Journal of Hip Preservation Surgery, 2022, **9**, 107–118
DOI: https://doi.org/10.1093/jhps/hnac012
Advance access publication date: 10 March 2022
Review article

Arthroscopic hip surgery offers better early patient-reported outcome measures than targeted physiotherapy programs for the treatment of femoroacetabular impingement syndrome: a systematic review and meta-analysis of randomized controlled trials

Samer S. S. Mahmoud [1], Amir Takla[2], Denny Meyer[3], Damian Griffin [4] and John O'Donnell[5,6*]

[1]Hip Arthroscopy Australia, 21 Erin Street, Richmond, VIC 3121, Australia, [2]Department of Health Professions, Faculty of Health, Arts and Design, Sports & Musculoskeletal Physiotherapist, Australian Sports Physiotherapy, Swinburne University of Technology, Hip Arthroscopy Australia, 21 Erin Street, Richmond, VIC 3121, Australia, [3]Department of Health Sciences and Biostatistics, School of Health, Swinburne University of Technology, PO Box 218, Hawthorn, VIC 3122, Australia, [4]Department of Orthopaedic Surgery, University of Warwick, University Hospitals of Coventry and Warwickshire NHS Trust, Clifford Bridge Road, Coventry CV2 2DX, UK, [5]Department of Orthopaedics, Swinburne University of Technology, PO Box 218, Hawthorn, VIC 3122, Australia and [6]Hip Arthroscopy Australia, 21 Erin Street, Richmond, VIC 3121, Australia.

*Correspondence to: J. O'Donnell. E-mail: john@johnodonnell.com.au

ABSTRACT

Targeted physiotherapy programs (TPP), and surgery, using either open surgical hip dislocation or hip arthroscopy (HA), are the treatment modalities available for femoroacetabular impingement syndrome (FAIS). Randomized controlled trials have recently been performed to compare these treatment options. This review was performed to provide a focused synthesis of the available evidence regarding the relative value of treatment options. A systematic search was performed of Medline, Embase, Cochrane Library and ClinicalTrials.gov databases. Inclusion criteria were randomized controlled trials comparing treatment methods. The Cochrane Risk of Bias assessment tool (RoB2) was used to assess the selected studies. A meta-analysis was performed between homogenous studies. Four trials were identified including 749 patients (392 males). The mean ages of the cohorts ranged between 30.1 and 36.2 years old. Three hundred thirty-five patients underwent HA by 46 surgeons among all trials. Fifty-two patients crossed over from the TPP to the HA group. One of the trials was found to have a high risk of bias, while the other three were between low risk and some concerns. The iHOT-33 was the most commonly used patient-reported outcome measure followed by the HOS ADL and EQ-5D-5L. Others scores were also identified. Scores from two trials could be pooled together for meta-analysis. Apart from SF-12 and GRC, all other scores have shown significantly better outcomes with HA in comparison to TPP at 8- and 12-months follow-up points. HA offers better patient-reported outcomes than TPP for management of FAIS at 8- and 12-months follow-up.

INTRODUCTION

The term femoroacetabular impingement (FAI) was initially coined by Myers et al. in 1999 as a complication secondary to periacetabular osteotomy surgery [1]. Primary FAI morphology was identified in asymptomatic individuals [2], and many theories have been proposed to provide an explanation for this anatomical variation. These included unrecognized mild slippage of the capital femoral epiphysis (SCFE) [3] and excessive stresses placed on the growing physis by sports participation [4].The term FAI Syndrome (FAIS) is used broadly to describe a triad of symptoms, signs and imaging in association with any abnormal structural conflict between the femoral head (and/or neck) and the acetabulum [5]. This can be due to (i) incomplete sphericity of the femoral head (cam-type morphology or pistol grip deformity), (ii) excessive coverage of the femoral head by the acetabular margin or the periacetabular bone (pincer-type lesion) or (iii) a combination of both (i and ii).

Patients usually present with symptoms, including, but not limited to, groin pain limiting many daily activities, decline in sports efficiency and painful hip flexion. Mechanical and/or painful limitation of hip flexion and internal rotation is the principal finding in clinical examination. Loss of

Submitted 29 January 2022; Revised 1 March 2021; revised version accepted 10 February 2022

