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Systematic Review & Meta-Analysis

Outcomes of Nonoperative Management, Iliopsoas Tenotomy, and Revision Arthroplasty for Iliopsoas Impingement after Total Hip Arthroplasty: A Systematic Review

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ABSTRACT

Background: Nonoperative and operative management of iliopsoas impingement (IPI) is commonly performed following total hip arthroplasty (THA). The purpose of this systematic review is to compare patient-reported outcomes (PROs) following conservative treatment, iliopsoas (IP) tenotomy, and revision arthroplasty in patients presenting with IPI after THA.

Methods: The PubMed and Embase databases were searched for articles regarding IPI following THA. Studies were included if (1) IPI after THA was treated with conservative management, an IP tenotomy, or acetabular component revision and (2) included PROs.

Results: Eleven articles were selected for review and there were 280 hips treated for IPI following THA. Harris Hip Scores reported for the conservative group, the IP tenotomy group, and the cup revision group were 59.0 preoperatively to 77.8, 58.0 preoperatively to 85.4, and 58.1 preoperatively to 82.4 at latest follow-up, respectively. The IP tenotomy cohort also demonstrated superior postoperative functional outcomes using the Western Ontario and McMaster Universities Index, Medical Research Council score, Oxford Hip Score, and Merle d'Aubigné-Postel Pain Score. Patients who had a revision exhibited higher Oxford Hip Scores, higher Medical Research Council scores, and lower Visual Analog Scale Pain scores postoperatively.

Conclusion: Management of IPI following THA includes nonoperative measures, IP tenotomy, or acetabular component revision. Patients have been shown to experience favorable PROs at latest follow-up, with an apparent advantage for surgical treatment. Compared to revision arthroplasty, IP tenotomy resulted in a lower overall rate of complications with less severe complication types. Therefore, IP tenotomy should be considered as a second line of treatment for patients who failed conservative measures. Revision arthroplasty should be reserved for recalcitrant cases.

Level of Evidence: IV.

Total hip arthroplasty (THA) is a commonly performed and highly successful procedure for alleviating hip pain and improving quality of life for patients with degenerative joint disease of the hip [1–3]. However, this gold standard procedure is not without limitations. When a patient presents with postoperative pain after hip arthroplasty, it is best to follow a structured algorithm to determine an underlying etiology. As described by Brown et al, the "four I's" encompass potential causes of postoperative pain following joint arthroplasty [2–4]. The four I's stand for wrong indication, postoperative infection, instability, and soft tissue impingement. Iliopsoas impingement (IPI), a subcategory of soft tissue impingement (the fourth I), has been found to affect up to 4.3% of patients who undergo THA [5–7].

Several etiologies have been identified as causing mechanical irritation to the iliopsoas (IP) in patients who underwent THA, including a protruding screw, cement extrusion, or malposition of

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the acetabular component [6,8–11]. Clinical findings of IPI include groin pain, aggravated by active hip flexion or passive extension [8,12]. At times, IPI may manifest as significant IP bursitis, palpable at the level of the inguinal ligament [6]. Conservative treatment includes rest, analgesics, nonsteroidal anti-inflammatory drugs, and physical therapy. In addition, injections of a local anesthetic and corticosteroid into the IP tendon sheath may serve as both a diagnostic and a therapeutic tool [13]. Patients who are refractory to conservative treatment may proceed to surgical treatment which includes IP tenotomy and acetabular component revision, depending on whether a mechanical abnormality causing the IPI was identified or not [14]. Literature supports a relationship between large femoral heads and dual-mobility cups with IPI following THA [15]. With the rise in use of dual-mobility implants, we suspect there will be an increase in the incidence of IPI following THA. There is limited literature regarding outcomes of IPI following THA, and to our knowledge, this is the first systematic review to compare outcomes of conservative treatment, IP tenotomy, and acetabular component revision in patients presenting with IPI after THA. The purpose of our study is to analyze the respective patient-reported outcomes (PROs) to refine the decision-making process of treating IPI following THA.

Methods

Search Strategy

The PubMed and Embase databases were searched for articles regarding IPI following primary or revision arthroplasty (THA) in March 2019. The search was conducted according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) guidelines [16]. The following search algorithm was used: ((((“Arthroplasty”[Mesh]) OR “Arthroplasty, Replacement, Hip”[Mesh]) OR “Arthroplasty, Replacement”[Mesh])) AND iliopsoas.

Two reviewers (J.S., P.J.R.) independently reviewed the titles and abstracts to select relevant articles. Both reviewers then determined eligibility by reviewing the full text, and if any disagreements were met, a third reviewer (x.x.x.) helped reach consensus. The bibliographies of these articles were also reviewed for relevant studies. Studies were included if (1) IPI after THA was treated with conservative management, IP tenotomy, or acetabular component revision and (2) included analysis of PROs. Studies were excluded if their reported outcomes did not differentiate between patients

Table 1
MINORS Score and Level of Evidence (LOE).

Study (First Author, Year)	MINORS Score	LOE
Batailler et al [18], 2017	15	IV
Chalmers et al [19], 2017	14	III
Di Benedetto et al [20], 2019	12	IV
Dora et al [10], 2007	12	IV
Filanti et al [21], 2016	12	IV
Gedouin and Huten [22], 2012	9	IV
Guicherd et al [23], 2017	14	IV
Nunley et al [24], 2010	14	IV
O'Sullivan et al [12], 2007	13	IV
Schoof et al [25], 2017	9	IV
Van Riet et al [26], 2011	11	IV

