

Are changes in pain associated with changes in quality of life and hip function 2 years after periacetabular osteotomy? A follow-up study of 321 patients

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ABSTRACT

Symptomatic hip dysplasia is primarily treated surgically with periacetabular osteotomy (PAO). It is unclear whether changes in quality of life (QoL) and changes in hip function follow the same pattern of improvement as pain following PAO. The aim of the study is to investigate whether changes in pain were associated with changes in QoL and hip function 2 years after PAO. Furthermore, to examine patient satisfaction 2 years after PAO. This is a follow-up study with data from Aarhus University Hospital Denmark. Pain was measured using the Visual Analogue Scale, QoL with Short-Form 36 and hip function with Hip disability and Osteoarthritis Outcome Score both preoperatively and 2 years after PAO in 321 patients. Multiple linear regressions were applied. Significant mean improvements in pain, QoL and hip function were found ($P < 0.05$). Significant associations between changes in pain and changes in physically related QoL and changes in hip function, respectively were found ($P < 0.05$). A non-significant association between changes in pain and changes in mentally-related QoL was found ($P = 0.13$). The majority of patients (84%) reported satisfaction with the result of PAO and would undergo PAO again if they had known the results in advance. The study had a loss to follow-up of 26%. Decreased pain was significantly associated with increased physically related QoL and improved hip function 2 years after PAO. A non-significant association between decreased pain and increased mentally related QoL was found. Patients were in general satisfied with treatment and results 2 years after PAO.

INTRODUCTION

Symptomatic hip dysplasia may lead to pain and reduced hip function [1, 2]; if untreated, it is a known risk factor to secondary osteoarthritis [1, 3]. The causes of hip dysplasia are believed to be multifactorial and known common risk factors are familiar disposition and female gender [4, 5]. In Denmark, the estimated prevalence of hip dysplasia is ~3.4%, but not all patients will experience symptoms [6, 7]. The typical patient with hip dysplasia experiences symptoms from the age of 20–40 years and has an average

activity level before onset of symptoms [2, 8]. Hip dysplasia can be treated surgically with periacetabular osteotomy (PAO) to increase acetabular coverage of the femoral head and decrease pressure on the hip joint [9]. The clinical aim of PAO is to reduce pain, to maintain or improve the patient's function and quality of life (QoL) and furthermore to prevent or delay the development of osteoarthritis [3, 10]. Several studies have reported positive changes in hip function after PAO [3, 11–14] and the majority of physically active patients return to the preoperative or

higher activity level [15]. PAO may improve pain [12, 14, 16] and QoL [12, 17], but no previous studies have examined associations between changes in pain and changes in QoL and hip function after PAO. Thus, the aim of this study was to investigate whether changes in pain were associated with changes in QoL and hip function 2 years after PAO. Furthermore, to examine patient satisfaction 2 years after PAO.

MATERIALS AND METHODS

Study design and setting

This study is a follow-up study and data were collected from a local database at Department of Orthopaedic Surgery at Aarhus University Hospital (AUH). The database contains information about 1771 patients undergoing reverse PAO, femoral osteotomy and PAO using the minimally invasive transartorial approach and operated by co-authors K.S. or S.S.J.

Study population and selection

The study population consists of patients diagnosed with hip dysplasia operated with the minimally invasive transartorial PAO approach at AUH and the Private Hospital Mølholm in the period between 1 January 2012 and 1 April 2016. Indications for PAO were centre-edge angle $<25^\circ$, persistent hip pain, reduced walking distance, hip congruence, Tönnis osteoarthritis Grade 0–1, hip flexion $>110^\circ$ and internal hip rotation $>15^\circ$.

Patients were included if they: (i) had hip dysplasia, (ii) underwent PAO with the minimally invasive transartorial approach at AUH or at the Private Hospital Mølholm and (iii) had completed the preoperative questionnaire. Patients were excluded if they: (i) had not fully completed the Visual Analogue Scale (VAS), Hip disability and Osteoarthritis Outcome Score (HOOS) and Short-Form-36 (SF-36) in the preoperative questionnaire or at follow-up after 2 years, (ii) underwent PAO due to other diagnoses than hip dysplasia, (iii) underwent reverse PAO or femoral osteotomy and finally, (iv) in patients operated bilaterally, the second operated hip was excluded. Data from the preoperative questionnaire are included in the database from the year 2012, and thus data from patients operated from this year onwards were included in the study. A total of 629 patients completed the pre-operative questionnaire between 1 January 2012 and 1 April 2016. Among the 629 patients, 158 were excluded. In the remaining 471 patients, 121 were lost to follow-up and 29 patients were excluded due to not fully completing the questionnaire at follow-up. Thus, 321 patients were included in the study (Fig. 1).

