Systematic Review

The Definition of Failure in Hip Arthroscopy May Include Factors Outside of Reoperation: A Systematic Review

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Purpose: To perform a systematic review about the varying definitions of "failure" of hip arthroscopy (HA) in the current literature and to provide a recommendation for the standardization of defining failure of HA. **Methods:** A systematic search of electronic databases was conducted to identity Level I-IV clinical studies on HA failure published between January 2016 and July 2021 according to Preferred Reporting Items for Systematic Reviews and Meta-analyses guidelines. Inclusion criteria consisted of studies of patients who underwent an arthroscopic hip procedure and included a definition of failure. Studies with patients who underwent open hip procedures and non—full-text articles were excluded. **Results:** Of 1,290 titles, 85 (6.6%) met inclusion criteria and were analyzed in this review. The most common definition of HA failure used was the need for any subsequent ipsilateral hip surgery (80/85, 94.1%). Among studies that noted reoperation as a cause for failure, conversion to total hip arthroplasty was most frequently cited (66/85, 77.6%) followed by any other reoperation on the ipsilateral hip, including repeat HA, hip resurfacing, and hip periacetabular osteotomy (65/85, 76.5%). Multiple studies used subjective patient-reported outcomes, with use of the modified Harris Hip Score being the most common (17/85, 20%). **Conclusions:** There are numerous definitions of the term "failure" of HA used by authors in the peer-reviewed literature. A standardized definition of HA failure should be multifactorial. It may include any unplanned subsequent procedures; patient-reported outcomes with emphasis on minimal clinically important difference, substantial clinical benefit, and/or patient acceptable symptom state values; and the inability to return to normal function or sports. **Level of Evidence:** Level IV, systematic review of Level III and IV studies.

Hip arthroscopy (HA) is a common procedure performed by orthopaedic surgeons to aid in the diagnosis and treatment of a diverse range of hip pathologies. The treatment of septic arthritis, chondral injuries, femoroacetabular impingement, and labral tears, among others, has been historically performed with open surgical dislocation of the hip, but with advancing technology, has now been successfully performed using HA.[1-3] In addition, it may serve as a diagnostic tool, allowing for visualization and assessment of the extent and pattern of chondral damage in patients with hip dysplasia to assist with the decision making of salvage or reconstruction options for those patients.[4,5]

HA is becoming a common alternative to open surgical dislocation of the hip for less-traumatic pathologies, given the minimally invasive nature of the procedure and quicker recovery.[3] It can be considered a low-risk alternative to more complex open hip procedures, with evidence of a low complication rate of 1.4%.[6] In addition, outcomes after HA have generally demonstrated positive results, with improved patient-reported outcomes (PROs) postoperatively at short-, mid-, and long-term follow-up.[1,2] These systematic reviews also demonstrate that there are many tools used to assess the outcomes of patients after HA.[1,2] As a result, there is also significant variation in how an arthroscopic hip procedure is described as a failure in the literature. Some authors define "failure" as a failure to achieve the minimal clinically important difference (MCID) of the modified Harris hip score (mHHS),

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whereas others indicate a secondary operation such as a conversion to total hip arthroplasty (THA) as "failure."[7,8] Other secondary operations may include revision arthroscopy and periacetabular osteotomy (PAO). It has been well documented that although secondary operations improve PROs, they do not improve as significantly as from the primary operation.[9]

As a result of the heterogeneity found within the literature, it is vital to determine a more standardized definition of "failure" in HA. Standardizing the definition allows for a better assessment of patient outcomes and develop ways to potentially mitigate risk factors for failure on future operations. A standardized definition will also allow a better comparison across future studies by decreasing the heterogeneity of reported outcome measures. Therefore, the purposes of this study were to perform a systematic review about the varying definitions of “failure” of HA in the current literature and to provide a recommendation for the standardization of defining failure of HA. Our team’s hypothesis was that the definition of failure in HA would be multifactorial, including the incidence of reoperation, patient outcome measures, and return to sport (RTS) in the athletic population.

Methods

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines[10] were used to conduct this systematic review, and institutional review board approval was not required. A systematic search of Cumulated Index to Nursing and Allied Health Literature, Embase, PubMed (MEDLINE), and SPORTDiscus was conducted by a university librarian to identify studies related to HA failure. The search terms used included “hip,” “femoroacetabular,” “arthroscopy,” “arthroscopic,” “failure,” “failed,” and “fail.”

Included articles must have met these criteria: human studies published in the English language from January 2016 to July 2021, levels of evidence I-IV, evaluated arthroscopic hip procedures, and included a definition of "failure" of HA. Exclusion criteria included review articles, cadaveric studies, animal studies, technique papers, systematic reviews, case reports, publications primarily evaluating open hip procedures, THA, hip resurfacing, or PAO.

Once all studies from the aforementioned databases listed were identified and duplicates removed, 2 research team members, E.B. and L.A., independently screened each article’s title using previously determined criteria. The remaining articles were then screened by their abstracts. The full text of each qualifying article was then reviewed and either included or excluded from the final list (Fig 1).