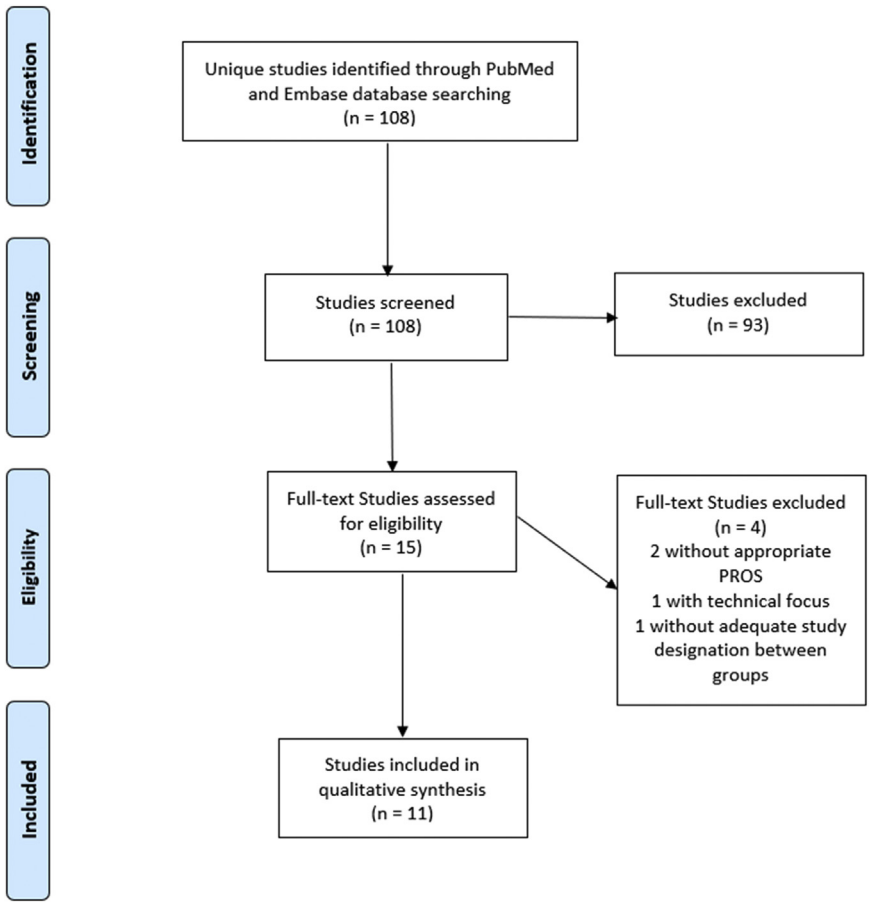

Fig. 1. PRISMA Flow Diagram. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-analyses.

who underwent IP tenotomy and patients who underwent revision after THA. In addition, case reports, reviews, imaging studies, cadaveric studies, and studies not published in the English language were excluded from our analysis.

Selected studies were reviewed for patient demographics, mean follow-up time, surgical treatment, PROs, and complication rates. Preoperative physical examination findings and preoperative radiographic measurements were also noted.

Quality Assessment

Three authors (J.S., P.J.R., A.C.L.) independently assigned scores to the chosen studies based on the validated Methodological Index for Non-randomized Studies criteria [17]. This scoring system included an assessment of the purpose of the study, the end points in the study, its follow-up percentages, and the nature of its data collection [17]. A consensus was reached on any differences in scoring and level of evidence. A full-text review of all articles that met the inclusion criteria was performed to determine age, follow-up period, time to revision, number of hips undergoing conservative treatment, IP tenotomy, and revision arthroplasty surgery. Preoperative PROs, if present, and postoperative PROs were noted. Most included studies were, by design, nonrandomized case series without a control group. Of the 11 selected studies, the average Methodological Index for Non-randomized Studies score was 12.3 (Table 1).

Statistical Analysis

Postoperative PROs were summarized and presented in our analysis. Specifically, for studies which used the same postoperative PROs, weighted averages for each of the 3 treatment groups were calculated using Microsoft Excel (Microsoft, Redmond, WA). These average PROs were weighted by the number of hips included in each analysis. Additionally, the proportion of patients who achieved the literature values for the minimal clinically important difference (MCID) and patient acceptable symptomatic state (PASS) for Harris Hip Score (HHS; the most commonly reported PRO) was reported [27]. For this analysis, we used the threshold values for the modified Harris Hip Score (mHHS), as literature states that there is no statistically significant or clinically meaningful difference between HHS and mHHS [28].

To compare the effect size of the interventions (conservative, tenotomy, and revision), the standardized mean difference (SMD) was calculated in the method described by Griffin et al [29] if preoperative, postoperative, and variance data were available. The