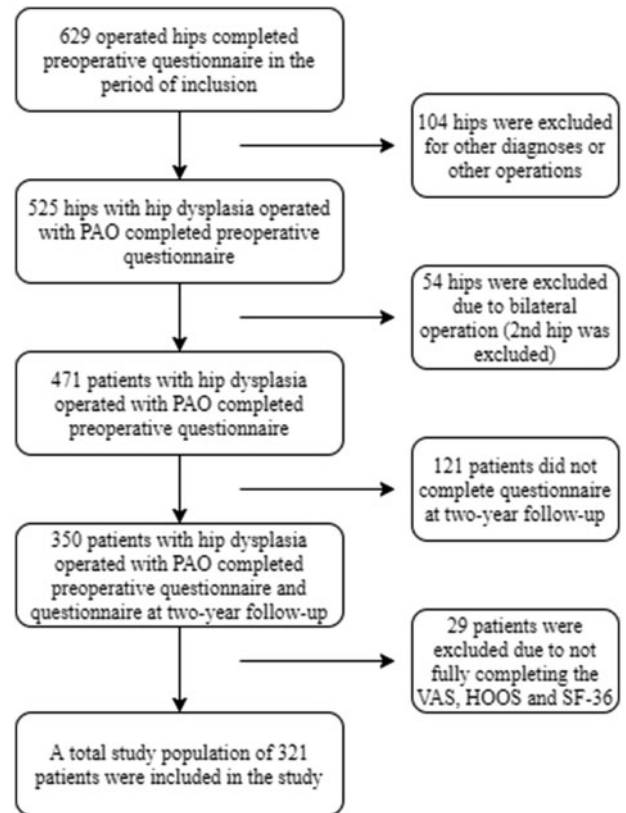


Fig. 1. Flowchart showing inclusion and exclusion of patients. PAO, periacetabular osteotomy; VAS, Visual Analogue Scale; HOOS, Hip Disability and Osteoarthritis Outcome Score; SF-36, short-Form 36.

Data collection

Patients were invited to a pre-operative information meeting and encouraged to complete the preoperative questionnaire online or on paper. Information on demographics, VAS, SF-36 and HOOS was extracted for this study. At 2-year follow-up, the questionnaire was sent to the patients online or by mail. A reminder was sent to the patients if they did not respond within a month. A second reminder was sent if patients did still not answer. After this, patients were not contacted any further. Information on VAS, SF-36, HOOS and patient satisfaction was extracted at 2-year follow-up. On the day of surgery, the surgeon completed a questionnaire with information about the operation, diagnosis, clinical tests and other patient relevant information. Data were extracted from this questionnaire on diagnosis, right/left hip and type of operation.

Changes in pain

Information on hip pain at rest was self-reported using the VAS. The VAS is a validated, reliable and clinically relevant

tool to measure pain [18]. A score of 100 indicates ‘the worst possible pain’ [18, 19].

Changes in QoL

Changes in QoL were self-reported using the questionnaire SF-36 completed at baseline and at 2-year follow-up. The SF-36 is a validated and reliable measure of health-related mental and physical QoL [20–23] and consists of 36 questions within eight health domains. From the eight health domains are two health components calculated: physical component summary score (PCS) and mental component summary score (MCS) [21–23], which are used as outcome measures in this study. All health domains contribute to the two health components, but in varying degrees [24]. The score in the two health components range from 0 to 100; 100 indicates best possible health status [23].

Changes in hip function

Changes in hip function were self-reported using the questionnaire HOOS completed at baseline and at 2-year follow-up. The HOOS is used for patients with reduced hip function with or without hip osteoarthritis [25]. The HOOS consists of five subscales: HOOS pain, HOOS symptoms, HOOS activities of daily living (ADL), HOOS sport/recreation and HOOS QoL. A HOOS score is calculated for each subscale ranging from 0 to 100; 0 indicates an extreme degree of symptoms and 100 indicate no symptoms [25]. The HOOS is valid and reliable in patients with osteoarthritis and patients undergoing hip arthroscopic surgery. Furthermore, it was found sensitive to measure changes over time [26, 27]. The subscales HOOS ADL, HOOS sport/recreation and HOOS symptom were used.

