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Subchondral insufficiency fractures of the femoral head: systematic review of diagnosis, treatment and outcomes

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ABSTRACT

Subchondral insufficiency fractures of the femoral head (SIFFH) are a cause of femoral head collapse leading to degenerative hip disease. SIFFH is often mistaken for osteonecrosis given similar clinical and radiographic features. These similarities often lead to missed or delayed diagnosis which can often delay or change management. The purpose of this article is to systematically review the spectrum of demographics, diagnostic and treatment options, including hip preservation in young patient populations. A systematic review was conducted according to the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines. All related peer-reviewed publications from January 1999 to January 2019 were reviewed using the following databases: Medline, EMBASE, Scopus and Web of Science. The systematic review identified 54 articles, encompassing 482 patients (504 hips) diagnosed with SIFFH. One hundred and seventy-six (35%) males and 306 (63%) females were included, with a mean age of 53.6 ± 17.5 years and mean body mass index of 23.4 ± 4.0 kg/m^2. Mean follow-up was 23.4 ± 15.9 months. Treatment decisions were 256 (55%) non-operative, 157 (34%) total hip arthroplasty (THA), 24 (5%) transtrochanteric anterior rotational osteotomy, 9 (2%) hip arthroscopy, 7 (2%) hip resurfacing, 3 (1%) bone grafting, 3 (1%) hemiarthroplasty and 1 (1%) tantalum rod insertion. Overall, 35% of SIFFH hips were converted to THA at latest follow-up. A majority of SIFFH patients had symptom resolution with non-operative management. Failure most often resulted in THA. In younger patients, hip preservation techniques have shown promising early results and should be considered as an alternative.

INTRODUCTION

Subchondral insufficiency fractures of the femoral head (SIFFH) are a cause of femoral head collapse which can lead to degeneration of the joint. SIFFH was first reported as a distinct disease in 1996 [1]. More recently, SIFFH has been shown to be histopathologically different from osteonecrosis, another cause of femoral head collapse [2, 3]. Because of the similarities clinically and radiologically between SIFFH and osteonecrosis of the femoral head, they are difficult to distinguish; however, their etiologies are different. Bone fragility has been purported as an important cause of SIFFH and the typical patient described is an elderly female [4–7]. In addition to causing hip degeneration, SIFFH has been also been implicated as a potential cause of rapidly destructive arthritis [7–9], and its role in hip pain and degeneration in younger patient populations is of clinical interest.

There is a wide range in presentation of SIFFH, which impacts the treatment decisions. While SIFFH is typically described in older patients, it has been seen in younger patients, specifically military recruits, transplant patients and patients with tumor osteomalacia [10–12]. Depending on the extent of the fracture and collapse, various treatments for SIFFH have been reported, including non-operative management, total hip arthroplasty (THA), hip arthroscopy, transtrochanteric anterior rotational osteotomy (TARO) and coring [13–16]. Because of this variability, there is little consensus as to the appropriate treatment option for a patient with SIFFH.

The purpose of our study is to systematically review the literature to determine the demographics, diagnostic techniques and treatment options in SIFFH management. Based on prior literature, we hypothesized that SIFFH patients may be younger than previously reported. Accordingly, the use of joint preservation techniques may be more prevalent in younger patients given advances in surgical technique and the desire to preserve native anatomy.

MATERIALS AND METHODS

A systematic review was conducted according to the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines and checklist [17]. All peer-reviewed publications related to SIFFH, published from January 1999 to January 2019, were identified. Two reviewers independently conducted the search in February 2019 using the following databases: Medline, EMBASE, Scopus and Web of Science. Each search included the following terms: subchondral AND insufficiency AND fracture AND femoral AND head.

Our inclusion criteria consisted of English language or articles with English translations, studies with patients' gender and age with SIFFH and reporting of treatment of SIFFH. Exclusion criteria were non-English language studies, studies, studies without specific reporting on treatment of SIFFH and studies without specific reporting on how many SIFFH patients/hips were included.

Following the two independent authors (MAG, LTS) search of the previously stated databases, a total of 120 citations were identified. A consensus for any uncertainties was reached with the help of a third author (BM). Duplicate articles were excluded. The search process is shown in the flow diagram (Fig. 1). Title and abstracts were assessed for relevancy, and a total of 54 full-text articles were selected for further evaluation. References within each article were cross-referenced for inclusion to ensure that all studies available were identified.