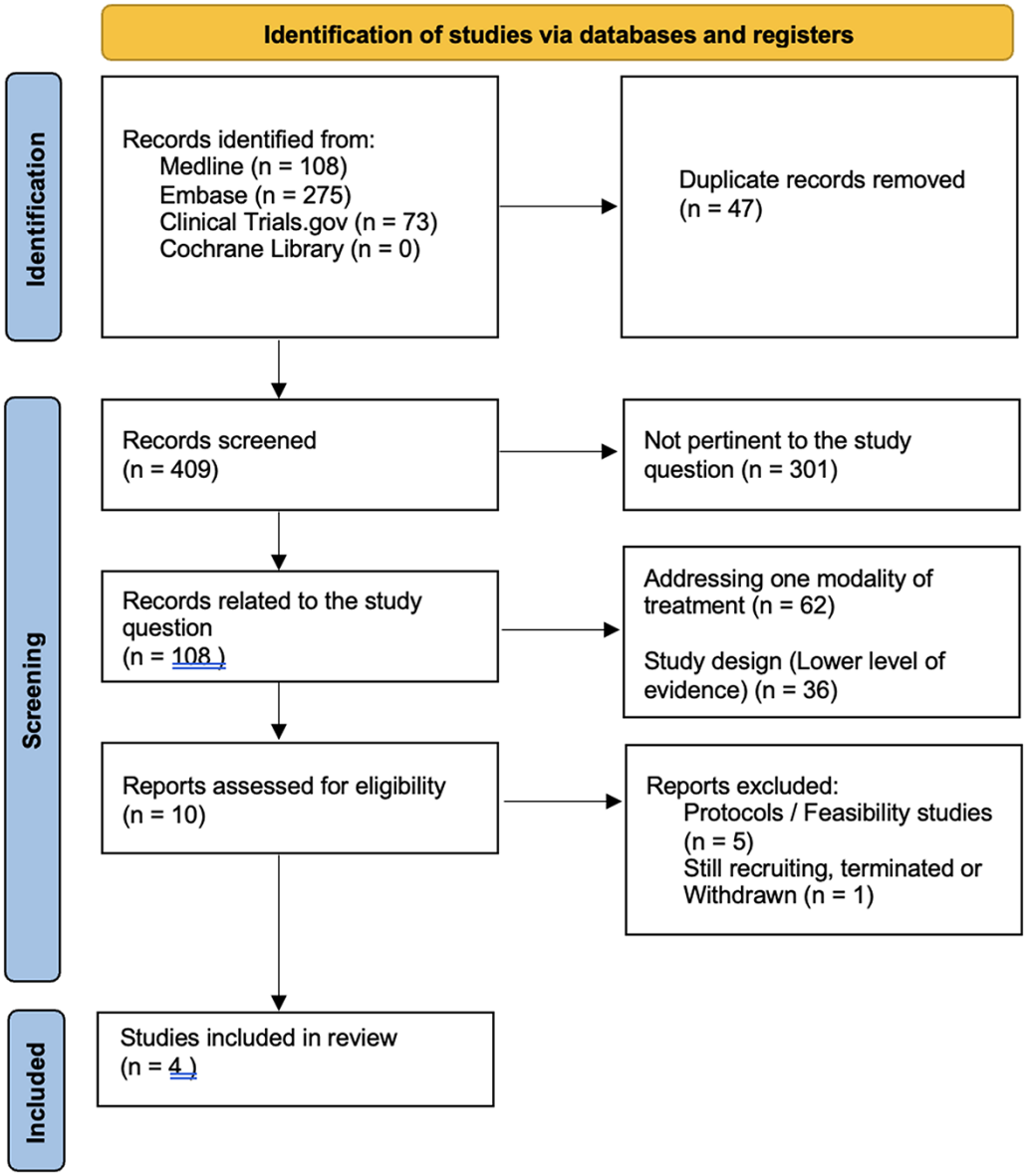

Fig. 1. PRISMA flow diagram showing the search strategy and results.

adduction and internal rotation was confirmed by biomechanical studies [6].

Imaging studies of asymptomatic individuals have demonstrated cam and pincer morphology in between 10% and 67% [2, 7]. This may suggest that the pathology in patients with symptoms is not just about the bony shape but may include unsatisfactory muscle strength, control and movement patterns. There have been several reports [8–11] of targeted physiotherapy programs (TPP) that seek to improve these latter factors. In one study, half of FAIS patients benefited from TPP in the short term, but the presence of cam morphology was a predictor of poor outcome [12]. Most of these programs have included activity restriction [8, 10], but this is not always an acceptable treatment modality.

Surgical bone reshaping can correct the structural component of the pathology. Initially, open surgery was the only available option for the correction of impingement. However, the last two decades have witnessed a huge development in hip arthroscopic techniques. These have been employed in the treatment of FAIS and associated pathologies and reported good outcomes, return to sports and restoration of range of movement [13–16].

Until recently, few studies compared physiotherapy to hip arthroscopy (HA) for the treatment of FAIS [17–20]. The aim of this review is to provide a systematic review of the current level-I evidence comparing physiotherapy to the arthroscopic treatment of FAIS.

METHODS

Our proposed research question was: 'Does arthroscopic hip surgery produce better patient-reported outcomes than targeted physiotherapy in the treatment of patients with FAIS?'

A preliminary search was performed to not only examine the availability of articles that address the question but also to

Table I. Study centres, location, patients and surgeons

Author/trial/year	*Country*	*Journal*	*Sample size (n)*	*Mean age [SD] (years)*	*Male event (%)*	*Recruitment centres*	*Surgeons (n)*	*Physiotherapists (n)*
Hunter et al. Australian FASHION. 2021	Australia	BMC Musculoskeletal	99	32.9 [SD 10.5]	58	10 Australian sites	8	24 PT centres (number of physiotherapists: NA)
Palmer et al. FAIT, 2019	United Kingdom	BMJ	222	36.2 [SD 9.7]	34	7 UK NHS sites	10	21
Griffin et al. UK FASHION, 2018	United Kingdom	Lancet	348	35.3 [SD 9.6]	61.2	23 UK NHS sites	27	47
Mansell et al. 2018	United States	Am J Sp Med	80	30.1 [SD 7.4]	58.8	Single Army Medical Centre	1	Single centre (number of physiotherapists: NA)

avoid duplication of previously published reviews. The review was registered on PROSPERO, the National Institute of Health Research-funded International prospective register of systematic reviews [21].

Search strategy

A systematic review was performed following the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines [22]. Each of the online published databases of Medline and EMBASE was searched individually through the OVID Online research platform. The Cochrane Library and ClinicalTrials.gov were searched through their websites. Search dates for Medline were from 1946 and for Embase from 1974 to 20 August 2021. The MeSH terms searched were 'Femoroacetabular', 'Impingement' AND 'Trials'. Search terms were 'Exploded' and relevant subheadings were included. The terms were then combined to produce lists of results. Finally, a search was performed using the Medline powered PICO (Population, Intervention, Comparison and Outcome) Linguist [23], and an additional concise list of studies was created on 25 August 2021.

Eligibility criteria

Inclusion criteria were based on the PICO approach [24] as P: Adult Humans with Femoroacetabular impingement Syndrome, I: Hip Arthroscopy, C: Physiotherapy (targeted physiotherapy programs) and O: Outcome Measures (e.g. iHot-12 and 33, HOS, etc.). The second consideration was the study design, being exclusive to Level-I Randomized Controlled Trials (RCTs) pertinent to the study question. Exclusion criteria were non-human studies, those published in a language other than English, all non-level-1 studies and published protocols of studies that were not executed by the date of the search.

Study selection and critical appraisal

Search results were presented in the form of lists of titles and abstracts. Two authors (SSSM and AT) scanned the lists independently to extract eligible studies and reported reasons for exclusion. The risk of bias of each of the included trials was assessed by the Cochrane risk-of-bias tool (RoB 2) [25]. In case of disagreement, the final decision was made by discussion with the senior author (JOD).

Data extraction

Full texts of eligible studies were downloaded, data extracted and used to synthesize results.

RESULTS AND REVIEW

Search results

Figure 1 shows a diagrammatic presentation of the PRISMA guided search strategy and its results. The electronic search yielded a total of 456 records. Exclusion criteria were applied and only four published RCTs were identified, which provided specific answers to the question posed by the review [17–20]. We identified a published protocol of an RCT that is still recruiting. The study is comparing arthroscopic femoral and/or acetabular osteochondroplasty to sham surgery, and it was excluded [26].

