of strength in the salvage arthroplasty patients can be explained by the need to recover from multiple surgeries and an additional incision and exposure for the arthroplasty (which is more extensive than for internal fixation, depending on the type of prostheses and the surgical approach). This extra surgery causes more damage to the underlying tissue, mainly the abductor muscles. Furthermore, these patients have often suffered from a period of pain and limping, and have been hampered in their rehabilitation process preceding the salvage surgery, mainly caused by the primary reason of the salvage arthroplasty (usually avascular necrosis or non-union/implant break-out). Our results show that the re-operation cannot salvage the functional level following a long period with a suboptimal internal fixation. In accordance, salvage surgery patients may benefit from more specific rehabilitation programs aimed at improving hip muscle strength (*e.g.* gait assisted functional electro stimulation).

The inferior functional outcome of salvage arthroplasty patients in the current study and in the study by Blomfeldt *et al.* suggests that patients receiving internal fixation of a femoral neck fracture should be selected very carefully. The notion that salvage arthroplasty is a safe procedure if internal fixation fails, should perhaps be reconsidered with caution. This aspect should receive more attention as previous studies suggest little difference in functional outcome.^{6,8} In the current study, patients receiving a salvage arthroplasty more frequently had a displaced fracture classification (both Garden and Pauwels). As such, our data suggest that

surgeons could more liberally consider a primary arthroplasty for patients with displaced (Garden III-IV), sheer (Pauwels 3) femoral neck fractures.¹⁶ However, further research comparing functional outcome in patients after primary and salvage arthroplasty should render more evidence on this matter.

Our data do not suggest superiority of any type of arthroplasty over the other, as patients treated with salvage hemiarthroplasty and total hip arthroplasty had similar patient independency and quality of life scores. Surgeons do seem to take patient characteristics into account when deciding on type of arthroplasty, as salvage total hip arthroplasty patients were significantly younger and more independent in their functioning pre-fracture.

The main limitation of this study is the restricted number of included patients in the secondary gait analysis study. Multivariable analyses were not feasible. Selection bias seems unlikely, as the patient characteristics of the 28 patients that did not participate did not differ significantly from those in the included population. Due to a limited number of patients in the salvage arthroplasty group it was not possible to perform subgroup analyses by surgical approach or type of prosthesis. A larger sample size is needed in order to perform more detailed analyses on the factors that contribute to the inferior functional outcome of salvage surgery patients.

A second limitation is the difference in time since last surgery between the study groups, indicating that the study groups may not have been completely comparable. However, the median time since last surgery was >20 months in both groups. The functional progression that can be expected after that time period is limited. This difference will therefore probably have only very limited influence on the results of this study.

The population in the current study consisted of relatively young and healthy persons; demented patients and patients unsuitable for internal fixation were excluded. The results of this study should therefore not be generalized to all hip fracture patients,

In conclusion, patients requiring salvage arthroplasty after initial internal fixation of a femoral neck fracture have inferior functional outcome than patients who healed after internal fixation. A greater loss of muscle strength and a more deviant gait pattern may have contributed to this. Despite lower functional outcome scores, these patients do not have a worse health-related quality of life, probably caused by an adequate coping mechanism of our relatively young and healthy study population. When considering IF for fitter FNF patients the possibility of a salvage arthroplasty must be acknowledged and patients can be informed about slightly lesser functional outcome.