Data collected from the studies was level of evidence, number of patients with SIFFH, mean age, mean body mass index (BMI), primary diagnosis imaging modality, treatment, purposed etiology, mean follow-up and outcome of SIFFH post-diagnosis. If means were not given, medians were used. For case reports with two or fewer patients, we reported the ages of cases separately. Our primary outcome of interest of SIFFH post-diagnosis was reported as conversion to THA at latest follow-up. SIFFH patient outcomes managed specifically with hip preservation techniques at index treatment point were recorded separately. Values were compared against the patient acceptable symptomatic state (PASS) reported by Chahal *et al.* [18].

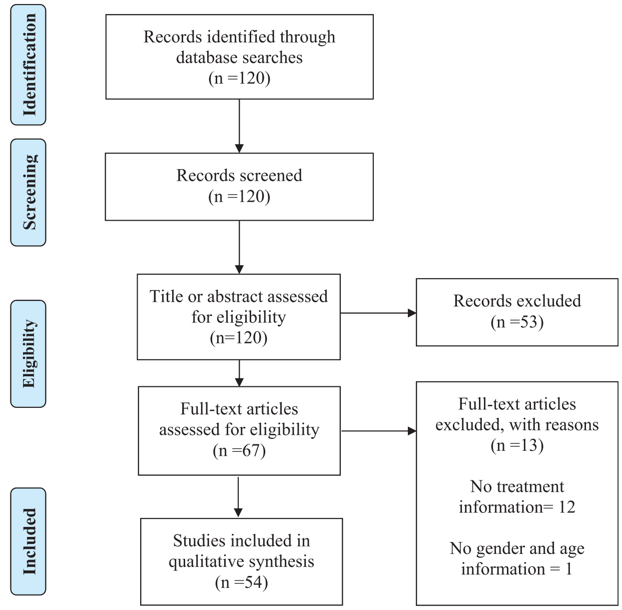

Fig. 1. Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) flowchart of studies.

Statistical analysis was utilized to calculate mean age, mean BMI, prevalence of bone marrow edema (BME) on magnetic resonance imaging (MRI), prevalence of treatment, etiology, mean follow-up and prevalence of outcome of SIFFH on diagnosis. When provided, these values were calculated using an unpaired Student's *t*-test. Means and standard deviations were calculated from patient series if none were reported. All statistical analyses were performed using Microsoft Excel software (Version 16.16.17, Microsoft, Redmond, WA, USA).

RESULTS

Based on the PRISM guidelines, 54 full-text articles were selected for analysis (Fig. 1). Of the 13 excluded, six articles did not include treatment of SIFFH, three articles did not include SIFFH, two articles had SIF but not of the femoral head, one did not include demographic information and one did not have details on diagnosis.

Of the 54 articles included, 482 patients (504 hips) diagnosed with SIFFH included 176 (35%) males and 306 (63%) females. Mean age was 53.6 ± 17.5 years and mean

BMI was 23.4 ± 4.0 kg/m^2. The most common imaging modality (93%) used to diagnosis was MRI, with 9% using primarily X-ray or computed tomography (CT). On MRI, 88% (294) of SIFFH patients showed signs of BME. The mean follow-up was 23.4 ± 15.9 months.

Treatment decisions were: 256 (55%) non-operative, 157 (34%) THA, 24 (5%) TARO, 9 (2%) hip arthroscopy, 7 (2%) hip resurfacing, 3 (1%) bone grafting, 3 (1%) hemi-arthroplasty and 1 (1%) tantalum rod insertion. The etiology of SIFFH patients was as follows: 24% (16) chronic steroid use, 24% (16) tumor osteomalacia, 10% (7) organ transplant, 7% (5) osteoporosis, 6% (4) radiation, 6% (4) overexertion, 6% (4) alcohol abuse, 3% (2) previous internal fixation, 3% (2) systemic lupus erythema, 1% (1) acetabular over-coverage, 1% (1) acetabular over-coverage, 1% (1) anorexia, 1% (1) alkaptonuria, 1% (1) dysplasia and inverted labrum, 1% (1) rapid destructive arthrosis, 1% (1) renal failure, 1% (1) Turner syndrome and 1% (1) adrenocorticotropic adenoma. Overall, 35% of SIFFH hips were converted to THA at latest follow-up. Full results are recorded in Table I. SIFFH patient outcomes managed specifically with hip preservation techniques at index treatment point are recorded in Table II.

