

Total hip arthroplasty in patients with slipped capital femoral epiphysis: a systematic analysis of 915 cases

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Abstract

There is limited evidence on the outcomes of Total Hip Arthroplasty (THA) in Slipped Capital Femoral Epiphysis (SCFE) patients. This systematic review aims to evaluate the current literature in terms of survival rate, functional outcomes, complications and types of implants of THA in SCFE patients. Following the established methodology of PRISMA guidelines, PubMed, Cochrane library, ScienceDirect and Ovid MEDLINE were systematically searched from inception to September 2018. The search criteria used were: (“total hip arthroplasty” OR “total hip replacement” OR “hip arthroplasty” OR “hip replacement”) AND (“slipped capital femoral epiphysis” OR “slipped upper femoral epiphysis” OR “femoral epiphysis”). Ten studies were finally included in the analysis and were qualitatively appraised using the Newcastle-Ottawa tool. Variables were reported differently between studies. The sample size varied from 12 to 374 THAs. A total of 877 patients undergone 915 THAs. The mean reported follow-up ranged from 4.4 to 15.2 years and the mean patients’ age at the time of THA from 26 to 50 years. Four studies specified the type of implants used, with 62% being uncemented, 24% hybrid (uncemented cup/cemented stem)

and 14% cemented. All but three studies reported the mean survival of implants that ranged from 64.9% to 94.8%. A limited number of complications were mentioned. There was a tendency for more favorable functional outcomes in modern studies. Modern THA-studies in SCFE patients showed improvement of survivorship, clinical outcomes and patient satisfaction. Future higher-quality studies are necessary to estimate long-term postoperative outcomes better.

Introduction

Slipped Capital Femoral Epiphysis (SCFE) is considered the most common hip disorder affecting adolescents.¹⁻⁴

It is a Salter-Harris type I fracture characterized by slippage through the hypertrophic zone of the upper femoral epiphysis in a backward direction.⁵⁻⁸ The aetiology remains controversial but generally multifactorial in origin; implicating genetic, constitutional and endocrine factors.⁹⁻¹² The annual incidence is reported to be 8.81 to 10.82 per 100,000 children in the USA;^{2,13} however, the global rate varies.^{13,14}

In time diagnosis and proper management of SCFE are crucial to impede possible complications of the disease.^{7,15,16} Delayed or missed diagnosis typically lead to femoroacetabular impingement and abnormal hip kinematics that augmenting contact hip stress predisposes to secondary hip arthritis in the fourth to fifth decade of life.^{7,15,17,18} Chondrolysis and osteonecrosis of the femoral head are other less frequent complications leading to arthritis and severe joint deterioration.¹⁹⁻²¹

Total Hip Arthroplasty (THA) is the primary treatment option for the management of end-stage hip Osteoarthritis (OA) in SCFE patients.¹⁵ However, a mismatch is reported between the incidence of the disease and the number of patients undergoing THA after SCFE.^{13,22} Patients with SCFE represent a minority group among those treated with primary THA.²³ The surprisingly low incidence of THA after SCFE is probably the sequel of a truly low progression to significant joint deterioration after SCFE or more likely of recording difficulties or missed diagnoses.^{13,22}

The complex anatomic and biomechanical alterations of the hip and the relatively young age of SCFE patients predispose to unique reconstructive challenges and higher failure rates.^{22,24,25}

The loss of head-neck offset, femoroacetabular impingement, previous surgical procedures, soft-tissue contractures are part of the difficulties rendering hip reconstruc-

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tion a technically demanding procedure.^{23,26}

There is limited evidence on the outcomes of THA in SCFE patients.^{7,13,22,24,27-32}

The purpose of this systematic review was to evaluate the current literature in terms of survival rate, functional outcomes, type of implants and complications of THA in SCFE patients.

Materials and Methods

This systematic review was implemented according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.³³ The review protocol was registered in the International Prospective Register of Systematic Reviews PROSPERO under the registration number CRD42018115949.

Data sources and search strategy

We systematically searched PubMed, Cochrane library, ScienceDirect and Ovid MEDLINE from inception to September 2018. For registered, ongoing trials, a search was performed on ClinicalTrials.gov. The reference lists of the relevant studies identified were also hand-screened for additional missing records.