Confounding

Potential confounders for the association between changes in pain and the two primary outcomes, changes in QoL and changes in hip function, were identified through a systematic literature search and clinical reasoning. The following variables were identified: gender [12], age [10, 12, 16], body mass index (BMI) [12], pre-operative hip function [11, 28], pre-operative QoL and unilateral/bilateral surgery throughout the study period.

Patient satisfaction

At 2-year follow-up, patients indicated level of satisfaction responding to the following three questions:

- i. When you think of your daily life, your pain, your symptoms, disability and QoL, do you see your current situation as satisfying?

- ii. On a scale from 0 to 10, where 10 is the best, how satisfied are you overall with the progress and result of your hip surgery so far?
- iii. If you had known your progress and result of the surgery before you were operated, would you then still undergo surgery?

Statistical analysis

All analyses were performed in STATA 15 (StataCorp LP, College Station, TX, USA) and all hypotheses were tested using a 5% significance level. Demographics were described. Mean changes in pain; QoL and hip function were tested for statistical significance using the paired *t*-test. Analyses of mean changes were performed in such a way that positive estimates indicated improvement. A check for floor and ceiling effect was performed on all five HOOS subscales and was considered present if more than 15% achieved the lowest or highest possible score.

The primary aim of the study was investigated through multiple linear regressions including adjustment for potential confounding. Crude and adjusted β -coefficients were estimated for all possible outcomes. Change in pain was considered the independent continuous variable. Change in QoL and change in hip function, respectively were considered dependent continuous variables. Model assumptions for multiple linear regressions with check for linear associations, normal distribution of residuals, constant variance of residuals and assumption of independent observations were performed through QQ-plots, scatter plots and dot plots.

A drop-out analysis was performed to investigate whether patients who did not complete the 2-year follow-up questionnaire differed significantly from patients who completed.

RESULTS

Baseline characteristics

Baseline characteristics of the 321 patients are presented in Table I.

A ceiling effect was present for the subscales HOOS ADL (15.89%) and HOOS sport/recreation (15.26%) at 2-year follow-up.

Changes in pain, QoL and hip function 2 years after PAO

Pain improved significantly between baseline and 2-year follow-up with a mean on 23.96 (95%CI: 21.09; 26.83). The SF-36 component scores and HOOS subscales all improved significantly from baseline to 2-year follow-up (Table II).

At 2-year follow-up the SF-36 scores were almost similar to the Danish background population [21], especially in the primary mental health domains (Role-Emotional,

Table I. Baseline characteristics of the 321 included patients

Variable, <i>n</i> = 321	
Age, median (IQR)	31 years (22–39)
Range	14–49 years
Gender, <i>n</i> (%)	283 females (88.16%) 38 men (11.84%)
BMI, median (IQR) <i>n</i> = 319	23 kg/m ² (21–25)
Range	16–34
Side of operation, <i>n</i> (%)	173 right (53.89%) 148 left (46.11%)
Unilateral surgery, <i>n</i> (%)	274 patients (85.36%)
Bilateral surgery, <i>n</i> (%)	47 patients (14.64%)
VAS	
Median (IQR)	34 (17–55)
Range	0–98
SF-36, mean (SD)	
PCS score	35.68 (8.27)
MCS	50.39 (11.73)
HOOS, mean (SD)	
Pain	53.15 (17.84)
Symptoms	51.54 (19.97)
ADL	63.55 (19.80)
Sport/recreation	42.76 (22.92)
QoL	33.35 (16.21)

IQR, interquartile range; *n*, number; SD, standard deviation; BMI, body mass index; VAS, Visual Analogue Scale; SF-36, Short-Form 36; HOOS, Hip Disability and Osteoarthritis Outcome Score; ADL, activities of daily living; QoL, quality of life.

Mental Health, Social Functioning, Vitality), whereas the scores for the physical health domains showed improvements, but did not reach the level of the Danish background population (Fig. 2).

Associations

In the adjusted linear regression analyses, linear associations between changes in pain and changes in QoL measured with SF-36 PCS and changes in hip function measured with HOOS symptoms, HOOS ADL and

HOOS sport/recreation were statistically significant (Table III). The linear association between changes in pain and changes in QoL measured with SF-36 MCS were not statistically significant (Table III).