Conflicts of interest and source of funding

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Figures

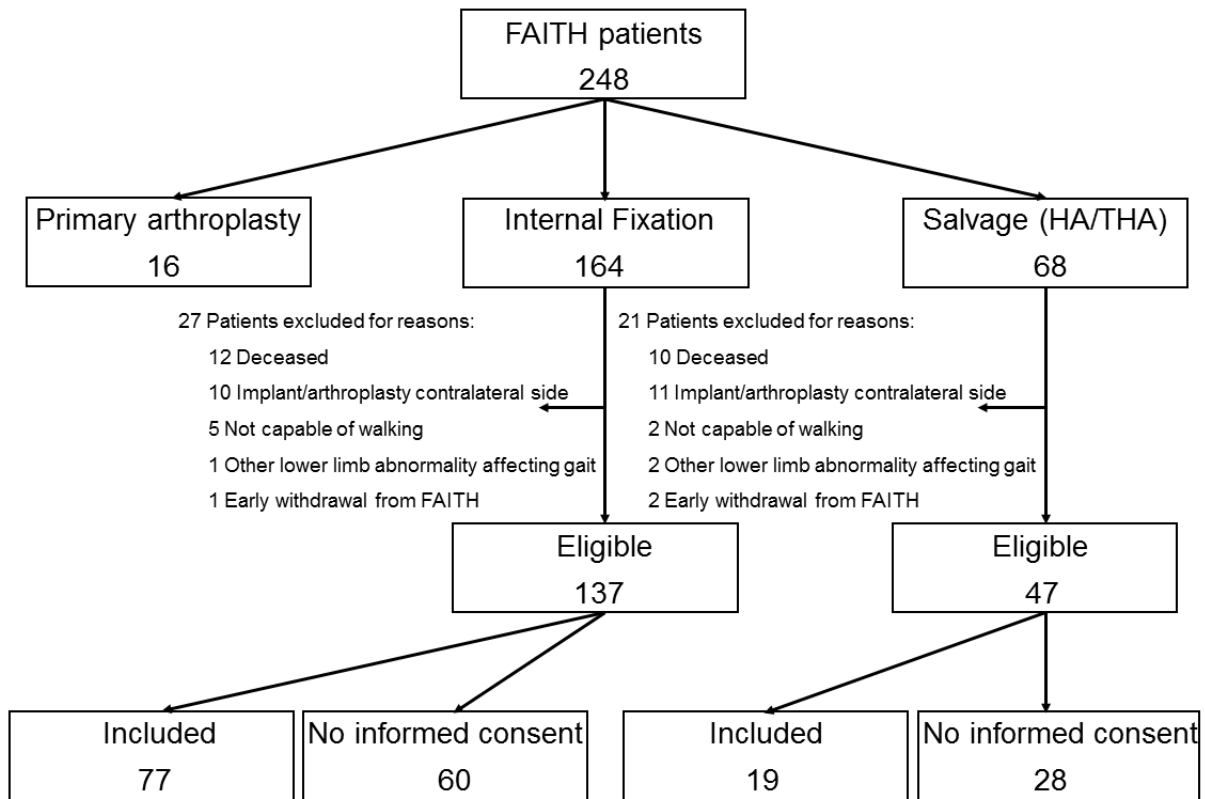


Figure 1. Flowchart of salvage arthroplasty patients participating in the gait analysis study

* The 77 patients in the control group (*i.e.*, patients who healed after internal fixation) were selected and included from this subgroup.

Table 1. Patient, fracture, and treatment characteristics

	Salvage arthroplasty (HA/THA) (N=68)	Internal Fixation (N=164)	P-value
Age (years) ¹	72 (66-79)	70 (62-78)	0.301
Males ²	21 (31)	73 (45)	0.058
BMI (kg/m ²) ¹	24 (22-27)	24 (22-26)	0.151
ASA score ³	8 (12)	23 (14)	0.329
Institutionalized pre-fracture ²	4 (6)	3 (2)	0.199
Pre-fracture use of walking aids ²	11 (16)	21 (13)	0.533
Displaced fracture (Garden III-IV/AO 31-B2-3) ²	42 (62)	57 (35)	<0.001
Pauwels ³	35 (52)	42 (26)	<0.001
Implant removed ²	N.A.	38 (23)	N.A.
Revision to THA ²	45 (66)	N.A.	N.A.
Time since last surgery (months) ^{1*}	21 (15-24)	25 (24-28)	<0.001
Follow-up duration (months) ¹	26 (25-28)	26 (25-28)	0.762

HA, Hemiarthroplasty; THA, Total Hip Arthroplasty; BMI, Body Mass Index; ASA, American Society of Anesthesiologists; N.A., not applicable.

Differences between groups were tested with the Mann-Whitney U-test for continuous variables, and with the Chi-squared test or Fisher's exact test for categorical variables.

¹ Data are presented as median with P₂₅-P₇₅ given between brackets. ² Data are presented as number with percentages.

Functional outcome after salvage arthroplasty

*This parameter reflects the time since the last surgery (*i.e.*, either the primary internal fixation, the implant removal, or the salvage arthroplasty procedure).