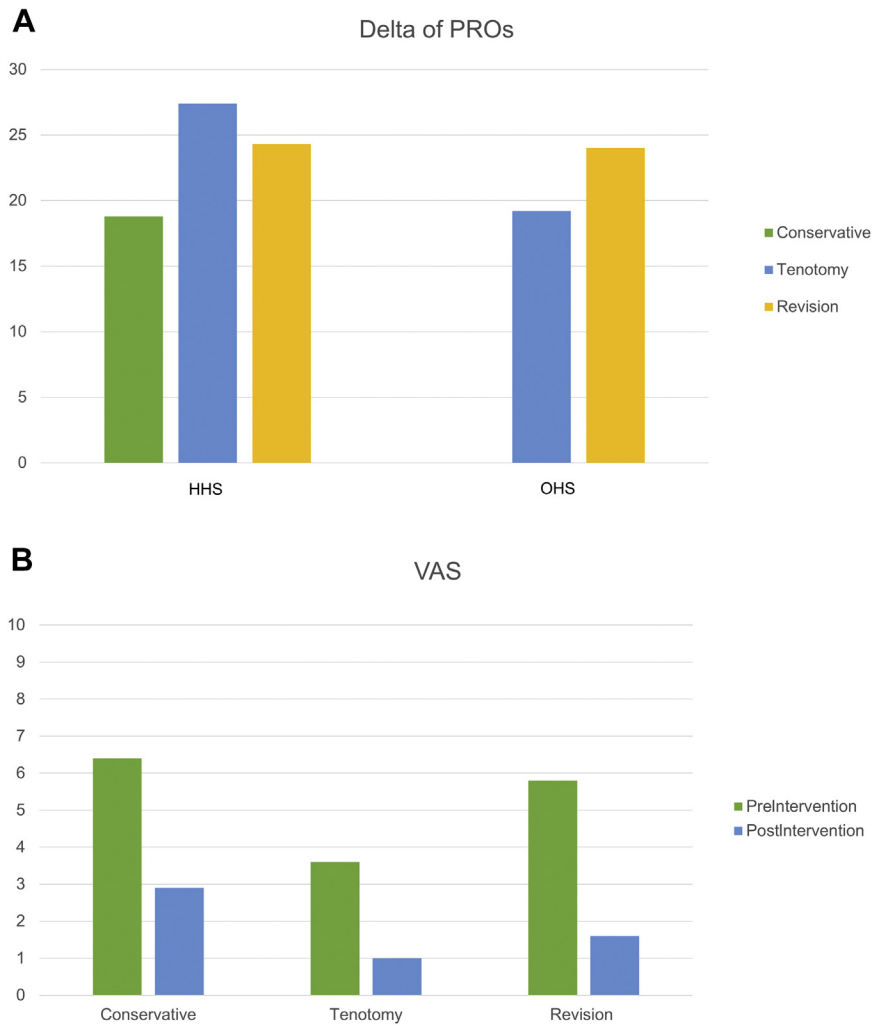

Fig. 2. (A) Average patient-reported outcome (PRO) improvement. HHS, Harris Hip Score; OHS, Oxford Hip Score. (B) PRO improvement. VAS, Visual Analog Pain Scale on a 0-10 scale.

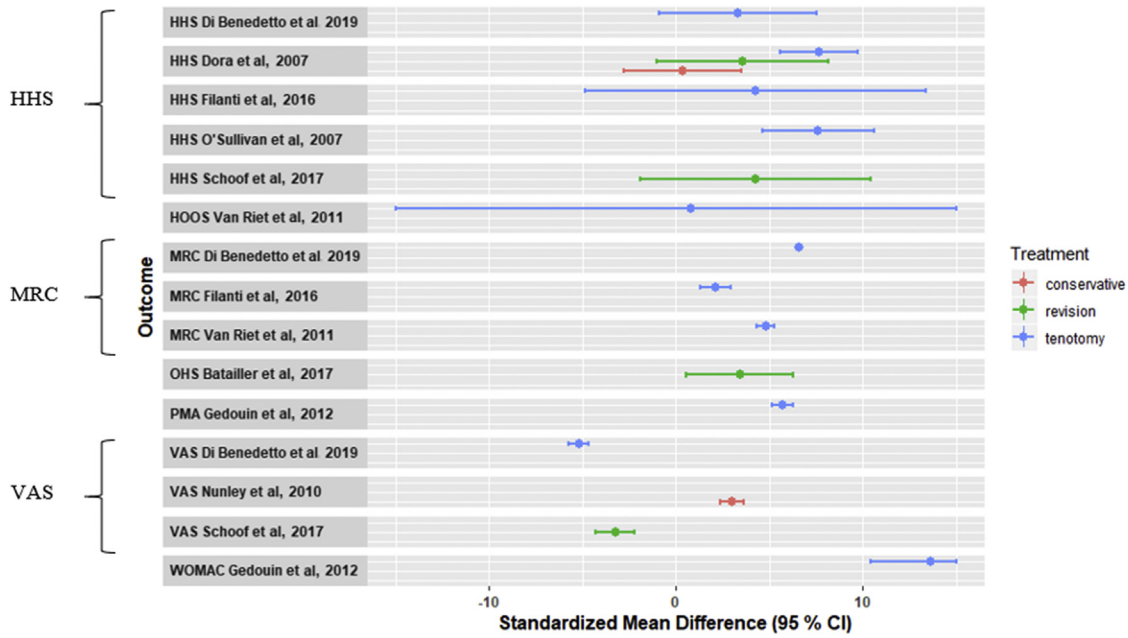

Fig. 3. Comparison of standardized mean difference (SMD) comparing the conservative, revision, and tenotomy groups. Effect size is displayed on the *x*-axis and the outcome (study) is displayed on the *y*-axis. The 95% confidence interval (CI) for the SMD is also shown. HHS, Harris Hip Score; HOOS, Hip disability and Osteoarthritis Outcome Score; MRC, Medical Research Council; OHS, Oxford Hip Score; PMA, Merle d'Aubigné-Postel Pain Score; VAS, Visual Analog Scale for Pain. WOMAC, Western Ontario and McMaster Universities Index.

standard error of the SMD was calculated as explained by Kelley [30], and the 95% confidence interval of the SMD was generated with SMD ± 1.96 ×× standard error. The effect sizes were interpreted using the literature values of SMD: weak, SMD between 0.2 and 0.49; moderate, SMD between 0.5 and 0.79; and large, SMD ≥ 0.8 [31].

Results

A comprehensive literature search identified 108 unique articles from the PubMed and Embase databases (Fig. 1). We selected 15 articles for full-text review after a preliminary title and abstract review. There were 2 studies that did not report PROs, 1 technical paper, and 1 study that did not report PROs for each treatment group. After the preliminary full-text review, 11 articles, with a collective study period of February 1992 to March 2018, were selected for our analysis [10,12,18–26].

All patients in our selected studies experienced symptomatic IPI. Among the studies that included patients with differing treatment for IPI, the treatment algorithms were as follows: for patients in debilitating pain, revisions were performed if the cup overhang was >8 mm, releases were performed if the cup overhang was <8 mm [19]; or the decision of revision or release was based on age, health status, and anticipated loss of bone during a potential revision [10]; or the decision of revision or release was based on the positioning of the acetabular component [24].