Centers, patients, surgeons and physiotherapists

Three of the included trials were multicenter studies: two from the United Kingdom [18, 19] and one from Australia [17]. One single-center study was American [20]. A total cohort of 749 patients were investigated, the majority of which were males with mean age ranging between 30.1 and 36.2 years old. Three hundred thirty-five patients underwent HA out of 370 originally allocated for the procedure. The largest difference between allocation and actual surgery was noted in one study [20]. In the physiotherapy groups, 46 patients did not receive their allocated treatment (46 out of 349 allocated). Two studies contributed to the majority of this difference in the TPP group [17, 20]. A single surgeon operated on all cases in the single-center trial, whereas 45 surgeons in total performed the surgeries in the other three. Those studies specified that the surgeons were specialist

Table II. Methodology: assessment tools, physiotherapy program details, allocations and follow-up

Study	*Outcomes*	*PT program details*	*Study arms (allocated/intention-to-treat)- HA TPP*	*Last follow-up (months)*
Hunter et al.	Primary: dGEMRIC Secondary: - HOMAS Hip OA MRI - iHOT-33 - HOOS - EQ-5D - SF-12 - GIS - Modified UCLA activity score	- 6 PT sessions during the first 12 weeks of the trial - If needed, additional sessions between 12 weeks and 6 months, up to a total maximum of 10 sessions - Further PT sessions were allowed as a co-intervention. - Ultrasound guided intra-articular injection should the pain prevents engagement with the program	dGEMRIC: 49/27 50/26 PROMs: 47/49 50/50	12
Palmer et al.	Primary: HOS ADL Secondary: - HOS sport - NAHS - HAGOS - OHS - iHOT-33 - EQ-5D-3L - PainDETECT - HADS	- Emphasis on muscle strengthening to improve core stability and movement control - Participants were encouraged to avoid impingement positions (extremes of hip flexion, abduction and internal rotation). - A maximum of eight sessions over a 5-month period	110/99 112/91	8 (at least 6 months following treatment)
Griffin et al.	Primary: - iHOT-33 Secondary: - EQ-5D-5L - SF-12 (version 2)	- 6–10 face-to-face PT sessions over 12–24 weeks - Muscle strengthening home program - One X-ray or ultrasound guided injection when the pain prevents performance of the exercise program	171/171 177/174	12
Mansell et al.	Primary: - HOS ADL Secondary: - iHOT-33 - Perception of improvement on GRC	- Supervised program, twice per week for 12 sessions - Typically, program will include hip mobilization and therapeutic exercises. - However, other interventions can be applied based on the discretion of the treating physiotherapist.	40/38 40/12	24

dGEMRIC: delayed Gadolinium-Enhanced Magnetic Resonance Imaging of Cartilage, HOMAS: whole Hip Osteoarthritis MRI Score, iHOT-33: International Hip Outcome Tool-33, HOOS: Hip disability and Osteoarthritis Outcome Score. GRC: Global Rating of Change,.
EQ-5D: European Quality of Life Five Dimension scores, SF-12: 12-Item Short Form Survey, GIS: Global Improvement Scale, Modified UCLA: Modified University Carolina Los Angeles activity score, HOS ADL: Activities of Daily Living domain of the Hip Outcome Score, NAHS: Non-arthritic hip score, HAGOS: Copenhagen hip and groin outcome score, OHS: Oxford hip score, HADS: Hospital anxiety and depression score.

HA surgeons. TPP were delivered by multiple centers and physiotherapists in each of the trials apart from one where PT was delivered in a single center [20]. Numbers of physiotherapists involved in each trial are listed in Table I. Details of the TPP programs are listed in Table II.

Cross over

Fifty-two participants crossed over between the treatment groups among the trials reviewed. All incidents were for patients crossing over from TPP to HA except for four FAIT Study participants [19].

Critical appraisal

The results of RoB2 assessment [25] are listed in detail in Table III. It is expected that blinding of patients and personnel delivering interventions in such studies is impossible. Nevertheless, the post-intervention assessors were blinded in all trials.

Table III. Risk of bias of the included studies

Study/bias	*Arising from the randomization process*	*Due to deviations from intended interventions*	*Due to missing outcome data*	*In measurement of the outcome*	*In selection of the reported result*	*Overall risk of bias*
Hunter et al. (primary outcome)	Low	High	High	High	Some concerns	High
Hunter et al. (secondary outcomes)	Low	Some concerns	Low	Low	Low	Some concerns
Palmer et al.	Low	Low	Low	Low	Low	Low
Griffin et al.	Low	Low	Low	Low	Low	Some Concerns
Mansell et al.	Low	Some concerns	High	Some concerns	High	High

Mansell et al. [20] was the first randomized controlled trial to address the question and concluded that patients did not benefit from surgery compared to a TPP; however, there was a high risk of bias on the RoB2 assessment. Firstly, the study is a single-center, single-surgeon trial. Secondly, the study participants were all military personnel, a specific patient group; hence, the results cannot be generalized to the public. In addition, there is an added factor of workers' compensation, which is known to be associated with worse outcomes in HA [27], as military personnel are entitled to workers' compensation. By the end of the follow-up interval, 45% (33 patients) of the patients had left the military service, of whom 72.7% (24 patients) had received a medical separation related to their hips. Thirdly, there was a very high crossover rate (70%) from the TPP group to the HA group leaving only 12 patients (of a total cohort of 80 patients) receiving TPP. The analysis was still performed according to the initial randomization on an intention-to-treat basis. In their discussion, the authors confirmed that the high crossover rate greatly increased the risk of type-II error (erroneous negative finding). Finally, there were 18 patients (22.5%) lost at the final follow-up. The reported results were based on two follow-up points for most of the patients; these could be 6 or 12 months. The author did not specify which follow-up points were used, and the analysis assumed the lost data to be at random.

Both the FAIT [19] and UK FASHION [18] trials showed a lower risk of bias and a lower percentage of crossover between groups of 5% and 8%, respectively.

In the FAIT trial, the end-point follow-up was at 8 months from randomization (or at least 6 months following the intervention). 80% of the TPP group completed their 8-months follow-up, while in the HA group, the percentage was 89%.

In the UK FASHION trial, the follow-up was at 6 and 12 months after randomization. The median waiting time to receive treatment was 122 days for the HA and 37 days for TPP. At 12-months follow-up, 84% of the HA group had undergone their procedure, and 95% had received their TPP.

In the most recently published Australian Fashion trial (Hunter et al.), the functional outcomes in the form of patient-reported outcome measures (PROMs) showed a lower risk of bias in all aspects. Cross over rate was only 6% (3 participants crossing from TPP to HA group). Ninety-one participants (100%) completed their 12-month follow-up scores for iHOT-33, EQ-5D-5L index and EQ-5D VAS scores, and 83 (91.2%) completed the HOOS questionnaire.

Outcome measures

All four studies employed various PROMs to assess patient's progression. Only in the study by Hunter et al. did the investigators also use the changes in delayed Gadolinium-Enhanced Magnetic Resonance Imaging of Cartilage (dGEMRIC) as an outcome tool in order to try to compare the changes in d-GEMRIC scores between both treatment modalities at the final follow-up.

Patient-reported hip-related outcomes

iHOT-33

The iHOT-33 was the most commonly used hip outcome tool among all studies. The results of the FAIT demonstrated a significant improvement in the HA group compared to TPP group at 8-months follow-up [19].