DISCUSSION

The current study reviewed the available literature, and found SIFFH patients to be, on average, 54 years of age, female and low-normal to overweight BMI. MRI was the dominant mode of diagnosis. Most patients were treated non-operatively, with THA being the most common surgical intervention. SIFFH presents with acute hip pain and can be collapsed or stable on imaging. We found a relatively large percentage of patients eventually suffer a worsening of their disease and required surgical treatment. The exact cause of collapse and worsening of symptoms is not known and warrants further research.

SIFFH is a cause of acute hip pain in the elderly; however, SIFFH must be included in the differential diagnosis in younger patients. Yamamoto and Bullough [2, 13, 19] described SIFFH patients to be an elderly female with a high BMI, and, due to the prevalence of osteoporosis, this characterization has continued throughout the literature, even in recently published studies. We found SIFFH to be shown in a wide variety of adult patients. On average, the patient was middle aged and had a normal BMI. SIFFH was seen in patients as young as 16, and several studies reported on only young patients with SIFFH [10, 14, 20, 21].

MRI was the most commonly used imaging modality to diagnose SIFFH, and there has been extensive research on the diagnostic signs of SIFFH. Because of the similarity in presentation to osteonecrosis, it is important to distinguish between the two. SIFFH is characterized by a low signal intensity band on T1 weighted MRI and is commonly described as irregular and convex. Osteonecrosis has a smooth low intensity band due to circumscription of necrotic segments [22]. A BME pattern is another commonly described feature of SIFFH and osteonecrosis and is seen in most patients on MRI [11, 23]. BME is fluid exudation caused by the chronic inflammation and proliferating fibroblasts [15]. Based on our review, BME is a frequent concomitant sign of SIFFH on MRI. Sonoda *et al.* [23] described T2 imaging of SIFFH which had low intensity bands and BME and found that absence of BME could be related to progression to collapse. More research is needed to determine which diagnostic features affect prognosis of SIFFH.

In older studies, X-ray imaging was used to diagnose. These studies used the crescent sign, a less radiolucent linear defect, with a slight sclerotic rim which is typically associated with osteonecrosis [2, 8]. Histopathological confirmation was needed to differentiate between SIFFH and osteonecrosis [2]. Additionally, X-ray can be used when prior implants make visualization on MRI difficult [24]. Uchida *et al.* [15] used CT as an adjunct to MRI to visualize the fracture line. Overall, MRI findings have been clearly reported and is the most commonly used to identify SIFFH. The ongoing study did not find a difference in imaging modality leading to a difference in treatment.

Another important and rare disease of the hip to include in the differential is idiopathic transient osteoporosis of the hip. This pathology is seen typically in pregnant women in the last trimester, however, in recent studies, it is more prevalent in middle aged men [25, 26]. On imaging, there is a similar BME pattern and increased signal intensity on T2 MRI [27]. The etiology of the disease is unknown, however, microfractures are thought to be involved and the risk factors are similar to SIFFH. In contrast though, the disease is typically self-limiting and resolves in months [27].

Non-operative management was most commonly used for SIFFH. This includes rest, non-weight bearing with crutches and appropriate medical management. THA was the most commonly used surgical treatment in our review. The prevalence of THA use in SIFFH management is expected given the overall average age of patients in our review and the successful outcomes of the procedure. SIFFH was treated with THA presenting with diverse etiologies, such as organ transplant, systemic erythematous lupus, fatigue fracture, anorexia nervosa and Turner syndrome [10, 28–31].

Interestingly, in the majority of cases reviewed, SIFFH has been seen to resolve with non-operative measures such