Data from each full text article were then extracted. Failure data were obtained from each study and divided into the following categories: Reoperations including THA and other ipsilateral hip procedures; PROs including Non-Arthritic Hip Score (NAHS), mHHS, Merle d’Aubignéscore, Numeric Rating Scale (NRS), and lack of significant improvement/dissatisfaction/persistent pain; arthritis including Tönnis Osteoarthritis Scale and progression of osteoarthritis (OA); and other, including suture anchor pullout and no RTS (Fig 2).

The failure rate within the different categories was then assessed and reported. Descriptive statistics, such as mean and percentages, were used to report these data.

Results

Of 1,290 initial search titles, 85 (6.6%) met inclusion criteria and were analyzed in this systematic review. Most of the studies included in this systematic review were either Level III or IV evidence, composed mainly of case series, retrospective cohort studies, or case controls. Basic demographics can be viewed in Table 1.[7-93]

There were various definitions of “failure” of HA surgeries used in the current literature and numerous studies included more than 1 criterion into their definition (Table 2).[7-93]

Overall failure rates among studies ranged from 0% to 55%. Multiple definitions of failure were used in 47 (55.3%) studies, whereas a single definition was used in 38 (44.7%) studies. Of the studies that included a single definition of failure, many studies reported ipsilateral hip reoperation as their definition for failure.

Most publications included ipsilateral hip reoperations in their definition of failure (80/85, 94.1%). Among those studies, the most commonly cited reoperation defining failure was conversion to THA (66/85, 77.6%). Other reoperations on the ipsilateral hip, including but not limited to repeat HA, hip resurfacing, and hip PAO, were also commonly reported as reasons for failure of the index procedure (65/85, 76.4%). Reasons for additional operations included OA progression, labral retear, labral adhesions, suture anchor pullout, heterotopic ossification, and inadequate correction of pathology, including inadequate femoroplasty. Failure rates for studies that included an ipsilateral hip reoperation in their definition ranged from 0% to 55%.

Because of the significant variability of PRO selected to define failure, this section has been divided into scored PROs and more subjective PROs. Overall, there were 32 articles that used PROs to help define a failed HA surgery (32/85, 37.6%). Scored PROs, including the NAHS, the mHHS, the Merle d’Aubigne score, and the NRS, were mentioned in the published literature 22 times (22/85, 25.9%). Subjective PROs including but not limited to pain, patient satisfaction, and outcome ratings to define a failed procedure were mentioned 10

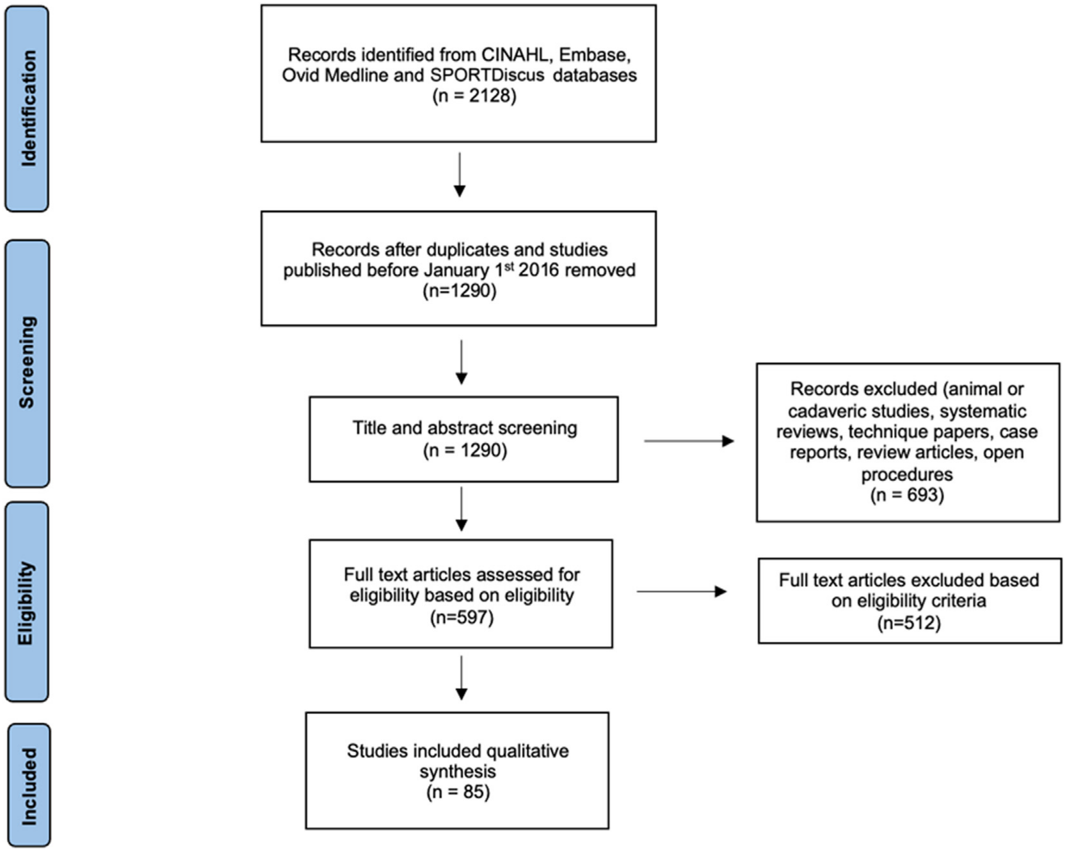

Fig 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram.

times (10/85, 11.8%). Failure rates of studies that included PROs ranged from 0% to 55%.