In the study by Mansell et al. [20], there was no difference between the TPP and HA groups at any time point. However, upon analyzing patients as per-surgery, a significant improvement was noted from the baseline to 1 and 2 years follow-up in the HA group, unlike the TPP group. iHOT-33 scores from both FASHION trials were pooled together in our meta-analysis, as explained below.

On pooling the Australian and UK FASHION results, meta-analysis has shown that the HA group had significant improvement in comparison to the TPP group on both a fixed- and a random-effect model at 12 months.

HOS (ADL component)

HOS (ADL) was the second most commonly performed PROM. In the FAIT trial [19], the HA participants showed significantly higher scores than their TPP counterparts, and the author has further confirmed that the difference was clinically relevant.

The results of Mansell et al. [20] showed the HOS ADL scores of their cohort followed the same pattern of the iHOT-33 scores mentioned above.

General quality of life (EQ-5D-5L)

EQ-5D-5L was equally used by two trials. In the Australian FASHION, the scores were significantly better in the HA group ($P = 0.007$); however, in the UK FASHION, there was no difference ($P = 0.397$) between both groups. On pooling the results together, meta-analysis has shown that the HA group had significant improvement in comparison to the TPP group on

Table IV. Results of the outcome tools used by different trials

Score/study	*Hunter et al. (12 months outcomes)*	*Palmer et al. (8 months)*	*Griffin et al. (12 months)*	*Mansell et al. (24 months)*
iHOT-33	HA better than TPP ($P = 0.002$)	HA better than TPP ($P < 0.001$)	HA better than TPP ($P = 0.0093$)	No difference between HA and TPP
HOS		HA better than TPP ($P < 0.001$)		No difference between HA and TPP
ADL				
Sports		HA better than TPP ($P < 0.001$)		
SF-12			No difference ($P = 0.099$)	
NAHS		HA better than TPP ($P < 0.001$)		
HAGOS		All scales: HA better than TPP ($P < 0.001$)		
OHS		HA better than TPP ($P < 0.001$)		
EQ-5D-3L		HA better than TPP ($P = 0.003$)		
EQ-5D-5L	HA Better than TPP ($P = 0.007$)		No difference ($P = 0.397$)	
HOOS				
- Pain	- HA Better than TPP ($P = 0.001$)			
- Symptom	- HA Better than TPP ($P = 0.007$)			
- ADL	- HA Better than TPP ($P = 0.000$)			
- Sport	- HA Better than TPP ($P = 0.003$)			
- QOL	- HA Better than TPP ($P = 0.004$)			
Modified UCLA activity score		HA better than TPP ($P = 0.01$)		
Perception of improvement on GRC				No difference between HA and TPP
dGEMRIC	Femoral: No difference ($P = 0.240$) Acetabular: No difference ($P = 0.125$) Combined: No difference ($P = 0.137$)			
HOMAS	Worse cartilage score ($P = 0.002$) and higher number of worsened regions for labral score ($P = 0.0009$) for arthroscopy compared to PHT			
PainDETECT		HA better than TPP ($P = 0.03$)		
HADS				
- Anxiety		- No difference ($P = 0.18$)		
- Depression		- HA better than TPP ($P = 0.004$)		

a fixed-effect model at 12 months but not on a random-effect model.

Other outcome scores utilized by the trials, and their results are listed in Table IV.

Perceived improvement

On a further analysis of the HOS ADL scores, the FAIT investigators found that more HA participants reached acceptable symptomatic state (48% versus 19%) and achieved their

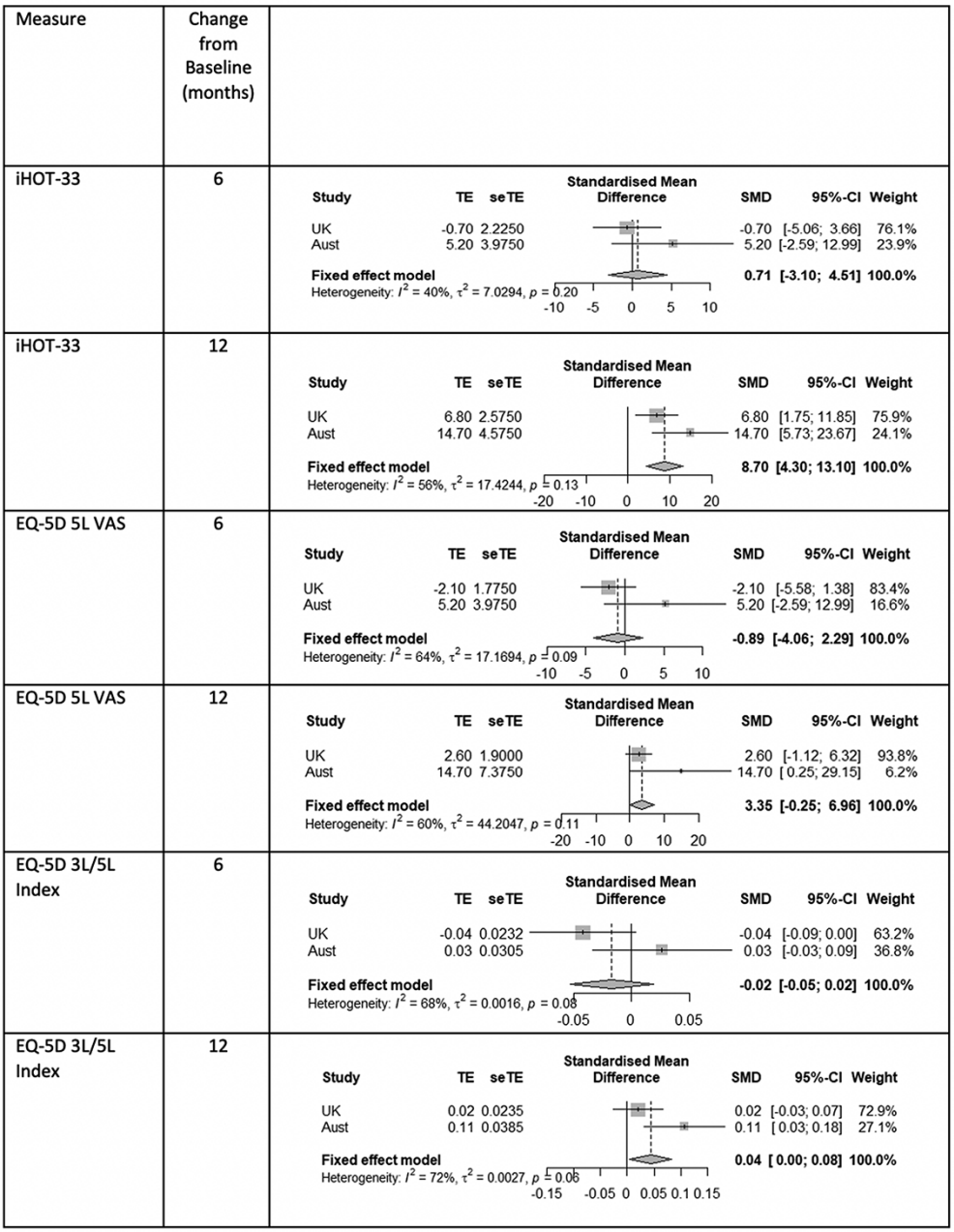

Fig. 2. Forest plot showing results for fixed-effects meta-analysis.