Table I. Overview of all studies included in systematic review

Study	*Level of evidence*	*Number of patients with SIFFH*	*Number of hips with SIFFH*	*Mean patient age (years ± SD)*	*Mean BMI (kg/m²)*	*Diagnosis imaging modality*	*Imaging finding*	*Treatment*	*Etiology*	*Follow-up (months)*	*Conversion to THA*
Hackney *et al.* [11]	III	M: 24 F: 27	35*	60 ± 16	27.4 ± 5.6	MRI	BME: 44/51	Non-op 19/35 THA 16/35	Chronic steroid use: 4 Radiation: 4 Organ transplant: 3	25 (2–105)	46% (16/35)
Kobayashi *et al.* [12]	IV	M: 5 F: 2	11	M: 56± 9 F: 67± 3	—	MRI	BME: 10/11	Non-op 10/11 THA 1/11	Tumor induced osteomalacia: 11	58 (6–120)	9% (1/11)
Iwasaki *et al.* [32]	III	M: 13 F: 20	33	—	—	MRI	—	Non-op 23/33 THA 7/33 TARO: 3/33	—	—	21% (7/33)
Sonoda *et al.* [23]	III	M: 12 F: 25	40	55.8 (22–78)	—	MRI	BME: 40/40	Non-op 26/40 THA: 4/40 TARO: 4/40	—	21 (3–68)	10% (4/40)
Uchida *et al.* [15]	IV	M: 4 F: 5	9	49^{m} (43–65)	24.3^{m} (20–31)	MRI or CT	BME: 9/9	Hip arthroscopy: 9/9	—	30 (12–56)	0% (0/9)
Utsunomiya *et al.* [36]	V	M: 1	1	59	26.1	MRI	BME: 1/1	THA: 1/1	Osteopenia + overexertion (load): 1	4	100% (1/1)
Kimura *et al.* [4]	V	F: 1	1	53	—	MRI	BME: 1/1	Non-op: 1	Acetabular over-coverage: 1	24	0% (0/1)
Yamamoto *et al.* [34]	IV	M: 14 F: 25	39	M: 44.1 ± 12.7 F: 66.3 ± 13.9	M: 23.5 ± 1.0 F: 23.8 ± 0.7	MRI	BME: 39/39	Non-op 24/39 THA: 1/14* TARO: 1/14	—	—	—
Ikemura *et al.* [37]	III	M: 1 F: 4	5	74 ± 12.8	21.2 ± 2.6	MRI	—	Non-op 4/5 THA 1/5	Internal fixation	13 (12–18)	20% (1/5)
Kasahara et al. [29]	V	F: 1	1	40	11.6	MRI	BME: 0/1	THA 1/1	Pregnancy and anorexia nervosa	18	100% (1/1)
Ikemura *et al.* [19]	III	M: 5 F: 13	18	68 (41–85)	22.9 (16.6–32.2)	MRI	—	THA 18/18	Chronic steroid use: 4 Alcohol abuse: 1	—	100% (18/18)
Baba *et al.* [38]	V	F: 1	1	63	19.4	MRI	BME: 1/1	Non-op 1/1	Chronic steroid use: 1	—	0% (0/1)
Miyanishi *et al.* [39]	III	M: 3 F: 7	10	70 (58–85)	26.2	MRI	BME: 10/10	Non-op 8/10 THA 2/10	—	7 (1.2–18.2)	20% (2/10)
Yamamoto *et al.* [20]	IV	M: 3 F: 2	5	22 (16–29)	23.1	MRI	—	Non-op 1/5 TARO 4/5	Unclear	4 (2–9)	0% (0/5)
Kim *et al.* [10]	IV	M: 27 F: 1	34	21.4 (19–26)	22.4 (19.3–26.2)	MRI	BME: 34/34	Non-op 21/34 THA 3/34 Resurfacing 7/34 Rod 1 Core 2	Fatigue fracture	57.4 (12–159)	12% (4/34)

(continued)

Table I. (continued)