Of the 32 articles including PROs, only 3 publications used the NAHS in their definitions for failure (3/85, 3.5%). Two publications defined failure as "a change in the NAHS value of <10 points" (2/85, 2.4%) whereas another article established the threshold of <80 to define a failed operation (1/85, 1.2%). Failure rates for studies that included the NAHS in their definition ranged from 5.4% to 22.9%.[39,67,83]

The mHHS was the most common PRO used to determine failure and was mentioned a total of 18 times (18/85, 21.2%) (Table 3). Among studies using mHHS, an absolute score of <70 was the criteria used most often to determine failure (9/85, 10.6%).[18,19,22,24,25,48,58,65,81] An absolute score of <80 was used to define failure in multiple studies (3/85, 3.5%),[43,45,55] whereas <85 (1/85, 1.2%)[27] and <90 (1/85, 1.2%)[66] were only found once, respectively. An improvement of <8 points on the mHHS was considered a failure after HA in one study (1/85, 1.2%),[13] whereas another study defined failure as an improvement of <10 points on the mHHS (1/85, 1.2%).[12] One study defined failure of HA as being unable to achieve the MCID using the mHHS (1/85, 1.2%); however, the specific value for MCID was not mentioned in the study.[7] Another study included the inability to pass the threshold of the patient acceptable symptomatic state (PASS) postoperatively for the mHHS as a way to define failure (1/85, 1.2%).[17] Failure rates for studies that included the mHHS in their definition ranged from 0% to 55%.

The Merle d'Aubigné score was only used in 1 article, with failure defined as a score of <15 (1/85, 1.2%). The failure rate for the study that included the Merle d'Aubigné score was noted to be 19%.[92]

The NRS was used in one article with failure being defined as an NRS of <7 (1/85, 1.2%). The failure rate for the study that included an NRS was noted to be 29.5%.[66]

Outcome ratings were used once in the literature, but measures were poorly defined, and criteria were not clearly outlined. For example, one article included "a rating of abnormal or severely abnormal" to define failure (1/85, 1.2%).[62] The failure rate for the study that included a subjective outcome rating was noted to be 21.1%.

Other PROs used to define failure in HA focused on patient satisfaction. One study measured satisfaction using dichotomic values of YES = satisfied and NO = dissatisfied, with NO meeting failure criteria (1/85, 1.2%).[66] The failure rate for the study that included

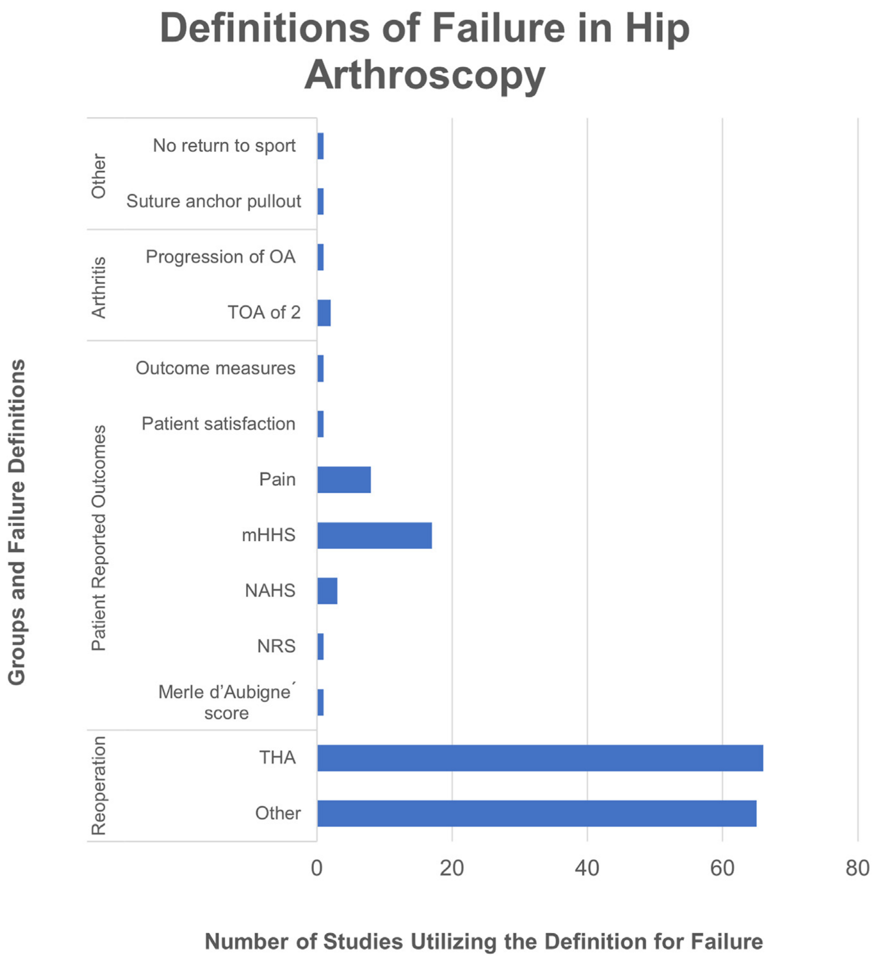

Fig 2. Grouped failure definitions. (mHHS, modified Harris Hip Score; NASH, Non-Arthritic Hip Scale; NRS, Numerical Rating Scale; OA, osteoarthritis; THA, total hip arthroplasty; TOA, Tönnis Osteoarthritis Scale.)

patient satisfaction in its definition of failure was noted to be 29.5%.