A statistically significant positive dose-response association between changes in pain and changes in QoL measured with SF-36 PCS was estimated, where changes in QoL improved significantly with 0.14 (95%CI: 0.09; 0.18) per one point increase in changes in pain measured with VAS (Table III). Changes in pain may together with potential confounders in the adjusted analysis explain 24% ($R^2 = 0.24$) of the variation in changes in QoL measured with SF-36 PCS. Likewise, changes in pain may together with potential confounders explain 34% ($R^2 = 0.34$) of the variation in the changes in hip function measured with HOOS symptoms, 43% ($R^2 = 0.43$) of the variation in changes in hip function measured with HOOS ADL and 21% ($R^2 = 0.21$) of the variation in changes in hip function measured with HOOS sport/recreation. Changes in pain may together with potential confounders explain 6% ($R^2 = 0.06$) of the variation in changes in QoL measured with SF-36 MCS, though not statistically significant.

Patient satisfaction

A total of 206 patients (64.17%) out of 321 patients indicated that their current situation in relation to daily life, pain, symptoms, disability and QoL was satisfactory. A total of 320 patients completed the questions about overall satisfaction with progress and result of the surgery with a median value of 8 (IQR: 8–9); 270 patients (84.11%) out of 321 patients indicated that they would undergo surgery again if they had known their progress and result in advance.

Drop-out analysis

A total of 121 patients of the 471 patients diagnosed with hip dysplasia and undergoing PAO, did not complete the follow-up questionnaire, resulting in a loss to follow-up of 25.69%. A significantly higher proportion of men were lost to follow-up (Table IV).

DISCUSSION

This study showed positive statistically significant associations between changes in pain and changes in QoL and changes in hip function, respectively measured with SF-36 PCS, HOOS symptoms, HOOS ADL and HOOS sport/recreation 2 years after PAO. The study showed a statistically non-significant association between changes in pain and changes in QoL measured with SF-36 MCS 2 years after PAO.

Table II. Mean changes from baseline to 2-year follow-up for primary outcomes for QoL and hip function

Outcomes (n = 321)	Baseline, mean (SD)	Two-year follow-up, mean (SD)	Mean changes (follow-up – baseline), mean (95%CI)	P-value ^a
SF-36 Psychological component summary score	35.68 (8.27)	44.93 (10.38)	9.26 (8.10; 10.42)	0.000
SF-36 MCS	50.39 (11.73)	54.26 (9.93)	3.87 (2.54; 5.20)	0.000
HOOS pain	53.15 (17.84)	77.65 (19.78)	24.50 (22.03; 26.97)	0.000
HOOS symptoms	51.54 (19.97)	71.37 (21.62)	19.83 (17.18; 22.48)	0.000
HOOS ADL	63.55 (19.80)	83.62 (18.34)	20.08 (17.83; 22.33)	0.000
HOOS sport/recreation	42.76 (22.92)	69.49 (25.48)	26.73 (23.63; 29.83)	0.000
HOOS QoL	33.35 (16.21)	58.93 (24.75)	25.58 (22.83; 28.32)	0.000

n, number; SD, standard deviation; SF-36, Short-Form 36; HOOS, Hip Disability and Osteoarthritis Outcome Score; ADL, activities of daily living; QoL, quality of life.

^aPaired *t*-test.