expectations post-randomization (31% versus 15%). In the study by Mansell et al., there was no difference between both groups in their perceived current level of function on both domains of the HOS. However, a larger number of the HA group (45.2%) reported a GRC of 13 or more, in contrast to 25% of the TPP group. The Australian FASHION trial has shown significant improvement of all components of the HOOS score of the HA patients in comparison to the TPP patients. Together with the UK FASHION, they showed similar results on the EQ-5D-5L scores (HA is significantly better than TPP).

Range of movement

This was only examined by the FAIT trial, and it showed a significantly better range of hip flexion in the HA group in comparison to the TPP participants ($P = 0.003$).

Radiological (dGEMRIC)

The Australian FASHION Trial did not show a significant difference between HA and TPP at 12-months follow-up.

Meta-analysis

Due to the heterogeneity of the follow-up intervals and outcome tools, data could be pooled together from only two out of the four trials (Griffin et al. [18] and Hunter et al. [17]). iHOT-33 and EQ-5D scores could be pooled for analysis from both trials.

Heterogeneity between the FASHION trials was measured using the I^2 statistic, with values of less than 25% usually viewed as low heterogeneity, between 25% and 50% as moderate and over 50% as high heterogeneity. Cochran's Q test for homo-

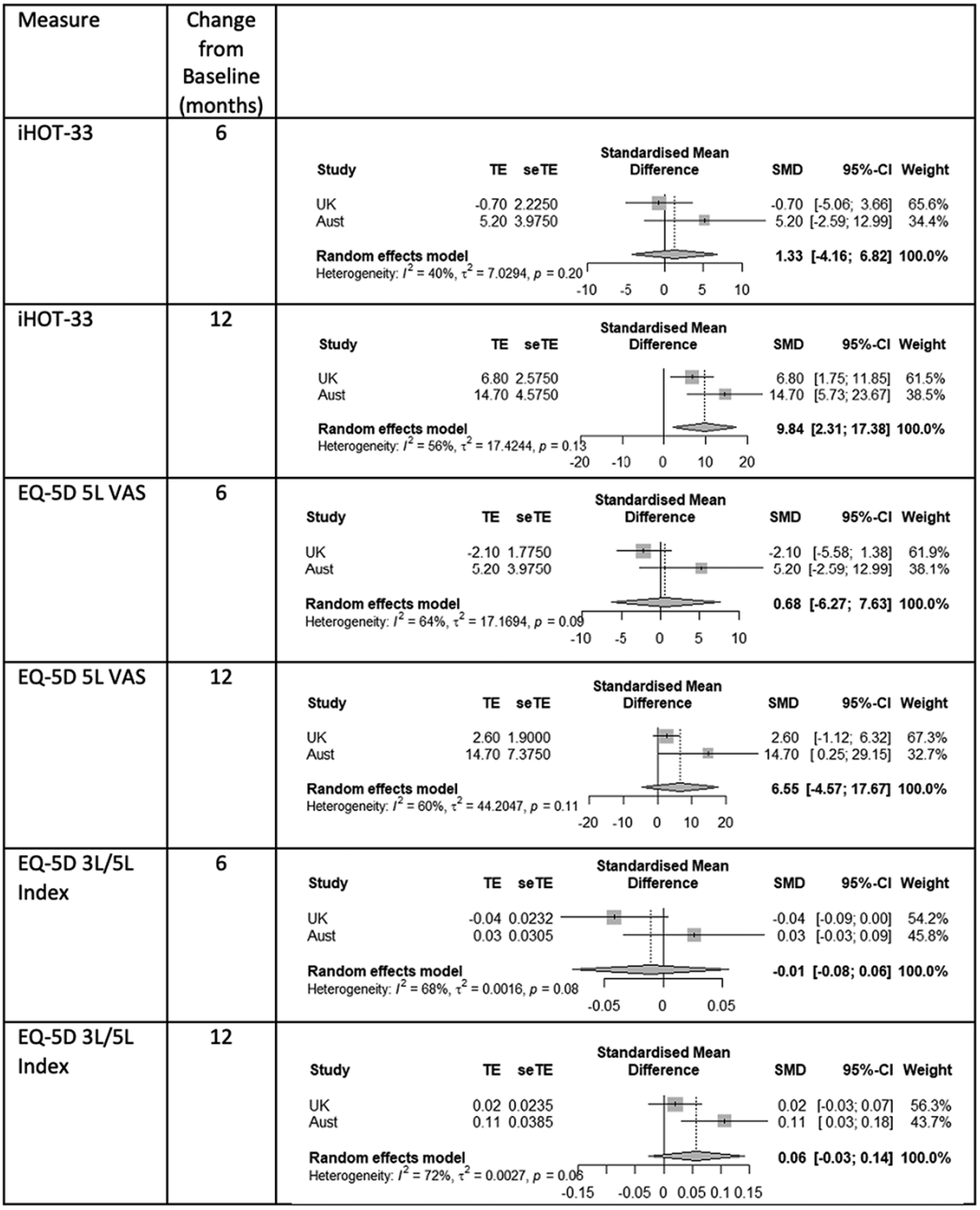

Fig. 3. Forest plot showing results for random-effects meta-analysis.

geneity is underpowered when few studies have been included or when event rates are low, requiring the use of a significance level of above 5%. Since only two studies are included in this analysis, we have applied a 15% significance level in our test of homogeneity [28].

We conducted a meta-analysis using the {meta} package in R [29] assuming a fixed-effects model. Given the robust performance of this model for continuous outcome data, the restricted maximum likelihood estimator was used. For each study, the adjusted treatment effect estimates from the adjusted mixed-effects model (primary) analysis were used with the associated standard errors. An estimate of the between-study variance in a random-effects meta-analysis (known as tau-squared (τ^2 or Tau^2) was also carried out.