Study	*Level of evidence*	*Number of patients with SIFFH*	*Number of hips with SIFFH*	*Mean patient age (years ± SD)*	*Mean BMI* (kg/m^2)	*Diagnosis imaging modality*	*Imaging finding*	*Treatment*	*Etiology*	*Follow-up (months)*	*Conversion to THA*
Patel and Kamath [16]	V	M: 1	1	48	—	MRI	BME: 1	Core 1	Unclear	—	0% (0/1)
Hamada *et al.* [40]	V	F: 1	2	69	—	MRI	BME: 1	THA 2/2	Alkap tonuria	20	100% (2/2)
Yoon *et al.* [41]	IV	M: 5 F: 26	31	68.9 (53–90.3)	22.8 (16–39.7)	MRI	—	Non-op 16/31 THA 15/31	—	—	48% (15/31)
Ikemura *et al.* [37]	IV	M: 5 F: 9	15	65.9 ± 14.1	24.1 ± 4.5	MRI	BME: 15/15	Non-op 8/15 THA 7/15	Chronic steroid use: 2 Alcohol abuse: 3	3.8 (3–5)	47% (7/15)
Ghate and Samant [42]	V	M: 1	1	54	—	MRI	—	Non-op 1/1	—	12	0% (0/1)
Kim *et al.* [43]	IV	M: 3 F: 1	5	39 (33–46)	—	MRI	BME: 4/4	Non-op 4/4	—	—	0% (0/4)
Sonoda *et al.* [24]	V	F: 1	1	70	21.6	X-ray	—	THA 1/1	Internal fixation	—	100% (1/1)
Song *et al.* [14]	IV	M: 5	7	21 (20–22)	21.9 (19.4–24.1)	MRI	BME: 7/7	Non-op 4/7 THA 1/7 Drilling 1/7 Bone graft 1/7	Fatigue	40 (18–68)	14% (1/7)
Ikemura *et al.* [44]	V	F: 2	2	26 43	—	MRI	BME: 2/2	Non-op 1/2 TARO: 1/2	Internal fixation: 2	—	0% (0/2)
Ohtsuru *et al.* [45]	V	M: 2	4	57 53	—	MRI	BME: 2/2	Non-op 2	Renal transplant: 2	—	0% (0/2)
Sonoda *et al.* [13]	III	M: 7	7	30.1 ± 9	20.9 ± 1.7	MRI	—	TARO: 7	—	3.6 ± 1.4 years	0% (0/7)
Yamamoto *et al.* [46]	V	F: 1	1	65	24.1	MRI	BME: 1	THA: 1	Osteoporosis	—	100% (1/1)
Jo *et al.* [47]	III	M: 4 F: 33	37	70.5 ± 7.4	24.3 ± 2.4	MRI	—	Non-op: 8 THA: 29	—	—	78% (29/37)
Yoon *et al.* [46]	V	M: 1	2	27	18.4	MRI	BME: 1	Non-op: 1 Bone graft: 1	Fatigue	24	0% (0/2)
Kawano *et al.* [49]	V	F: 1	1	74	28.4	CT/X-ray	—	THA: 1	—	—	100% (1/1)
Miyanishi *et al.* [6]	IV	M: 5 F: 22		72 (51–85)	—	MRI	BME: 27	Non-op: 14 THA: 13	—	28 (9–93)	48% (13/27)
Buttaro *et al.* [5]	V	F: 4	4	70 (64–75)	28.9 (24–31)	MRI	BME: 1/4	Non-op: 1 THA: 3	—	—	75% (3/4)

(continued)

Table I. (continued)

Study	*Level of evidence*	*Number of patients with SIFFH*	*Number of hips with SIFFH*	*Mean patient age (years ± SD)*	*Mean BMI (kg/m²)*	*Diagnosis imaging modality*	*Imaging finding*	*Treatment*	*Etiology*	*Follow-up (months)*	*Conversion to THA*
Ishihara *et al.* [50]	III	M: 1 F: 12	13	71.2 ± 7	23.9 ± 4.7	MRI	BME: 13/13	Non-op: 13	—	—	0% (0/13)
Yamamoto *et al.* [2]	IV	F: 10	10	75.3 ± 7.1	25.7 ± 5.1	X-ray/MRI	BME: 3/3	THA: 10	—	—	100% (10/10)
Lee *et al.* [33]	IV	M: 9	9	22.6 ± 4.4	22.5 ± 2.9	MRI	BME: 9/9	Non-op: 6 Drilling: 2 Bone graft: 1	Fatigue	5.8 ± 2.1	0% (0/9)
Fukui *et al.* [51]	V	F: 1	1	71	22.7	MRI	BME: 1	THA: 1	Dysplasia + inverted labrum	—	100% (1/1)
Yamamoto *et al.* [52]	V	M: 1 F: 1	2	29 23	26.8 20	MRI	BME: 2/2	Non-op: 2	—	—	0% (0/2)
Iwasaki *et al.* [21]	IV	M: 3 F: 2	5	23.4 (16–29)	23.1 (20.2–26.6)	MRI	BME: 5/5	Non-op: 1/5 TARO: 4/5	—	44 (24–105)	0% (0/5)
Chouhan *et al.* [53]	V	M: 1	2	32	—	MRI	BME: 0/2	Non-op: 2	Tumor induced osteomalacia: 2	—	0% (0/2)
Yamamoto *et al.* [54]	V	F: 1	1	55	27.4	MRI	BME: 1	THA: 1	Lupus	—	100% (1/1)
Yamamoto and Bullough [55]	IV	M: 2 F: 9	11	69 (61–78)	—	X-ray/MRI	BME: 2/2	THA: 11	RDA	—	100% (11/11)
Ikemura *et al.* [56]	V	F: 1	1	47	18.4	MRI	BME: 0/1	Non-op 1	Renal transplant: 2	10	0% (0/1)
Niimi *et al.* [57]	V	F: 1	1	75	17	MRI	BME: 1/1	THA: 1	—	—	100% (1/1)
Motomura *et al.* [58]	V	F: 1	1	64	33.3	MRI	BME: 1/1	THA: 1	—	—	100% (1/1)
Iwasaki *et al.* [59]	V	F: 1	1	53	23.7	MRI	BME: 0/1	Non-op: 1	Liver transplant: 1	17	0% (0/1)
Iwasaki *et al.* [22]	IV	M: 6 F: 19	25	56.9 (9–88)	20.8 (18.3–31.6)	MRI	BME: 0/25	Non-op 25/25	Osteoporosis: 4 Chronic steroid use: 3 Chronic renal failure: 1	24 (4–64)	0% (0/25)
Huang *et al.* [28]	V	F: 1	1	31	18	X-ray	—	Hemiarthroplasty: 1	Turner syndrome: 1	—	0% (0/1)
Gerot *et al.* [30]	IV	M: 2 F: 5	7	50.3 (37–76)	—	MRI	—	Non-op: 7/7	Liver transplant: 2 Chronic steroid use: 2 ACTH adenoma: 1	29.2 (11–39)	0% (0/7)
Chan *et al.* [60]	V	F: 1	1	65	—	MRI	BME: 1/1	Hemiarthroplasty: 1	—	—	0% (0/1)
Zhao *et al.* [61]	V	F: 1	1	73	27.2	MRI	BME: 1/1	THA: 1	—	—	100% (1/1)