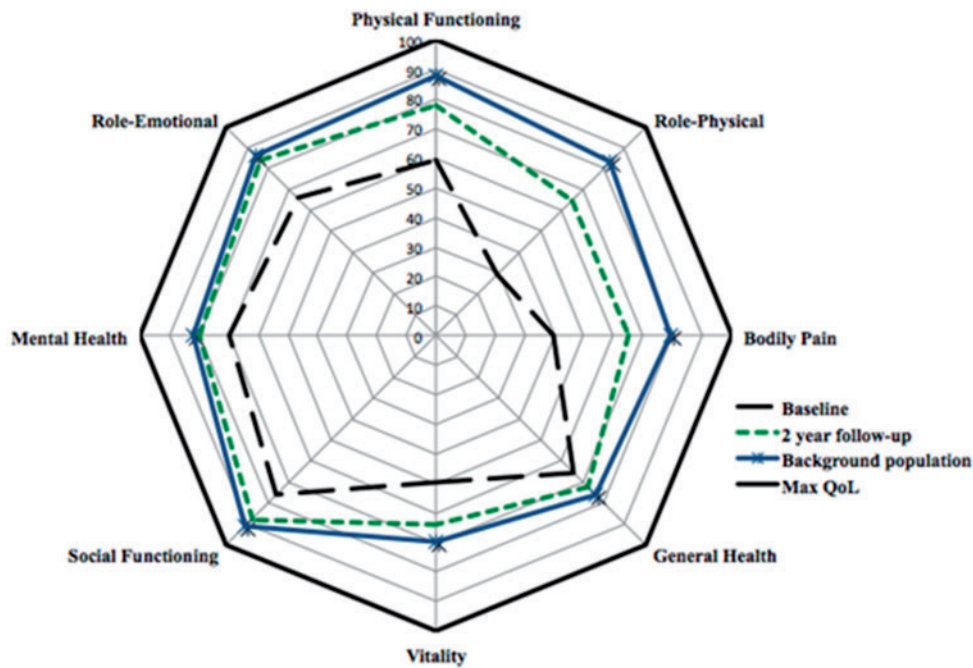


Fig. 2. Mean scores for QoL within the eight health domains in SF-36 at baseline, 2-year follow-up and for the Danish background population [21].

To our knowledge, no previous studies have investigated the association between changes in pain and changes in QoL after PAO. A few studies have addressed mean changes in QoL after PAO [12, 17]. Van Bergayk *et al.* [17] in a prospective follow-up study reported a significant improvement in QoL measured with SF-36 PCS 2 years

after PAO; this is in line with the results of this study. In the study by Van Bergayk *et al.* [17], no significant improvement on SF-36 MCS 2 years after PAO was found. This is in contrast to the results of this study where a significant improvement was found 2 years after PAO. The conflicting results may be due to differences in sample size

Table III. Unadjusted and adjusted estimates for β -coefficients from the linear regression analysis for the associations between changes in pain measured with VAS and changes in QoL and changes in hip function measured with SF-36 and HOOS from baseline to 2-year follow-up

	Unadjusted β -coefficients (95%CI), n = 321	P-value	Adj. R ²	Adjusted β -coefficients (95%CI), n = 319	P-value	Adj. R ²
Δ SF-36 PCS	$\beta = 0.17$ (0.12; 0.21)	0.000	0.16	$\beta = 0.14$ (0.09; 0.18)	0.000	0.24
Δ SF-36 MCS	$\beta = 0.09$ (0.04; 0.14)	0.001	0.03	$\beta = 0.04$ (-0.01; 0.10)	0.125	0.06
Δ HOOS symptoms	$\beta = 0.49$ (0.40; 0.58)	0.000	0.28	$\beta = 0.44$ (0.35; 0.53)	0.000	0.34
Δ HOOS ADL	$\beta = 0.46$ (0.39; 0.53)	0.000	0.34	$\beta = 0.37$ (0.30; 0.44)	0.000	0.43
Δ HOOS sport/recreation	$\beta = 0.47$ (0.36; 0.58)	0.000	0.19	$\beta = 0.43$ (0.32; 0.55)	0.000	0.21

Adjusted for gender, baseline age, baseline BMI, unilateral/bilateral surgery, baseline SF-36 and baseline HOOS. In the adjusted analyses, no adjustments were made for the SF-36 or HOOS baseline score, which are in the same subscale as the outcome. *n*, number; Δ , change; Adj., adjusted; VAS, Visual Analogue Scale; SF-36, Short-Form 36; PCS, physical component summary score; MCS, mental component summary score; HOOS, Hip Disability and Osteoarthritis Outcome Score; ADL, activities of daily living.

Table IV. Drop-out analysis with baseline characteristics for patients lost to follow-up compared with participating patients

	Patients lost to follow-up (n = 121)	Participating patients (n = 321)	P-value
Age, median (IQR)	27 years (21–37)	31 years (22–39)	<i>P</i> = 0.193 ^a
Range	14–48 years	14–49 years	
Gender, <i>n</i> (%)	96 females (79.34%)	283 females (88.16%)	<i>P</i> = 0.018 ^b
	25 men (20.66%)	38 men (11.84%)	
BMI, median (IQR)	23 kg/m ² (21–26)	23 kg/m ² (21–25)	<i>P</i> = 0.113 ^a
Range	15–34	16–34 <i>n</i> = 319 ^c	
VAS, median (IQR)	33 (17–58)	34 (17–55)	<i>P</i> = 0.684 ^a
Range	0–91	0–98	
SF-36, mean (SD)			
PCS	36.39 (9, 51)	35.68 (8, 27)	<i>P</i> = 0.439 ^c
MCS	49.45 (10, 78)	50.39 (11, 73)	<i>P</i> = 0.441 ^c
HOOS, mean (SD)			
Pain	55.17 (20.91)	53.15 (17.84)	<i>P</i> = 0.348 ^c
Symptoms	55.70 (19.25)	51.54 (19.97)	<i>P</i> = 0.050 ^c
ADL	64.60 (21.26)	63.55 (19.80)	<i>P</i> = 0.627 ^c
Sport/recreation	44.78 (25.11)	42.76 (22.92)	<i>P</i> = 0.420 ^c
QoL	34.48 (18.06)	33.35 (16.21)	<i>P</i> = 0.528 ^c