The results for the fixed-effects meta-analysis are presented in Table V and Fig. 2. For this model, no significant treatment differences in improvement were observed over 6 months. In contrast, at 12-months follow-up, significantly better improvements were observed in the HA group in comparison to the TPP participants on the iHOT-33 and EQ-5D 3L/5L Index scores (iHOT-33 95% CI = 4.30, 13.10 and EQ-5D 3L/5L 95% CI = 0.004, 0.083, $P = 0.031$). I^2 statistics of between 40.4% and 72.5%, as well as the rejection of the Cochran's Q test for homogeneity in most cases, suggested that a meta-analysis assuming a random-effects model should be conducted. When this analysis was performed, the HA group also performed better on the iHOT-33 scores at 12 months (95% CI= 2.31, 17.38). The results are presented in Table VI and Fig. 3.

Table V. Meta-analysis fixed effects model results. results showing significant difference between HA and TPP are highlighted in bold

				Significance test		*Adjusted difference (Standard error)*	
Measure	*Change from baseline (months)*	*Overall effect*	*95% Confidence interval*	*z-value*	*P-value*	*United Kingdom*	*Australia*
iHOT-33	6	0.708	(−3.10,4.51)	0.36	0.7155	−0.7 (2.225)	5.2 (3.975)
iHOT-33	12	**8.70**	(4.30,13.10)	3.88	0.0001	6.8 (2.575)	14.7 (4.575)
EQ-5D 5L VAS	6	−0.886	(−4.06,2.29)	−0.55	0.5845	−2.1 (1.775)	5.2 (3.975)
EQ-5D 5L VAS	12	3.35	(−.25,6.96)	1.82	0.0684	2.6 (1.9)	14.7 (7.375)
EQ-5D 3L/5L Index	6	−0.017	(−.053,0.019)	−0.92	0.3577	−0.042 (0.0233)	0.026 (0.0305)
EQ-5D 3L/5L Index	12	**0.043**	(0.004,0.083)	2.16	0.0307	0.020 (0.0235)	0.106 (0.0385)

Table VI. Meta-analysis random effects model results with significant results highlighted in bold

				Significance test		*Test for heterogeneity*			
Measure	*Change from baseline (months)*	*Overall effect*	*95% Confidence interval*	*z-value*	*p-value*	*I^2 (%)*	*tau^2*	*Q Statistic (df = 1)*	*p-value*
iHOT-33	6	1.33	(−4.16, 6.82)	0.47	0.6350	40.4	7.03	1.68	0.20
iHOT-33	12	**9.85**	(2.31, 17.38)	2.56	0.0105	55.8	17.42	2.26	0.13
EQ-5D 5L VAS	6	0.68	(−6.27, 7.63)	0.19	0.8471	64.4	17.17	2.81	0.09
EQ-5D 5L VAS	12	6.55	(−4.57, 17.67)	1.15	0.2483	60.4	44.20	2.52	0.11
EQ-5D 3L/5L Index	6	−0.011	(−0.077, 0.056)	−0.32	0.7484	68.2	0.0016	3.14	0.08
EQ-5D 3L/5L Index	12	0.058	(−0.026, 0.141)	1.35	0.1770	72.5	0.0027	3.64	0.06

Table VII. Actual values of individual scores for the iHOT-33, HOS ADL and the EQ-5D

Score/Study	*Hunter et al. (Change in score at 12 months from baseline)*		*Palmer et al. (Change in score at 8 months from baseline)*		*Griffin et al. (Scores at 12 months)*	
	HA	PT	HA	PT	HA	PT
iHOT-33 (mean)	29.6	15.4			58.8	49.7
HOS ADL (mean)			12.5 ($P < 0.001$)	3.3		
EQ-5D-5L	0.194 ($P = 0.0046$)	0.101				

In the Australian FASHION trial, the authors published the difference between 12 months follow-up and the baseline scores, while in the FAIT trial, Palmer et al. reported the end results of the HOS scores (8 months) together with the baseline values. The results above are the difference between those scores. The end results (12 months) of the iHOT scores of the UK FASHION are demonstrated above.

In addition to the statistical meta-analysis, the clinical impact of the improvement in the PROMs scores should be emphasized (Table VII). Since the introduction of the iHOT-33 scoring system, its Minimal Clinically Important Difference (MCID) was found to be 6 points [30].

This threshold was exceeded in both FASHION trials [17, 18]. In the Australian FASHION trial. the authors showed improvement from baseline by 29.6 points in the HA group [17]. In the UK FASHION, Griffin et al. confirmed that MCID threshold was achieved, and they have published the final scores exceeding the Patient Acceptable Symptomatic State (PASS) of 58 [31] in the HA patient group. The PASS of the HOS ADL was calculated as 87 points for patients undergoing HA for FAIS [32]. In the FAIT trial, this value was achieved more in the HA group of patients than the TPP group. The difference was found to be statistically significant (48% in the HA group versus 19% for the TTP group) [19]. The MCID of the EQ-5D-5L (0.16) [33] was reached by the HA group, but not by the TPP group, in the Australian FASHION trial [17].

DISCUSSION

Several reviews have been performed previously, which assessed the first three of the four RCTs assessed in this review.

The addition of the fourth RCT (Australian FASHION; Hunter, et al.) adds a significant cohort of 99 patients with a high follow-up rate, and very low treatment crossover rate, and therefore adds significantly to the overall data.

In addition, the very similar study protocols of the United Kingdom, and Australian FASHION studies allowed a meta-analysis to be performed for the first time using data from these published RCTs. These results were derived from a large number of surgeons and patients in two countries suggesting that the reported outcomes are likely to be generalizable.

This review demonstrates the overall superiority of hip arthroscopic surgery over a targeted physiotherapy program as the treatment strategy for patients with femoroacetabular impingement syndrome. This effect has been seen across a range of PROMs known to be sensitive and specific for the effect of hip surgery on young active individuals.

Whilst the role of surgery for this condition looks promising, there are some caveats:

a. ***Duration of effect.*** The studies in this review measured outcomes at 8–12 months. This is short term in the context of young adults with most of their life still to live with the affected hip or hips. Observational studies have demonstrated good outcomes from HA at 5 and 10 years [28, 34], but we look forward to the long-term results of the randomized trials in this review.
b. ***Patient-specific effect of surgery.*** This review has demonstrated the superiority of HA over TPP for FAIS on average. It is very unlikely that FAIS patients are homogeneous and that the effect of surgery is uniform. It may be that some groups of patients can be satisfactorily managed by TPP, and some groups should be encouraged to have early surgery. However, the published data do not yet identify the factors that influence in which group a patient lies, and so does not support individualized recommendations.
c. ***It is not clear how surgery works.*** The idea that mechanical impingement is relieved by reshaping is logically consistent and is supported by the increased range of motion seen after surgery [13, 19]. However, the subsequent idea that cumulative damage to the labrum and articular cartilage is arrested or slowed has not yet been demonstrated. A difficulty has been in finding suitable imaging to measure cartilage damage. Among the possible candidates, dGEMRIC scores have been shown to predict the outcome of periacetabular osteotomy in hip dysplasia [35] and have been used to assess the condition of hips in patients with FAIS [36]. In one previously published observational study [37], dGEMRIC scans were performed in two groups of FAIS patients, treated operatively and non-operatively. The surgical group included a mix of HA and open surgery. The follow-up dGEMRIC scans showed a decline in the cartilage of both groups, more pronounced on the femoral side of the surgical dislocation group. The authors concluded that *'The observed decline in dGEMRIC indices neither confirms the benefit of surgical treatment of FAI nor does it disprove the first reported favorable long- term results after FAI surgery in the literature. Longer term studies will be needed to determine whether the cartilage matrix changes seen here are permanent or reversible'*. The Australian FASHION trial was the first attempt to use dGEMRIC in a randomized trial of FAIS treatment, but it did not show significant benefits of either arthroscopic or TPP treatments in terms of cartilage d-GEMRIC scores. This may have been due to the small number of patients who completed the two d-GEMRIC scans according to the study protocol, or perhaps the outcome measure was inappropriate as an assessment of cartilage health after surgery, or the time scale was too short, or the methodological issues overwhelmed the effect, as suggested by the previous study.

Despite these caveats, the evidence collated in this review shows that HA is a more effective strategy than prolonged TPP among FAIS patients who do not improve after initial physiotherapy assessment and treatment. HA was found to be successful in 81.1% of the FAIS patients at a minimum of 2-years follow-up [38]. Whilst targeted postoperative physiotherapy is a valuable part of a surgical strategy [39, 40], delayed surgery has been reported to be associated with significantly inferior outcomes [41] and worse intra-articular pathology [42]. This is important because FAIS is a risk factor for osteoarthritis [43–46], and so delayed surgical treatment may not only lead to prolonged symptoms but also result in earlier onset or worse degenerative change.

In conclusion, this review demonstrates that both HA and TPP lead to improved patient PROMs. On average, HA leads to significantly greater improvements than TPP in the treatment of FAIS in the short term. Future research should aim at investigating the long-term outcomes of HA for FAIS [47].

ACKNOWLEDGEMENT

None declared.

FUNDING

There was no external funding received for this work. No financial support was received for this work.

CONFLICT OF INTEREST STATEMENT

None declared.

REFERENCES

1. Myers SR, Eijer H, Ganz R. Anterior femoroacetabular impingement after periacetabular osteotomy. *Clin Orthop Relat Res* 1999: 93–9.
2. Laborie LB, Lehmann TG, Engesæter IØ *et al.* Prevalence of radiographic findings thought to be associated with femoroacetabular impingement in a population-based cohort of 2081 healthy young adults. *Radiology* 2011; **260**: 494–502.
3. Leunig M, Casillas MM, Hamlet M *et al.* Slipped capital femoral epiphysis: early mechanical damage to the acetabular cartilage by a prominent femoral metaphysis. *Acta Orthop Scand* 2000; **71**: 370–5.
4. de Silva V, Swain M, Broderick C *et al.* Does high level youth sports participation increase the risk of femoroacetabular impingement? A review of the current literature. *Pediatr Rheumatol Online J* 2016; **14**: 16.
5. Griffin DR, Dickenson EJ, O'Donnell J *et al.* The Warwick Agreement on femoroacetabular impingement syndrome (FAI syndrome): an international consensus statement. *Br J Sports Med* 2016; **50**: 1169–76.
6. Hunt MA, Guenther JR, Gilbart MK. Kinematic and kinetic differences during walking in patients with and without symptomatic