In 9 of the selected articles, physical examinations corroborated the clinician's diagnosis of IPI [10,12,18,20,21,23–26]. Common findings among patients with IPI were groin pain, pain with resisted hip flexion, and difficulty with mounting the examination table [10,12,18,20,21,23–26]. Among the most common physical examination maneuvers, straight leg raise reproduced weakness and pain most frequently in patients with IPI [10,12,20,23–26]. All studies used radiographic data, X-rays or computed tomography (CT) scans, to evaluate inclination, anteversion, and anterior cup prominence [10,12,18–26]. The views used in our selected articles were anteroposterior [10,12,18,19,21–26], false profile [18,22,23], lateral [10,12,19–21,24,25], and Dunn [26]. Four studies [18,23–25] reported mean preoperative acetabular inclinations of 44.9° (24°-67°), 50° (29°-75°), 50.1° (38°-58°), and 44.8° (35°-60°). Using CT scans of the pelvis or Lequesne radiographs, 4 studies [10,18,19,24] reported acetabular component anterior prominence of 5.8 mm (2-10), 8 mm (2-18), 2 mm (−6 to 9), and 9.9 mm ± 4.5 (2-22). Three studies reported anteversion values of 8° ± 9° (−10° to 35°) [18], 20.1° ± 10.3° [24], and 17.6° (0°-38°) [23].

Table 2
PROs Among Conservative Treatment Group.

Study (First Author, Year)	Number of Hips	Sex	Mean Age (Range; y)	Mean Follow-Up (Range; mo)	Mean Number of Injections	PRO	Mean Scores	
							Pretreatment	Posttreatment
Chalmers et al [19], 2017	20	7 M and 13 F	69	50 (12-144)	1.4	HHS	—	79
Dora et al [10], 2007	7[a]	3 M and 5 F	57 (37-78)	41 (24-65)	NR	HHS	57 (50-68)	58 (42-68)
Nunley et al [24], 2010	27[b]	12 M and 15 F	59.7 (31-84)	44.6 (25-68)	1.33	HHS, VAS Pain	61, 6.4 (3-10)	82, 2.9 (0-8)

F, female; HHS, Harris Hip Score; M, male; NR, not reported; PROs, patient-reported outcomes; VAS, Visual Analog Scale for Pain.
[a] One patient lost to follow-up.
[b] Six patients underwent further surgery (2 tenotomy, 4 acetabular revision).

Table 3
PROs Among Tenotomy Treatment Group.

Study (First Author, Year)	Number of Hips	Sex	Mean Age (Range; y)	Mean Follow-Up (Range; mo)	PRO	Mean Scores	
						Preoperative	Postoperative
Chalmers et al [19], 2017	8	NR	62[b]	42 (24-96)[b]	HHS	53	86
Di Benedetto et al [20], 2019	13	9 M and 4 F	65 (47-82)	10 (3-12)	HHS	66.8 (48.9-81.8)	85 (80-95)
					MRC	3.6 (3-4)	4.7 (3-5)
					VAS	3.6 (2-6)	1 (0-3)
Dora et al [10], 2007	6	3 M and 3 F	73 (67-81)	36 (24-50)	HHS	59 (56-67)	73 (67-89)
Filanti et al [21], 2016	7	NR	57 (29-77)	24	HHS MRC	46.4 ± 8.7 (32-56)	83.3 ±10.3 (61-91)
						3 ± 0.8 (2-4)	4.7 ± 0.8 (3-5)
Gedouin et al [22], 2012	10	5 M and 5 F	58 (45-80)	20 (12-60)	PMA WOMAC	3.1 (11-15)	16.9 (15-18)
						34 (24-46)	84 (60-95)
Guicherd et al [23], 2017	64	24 M and 40 F	56.3 (33-78)	8	OHS	21.8	40
O'Sullivan et al [12], 2007	16	4M and 11 F[a]	55.5 (33-75)	36.4 (5-63)	HHS	58 (44-70)	91 (78-95)
Van Riet et al [26], 2011	9	NR	51 (24-81)	11 (4-20)	HOOS MRC	41 ± 20.7 (11-53)	58 ± 22.4 (32.5-100)
						2.6 ± 0.5 (2-3)	5.0

F, female; HHS, Harris Hip Score; HOOS, Hip disability and Osteoarthritis Outcome Score; M, male; MRC, Medical Research Council; NR, not reported; OHS, Oxford Hip Score; PROs, patient-reported outcomes; PMA: Merle d'Aubigné-Postel Pain Score; VAS, Visual Analog Scale for Pain; WOMAC, Western Ontario and McMaster Universities Index.
[a] One female presented with bilateral iliopsoas tenotomy.
[b] Mean age and mean follow-up not separated among revision and tenotomy groups.

Eleven studies reported PROs for a conservative treatment group, an IP tenotomy group, and/or a revision group. One study reported on a conservative cohort only [24], 6 studies reported on an IP tenotomy group only [12,20–23,26], 2 studies reported on a revision cohort only [18,25], and 2 studies reported on all 3 groups [10,19].

There were 280 hips treated for IPI following THA [10,12,18–26]. The conservative group [10,19,24] was composed of 54 patients who did not undergo surgical treatment for their symptomatic postoperative IPI and, instead, were treated with local injections and physical therapy [10,19,24]. The second group was composed of 133 patients who underwent IP tendon tenotomy [10,12,19–23,26], either arthroscopic or endoscopic or via open approach. The third group consisted of 93 patients who underwent a formal revision arthroplasty procedure that involved exchanging the acetabular component [10,19,25].

For all patients included in this systematic review, the mean age in years of the conservative, tenotomy, and revision treatment groups was 63, 58, and 65, respectively. Mean follow-up times were 46 months, 17 months, and 33 months for the conservative, tenotomy, and revision treatment groups, respectively. Seven studies used the HHS [10,12,19–21,24,25], 3 studies reported pain scores [22,24,25], 1 study reported the Western Ontario and McMaster Universities Index [22], 2 studies reported the Oxford Hip Score (OHS) [18,23], 1 study reported the Hip disability and Osteoarthritis Outcome Score (HOOS) [26], and 4 studies reported the Medical Research Council (MRC) score [18,20,21,26].