(continued)

Table I. (continued)

Study	Level of evidence	Number of patients with SIFFH	Number of hips with SIFFH	Mean patient age (years ± SD)	Mean BMI (kg/m^2)	Diagnosis imaging modality	Imaging finding	Treatment	Etiology	Follow-up (months)	Conversion to THA
Yamamoto *et al.* [62]	V	F: 1	1	59	30.3	MRI	BME: 1/1	Hemiarthroplasty: 1	—	—	0% (0/1)
Watanabe *et al.* [7]	V	F: 1	1	80		MRI	BME: 1/1	THA: 1	—	—	100 % (1/1)
Lee *et al.* [63]	V	F: 1	1	37	22.3	MRI	BME: 1/1	THA: 1	Lupus	—	100 % (1/1)
Bhimani *et al.* [9]	V	F: 1	1	62	—	MRI	BME: 1/1	THA: 1	—	—	100 % (1/1)

*, limited follow-up documentation available; BME, bone marrow edema; CT, computed tomography; F, female; M, male; m, statistical median used; MRI, magnetic resonance imaging; Non-op, non-operative management; SD, standard deviation; SIFFH, subchondral insufficiency fractures of femoral head; TARO, transtrochanteric anterior rotational osteotomy; THA, total hip arthroplasty.

as non-weight bearing for 6–8 weeks [32]. This is an important distinction, as it is in contrast to the findings in osteonecrosis which presents similarly, yet most often progresses to degenerative joint disease [33]. Therefore, proper diagnosis is the first hurdle for the clinician. Several studies reported on patients, typically younger ones, which were previously misdiagnosed as osteonecrosis and received drilling, rod insertion and THA [10, 14, 33]. It is less clear in the literature as to what causes worsening pain or collapse of the femoral head on imaging in some patients. Because of the diversity of etiologies of SIFFH, it is difficult to highlight reasons for worsening and even among similar etiological cohorts there exists variation of recovery or worsening.