The search terms used were “total hip arthroplasty”, “total hip replacement”, “slipped capital femoral epiphysis”, “slipped upper femoral epiphysis”, “hip arthroplasty”, “hip replacement”, “femoral epiphysis”. Free text searching was combined with Medical Subject Headings terms, and the detailed search strategy utilized can be found in the Supplementary Table 1.

Inclusion and exclusion criteria

The search was narrowed to articles that were published in English language. Eligible study designs for inclusion were randomised controlled trials, controlled (non-randomized) clinical trials, retrospective and prospective cohort studies as well as case-control studies. We included studies that evaluated patients with end-stage hip OA due to SCFE that received THA as a primary treatment.

Reviews or conference presentations, case series with five or fewer participants and studies reporting outcomes of THA in SCFE combined with other paediatric diseases and thus not clearly stating results for SCFE patients were excluded.

Outcome measures

The primary outcome was the survival rate of THA in SCFE patients. Secondary outcomes were i) functional outcomes; ii) complications namely infection, periprosthetic fractures and dislocations; iii) implant characteristics.

Study selection and data extraction

In the first review of the literature, two primary investigators (EK, PK) screened independently the full-text articles of the potentially eligible studies. Any potential disagreement was resolved through consensus, and where deemed necessary, a third investigator (ET) independently evaluated the study. Consequently, eligibility was defined by agreement with all authors. The various reasons for ineligible trials are presented in the flow diagram of Figure 1.

Data were extracted independently from two reviewers (EK, PK) and in duplicate for each eligible study. Data collected included demographics, methodological features of

the research, interventions, study design, primary and secondary outcomes, as well as complications. Disagreements were solved by discussion between the investigators, and where appropriate, a third author was contacted and independently extracted the data before consensus was reached.

Data analysis and methodological quality assessment

A narrative synthesis of the literature was used to evaluate the included data. The outcomes were recorded as defined by the original studies. We used the Newcastle–Ottawa Scale (NOS) to assess the methodological rigour in observational studies.³⁴ The NOS assesses the selection and comparability of study groups and ascertainment of the exposure-outcome; it utilizes a “star system” where studies can be granted up to nine stars.

Results

Search results

The search in PubMed, Cochrane, Science Direct, Ovid MEDLINE and Clinical Trials revealed 1939 available ref-

Table 1. Demographics, baseline patient and study characteristics.

Author	Study Type	Number of THAs/patients	Involves Only SCFE patients	Age* (years)	Follow up* (years)	Sex (Males %)	Severity of SCFE**	SCFE Therapy**	Years from SCFE to THA*
Case Series									
Schoof <i>et al.</i> 2013 ⁷	RCS	32/28	Yes	43 (17-58)	11.2 (8-24)	55.5	No	Yes	-
Traina <i>et al.</i> 2012 ²⁴	RCS	32/28	Yes	45 (20-74)	8.2 (2-17)	62.5	No	Yes	27.3 (5-55)
Larson <i>et al.</i> 2010 ¹³	RCS	28/-	Yes	26 (12-56)	15.2 (1-52)	69,6	Yes	Yes	7.6
Nizard <i>et al.</i> 2008 ²⁷	RCS	12/-	No	-	6.9 (1-26)	-	No	No	-
Taheriazam <i>et al.</i> 2018 ²⁹	PCS	12/6	No	-	-	-	No	No	-
Hannouche <i>et al.</i> 2016 ²⁸	RCS	12/-	No	-	8,8 (2-34,4)	-	No	No	-
Registry Studies									
Lehmann <i>et al.</i> 2012 ³⁰	NRCS	29/-	No	27.5 (26-29)	-	-	No	No	-
Engesaeter <i>et al.</i> 2012 ³¹	NRCS	374/-	No	49.7	7.4	67.1	No	No	-
Boyle <i>et al.</i> 2012 ²²	NRCS	117/117	No	48.5	4,4	60.7	No	No	-
Thillemann <i>et al.</i> 2008 ³²	NRCS	267/243	No	NA (10-80)	-	66.3	No	no	-

RCS: Retrospective Case Series, PCS: Prospective Case Series, NRCS: National Registry Comparative Study. NA: Not Answered, THA: Total Hip Arthroplasty. * Results are given as a mean with the range in parentheses. ** Results are given as whether mentioned in the studies or not.

erences. After removing duplicates and irrelevant studies by screening from title and abstract, 30 studies were selected for full-text eligibility. The full text of the remaining studies reviewed in detail. Twenty articles were excluded mostly due to the fact that results for SCFE patients were combined with other paediatric diseases and not explicitly stated. Altogether ten studies were included in the systematic review, the descriptive characteristics of which are presented in Table 1. Details of the study screening and selection are shown in Figure 1.