Subjective pain measures were used several times in articles when defining a failed outcome for patients. Phrases such as "persistent pain, lack of improvement in pain, aggravation of pain or recurrence of pain" were noted in 8 articles (8/85, 9.4%). Failure rates for studies that included subjective pain measures in their definition ranged from 0% to 47.9%.

OA was another factor used to determine failure in HA (3/85, 3.5%). The Tönnis Osteoarthritis Scale grade using a threshold of 2 (2/85, 1.2%)[27,77] was used to define failure as well as a more subjective criteria of "progression of osteoarthritis" (1/85, 1.2%).[92] Failure rates for studies that included OA in their definition ranged from 19% to 32.1%.

Other tools used to help define HA failure in the published literature included suture anchor pullout (1/85, 1.2%)[11] and "not returning to sport" (1/85, 1.2%).[66] The failure rate for the study that mentioned suture anchor pullout as its definition of failure noted a failure rate of 1.6%, whereas the study mentioning not returning to sport had a failure rate of 29.5%.

Discussion

In this systematic review, we found that there are numerous definitions of HA failure used by authors in the peer-reviewed literature. A standardized definition of HA should be multifactorial, emphasizing unplanned subsequent procedures and PROs using MCID, substantial clinical benefit (SCB), and/or PASS values. Providers treating athletic populations also may consider RTS in their "failure" assessment. Without a standardized definition of failure, there are challenges when comparing results between studies with differing definitions of failure after an HA procedure. Providing a better understanding of failures that occur after HA will allow us to best mitigate potential risk factors for failure and ultimately improve treatment of various hip pathologies and overall patient outcomes. In this study, the most commonly reported definition of HA failure was reoperation on the ipsilateral hip, appearing in 94.1% of included studies. The other 5.9% of studies included failure definitions such as persistent pain, suture anchor pullout, and PROs.[11,13,40,42,82] Among studies that used reoperation as a definition of failure, conversion to THA often is independently described and

Table 1. Study Characteristics and Demographics of Included Studies (N = 85)

Study	Publication Year	Level of Study	Study Description	Mean age, yr	Percentage Female	Mean Follow-up Time, mo
McQuivey et al.[7]	2020	III	Case-control	31.4	80.4	41
Grammatopoulos et al.[8]	2017	III	Case-control	40.9	70.2	54
Byrd et al.[11]	2018	IV	Case series	34.2	58.5	NR
Amar et al.[12]	2018	IV	Case series	43	40	36.2
Murtha et al.[13]	2021	IV	Case series	15.7	58	35.7
Giordano et al.[14]	2020	III	Cohort study	37.7	50	75.2
Lin et al.[15]	2021	III	Cohort study	43.1	69	74.2
Hevesi et al.[16]	2018	III	Cohort study	31.6	52.8	68.4
Maldonado et al.[17]	2018	III	Case-Control	26	81.1	24 (min)
Larson et al.[18]	2016	III	Cohort study	33.9	71	26
Martinez et al.[19]	2020	III	Cohort study	38.5	55	51
Chandrasekaran et al.[20]	2019	III	Cohort study	37.9	47	24 (min)
Lee et al.[21]	2019	IV	Case series	34.6	48.7	92.4
Larson et al.[22]	2019	IV	Case series	15.9	25	39.8
Duman et al.[23]	2020	IV	Case series	5.2	40	0.1
Mardones et al.[24]	2016	IV	Case series	63.4	NR	52.8
Hufeland et al.[25]	2016	IV	Case series	34.3	45.4	66.3
White et al.[26]	2018	III	Cohort study	32.6	79.3	48
Uchida et al.[27]	2016	III	Case-control	28.4	78.6	37.9
Domb et al.[28]	2016	II	Cohort study	36.3	54.5	28.8
Capogna et al.[29]	2016	IV	Case series	65.8	81	26.4
Beck et al.[30]	2021	III	Cohort study	35.1	71.3	60 (min)
Truntzer et al.[31]	2017	IV	Case series	NR	62.5	60 (min)
Mygind-Klavsen et al.[32]	2019	III	Cohort study	37.9	53	NR
Kaplan et al.[33]	2021	IV	Case series	39.4	68	76.5
Beaulé et al.[34]	2017	IV	Case series	39	49.8	30
Chenard et al.[35]	2020	III	Cohort study	39.4	62.3	24
Mercier et al.[36]	2019	III	Case-control	33	25.6	29.6
Haskel et al.[37]	2020	III	Cohort study	48.2	75.8	24
Dierckman et al.[38]	2017	IV	Case series	36.6	64	24
Gupta et al.39	2016	IV	Case series	38	61.7	29
Ricciardi et al.[40]	2017	III	Cohort study	25.5	91	18
Fagotti et al.[41]	2019	III	Cohort study	30.9	75	25
Bauwens et al.[42]	2021	IV	Case series	73.3	66.7	24
Bryan et al.[43]	2018	IV	Case series	33.4	85	58
Davies et al.[44]	2018	III	Case-control	44.5	73.6	24
Poehling-Monaghan et al.[45]	2017	III	Case-control	30.4	51	30
Kester et al.[46]	2020	III	Cohort study	41	45.6	48
Frank et al.[47]	2018	IV	Case series	31.3	62	24 (min)
Domb et al.[48]	2018	IV	Case series	22.9	89.5	68.8
Menge et al.[49]	2021	IV	Case series	16	70	144
Beck et al.[50]	2021	IV	Case series	17.6	76.5	60 (min)
Akpinar et al.[51]	2021	III	Cohort study	43.4	67	73.7
Akpinar et al.[52]	2021	IV	Case series	41.4	69	72.1
White et al.[53]	2020	III	Cohort study	43.7	80.7	50.4
Vahedi et al.[54]	2019	III	Case-control	32.6	NR	50.4
Maldonado et al.[55]	2020	III	Cohort study	24.2	65.1	65
Kaplan et al.[56]	2021	IV	Case series	38.1	59	32.4
Kester et al.[57]	2018	III	Case-control	35.8	55	24 (min)
Nakashima et al.[58]	2021	III	Cohort study	53.8	55	32.4
Slullitel et al.[59]	2020	III	Case-control	31	23	43
Brinkman et al.[60]	2020	IV	Case series	34.2	56	24 (min)
Hevesi et al.[61]	2019	III	Cohort study	34.5	40	58.8
Krych et al.[62]	2016	III	Cohort study	41	50	24 (min)
Baron et al.[63]	2020	III	Cohort study	NR	64.1	12 (min)
Comba et al.[64]	2016	IV	Case series	38	35.7	91
Li et al.[65]	2017	IV	Case series	36.3	45	57.6
Pierannunzii et al.[66]	2019	IV	Case series	34	40	37.5
Forster-Horvath et al.[67]	2021	IV	Case series	33.1	39.8	77
Lee et al.[68]	2020	IV	Case series	48	37.5	70.3
Hevesi et al.[69]	2018	III	Cohort study	32	66.7	68.4