Surgical options for patients under 50 years old with SIFFH were more diverse, as attempts at hip preservation may be considered due to longer patient life expectancy and high activity level. TARO was the most common surgical procedure amongst the hip preservation patients and second most common overall after THA. Due to the common anterosuperior location of SIFFH, TARO has been shown to be effective management [13, 20, 21, 23, 32, 34, 35]. Yamamoto *et al.* [20] reported on four patients that underwent TARO and found no evidence of further collapse and excellent Harris Hip scores (HHS) at 2 years of follow-up. Sonoda *et al.* had similarly positive results in seven patients with a mean follow-up of 3.6 years and found the technique to be successful with excellent HHS. While longer follow-up and more patients are needed to definitively show the success of the technique, initial results are promising; this specialized technique may be training and institution dependent. Hip arthroscopy was the third most commonly reported procedure. Uchida *et al.* [15] reported on a cohort of nine patients that underwent hip arthroscopy for pre-collapse SIFFH and had excellent modified HHS at short-term follow-up. Acetabular labral tears were found in all patients, and a mix of femoroacetabular impingement and dysplasia morphology was found. Arthroscopic fragment fixation with hydroxyapatite poly-lactate acid (HA/PLLA) composite pins were used in the SIFFH lesion in addition to surgical management of the bony and soft tissue hip disease. Similarly, the results are promising but longer follow-up and more patients are needed. Another technique with positive post-operative results was core hip decompression with bone void filler as reported by Patel and Kamath [16]. While it is only one case, it represents another potential option that is less invasive than TARO. Mean modified Harris Hip score was considerably higher than the PASS level of 74 as reported by Chahal *et al.* [18]. While primarily used in younger patients, hip

Table II. Studies involving subchondral insufficiency fractures of the femoral head (SIFFH) managed with hip preservation surgery

Study	*Number of patients*	*Number of hips treated with preservation*	*Mean patient age (years ± SD)*	*Mean BMI (kg/m^2)*	*Treatment*	*Follow-up (months)*	*Outcome measure*	*Last follow-up score*	*Complications/ revisions*
Uchida *et al.* [15]	M: 4 F: 5	9	49^m (43–65)	24.3^m (20–31)	Hip arthroscopy	30 (12–56)	mHHS	96.8 (82.5–100)	None
Sonoda *et al.* [13]	M: 7	7	30.1 ± 9	20.9 ± 1.7	TARO	43.2 ± 16.8	HHS	96.9 ± 3.8	None
Yamamoto *et al.* [20]	M: 2 F: 2	4	22 (16–29)	23.1	TARO	49 (109–24)	HHS	98.6 ± 2.3	None
Lee *et al.* [33]	M: 3	3	20.7 ± 0.6	19.9 ± 3.0	Drilling: 2 Bone graft: 1	94.4 ± 16.8	HHS	89 ± 11.3 91	None
Patel and Kamath [16]	M: 1	1	48	—	Core + bone filler	18	Clinical	Full return to ADLs and sports	None

ADL, activities of daily living; BMI, body mass index; F, female; HHS, Harris Hip score; M, male; ^{m}, statistical median used; mHHS, modified Harris Hip score; SD, standard deviation; TARO, transtrochanteric anterior rotational osteotomy.

preservation technique results are promising in small groups of patients reported, and more research is needed as to whether they can prevent further collapse of the femoral head over the long term and in larger patient numbers.

Our study was not without limitations. Because SIFFH is relatively uncommon, most articles found were case reports with low numbers of patients. While compiling them helps to draw conclusions, there exists a need for more robust studies with less potential bias. Additionally, we did not find consistent long-term post-operative follow-up in most studies; therefore, the differences in etiology and treatment we presented have an unknown impact on these patient post-operative outcomes. This makes it difficult to draw conclusions about the proper treatments. Longer follow-up would allow for better conclusions on treatment efficacy in preventing femoral head collapse and the durability of both non-surgical and surgical treatment options. Also, the etiology and diagnostic standards for SIFFH has evolved over the past decades; therefore, it is always possible that patients captured in earlier studies might have different outcomes impacting overall results.

CONCLUSION

A review of the literature identified that SIFFH should be considered as a cause of acute hip pain in elderly and younger patients that are subject to high stress or relative osteopenic conditions. A majority had symptom resolution with non-operative management, and those that worsened were typically managed surgically with THA. In younger patients, hip preservation techniques have shown promising early results and should be considered as an alternative.

CONFLICT OF INTEREST STATEMENT

All conflict of interest is outside of this submitted work. A.F.K. declares the following: AAOS: Board or committee member, American Association of Hip and Knee Surgeons: Board or committee member, BMC Musculoskeletal Disorders: Editorial or governing board, DePuy, A Johnson & Johnson Company: Paid consultant; Paid presenter or speaker; Research support, Innomed: IP royalties, Johnson & Johnson: Stock or stock Options, Procter & Gamble: Stock or stock Options, Zimmer: Paid consultant; Paid presenter or speaker; Research support; Stock or stock Options.

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