Table 2. Patient independency, health-related and disease-specific quality of life (QOL)

	Salvage arthroplasty (HA/THA) (N=68)	Internal Fixation (N=164)	P-value
SF-12 score ¹	93 (82-109)	99 (86-109)	0.347
WOMAC score ¹	73 (56-94)	90 (71-97)	0.016
Currently institutionalized ²	10 (18)	18 (12)	0.550
Currently using walking aids ²	29 (52)	58 (39)	0.113
Currently receiving physical therapy ²	12 (21)	26 (19)	0.546
Duration of physical therapy (weeks) ^{1a}	26 (12-55)	11 (6-28)	0.002

HA, Hemiarthroplasty; THA, Total Hip Arthroplasty; SF-12, Short Form 12; WOMAC,

Western Ontario McMaster Osteoarthritis Index

Differences between groups were tested with the Mann-Whitney U-test for continuous variables, and with the Chi-squared test or Fisher's exact test for categorical variables.

¹ Data are presented as median with P₂₅-P₇₅ given between brackets. ² Data are presented as number with percentages.

^a Data on the duration of the physical therapy were only collected in the 96 patients that participated in the gait analysis study

Table 3. Gait analysis, muscle strength, and leg length discrepancy

	Salvage arthroplasty (HA/THA) (N=19)	Internal Fixation (N=77)	P-value
Gait velocity (m/s) ¹	1.0 (0.6-1.2)	1.2 (1.1-1.5)	0.413
Stance time (% of gait cycle) ^{1§b}	-1.8 (-5.2-0.1)	-1.6 (-3.8- -0.1)	0.446
Single support phase (% of gait cycle) ^{1§b}	-2.2 (-4.0- -0.2)	-0.5 (-4.4-1.0)	0.554
Double support phase (% of gait cycle) ^{1§b}	-0.3 (-1.7-1.1)	0.2 (-2.1-2.6)	0.545
Step length (cm) ^{1§}	1.8 (-1.5-4.1)	0.0 (-3.2-3.8)	0.249
Foot axis (°) ^{1§}	-2.3 (-10.2-9.0)	0.6 (-5.1-4.9)	0.402
COP ΔY (cm) ^{1§}	-8.9 (-13.0- -1.8)	0.4 (-8.1-6.8)	0.013
VAS score satisfaction with gait pattern ¹	7.1 (4.7-8.5)	7.4 (5.0-8.7)	0.847
Flexion (N) ^{1§}	-18.6 (-41.1-9.3)	-1.3 (-13.5-4.1)	0.108
Extension (N) ^{1§}	-14.1 (-37.5-6.2)	-3.5 (-26.9-13.2)	0.226
Adduction (N) ^{1§}	-6.9 (-26.0-11.6)	-2.8 (-29.3-19.0)	0.713
Abduction (N) ^{1§}	-25.4 (-67.5- -17.8)	-20.4 (-35.0-0.7)	0.025
LLD (cm) ¹	0.0 (-0.8-1.0)	0.8 (0.3-1.8)	0.001
Feeling of LLD ²	3 (16)	31 (40)	0.061
VAS score complaints LLD ^{1a}	4.9 (2.6-6.0)	4.0 (1.5-7.2)	0.813
Heel lift use ²	1 (5)	23 (30)	0.036

HA, Hemiarthroplasty; THA, Total Hip Arthroplasty; LLD, Leg Length Discrepancy; VAS,

Visual Analog Scale; COP, Center of Pressure line

Differences between groups were tested with the Mann-Whitney U test for continuous variables, and with the Chi-squared test or Fisher's exact test for categorical variables.

¹ Data are presented as median with P₂₅-P₇₅ given between brackets. ² Data are presented as number with percentages.

^a The VAS score for complaints as a result of a LLD was only measured in the 34 patients that indicated having the feeling of a LLD. ^b These variables had >10% missing data, because they require a completely measured gait cycle for both legs, which was often not feasible (Stance Time 14% missing and Single/Double Support Phase 54%).

[§] The values displayed for these variables represent the difference between the two legs (Parameter_{fractured leg} – Parameter_{contralateral leg}).

A negative value therefore represents a decrease in the fractured leg, a positive value an increase.

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