(continued)

Table 1. Continued

Study	Publication Year	Level of Study	Study Description	Mean age, yr	Percentage Female	Mean Follow-up Time, mo
Johannsen et al.[70]	2021	II	Cohort study	33.6	NR	78
Hartig-Andreasen et al.[71]	2017	IV	Case series	36.1	95	42
Wolfson et al.[72]	2019	IV	Case series	40.2	64	50
Scott et al.[73]	2019	IV	Case series	NR	62.5	NR
Zusmanovich et al.[74]	2020	III	Cohort study	51.6	58.8	26.4
Beck et al.[75]	2019	III	Cohort study	33.7	72.3	24
Li et al.[76]	2017	III	Cohort study	38.9	14.5	36
Hatakeyama et al.[77]	2018	III	Case-control	31.4	66.7	42.5
Chahla et al.[78]	2019	III	Case-control	34.5	65.8	27.8
Scanaliato et al.[79]	2020	IV	Case series	30.4	56.6	24.3
Scanaliato et al.[80]	2018	III	Cohort study	36.5	58.1	24
Bloom et al.[81]	2021	III	Cohort study	36.1	57.7	24 (min)
Tissot et al.[82]	2017	IV	Case series	29.6	52.9	28
Suarez-Ahedo et al.[83]	2017	III	Cohort study	34.6	63.7	29
White et al.[84]	2016	III	Cohort study	34	72.6	31.2
Allahabadi et al.[85]	2020	IV	Case series	37.2	57	58.8
Degen et al.[86]	2017	IV	Case series	38	53.9	NR
Essilfie et al.[87]	2020	III	Cohort study	36.1	67	24 (min)
Nepple et al.[88]	2020	II	Cohort study	24.9	56.7	51.6
Nho et al.[89]	2019	III	Case-control	33.3	62.9	24 (min)
Haynes et al.[90]	2018	III	Cohort study	24.9	80	29.8
Rosinsky et al.[91]	2019	III	Cohort study	37	65.5	24 (min)
Haefeli et al.[92]	2017	IV	Case series	35	89	84
Bedard et al.[93]	2016	IV	Case series	NR	63.2	60

NR, not reported.

included as failure as well as any other subsequent ipsilateral hip surgery. The popularity of these definitions of failure (∼76% to 77%) likely derives at least in part from the ease with which they can be measured. Databases can be queried to determine these values without the need for time-intensive interactions with individual patients. In addition, subsequent procedures lead to increased financial costs, rehabilitation, morbidity, and risks to the patient. As most, if not all, of these subsequent surgeries are unplanned, it is intuitive to include them in the definition of failure. The difficulty with solely evaluating failure on the basis of a reoperation is related to the fact that it is often not known whether a reoperation is performed because of failure of the index procedure itself or if a new injury/trauma with similar pathology has now surfaced. In addition, focusing exclusively on conversion to THA may not accurately depict the initial success of the HA procedure and, instead, may indicate the expected progression of OA.