Of the studies reporting preoperative and postoperative PROs for patients with IPI after hip arthroplasty, nearly all patients demonstrated improvement after conservative treatment, IP tenotomy, or revision (Fig. 2A and 2B). For the conservative group, there was a weak effect size with regard to HHS and large effect size with respect to Visual Analog Scale (VAS; Fig. 3) [10,24]. There was a large effect size (SMD $\geq$ 0.8) in all tenotomy and revision groups with respect to all PROs [10,12,18,20–22,25,26]. The HHS reported for the conservative group, the IP tenotomy group, and the cup revision group were 59.0 preoperatively to 77.8 (delta: 18.8) [10,19,24], 58.0 preoperatively to 85.4 (delta: 27.4) [10,12,19–21], and 58.1 preoperatively to 82.4 (delta: 24.3) [10,19,25] at latest follow-up, respectively (Tables 2-5). Five studies on IP tenotomy reported superior postoperative functional outcomes using the WOMAC index, MRC, OHS, and Merle d'Aubigné-Postel Pain Score [20–23,26]. Additionally, patients who had a revision exhibited higher OHS, higher MRC, and lower VAS scores postoperatively [18,25].

Two studies compared PROs between conservative, tenotomy, and revision groups [10,19]. Chalmers et al [19] found that the

Table 4
PROs Among Revision Treatment Group.

Study (First Author, Year)	Number of Hips	Sex	Mean Age (SD, Range; y)	Mean Follow-Up (Range; mo)	Mean Time to Revision (Range; mo)	PRO	Mean Score	
							Preoperative	Postoperative
Batailler et al [18], 2017	46	13 M and 33 F	66 ±12 (44-85)	21 (6-72)	34 (5-204)	OHS MRC	19 ± 7 (7-35)	43 ± 6 (25-48)
							3.6 (2-5)	4.6[a] (3-5)
Chalmers et al [19], 2017	21[c]	NR	62[b]	42 (24-96)[b]		HHS	58	79
Dora et al [10], 2007	14	6 M and 10 F	62 (29-82)	40 (24-65)		HHS	60 (48-85)	82 (55-95)
Schoof et al [25], 2017	12	7 M and 5 F	63.5 (44-71)	54 (20-130)	38.3 (9-71)	HHS VAS Pain	56 ± 7.7 (46-72)	89 ± 4.7 (78-96)
							5.8 ± 1.3 (4-8)	1.6 ± 1.3 (0-4)

HHS, Harris Hip Score; MRC, Medical Research Council; NR, not reported; OHS, Oxford Hip Score; PROs, patient-reported outcomes; SD, standard deviation; VAS, Visual Analog Scale for Pain.
[a] Eleven hips lost to follow-up.
[b] Mean age and mean follow-up not separated among revision and tenotomy groups.
[c] Three hips underwent simultaneous iliopsoas tenotomy.

Table 5
Mean PROs in All Groups.

Treatment Type	Number of Hips	Mean Age, y	PRO	Mean Scores	
				Pre	Post
Conservative					
	54	63.9	HHS	59.0	77.8
	27	59.7	VAS Pain	6.4	2.9
Tenotomy					
	50	50.1	HHS	58.0	85.4
	64	56.3	OHS	21.8	41
	29	58.2	MRC	3.1	4.8
	10	58	PMA	3.1	16.9
	10	58	WOMAC	34	84
	10	58	Pain score[a]	3.3	5.5
	10	65	VAS Pain	3.6	1
	9	51	HOOS	41	58
Revision					
	47	62.7[b]	HHS	58.1	82.4
	46	66	OHS	19	43
	46	66	MRC	3.6	4.6[c]
	12	63.5	VAS Pain	5.8	1.6

HHS, Harris Hip Score; HOOS, Hip disability and Osteoarthritis Outcome Score; MRC, Medical Research Council; OHS, Oxford Hip Score; PROs, patient-reported outcomes; PMA, Merle d'Aubigné-Postel Pain Score; VAS, Visual Analog Scale for Pain; WOMAC, Western Ontario and McMaster Universities Index.
[a] Pain score following Postel et al, 1990.
[b] Mean age reported for only 26 patients.
[c] Eleven hips lost to follow-up.

tenotomy group experienced the greatest magnitude of improvement in HHS. On the contrary, Dora et al [10] reported the greatest magnitude of improvement in HHS in the cup revision group of 14 patients. Due to a large standard deviation in PROs in the revision cohort, the SMD of the revision group was greater than that of the tenotomy group in the study by Dora et al (Fig. 3) [10].

Four studies [10,12,19,24] noted patients who underwent further treatment following either conservative management or IP tenotomy. Across the 3 studies, 7 of 54 (13.0%) patients failed to improve with conservative measures, 2 of whom underwent IP tenotomy and 5 who underwent acetabular component revision [10,19,24]. Two patients initially treated with IP tenotomy later underwent acetabular component revision [12,19]. In the tenotomy group, there were 5 (3.76%) complications, and in the revision group, there were 18 (19.4%) complications. The specific complications listed in each patient population are provided in Table 6.

Discussion

IPI after THA can be a complication that negatively affects the postoperative course. This study aimed at comparing outcomes of the primary treatment options available for postoperative IPI. We reviewed 11 studies that discussed PROs for 3 treatment groups: a conservative group, IP tenotomy group, and acetabular component revision group. In addition, we reported the common clinical and radiographic findings encountered in this patient population. Regarding PROs, all 3 treatment groups demonstrated improvement; however, the surgical treatment groups showed greater overall improvement compared to the conservative treatment group.

Table 6
Complications.

