Journal of Hip Preservation Surgery Vol. 7, No. 1, pp. 62–69
doi: 10.1093/jhps/hnz074
Advance Access Publication 3 February 2020
Research article

A tiered system using substantial clinical benefit and patient acceptable symptomatic state scores to evaluate 2-year outcomes of hip arthroscopy with the Hip Outcome Score

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Submitted 5 September 2019; Revised 24 December 2019; revised version accepted 27 December 2019

ABSTRACT

There is no information to define variations in hip arthroscopy outcomes at 2-year follow-up using the Hip Outcome Score (HOS). To offer a tiered system using HOS absolute substantial clinical benefit (SCB) and patient acceptable symptomatic state (PASS) scores for 2-year hip arthroscopy outcome assessment. This was a retrospective review of patients having hip arthroscopy for femoroacetabular impingement and/or chondrolabral pathology. On initial assessment and 2 years (±2 months) post-operatively, subjects completed the HOS activity of daily living (ADL) and Sports subscales, categorical self-rating of function and visual analog scale for satisfaction with surgery. Receiver operator characteristic analysis identified absolute SCB and PASS HOS ADL and Sports subscale scores. Subjects consisted of 462 (70%) females and 196 (30%) males with a mean age of 35.3 years [standard deviation (SD) 13] and mean follow-up of 722 days (SD 29). SCB and PASS scores for the HOS ADL and Sports subscales were accurate in identifying those at a 'nearly normal' and 'normal' self- report of function and at least 75% and 100% levels of satisfaction (area under the curve >0.70). This study provides tiered SCB and PASS HOS scores to define variations in 2-year (±2 months) outcome after hip arthroscopy. HOS ADL subscale scores of 84 and 94 and Sports subscale scores of 61 and 87 were associated with a 'nearly normal' and 'normal' self-report of function, respectively. HOS ADL subscale scores of 86 and 94 and Sports subscale score of 74 and 87 were associated with being at least 75% and 100% satisfied with surgery, respectively. Level of evidence: III, retrospective comparative study.

INTRODUCTION

Outcome assessment in orthopedic surgery continues to evolve with an interest in the interpretation of scores obtained from patient-reported outcome measures (PROM) [1–4]. Studies have found that while desired outcome may be achieved within 6 months, improvements may continue for at least 2 years [5, 6]. This supports a 2-year follow-up as the acceptable time period to report on surgical outcomes. The Hip Outcome Score (HOS) is a PROM commonly used to assess the outcomes of hip arthroscopy for femoroacetabular impingement (FAI) and/or chondrolabral pathology, with procedures that include osteoplasty, labral repair/debridement and labral reconstruction [3, 7–10]. In a study that looked at the psychometric properties of commonly used PROMs after arthroscopic FAI surgery, only pre-operative HOS scores were found to be predictive of patient outcomes [11, 12]. While there is evidence to support the interpretation of scores obtained from the HOS [7, 11–18], there is no information to interpret scores and define variations in outcome at a 2-year post-operative follow-up interval. A tiered system to evaluate variations in 2-year outcome could be useful in health care systems that rely on 'value-based care' and 'merit-based incentive payment systems' to dictate reimbursement [1, 19, 20].

Determining if a patient has improved in their daily activities using scores obtained from PROMs can be done with minimal clinically important difference (MCID), patient acceptable symptomatic state (PASS) and substantial clinical benefit (SCB) values [15, 21–24]. MCID is defined as a change in outcome that represents the lowest improvement from pre-operative status that the patient perceives as important [2, 23, 25]. Whereas MCID is the minimal acceptable goal for clinical benefit [25, 26] change score for SCB represents an improvement in outcome from pre-operative status that the patient considers to be a considerable or substantial [11, 21]. There are also absolute scores to define SCB and PASS values that can be used as standalone assessments [11]. An absolute SCB score represents a health status that the patient would consider as excellent, while a PASS score is defined as a satisfactory outcome [27]. A disadvantage of the MCID is that it cannot be used as a standalone value. Also, MCID is typically determined using a statistical calculation and may be difficult to interpret due to variability in calculation methods [28]. PASS and SCB values seek to determine how meaningful the change in status is to the patient and represent the intermediate and upper threshold for clinically significant improvement, respectively [15]. A tiered approach may establish specific values that define degrees of normalcy and satisfaction in outcome from the patient's perspective. A single PASS score only represents whether the patient is satisfied or not with their outcome and does not give information about the level of satisfaction. Similarly, a single SCB value does allow for defining variations in how close the patient may be too normal. Absolute PASS and SCB values are available to interpret HOS activities of daily living (ADL) and Sports subscale scores at a 1-year outcome interval following hip arthroscopy [11, 13–15]. At 1-year post-hip arthroscopy for FAI, absolute PASS and SCB values for the HOS ADL subscale were found to be 87 and 93, respectively [11, 13]. PASS and SCB values for the HOS Sports subscale at 1-year were found to be 75 and 84, respectively [11, 13]. These single values do not define variations in outcome related to the patient's perception of normalcy and satisfaction with their outcome. A tiered approach that establishes a number of stratified outcome scores to describe the degree of normalcy and satisfaction may be useful.