A substantial number of studies identified in this review highlight PROs as a measure of failure after HA. Evaluating and using self-reported outcomes as a determinant between success and failure is practical, because a common indication for HA is to improve pain and function. The mHHS was most frequently used, being involved in 21.2% (19/85) of included studies. Despite its popularity, there is heterogeneity to the ideal use for this scoring system in defining failure. For instance, approximately 50% (9/18) of studies that reported mHHS established a threshold of <70 to determine failure, whereas other studies used greater overall score thresholds.[27,43,45,55,66] The most common score threshold was <70, in reference to Harris.[94] It can be difficult to define a singular score threshold that indicates failure in all HA because of the potential differences in patient populations and their perception of postoperative outcomes. For instance, an athlete may meet the <70 score threshold but still have complaints of persistent pain, limiting their RTS or activity. Without a resolution of all symptoms, a reoperation may be indicated for this patient. Instead of score thresholds, some articles used the mHHS by comparing differences in pre- and postoperative scores.[7,12,13,17] All 4 studies cite Kemp et al.,[95] who suggest the MCID of at least 8 points on the mHHS. To provide a more categorical approach to PROs and better define the success or failure of a procedure, centered on the patient perspective, several systems have been developed. The MCID, SCB, and PASS are all values derived from PROs to better evaluate clinical outcomes.[96,97] These tools may provide a more realistic assessment of how patients performed postoperatively from a clinical perspective, and whether they benefited from surgery. They provide more context for how to interpret PRO values and are not reliant on a statistical significance but rather a clinical significance. Although specific values for the MCID, SCB, and PASS are unique to each

Table 2. Overall Failure Rates and Definitions of Failure by Study

Study	Overall Failure Rate	Failure Definition
McQuivey et al.[7]	32.4%	Failure to achieve MCID of mHHS or ipsilateral hip reoperation
Grammatopoulos et al.[8]	30.0%	Conversion to THA
Byrd et al.[11]	1.6%	Suture anchor pullout
Amar et al.[12]	9.0%	Improvement <10 points on mHHS or conversion to THA
Murtha et al.[13]	18.0%	Improvement <8 points on mHHS
Giordano et al.[14]	14.0%	Conversion to THA or hip resurfacing
Lin et al.[15]	40.3%	Revision hip arthroscopy or conversion to THA
Hevesi et al.[16]	21.5%	Ipsilateral hip reoperation
Maldonado et al.[17]	20.5%	Ipsilateral hip reoperation or below mHHS PASS
Larson et al.[18]	21.4%	mHHS <70 or subsequent pelvic/femoral osteotomy or conversion to THA
Martinez et al.[19]	0.0%	mHHS <70, or subsequent pelvic/femoral osteotomy or conversion to THA
Chandrasekaran et al.[20]	21.6%	Ipsilateral hip reoperation
Lee et al.[21]	2.4%	Conversion to THA
Larson et al.[22]	8.1%	mHHS <70 or subsequent pelvic/femoral osteotomy or conversion to THA
Duman et al.[23]	0.0%	Ipsilateral hip reoperation during same admission
Mardones et al.[24]	25.0%	mHHS <70 or revision hip arthroscopy or conversion to THA
Hufeland et al.[25]	10.8%	mHHS <70 or conversion to THA
White et al.[26]	15.5%	Ipsilateral hip reoperation
Uchida et al.[27]	32.1%	mHHS <85 or ipsilateral hip reoperation or TOA grade 2 or higher
Domb et al.[28]	14.6%	Revision hip arthroscopy or conversion to THA
Capogna et al.[29]	11.9%	Ipsilateral hip reoperation
Beck et al.[30]	6.3%	Revision hip arthroscopy or conversion to THA
Truntzer et al.[31]	10.5%	Revision hip arthroscopy or conversion to THA
Mygind-Klavsen et al.[32]	NR	Ipsilateral hip reoperation or lack or improvement in subjective outcomes
Kaplan et al.[33]	3.8%	Revision hip arthroscopy or conversion to THA
Beaulé et al.[34]	10.2%	Ipsilateral hip reoperation
Chenard et al.[35]	14.2%	Ipsilateral hip reoperation
Mercier et al.[36]	0.0%	Ipsilateral hip reoperation
Haskel et al.[37]	19.5%	Ipsilateral hip reoperation
Dierckman et al.[38]	7.9%	Conversion to THA or hip resurfacing
Gupta et al.39	17.0%	Revision hip arthroscopy or conversion to THA or change in NAHS <10
Ricciardi et al.[40]	NR	Hip pain did not resolve or returned within 5 years
Fagotti et al.[41]	22.0%	Ipsilateral hip reoperation
Bauwens et al.[42]	33.0%	Lack of improvement in hip pain and limping
Bryan et al.[43]	55.0%	mHHS <80 or ipsilateral hip reoperation
Davies et al.[44]	12.8%	Conversion to THA
Poehling-Monaghan et al.[45]	51.0%	mHHS <80 or ipsilateral hip reoperation
Kester et al.[46]	22.8%	Ipsilateral hip reoperation
Frank et al.[47]	0.0%	Revision hip arthroscopy or conversion to THA or persistent pain
Domb et al.[48]	19.0%	mHHS <70 or subsequent pelvic/femoral osteotomy or conversion to THA
Menge et al.[49]	10.0%	Revision hip arthroscopy
Beck et al.[50]	2.4%	Revision hip arthroscopy or conversion to THA
Akpinar et al.[51]	22.5%	Ipsilateral hip reoperation
Akpinar et al.[52]	24.7%	Revision hip arthroscopy or conversion to THA
White et al.[53]	11.2%	Ipsilateral hip reoperation
Vahedi et al.[54]	47.9%	Ipsilateral hip reoperation or persistent pain
Maldonado et al.[55]	9.4%	mHHS <80 or ipsilateral hip reoperation
Kaplan et al.[56]	NR	Revision hip arthroscopy or conversion to THA
Kester et al.[57]	9.6%	Ipsilateral hip reoperation or persistent pain
Nakashima et al.[58]	30.4%	mHHS <70 or conversion to THA
Slullitel et al.[59]	2.2%	Ipsilateral hip reoperation
Brinkman et al.[60]	6.0%	Revision hip arthroscopy or conversion to THA
Hevesi et al.[61]	0.0%	Ipsilateral hip reoperation
Krych et al.[62]	21.1%	Conversion to THA or abnormal or severely abnormal PROs
Baron et al.[63]	18.0%	Revision hip arthroscopy or conversion to THA
Comba et al.[64]	16.7%	Conversion to THA
Li et al.[65]	20.4%	mHHS <70 or ipsilateral hip reoperation
Pierannunzii et al.[66]	29.5%	Ipsilateral hip reoperation, satisfaction or NRS <7 or mHHS <90 or did not RTS
Forster-Horvath et al.[67]	22.9%	Revision hip arthroscopy, conversion to THA or NAHS <80
Lee et al.[68]	5.8%	Revision hip arthroscopy or conversion to THA
Hevesi et al.[69]	16.2%	Ipsilateral hip reoperation
Johannsen et al.[70]	16.1%	Revision hip arthroscopy