Methodological quality

Five studies were considered to be of high methodological quality,^{13,22,30,32} three were of moderate quality^{7,24,27} and two of low quality.^{28,29} Supplementary Table 2 summarizes the results of the quality assessment.

Study and sample characteristics

The included studies were published between 2008 and 2016; they were five retrospective^{7,13,24,27,28} and one prospective case series²⁹ and four cohort studies from national registries.^{22,30,32} The sample size ranged from 12 to 374 THAs with a mean reported follow up for each study from 4.4 to 15.2 years; a total of 877 patients had undergone 915 THAs. The mean reported age of the patients at the time of THA per study ranged from 26 to 50 years old. Six studies reported sex prevalence; the percentage of males was higher than females ranging from 55.5% to 67.1%.^{7,13,22,24,31,32} Three studies reported on comorbidities and health scores; generally, SCFE patients were younger with few comorbidities (Table 1).^{22,29,32}

Severity and initial management of the SCFE

Only one study evaluated the severity and chronicity of SCFE, but the results were not clearly stated.¹³ Three studies, including 92 patients, reported the initial management of the SCFE.^{7,13,24} The percentage of patients that had surgical treatment ranged from 71% to 92%. Twenty-seven hips had corrective osteotomies, 46 had closed reduction and pin or screw fixation, three had multiple surgeries, two hips had at first pin fixation and then corrective osteotomy, one hip underwent two femoral osteotomies, four cases had skeletal traction before pinning, three had unspecified surgery while eight were conservatively treated.

Time from SCFE and indication to arthroplasty

Only two studies reported the mean time from slip to arthroplasty that ranged

from 7.6 to 27.3 years.^{13,24} Two studies mentioned the indication for the index arthroplasty surgery.^{13,24} Out of 70 patients, 35 suffered from avascular necrosis; four had chondrolysis and 29 secondary hip OA while two suffered from impingement.

Intraoperative time and surgical approach

Two studies evaluated the intraoperative time^{22,32} and four of them,^{7,22,24,29} including 188 patients, described the surgical approach; 61 patients underwent posterolateral incision, 32 posterior, 79 anterolateral, three anterior, 12 Hardinge and in one patient direct lateral approach with trochanteric osteotomy was used (Table 2).

Type of implants and radiological evaluation

Four studies encompassing 448 patients reported the type of implant fixation.^{7,22,24,32} Cementless fixation was used in 62%, hybrid fixation (uncemented cup and cemented stem) in 24% and cemented in 14% of implants (Table 2). In the only study reporting the bearing surface, Traina *et al.*²⁴ demonstrated that 72% of the patients received ceramic on ceramic and 59% modular necks to restore anatomy and leg

length. Two studies radiologically evaluated the accuracy of stem and cup implantation.^{7,24} Out of 64 hips, four stems were implanted in *varus*, five in *valgus* and the remaining in neutral position. The cup abduction ranged from 20°–60°.

Survival rate

Survivorship was reported in seven studies including 500 THAs; the mean reported survival per study ranged from 64.9% to 94.8% at a mean follow-up from 4.4 to 11.2 years.^{7,13,22,24,27,28,32} Six studies specified the number and the type of failures.^{7,22,24,28,32} Among the 37 reported failures, the most common reason was the aseptic loosening of femoral, acetabular or both implants (n=16). Other reasons were infection (n=2), modular neck fracture (n=1), osteolysis (n=1), femoral fracture (n=1), dislocation (n=1), painful THAs (n=2), implant component failures (n=4), and unspecified (n=9). Three national registries compared revision rate following THA for SCFE and OA or other paediatric diseases.^{22,31,32} Two of them^{22,32} reported no significantly different revision rate between THA for SCFE and OA and the other³¹ between SCFE and Perthes' disease after adjusting for confounding factors. Survival