The purpose of this study was to offer a tiered system using absolute SCB and PASS scores for the HOS ADL and Sports subscales to assess post-operative outcomes of hip arthroscopy for FAI and/or chondrolabral pathology at a 2-year outcome interval. It was hypothesized that absolute SCB scores for the HOS ADL and Sports subscales would be accurate in identifying those at a 'nearly normal' and 'normal' self-report of function and PASS scores would be accurate in identifying those reporting being at least 75% and 100% satisfied with their surgery at a 2-year post-operative follow-up interval.

MATERIALS AND METHODS

This was a retrospective review of prospective collected data maintained in a secure electronic registry. The registry consisted of patients of seven independent surgeons who consented to undergo hip arthroscopy at one of seven centers between January 2015 and April 2017. Inclusion criteria specific to this study included subjects who underwent primary hip arthroscopy for FAI and/or chondrolabral pathology with pre-operative PROM available. Patients with dysplasia ($<20°$ lateral center edge angle) or borderline dysplasia ($20°$–$25°$) lateral center edge angle were included in the study, at the surgeons' discretion. Revision surgeries were excluded. The follow-up data were required to be collected 2-year ($\pm$ 2 months) post-surgery. Exclusion criteria included conditions contra-indicated for arthroscopic hip surgery, such as those with primary lumbopelvic pathology or hip arthrosis (>Tonnis 1). An inability to read or understand English was also exclusion criteria for the registry. Data were collected and entered into the registry by the surgeon or clinical-research support personal. An investigator assessed data and applied the

inclusion and exclusion criteria for this study. The pre-hoc collection and storage of agreed upon clinical data points was granted according to individual institutional requirements and Institutional Review Board approval granted to review the de-identified registry of patient data.

Pre-operatively subjects were given PROM that included the HOS ADL and Sports subscales and a categorical self-rating of function to complete. For 2-year (± 2 months) follow-up data collection, subjects were emailed the HOS subscales, self-rating of current function and post-operative satisfaction visual analog scale (VAS) to complete between 670 and 790 days after surgery. The self-rating of function consisted the following question: 'How would you rate your current level of function?' The subjects had the following categorical responses to choose from: 'severely abnormal', 'abnormal', 'nearly normal' or 'normal'. The post-operative satisfaction VAS considered the following questions: 'What is your overall satisfaction with your surgery?' and was scored using a 100 mm horizontal line with the anchors defined as '0% satisfied' (0 mm) and the '100% satisfied' (100 mm). Demographic information was recorded from the electronic registry.

Psychometric analysis

Absolute SCB and PASS scores were calculated with anchor-based methods in similar fashion to that previously described [11, 12, 15, 29]. Absolute post-operative SCB and PASS scores were calculated with receiver operator characteristic (ROC) analysis calculating the area under the curve (AUC) at a 95% confidence interval (95% CI) [30, 31]. Absolute post-operative SCB scores were calculated to determine a score that would be associated with a self-report of being 'nearly normal' and a score associated with a self-report of being 'normal'. PASS scores were calculated to determine a score that would be associated with a patient report of being at least 75% satisfied (≥75 mm) and a score associated with being 100% satisfied (100 mm) with surgery. The AUC of the ROC analysis defines the strength of association and the accuracy of the score in distinguishing between groups [31]. An AUC >0.7 and a 95% CI that does not contain 0.5 are considered acceptable levels of responsiveness [31–33]. Youden's Index was used to optimize sensitivity and specificity values to identify HOS scores that are likely to represent a patient who reports the following: (i) 'nearly normal' function; (ii) 'normal' function, (iii) being at least 75% satisfied with surgery and (iv) 100% satisfied with surgery [34]. Demographic and outcome information, including mean 2-year HOS ADL and Sports subscales score for those with age >50 years, body mass index (BMI) >30 and Tonnis grade >0, as well as scores for males and females, were determined. Statistical analysis was performed using the SPSS software package (Version 24, SPSS Inc., Chicago, IL, USA).