(continued)

Table 2. Continued

Study	Overall Failure Rate	Failure Definition
Hartig-Andreasen et al.[71]	21.0%	Conversion to THA
Wolfson et al.[72]	15.0%	Revision hip arthroscopy or conversion to THA
Scott et al.[73]	2.2%	Revision hip arthroscopy or conversion to THA
Zusmanovich et al.[74]	17.6%	Ipsilateral hip reoperation
Beck et al.[75]	1.6%	Ipsilateral hip reoperation
Li et al.[76]	12.7%	Conversion to THA
Hatakeyama et al.[77]	24.0%	Ipsilateral hip reoperation or TOA grade 2 or above
Chahla et al.[78]	2.8%	Revision hip arthroscopy or conversion to THA
Scanaliato et al.[79]	0.0%	Ipsilateral hip reoperation
Scanaliato et al.[80]	6.2%	Ipsilateral hip reoperation
Bloom et al.[81]	30.8%	mHHS <70 or ipsilateral hip reoperation
Tissot et al.[82]	17.6%	Persistence, aggravation or recurrence of pain.
Suarez-Ahedo et al.[83]	5.4%	Revision hip arthroscopy or conversion to THA or change in NAHS <10
White et al.[84]	17.3%	Ipsilateral hip reoperation
Allahabadi et al.[85]	5.3%	Conversion to THA
Degen et al.[86]	13.4%	Revision hip arthroscopy or conversion to THA or hip resurfacing
Essilfie et al.[87]	22.2%	Ipsilateral hip reoperation
Nepple et al.[88]	7.8%	Ipsilateral hip reoperation
Nho et al.[89]	3.6%	Revision hip arthroscopy or conversion to THA
Haynes et al.[90]	NR	Recurrent pain and symptoms leading to additional hip preservation procedure
Rosinsky et al.[91]	7.2%	Revision hip arthroscopy or conversion to THA or persistent pain
Haefeli et al.[92]	19.0%	Conversion to THA, progression of OA or Merle d'Aubignéscore <15 points
Bedard et al.[93]	5.3%	Conversion to THA

mHHS, modified Harris hip score; NAHS, Non-Arthritic Hip Score; MCID, minimal clinically important difference; NR, not reported; NRS, numeric rating scale; OA, osteoarthritis; PASS, patient acceptable symptom state; SCB, substantial clinical benefit; THA, total hip arthroplasty; TOA, Tönnis Osteoarthritis Scale.

PRO, these tools frequently have been used to assess outcomes after many other types of procedures as well and have been beneficial.[98-102] As these tools provide insight as to whether meaningful improvement has occurred postoperatively, it would be advantageous to consider their use in defining failure after HA.