IQR, interquartile range; *n*, number; SD, standard deviation; BMI, body mass index; VAS, Visual Analogue Scale; SF-36, Short-Form 36; HOOS, Hip Disability and Osteoarthritis Outcome Score; ADL, activities of daily living;

^aWilcoxon Rank Sum Test; ^b χ^2 test; ^cUnpaired *t*-test.

as the study of Van Bergayk *et al.* possibly has too low statistical power to show significant changes.

A big multicentre study by Clohisy *et al.* [12] demonstrated significant improvements in QoL measured with SF-12 PCS and MCS, which are comparable to the results of this study. Furthermore, this study demonstrated that the study population achieved QoL scores at 2-year follow-up close to scores for the Danish background population. This indicates that the mean changes in QoL in this study are clinically relevant for the patients.

Several studies report improvements in hip function and pain after PAO [3, 12, 15, 16]. In a systematic review from 2009, Clohisy *et al.* [3] described improvement in hip function after PAO among patients with hip dysplasia in all included studies. Furthermore, the clinical outcome analysis demonstrated improvement in pain among the majority of patients with short to midterm follow-up [3]. This supports the results of this study where significant improvements in pain and hip function 2 years after PAO were seen.

Bogunovic *et al.* [15] also found significant improvements in all five HOOS subscales with a mean follow-up time of 33 months. Bogunovic *et al.* [15] did not investigate the association between changes in pain and changes in hip function, but described that for 89% of the patients, reduction in pain was the primary cause of improvement in patient activities. This is not directly comparable to the primary result of this study, but parallels can be drawn to the fact that this study found positive associations between changes in pain and changes in hip function measured with three HOOS subscales.

Clohisy *et al.* [12] found significant and clinically relevant improvements in all five HOOS subscales and presented minimal clinically important differences on HOOS symptoms of 9, HOOS pain of 9, HOOS ADL of 6, HOOS sport/recreation of 10 and HOOS QoL of 11. The findings by Clohisy *et al.* support the results of this study, and demonstrate that the mean changes for all five HOOS subscales in this study are clinically relevant changes.

This study showed that patients were generally satisfied with the result of PAO at 2-year follow-up, which is also reported in other studies [12, 15].

Internal validity

The large sample size, the statistical analysis with adjustment for potential confounders and PAO being performed by only two surgeons are considered strengths of this study. The study used valid, reliable and patient relevant outcome measures, though not validated for the specific study population. Concerning limitations, this study has a high drop-out rate of 25.69%. This should be kept in mind

when interpreting the results, since it is unknown whether participation of patients lost to follow-up would have affected the associations in other directions. A significantly higher proportion of men were lost to follow-up, which may affect the generalising of the results in male populations.

The differences in adjusted and unadjusted analyses varied for the different outcomes. The adjustment for confounding especially influenced the results for the association between changes in pain and changes in QoL measured with SF-36 MCS, where the association went from significant to non-significant. In the specific analysis, baseline SF-36 PCS was significantly associated with changes in QoL measured with SF-36 MCS; thus, baseline SF-36 PCS may be considered a significant confounder for the association.

External validity

The results of this study may cautiously be generalised to patients with hip dysplasia undergoing PAO using the minimally invasive transsartorial approach under the same circumstances as described in this study. However, the internal validity should be considered, especially the large drop-out rate and the higher proportion of men dropping out.

CONCLUSION

This study demonstrated that changes in pain were associated with changes in physically related QoL and changes in hip function, respectively 2 years after PAO. Higher improvements in pain are associated with higher improvements in physically related QoL and hip function. No significant association between changes in pain and changes in mentally related QoL was demonstrated. Patients indicated an overall satisfaction with post-surgical progress and results 2 years after PAO.

CONFLICTS OF INTEREST STATEMENT

None declared.

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