Treatment	Complications
Release	One patient with 13-mm acetabular prominence had continued groin pain and subsequently underwent component revision [19] One patient had heterotrophic ossification [10] One anterior dislocation and 1 compressive hematoma affecting peroneal nerve (3.2% complication rate) [23] One periprosthetic ossification [21]
Revision	Four had recurrent groin pain; 1 DVT, 1 dislocation, 1 deep infection, 2 patients required further revision surgery (6.5% complication rate) [18] Trochanteric nonunion (1), anterior dislocation (1), superficial wound infection (1), trochanteric bursitis (5), disarticulation (1) [10]

DVT, deep vein thrombosis (number of cases).

The diagnosis of the post-THA IPI is based on both physical examination and imaging findings. Jasani et al [8] examined patients with groin pain after THA, which was aggravated by active and resisted flexion and active external rotation of the ipsilateral hip. As part of the workup, CT scans were used to demonstrate impingement on the deep surface of the psoas muscle by cement or prominent flanges of the acetabular implant. Diagnosis was confirmed by resolution of symptoms following injection of a glucocorticoid and local anesthetic mixture into the psoas muscle under image intensifier. Similarly, in this systematic review, the most common clinical findings for patients having IPI after THA were increased pain with active hip flexion or resisted straight leg raise (Stinchfield test) [10,12,18–21,23–26]. In 8 of the reviewed articles, injection of combined glucocorticoids and analgesics was infiltrated peritendinously to verify the diagnosis [10,12,18,19,21,23–25].

Mechanical impingement of the acetabular component on the IP tendon can be directly evaluated with radiographic analysis. Current literature shows a relationship between IPI and cup prominence, the difference between the size of the femoral head and the acetabular component, and the difference between the version of the acetabulum and the acetabular component. In their study, Cyteval et al [32] aimed at describing the radiographic and CT scan features of IPI on the acetabular component in patients who underwent THA. All patients with IPI had an acetabular cup overhang of more than 12 mm, whereas patients without IPI had a cup overhang of less than 8 mm. The authors therefore concluded greater than 12 mm overhang of the acetabular cup is a sensitive and specific parameter for diagnosing IPI. Another study conducted by Odri et al [33] examined the size difference between the native femoral head and the implanted cup. Patients who experienced postoperative pain, diagnosed with IPI, following THA had a significantly greater size difference (P <.001) between the native femoral head and the implanted cup, compared to patients who underwent THA and did not have IPI. The authors concluded that a size difference of 6 mm between the native femoral head and the implanted cup resulted in significantly higher rates of postoperative IPI. Specifically, patients with a head-to-acetabular component size difference of ≥6 mm were 14.4 times more likely to have persistent postoperative pain and 26 times more likely to experience anterior IPI [33]. In a similarly designed study, Park et al [34] found that the difference in anteversion between the native acetabulum and acetabular component, rather than the magnitude of postoperative cup version, was a significant risk factor in developing postoperative IPI.

All of the reviewed articles in this analysis used radiographic data from X-rays or CT scans to investigate cup prominence and inclination in patients with IPI after THA. The normal values for inclination and anteversion referenced from the literature are between 35° and 50° and between 5° and 25°, respectively [35]. Of the studies that reported acetabular component inclination and anteversion, the majority of patients in all treatment groups, on average, exhibited normal values for both measures [18,23–25]. The weighted mean acetabular component prominence was 7.1 mm for patients among the conservative, tenotomy, and revision cohorts [10,18,19,24]. Because cup prominence was reported for the entire cohort in the selected studies, it could not be differentiated among the 3 treatment groups. While cup prominence may be related to IPI, when analyzing cup geometric positioning, the

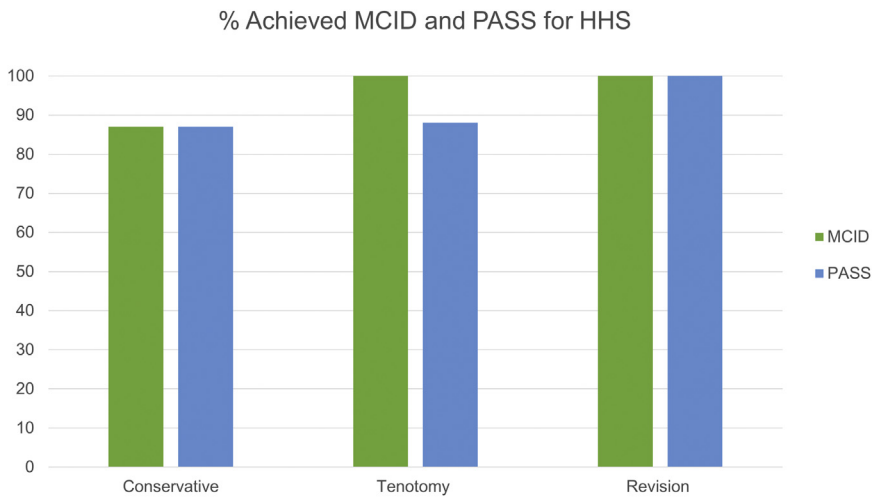

Fig. 4. Percent of patients on average who achieved minimal clinically important difference (MCID) and patient acceptable symptomatic state (PASS) for Harris Hip Score (HHS) at latest follow-up in the conservative, tenotomy, and revision cohorts.

literature does not routinely include cup prominence as a measure for correct positioning. However, prominence of the cup against the acetabular rim may deserve increased attention when performing THA, in order to avoid the necessity of revision arthroplasty, thereby preserving pelvic bone stock. In addition, a less-invasive procedure such as IP tenotomy seems to address the symptoms of IPI in the setting of cup prominence.