For athletic populations, RTS after a procedure is a vital part of the recovery and rehabilitation process. This is evident across numerous sports and pathologies and holds true for patients undergoing HA as well.[103-106] Therefore, RTS is another important element when defining HA failure in athletes. However, there is great complexity when considering the inclusion of RTS as a factor in defining failure. There are numerous reasons that an athlete may not RTS, many of which are not a direct result of an HA procedure. Patients may be able to return to their sport or activity but elected not to because of lack of interest. It is also possible the patient could not reach the same level of sport they participated in before their injury or have the adequate skills to compete at a higher level, such as in college athletics. Situations such as these should not be considered an HA failure. For athletes who do not RTS who would otherwise have an opportunity and desire to play but are unable to as a result of continued hip pain or dysfunction may be considered as an HA failure. Given the complex and multifactorial nature of the RTS process, it is important to further evaluate this patient population and subclassify on the basis of reason for not returning to sport rather than simply considering

Table 3. Different Failure Criteria Using mHHS

Specific mHHS Criteria	Number of Studies	Percentage of Papers Using mHHS	Percentage of All Included Articles
mHHS <70	9	50%	10.6%
mHHS <80	3	16.7%	3.5%
mHHS <85	1	5.6%	1.2%
mHHS <90	1	5.6%	1.2%
Failed to achieve MCID using mHSS*	1	5.6%	1.2%
Failure to achieve PASS using mHSS	1	5.6%	1.2%
Less than 10-point improvement in mHHS	1	5.6%	1.2%
Less than 8-point improvement in mHHS	1	5.6%	1.2%
Total	18		20%

MCID, minimal clinically important difference; mHHS, modified Harris hip score; PASS, patient acceptable symptom state.

*No mHHS definition of MCID was specifically reported in the article.

anyone who does not RTS as a failure. Overall, high rates of RTS have been demonstrated in the literature after HA. Frank et al.[47] demonstrated an exceedingly high percentage of competitive swimmers returning to their sport after femoral osteochondroplasty for treatment of femoroacetabular impingement. Scanaliato et al.[79] also provided promising results in athletes of many sports after HA.

Failure rates varied widely not only depending on the definition used for failure but also among studies that used some of the same terminology to define failure. Studies that included an ipsilateral hip reoperation, subsequent THA, pain, or used mHHS scores each had failure rates that ranged from 0% to nearly 50% or more. Given the heterogeneity of the patient populations as well as the pathologies treated in the varying studies, this likely contributed at least in part to the significant differences observed in the overall failure rates. It has previously been demonstrated that older age is a risk factor for reoperation after HA and would be more likely to convert to THA.[86] In addition, given that many of these definitions are combined together to generate an overall definition for failure, it is difficult to discern whether there is one specific category that seems to be driving the greater failure rates or may account for a majority of the failures reported in the literature. Of the 85 studies included, 47 studies used multiple definitions of failure whereas 38 studies used a single definition of failure. Among studies that only included a single definition of failure, many used ipsilateral hip reoperation as the definition of failure, which may be viewed as a more generalized definition of failure compared with defining a more specific revision reoperation. When only a single definition of failure is used, regardless of the definition, there was a 0% to 33% overall failure rate compared with a 0% to 55% failure rate when more than 1 definition was considered. This is intuitive, as if there are multiple factors in play that result in failure, then it is more difficult for a patient to pass each of the multiple criteria for failure rather than a single factor. Considering multiple factors in the definition of failure likely provides a better overall assessment of a patient's outcome and should be used rather than focusing on one specific outcome.

Overall, the authors believe that the best definition of failure of HA is multifactorial in nature. Any subsequent unplanned operation involving the pathology addressed in the index procedure should be included in the definition of failure. Outcomes that preclude patients from returning to reasonable function postoperatively are also an important component. This includes poor physical function or significant continued pain detailed in PROs as well as significant complications that occurred that limit function. We recommend surgeons use PROs with an emphasis on using MCID, SCB, and/or PASS values to identify failures. For athletic populations, if a patient does not RTS, the specific reason for not returning to sport should be elucidated and further classified. Only those who would otherwise have an opportunity and desire to play but are unable to as a result of continued hip pain or dysfunction should be considered as an HA failure. Although our recommendations will inherently increase "failure" rates among patients, it is important to use this knowledge to properly counsel patients about realistic outcomes after arthroscopic hip surgery. Using our recommendation for failures will equip surgeons with a better understanding of the risks, benefits, and consequences of HA, allowing for better education and expectations for patients.

Limitations

There are some limitations noted in this study. There was substantial heterogeneity in the studies included for this systematic review. HA encompasses numerous potential operations and therefore a broad array of procedure types with varying aims was included. These differing goals of surgery may have contributed to the heterogeneity of failure definitions. Patient populations also varied significantly among studies including age. With reoperations being the most commonly reported definition of failure, the patient population may have an effect on failure rates and the definitions included in some studies. Lastly, the follow-up period varied significantly between included studies or was not always clearly reported. Studies with longer follow up may have had greater time for failure to occur, impacting failure rates and what defined failure.

Conclusions

There are numerous definitions of the term "failure" of HA used by authors in the peer-reviewed literature. A standardized definition of HA failure should be multifactorial. It may include any unplanned subsequent procedures, PROs with emphasis on MCID, SCB, and/or PASS values, and the inability to return to normal function or sports.

Disclosures

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: S.M. reports consulting or advisory for Arthrex. B.V. reports consulting or advisory for Artelon and Stryker Orthopaedics; equity or stocks with Carbon 22, Spinal Simplicity, and Altior; and board membership, the American Orthopaedic Foot and Ankle Society. E.H. reports equity or stocks with Johnson & Johnson. L.A. reports equity or stocks with Johnson & Johnson and Stryker. All other authors (C.B.D., E.B., M.T., R.L., P.S., J.W., A.T.) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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