RESULTS

Participants

Out of 723 eligible patients, 658 (91%) subjects met the inclusion criteria for this study and had follow-up outcome data available for analysis (Fig. 1). The mean follow-up time was 722 [standard deviation (SD) 29] days. Demographic information, including age, sex, BMI, diagnosis and procedures performed are presented in Table I. A total of 518 (77%) subjects had more than one procedure performed during hip arthroscopy, with femoroplasty and labral repair being the most common combination.

Psychometric results

Mean pre-operative and 2-year post-operative HOS scores, pre-operative and post-operative rating of function and those reporting at least 75% and 100% satisfaction with their surgery are presented in Table II. The results of the ROC analysis for absolute HOS ADL and Sports subscale scores associated with a 'nearly normal' and 'normal' ratings of function, and PASS scores for those reporting at least 75% and 100% satisfaction with their surgery are

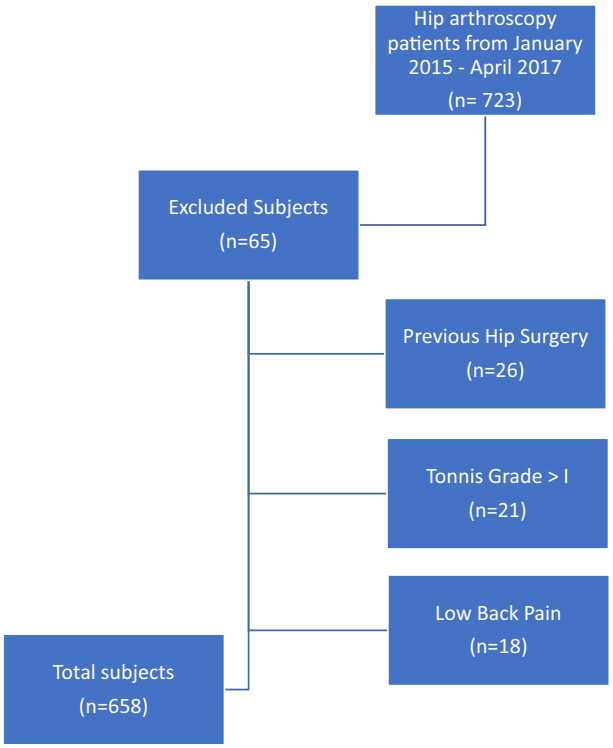

Fig. 1. PRISMA flowchart .

Table I. Subject demographics

Mean age	*35.3 years (SD 13)*
Sex	Female 462 (70%)
Mean BMI	Male 196 (30%) 25.3 (SD 10)
Diagnosis	
Labral pathology	612 (93%)
Femoroacetabular impingement	494 (75%)
Procedures performed	
Femoroplasty	427 (65%)
Labral repair	417 (63%)
Synovectomy	387 (59%)
Acetabuloplasty	263 (40%)
Acetabular chondroplasty	226 (34%)
Labral debridement	149 (23%)
Femoral chondroplasty	113 (17%)
Labral reconstruction	46 (7%)

SD, standard deviation; BMI, body mass index.

Table II. Pre- and post-operative HOS, rating of function and satisfaction with surgical outcome

	Pre-operative	*2-Year post-operative*
Mean HOS ADL	64 (SD 17)	86 (SD 17)
Mean HOS sports	39 (SD 21)	73 (SD 27)
Rating of function		
Normal	$N = 5$ (1%)	$N = 263$ (40%)
Nearly normal	$N = 114$ (17%)	$N = 265$ (40%)
Abnormal	$N = 416$ (63%)	$N = 117$ (18%)
Severely abnormal	$N = 98$ (15%)	$N = 13$ (2%)
Missing	$N = 25$ (4%)	
Overall satisfaction with surgery		
At least 75% satisfied		$N = 461$ (70%)
100% satisfied		$N = 224$ (35%)

ADL, activities of daily living; SD, Standard deviation.

presented in Table III. Absolute SCB and PASS scores for the HOS ADL and Sports subscales were accurate in identifying those at a 'nearly normal' self-report of function, least 75% satisfied, 100% satisfied and a 'normal' self-report of function at a 2-year (± 2 months) follow-up period as the AUCs were >0.70 with 95% CIs not containing 0.5. Mean 2-year (± 2 months) HOS ADL and Sports subscales score for those with age >50 years, BMI >30 and Tonnis grade >0 as well as scores for males and females are presented in Table IV.