femoroacetabular impingement. *Clin Biomech (Bristol, Avon)* 2013; **28**: 519–23.
7. Frank JM, Harris JD, Erickson BJ *et al.* Prevalence of femoroacetabular impingement imaging findings in asymptomatic volunteers: a systematic review. *Arthrosc J Arthrosc Relat Surg Off Publ Arthrosc Assoc North Am Int Arthrosc Assoc* 2015; **31**: 1199–204.
8. Pennock AT, Bomar JD, Johnson KP *et al.* Nonoperative management of femoroacetabular impingement: a prospective study. *Am J Sports Med* 2018; **46**: 3415–22.
9. Kemp JL, Coburn SL, Jones DM *et al.* The physiotherapy for femoroacetabular impingement rehabilitation study (physioFIRST): a pilot randomized controlled trial. *J Orthop Sports Phys Ther* 2018; **48**: 307–15.
10. Emara K, Samir W, Motasem EH *et al.* Conservative treatment for mild femoroacetabular impingement. *J Orthop Surg (Hong Kong)* 2011; **19**: 41–5.
11. Wall PDH, Fernandez M, Griffin DR *et al.* Nonoperative treatment for femoroacetabular impingement: a systematic review of the literature. *PMR* 2013; **5**: 418–26.
12. Casartelli NC, Bizzini M, Maffiuletti NA *et al.* Exercise therapy for the management of femoroacetabular impingement syndrome: preliminary results of clinical responsiveness. *Arthritis Care Res (Hoboken)* 2019; **71**: 1074–83.
13. Kelly BT, Bedi A, Robertson CM *et al.* Alterations in internal rotation and alpha angles are associated with arthroscopic cam decompression in the hip. *Am J Sports Med* 2012; **40**: 1107–12.
14. Singh PJ, O'Donnell JM. The outcome of hip arthroscopy in Australian football league players: a review of 27 hips. *Arthrosc J Arthrosc Relat Surg Off Publ Arthrosc Assoc North Am Int Arthrosc Assoc* 2010; **26**: 743–9.
15. Kaldau NC, Brorson S, Hölmich P *et al.* Good midterm results of hip arthroscopy for femoroacetabular impingement. *Dan Med J* 2018; **65**: 6.
16. Menge TJ, Bhatia S, McNamara SC *et al.* Femoroacetabular impingement in professional football players: return to play and predictors of career length after hip arthroscopy. *Am J Sports Med* 2017; **45**: 1740–4.
17. Hunter DJ, Eyles J, Murphy NJ *et al.* Multi-centre randomised controlled trial comparing arthroscopic hip surgery to physiotherapist-led care for femoroacetabular impingement (FAI) syndrome on hip cartilage metabolism: the Australian FASHIoN trial. *BMC Musculoskelet Disord* 2021; **22**: 1–16.
18. Griffin DR, Dickenson EJ, Wall PDH *et al.* Hip arthroscopy versus best conservative care for the treatment of femoroacetabular impingement syndrome (UK FASHIoN): a multicentre randomised controlled trial. *Lancet (London, England)* 2018; **391**: 2225–35.
19. Palmer AJR, Ayyar Gupta V, Fernquest S *et al.* Arthroscopic hip surgery compared with physiotherapy and activity modification for the treatment of symptomatic femoroacetabular impingement: multicentre randomised controlled trial. *BMJ* 2019; **364**: 185.
20. Mansell NS, Rhon DI, Meyer J *et al.* Arthroscopic surgery or physical therapy for patients with femoroacetabular impingement syndrome: a randomized controlled trial with 2-year follow-up. *Am J Sports Med* 2018; **46**: 1306–14.
21. PROSPERO. Published 2021. Available at: https://www.crd.york.ac.uk/prospero/logout.php. Accessed: 27 September 2021.
22. Page MJ, Mckenzie JE, Bossuyt PM *et al.* The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 2021; **372**: n71.
23. PICO. Linguist. Available at: https://babelmesh.nlm.nih.gov/pico.php. Accessed: 23 October 2021.
24. Schardt C, Adams MB, Owens T *et al.* Utilization of the PICO framework to improve searching PubMed for clinical questions. *BMC Med Inform Decis Mak* 2007; **7**: 16.
25. Sterne JAC, Savović J, Page MJ *et al.* RoB 2: a revised tool for assessing risk of bias in randomised trials. *BMJ* 2019; **366**: l4898.
26. Risberg MA, Ageberg E, Nilstad A *et al.* Arthroscopic surgical procedures versus sham surgery for patients with femoroacetabular impingement and/or labral tears: study protocol for a randomized controlled trial (HIPARTI) and a prospective cohort study (HARP). *J Orthop Sports Phys Ther* 2018; **48**: 325–35.
27. Salvo JP, Hammoud S, Flato R *et al.* Outcomes after hip arthroscopy in patients with workers' compensation claims. *Orthopedics* 2015; **38**: e94–8.
28. West SL, Gartlehner G, Mansfield AJ *et al. Comparative Effectiveness Review Methods: Clinical Heterogeneity*. Rockville, MD: Agency for Healthcare Research and Quality (US), 2010. Available at: https://www.Ncbi.Nlm.Nih.Gov/Books/NBK53310.
29. Schwarzer G, Carpenter J, Rucker G. *Meta-Analysis with R*. Springer International, 2015. 10.1007/978-3-319-21416-0.
30. Mohtadi NGH, Griffin DR, Pedersen ME *et al.* The development and validation of a self-administered quality-of-life outcome measure for young, active patients with symptomatic hip disease: The International Hip Outcome Tool (iHOT-33). *Arthrosc - J Arthrosc Relat Surg* 2012; **28**: 595–610.e1.
31. Maxwell S, Pergaminelis N, Renouf J *et al.* Identification of a patient acceptable symptomatic state score for the international hip outcome tool in people undergoing hip arthroscopy. *Arthrosc J Arthrosc Relat Surg Off Publ Arthrosc Assoc North Am Int Arthrosc Assoc* 2018; **34**: 3024–9.
32. Chahal J, Van Thiel GS, Mather RC 3rd *et al.* The patient acceptable symptomatic state for the modified harris hip score and hip outcome score among patients undergoing surgical treatment for femoroacetabular impingement. *Am J Sports Med* 2015; **43**: 1844–9.
33. Impellizzeri FM, Mannion AF, Naal FD *et al.* The early outcome of surgical treatment for femoroacetabular impingement: success depends on how you measure it. *Osteoarthr Cartil* 2012; **20**: 638–45.
34. Büchler L, Grob V, Anwander H *et al.* Good outcome scores and low conversion rate to THA 10 years after hip arthroscopy for the treatment of femoroacetabular impingement. *Clin Orthop Relat Res* 2021; **479**: 2256–64.
35. Cunningham T, Jessel R, Zurakowski D *et al.* Delayed gadolinium-enhanced magnetic resonance imaging of cartilage to predict early failure of Bernese periacetabular osteotomy for hip dysplasia. *J Bone Joint Surg Am* 2006; **88**: 1540–8.
36. Mamisch TC, Kain MSH, Bittersohl B *et al.* Delayed gadolinium-enhanced magnetic resonance imaging of cartilage (dGEMRIC) in Femoacetabular impingement. *J Orthop Res Off Publ Orthop Res Soc* 2011; **29**: 1305–11.
37. Schmaranzer F, Haefeli PC, Hanke MS *et al.* How Does the dGEMRIC index change after surgical treatment for FAI? A prospective controlled study: preliminary results. *Clin Orthop Relat Res* 2017; **475**: 1080–99.
38. Youm T, Wolfson T, Ryan MK *et al.* Outcome trends after hip arthroscopy for femoroacetabular impingement: when do patients improve? *J Hip Preserv Surg* 2016; **3**: hnw030.009.
39. Bennell KL, Spiers L, Takla A *et al.* Efficacy of adding a physiotherapy rehabilitation programme to arthroscopic management of femoroacetabular impingement syndrome: a randomised controlled trial (FAIR). *BMJ Open* 2017; **7**: e014658.
40. Takla A, O'Donnell J, Voight M *et al.* The 2019 International Society of Hip Preservation (ISHA) physiotherapy agreement on assessment and treatment of femoroacetabular impingement syndrome (FAIS): an international consensus statement. *J Hip Preserv Surg* 2020; **7**: 631–42.
41. Kunze KN, Nwachukwu BU, Beck EC *et al.* Preoperative duration of symptoms is associated with outcomes 5 years after hip arthroscopy for femoroacetabular impingement syndrome. *Arthrosc J Arthrosc Relat Surg Off Publ Arthrosc Assoc North Am Int Arthrosc Assoc* 2020; **36**: 1022–9.
42. Kunze KN, Beck EC, Nwachukwu BU *et al.* Early hip arthroscopy for femoroacetabular impingement syndrome provides superior outcomes when compared with delaying surgical treatment beyond 6 months. *Am J Sports Med* 2019; **47**: 2038–44.
43. Agricola R, Waarsing JH, Arden NK *et al.* Cam impingement of the hip: a risk factor for hip osteoarthritis. *Nat Rev Rheumatol* 2013; **9**: 630–4.

44. Clohisy JC, Dobson MA, Robison JF *et al.* Radiographic structural abnormalities associated with premature, natural hip-joint failure. *J Bone Joint Surg Am* 2011; **93**: 3–9.
45. Ganz R, Leunig M, Leunig-Ganz K *et al.* The etiology of osteoarthritis of the hip: an integrated mechanical concept. *Clin Orthop Relat Res* 2008; **466**: 264–72.
46. Ganz R, Parvizi J, Beck M *et al.* Femoroacetabular impingement: a cause for osteoarthritis of the hip. *Clin Orthop Relat Res* 2003: 112–20.
47. Lee CB. Surgical innovation and safety: femoroacetabular impingement and the IDEAL collaborative framework. *J Hip Preserv Surg* 2016; **3**: 89–96.