Our aim in this study is to assess the difference in the PROs for 3 treatment groups. In contrast, in a systematic review by O'Connell et al [36], the authors aimed at comparing the outcomes following arthroscopic and open surgical treatment for IPI following THA. In their study, however, successful outcome was defined as complete pain relief or lack of significant residual pain at final follow-up. Patients who had acetabular component overhang demonstrated pain relief in 75% of the patients who underwent open tenotomy compared to 93% of the patients who underwent arthroscopic tenotomy. They concluded that IP release is an effective procedure to relieve pain from IPI following THA, even in the presence of acetabular component malpositioning. In addition, with respect to complication rate, O'Connell et al [36] found no postoperative complications in the arthroscopic tenotomy group vs a 33.3% complication rate in the open tenotomy group including heterotopic ossification and trochanteric bursitis. In our systematic review, outcomes of patients undergoing IP tenotomy were compared to patients treated with conservative treatment alone or acetabular component revision. On average, all 3 treatment groups demonstrated improvements which surpassed the literature values for the MCID and PASS for HHS [27]. Of the 54 patients who underwent conservative management of IPI and had HHS, 47 (87%) showed improvements in HHS that surpassed MCID and [19,24] PASS for HHS. Of the 50 patients [10,12,19–21] who had reported HHS outcomes following IP tenotomy, 50 (100%) achieved MCID and 44 (88%) [12,19–21] achieved PASS following IP tenotomy. In the 3 studies that reported on PROs using the HHS following acetabular component revision, all patients (47/47) on average achieved MCID and PASS [10,19,25].

During evaluation of complications in our study, the acetabular component revision group noted an overall higher rate (19.4% vs 3.76%) as well as more severe complications compared to the tenotomy group (Table 6). In summary, both the cup revision group and the IP tenotomy group demonstrated favorable and comparable improvement in PROs. There was a larger calculated effect size for the tenotomy group (Fig. 3), while a greater proportion of the cup revision group surpassed the literature values for MCID and PASS for HHS (Fig. 4). Given the higher rate and more severe nature of the complications registered for the cup revision group and the evidence that patients improve following IP tenotomy even in the presence of cup malposition [36], IP tenotomy may be more suitable as a second line of treatment. Acetabular component revision should likely be reserved for refractory cases.

Strengths

To our knowledge, this is the first systematic review which compares 3 principal treatment groups for IP impingement in patients who underwent THA. Second, in order to provide clinical context of the mean PROs, we calculated the proportion of patients who achieved MCID and the PASS for HHS. Finally, we calculated the SMD for select studies to illustrate the magnitude of each intervention (conservative, tenotomy, and revision) on PROs.

Limitations

There are several limitations in this systematic review. First, there was heterogeneity in our selected studies with respect to the dispersion of the reported PROs, as illustrated by the forest plot. Second, none of the articles reported on a control group who did not experience IPI following THA, limiting the level of evidence of the selected studies. Additionally, we acknowledge there is a selection bias inherent in some of our reviewed studies, as the surgeon's decision-making process in performing a tenotomy vs revision was only elucidated in 3 studies. Finally, although we include 3 studies regarding outcomes on patients who underwent conservative management, it is likely that outcomes following conservative management are underreported in the literature.

Conclusion

Management of IPI following THA includes nonoperative measures, IP tenotomy, or acetabular component revision. Patients have been shown to experience favorable PROs at latest follow-up, with an apparent advantage for surgical treatment. Compared to revision arthroplasty, IP tenotomy resulted in a lower overall rate of complications with less severe complication types. Therefore, IP tenotomy should be considered as a second line of treatment for patients who failed conservative measures. Revision arthroplasty should be reserved for recalcitrant cases.