DISCUSSION

The most important finding from this study is the tiered absolute SCB and PASS HOS scores that can be used to evaluate 2-year (± 2 month) outcomes in patients following hip arthroscopy for FAI and chondrolabral pathology. HOS ADL subscale scores of 84 and 94 and Sports subscale score of 61 and 87 were associated with a 'nearly normal' and 'normal' self-report of function, respectively. HOS ADL subscale scores of 86 and 94 and Sports subscale score of 74 and 87 were associated with being at least 75% and 100% satisfied with surgery, respectively. The hypothesis of this study was supported as these values were associated with a high degree of accuracy. Clinically this tiered approach may be useful as stratified HOS scores have been defined to help describe the magnitude of the normalcy and level satisfaction.

There has been increased interest in a 'value-based care' and 'merit-based incentive payment systems' in the United States [1]. In order to assess post-operative patient outcomes, a tiered evaluation system has been suggested to better reward value [1]. PROMs are a direct measure of outcome from the patient perspective and, therefore, offer important insight into improvement and health care value. This study provides absolute SCB scores for what a patient would perceive as 'nearly normal' and 'normal' function as well as PASS scores for being at least 75% and 100% satisfied with surgery. Because absolute SCB and PASS values are each associated with limitations and not mutually exclusive, outcomes may be best interpreted when multiple scores are used in combination to assess for variations in outcome [1]. The absolute SCB and PASS scores defined in this study may also provide a way to grade a range of meaningful outcomes and be helpful in managing patient expectations [14]. SCB may best represent the functional domain where PASS represents satisfaction in outcome. PASS may, therefore, be more dependent on factors, such as pre-treatment expectations as well as psychosocial and cultural issues [27]. As expected Sports subscale absolute SCB and PASS scores were lower than ADL subscale scores and a report of 'nearly normal' was lower than 75%

Table III. Two-year absolute SCB and PASS values for the HOS ADL and Sports subscales

	Score	*Sensitivity*	*Specificity*	*AUC (95% CI)*
HOS ADL				
SCB nearly normal	84	0.86	0.86	0.92 (0.90–0.94)
PASS 75% satisfied	86	0.85	0.74	0.87 (0.85–0.90)
PASS 100% satisfied	94	0.78	0.75	0.82 (0.79–0.85)
SCB Normal	94	0.81	0.86	0.82 (0.79–0.85)
HOS sports				
SCB nearly normal	61	0.88	0.88	0.94 (0.92–0.96)
PASS 75% satisfied	74	0.81	0.78	0.87 (0.84–0.90)
PASS 100% satisfied	87	0.76	0.76	0.83 (0.80–0.86)
SCB normal	87	0.81	0.83	0.89 (0.86–0.92)

AUC, area under the curve; CI, confidence interval.

Table IV. Average mean two-year HOS ADL and Sports subscale scores for those with age >50 years, BMI >30 and Tonnis grade >0 as well for males and females

	2-Year mean HOS	
	ADL	*Sports*
Age >50 years	78 (SD 26)	60 (SD 33)
BMI >30	80 (SD 21)	65 (SD 29)
Tonnis grade >0	80 (SD 21)	68 (SD 25)
Female	86 (SD 17)	73 (SD 27)
Male	86 (SD 18)	73 (SD 27)

SD, standard deviation.

satisfaction. However, it was expected an absolute SCB score for 'normal' function would be higher than being 100% satisfied with surgery. The demographics of the patients in this study, including a mean younger age, may explain why the patients seemed to equate 100% satisfaction with a complete return to a normal level of function.