References

[1] Söderman P, Malchau H, Herberts P. Outcome after total hip arthroplasty: Part I. General health evaluation in relation to definition of failure in the Swedish National Total Hip Arthroplasty Register. Acta Orthop Scand 2000;71:354–9.
[2] Söderman P, Malchau H, Herberts P, Zügner R, Regnér H, Garellick G. Outcome after total hip arthroplasty: Part II. Disease-specific follow-up and the Swedish National Total Hip Arthroplasty Register. Acta Orthop Scand 2001;72:113–9.
[3] Berry DJ, Harmsen WS, Cabanela ME, Morrey BF. Twenty-five-year survivorship of two thousand consecutive primary Charnley total hip replacements: factors affecting survivorship of acetabular and femoral components. JBJS 2002;84:171–7.
[4] Brown EC, Clarke HD, Scuderi GR. The painful total knee arthroplasty: diagnosis and management. Orthopedics 2006;29:129–36.
[5] Ueno T, Kabata T, Kajino Y, Inoue D, Ohmori T, Tsuchiya H. Risk factors and cup protrusion thresholds for symptomatic iliopsoas impingement after Total Hip Arthroplasty: a retrospective case-control study. J Arthroplasty 2018;33:3288–3296.e1.
[6] Bricteux S, Beguin L, Fessy MH. Iliopsoas impingement in 12 patients with a total hip arthroplasty. Rev Chir Orthop Reparatrice Appar Mot 2001;87:820–5.
[7] Ala Eddine T, Remy F, Chantelot C, Giraud F, Migaud H, Duquennoy A. [Anterior iliopsoas impingement after total hip arthroplasty: diagnosis and conservative treatment in 9 cases]. Rev Chir Orthop Reparatrice Appar Mot 2001;87:815–9.
[8] Jasani V, Richards P, Wynn-Jones C. Pain related to the psoas muscle after total hip replacement. J Bone Joint Surg Br 2002;84:991–3.
[9] Taher RT, Power RA. Iliopsoas tendon dysfunction as a cause of pain after total hip arthroplasty relieved by surgical release. J Arthroplasty 2003;18:387–8.
[10] Dora C, Houweling M, Koch P, Sierra RJ. Iliopsoas impingement after total hip replacement: the results of non-operative management, tenotomy or acetabular revision. J Bone Joint Surg Br 2007;89:1031–5.
[11] Trousdale RT, Cabanela ME, Berry DJ. Anterior iliopsoas impingement after total hip arthroplasty. J Arthroplasty 1995;10:546–9.
[12] O'Sullivan M, Tai CC, Richards S, Skyrme AD, Walter WL, Walter WK. Iliopsoas tendonitis: a complication after total hip arthroplasty. J Arthroplasty 2007;22:166–70.
[13] Lachiewicz PF, Kauk JR. Anterior iliopsoas impingement and tendinitis after total hip arthroplasty. J Am Acad Orthop Surg 2009;17:337–44.
[14] Henderson RA, Lachiewicz PF. Groin pain after replacement of the hip: aetiology, evaluation and treatment. J Bone Joint Surg Br 2012;94:145–51.
[15] Combes A, Migaud H, Girard J, Duhamel A, Fessy MH. Low rate of dislocation of dual-mobility cups in primary total hip arthroplasty. Clin Orthop 2013;471:3891–900. https://doi.org/10.1007/s11999-013-2929-3.
[16] Moher D, Liberati A, Tetzlaff J, Altman DG, Group TP. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLOS Med 2009;6:e1000097. https://doi.org/10.1371/journal.pmed.1000097.
[17] Slim K, Nini E, Forestier D, Kwiatkowski F, Panis Y, Chipponi J. Methodological index for non-randomized studies (minors): development and validation of a new instrument. ANZ J Surg 2003;73:712–6.
[18] Batailler C, Bonin N, Wettstein M, Nogier A, Martres S, Ollier E, et al. Outcomes of cup revision for ilio-psoas impingement after total hip arthroplasty: retrospective study of 46 patients. Orthop Traumatol Surg Res 2017;103:1147–53.
[19] Chalmers BP, Sculco PK, Sierra RJ, Trousdale RT, Berry DJ. Iliopsoas impingement after primary total hip arthroplasty: operative and nonoperative treatment outcomes. JBJS 2017;99:557–64.
[20] Di Benedetto P, Niccoli G, Magnanelli S, Beltrame A, Gisonni R, Cainero V, et al. Arthroscopic treatment of iliopsoas impingement syndrome after hip arthroplasty. Acta Biomed 2019;90:104–9. https://doi.org/10.23750/abm.v90i1-S.8076.
[21] Filanti M, Carubbi C, Del Piccolo N, Rani N, Mazzotta A, Dallari D. The role of arthroscopy in the treatment of groin pain after total hip arthroplasty: our experience. Hip Int 2016;26:28–33.
[22] Gédouin J-E, Huten D. Technique and results of endoscopic tenotomy in iliopsoas muscle tendinopathy secondary to total hip replacement: A series of 10 cases. Orthop Traumatol Surg Res 2012;98:S19–25.
[23] Guicherd W, Bonin N, Gicquel T, Gedouin JE, Flecher X, Wettstein M, et al. Endoscopic or arthroscopic iliopsoas tenotomy for iliopsoas impingement following total hip replacement. A prospective multicenter 64-case series. Orthop Traumatol Surg Res 2017;103:S207–14.
[24] Nunley RM, Wilson JM, Gilula L, Clohisy JC, Barrack RL, Maloney WJ. Iliopsoas bursa injections can be beneficial for pain after total hip arthroplasty. Clin Orthop Relat Res 2010;468:519–26.
[25] Schoof B, Jakobs O, Schmidl S, Lausmann C, Fensky F, Beckmann J, et al. Anterior iliopsoas impingement due to a malpositioned acetabular component-effective relief by surgical cup reorientation. Hip Int 2017;27:128–33.
[26] Van Riet A, De Schepper J, Delport HP. Arthroscopic psoas release for iliopsoas impingement after total hip replacement. Acta Orthop Belg 2011;77:41–6.
[27] Levy DM, Kuhns BD, Chahal J, Philippon MJ, Kelly BT, Nho SJ. Hip arthroscopy outcomes with respect to patient acceptable symptomatic state and minimal clinically important difference. Arthroscopy 2016;32:1877–86. https://doi.org/10.1016/j.arthro.2016.05.014.
[28] Edwards PK, Queen RM, Butler RJ, Bolognesi MP, Lowry Barnes C. Are range of motion measurements needed when calculating the Harris hip score? J Arthroplasty 2016;31:815–9. https://doi.org/10.1016/j.arth.2015.10.016.
[29] Griffin DW, Kinnard MJ, Formby PM, McCabe MP, Anderson TD. Outcomes of Hip Arthroscopy in the older adult: a systematic review of the literature. Am J Sports Med 2016;45:1928–36. https://doi.org/10.1177/0363546516667915.
[30] Kelley K. Confidence intervals for standardized effect sizes: theory, application, and implementation. J Stat Softw 2007;20:9.
[31] Cohen J. Statistical power analysis for the behavioral sciences. Hillsdale, NJ: Erlbaum Associates; 1988.
[32] Cyteval C, Sarrabère MP, Cottin A, Assi C, Morcos L, Maury P, et al. Iliopsoas impingement on the acetabular component: radiologic and computed tomography findings of a rare hip prosthesis complication in eight cases. J Comput Assist Tomogr 2003;27:183–8.
[33] Odri GA, Padiolleau GB, Gouin FT. Oversized cups as a major risk factor of postoperative pain after total hip arthroplasty. J Arthroplasty 2014;29:753–6.
[34] Park KK, Tsai T-Y, Dimitriou D, Kwon Y-M. Three-dimensional in vivo difference between native acetabular version and acetabular component version influences iliopsoas impingement after total hip arthroplasty. Int Orthop 2016;40:1807–12.
[35] Bhaskar D, Rajpura A, Board T. Current concepts in acetabular positioning in total hip arthroplasty. Indian J Orthop 2017;51:386.
[36] O'Connell RS, Constantinescu DS, Liechti DJ, Mitchell JJ, Vap AR. A systematic review of arthroscopic versus open tenotomy of iliopsoas tendonitis after total hip replacement. Arthroscopy 2018;34:1332–9.