The approximate 2-year follow-up time period used in this study has several important implications for health care policy and research. Previous studies found patients who undergo hip arthroscopy may show improvement for at least 2-year post-surgery [5, 6]. Specifically, Nwachukwu *et al.* [5] found while desired outcome may be achieved within 6 months, improvements may continue for at least 2 years. As the US health care system has shifted toward 'value-based care' and 'merit-based incentive payment systems', a tiered system may become important to evaluate PROM scores and outcomes over a period that allows a patient to achieve maximal improvement. Absolute SCB and PASS scores have been defined for the HOS at a 1-year post-operative follow-up period [11, 13–15]. A summary of the results from these studies are presented in Table V. This current study found the HOS ADL and Sports subscales PASS values for being 100% satisfied and SCB values for 'normal' function at 2-year follow-up were similar to the SCB of 'much improved' for primary FAI at 1-year follow-up. The HOS ADL and Sports subscale PASS values for being 75% satisfied found in this current study were similar to the PASS score found using the question 'current state is satisfactory?' Given the SCB and PASS values seem similar between the 1- and 2-year follow-up periods, future research may look to identify patient characteristics that could be used to identify those who are likely to improve, remain the same, or decline in status over time.

The mean HOS ADL and Sports subscales scores for the subjects in this study, of 86 and 74, respectively met the PASS score for being 75% satisfied. Subjects with an age >50, BMI >30 and Tonnis grade >0 had lower mean 2-year (± 2 months) HOS ADL and Sports subscale scores with scores not meeting the PASS score for being 75% satisfied. This agrees with previous studies that found age, chondral status and arthritis to effect SCB values in hip arthroscopy [35–41]. Revision surgery is known to affect SCB values [15]. Because of these subjects with

Table V. One-year follow-up absolute SCB and PASS values for Hip Outcome Score ADL and Sports subscales

Authors		*Anchor*	*ADL*	*Sports*
Nwachukwu *et al.* [14]	SCB for primary FAI in adolescents	'Much improved'	99	97
Nwachukwu *et al.* [11]	SCB for primary FAI	'Much improved'	93	84
Nwachukwu *et al.* [15]	SCB for revision hip arthroscopy	'Much improved'	88	86
Chahal *et al.* [13]	PASS for primary FAI	'Current state satisfactory'	87	75

revision surgery were excluded as not to confound the results of those undergoing primary hip arthroscopy. A tiered system for those undergoing revision hip arthroscopy could be investigated in further studies. The study did not analyse radiographic information, such as center edge angle[42], which also may play a role in outcome. As there is some controversy as to the effect of sex on outcome [5, 43–45], it was interesting that males and females had identical mean 2-year (± 2 months) HOS ADL and Sports subscale scores. In addition to age, BMI, chondral damage, arthritis, previous surgery, sex, radiographic findings, as well as other factors, such as smoking and mental health status should be investigated to see how they may directly alter the interpretation of SCB and PASS values [46, 47].

Limitations

While this study represents a large multicenter study, there are a number of limitations that need to be acknowledged. These findings are only applicable to English speaking patients who underwent surgery for FAI and/or chondrolabral pathology at a 2-year (± 2 months) follow-up period. This study is also limited to the anchor-based questions and response for self-reported level of function and VAS for post-operative satisfaction used. Other methods to determine SCB and PASS values may provide different results. Additionally, only subjects with complete data sets were included and a majority of subjects were female which could introduce bias and affect the results. It also should be noted absolute SCB and PASS scores are only estimates and will have some error associated with them. A description of PASS and SCB values were intended to be at a 2-year follow-up time period. However, the average response was slightly <2 years as subjects had a 2-month window before and after their 2-year post-operative date to complete their PROM information. Finally, the HOS is only one of several PROMs that have been used for hip pathology. Although the HOS has been the subject of rigorous psychometric evaluation, there are other PROMs suitable for a population following hip arthroscopy for FAI.

CONCLUSION

This study provides tiered absolute SCB and PASS HOS scores that can be used to evaluate 2-year (± 1 month) outcomes in patients following hip arthroscopy for FAI and chondrolabral pathology. HOS ADL subscale scores of 84 and 94 and Sports subscale scores of 61 and 87 were associated with a 'nearly normal' and 'normal' self-report of function, respectively. HOS ADL subscale scores of 86 and 94 and Sports subscale score of 74 and 87 were associated with being at least 75% and 100% satisfied with surgery, respectively.

CONFLICT OF INTEREST STATEMENT

None declared.

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