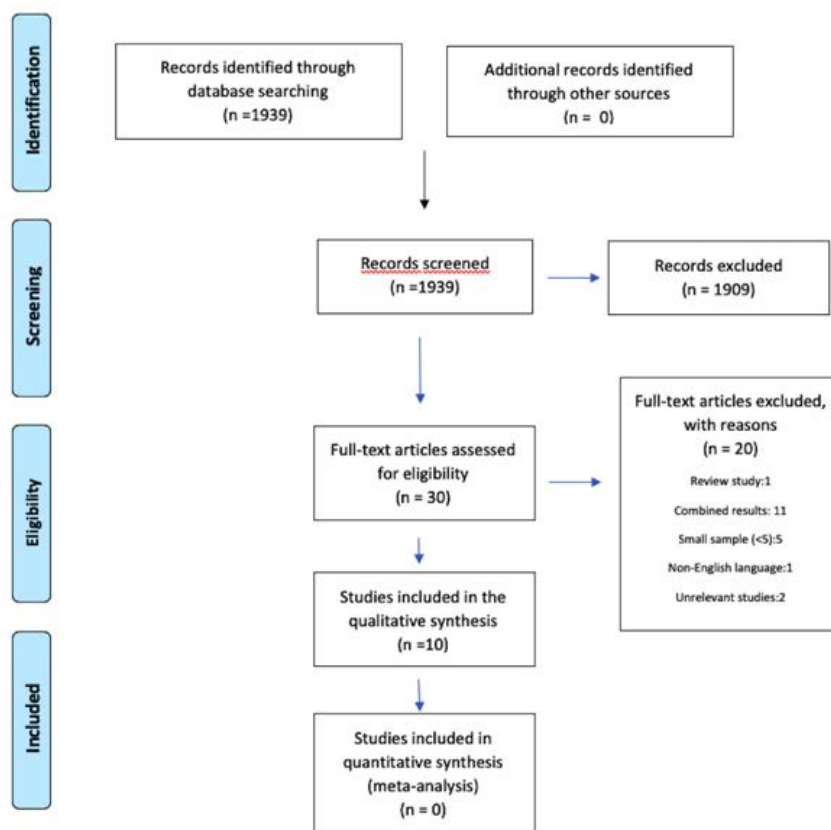


Figure 1. Preferred reporting items for systematic reviews and meta-analyses flowchart illustrating the search strategy.

rates of the included studies are shown in Table 2.

Functional outcomes

Six studies reported functional outcomes after THA.^{7,13,22,24,29,30} The majority of them reported a significant increase in functional scores at the last follow-up.^{7,13,22,24,29} Harris Hip Score (HHS) or the modified HHS were used in four studies.^{7,13,22,29} The mean preoperative HHS, ranging from 47 to 51, significantly improved postoperatively from 85 to 92.3. Oxford Hip Score (OHS), Postel-Merle d'Aubigné, Visual Analogue Score and EQ-5D were other clinical scores reported in studies (Table 2). Although not assessed preoperatively, Boyle *et al.* showed no significant difference in OHS between SCFE and primary OA at six months postoperatively.²² Outcomes from Norwegian Arthroplasty Registry highlighted that SCFE patients had a significantly better quality of life postoperatively compared with Perthes patients and that SCFE patients undergoing THA before 40 years

old are the only having a comparable quality of life with age-matched cohorts in the United Kingdom, in contrast with other paediatric hip diseases.³⁰

Complications

Among the other failures reported before, there was only one intraoperative fracture of lesser trochanter treated with cerclage wire. Traina *et al.* reported that 15 out of 32 hips of his series demonstrated heterotopic ossification in follow up, but only three of them were graded as type III or IV based on Brooker classification.²⁴ Two studies evaluated limb length discrepancy (LLD); the mean LLD decreased from 12-13.5 mm preoperatively to 4.5-6 mm postoperatively (Table 2).^{7,24}

Discussion

To the best of our knowledge, this is the first systematic review presenting the outcomes of THA in SCFE patients. We aimed

to evaluate and synthesize the results of all studies reporting the outcomes of THA in SCFE patients in terms of survival rate, functional results and implant characteristics.

Limitations

The principal limitation of this systematic review was the minimal number of articles reporting THA in SCFE patients. In addition, the majority of the studies included were retrospective case-series with limited evidence; however prospective results from national registries strengthen our findings. The difficulty of exporting data from studies that report combined data for SCFE and other pediatric diseases is also a limitation. Another restriction that may have influenced our results was the small sample size in several studies; registry data with larger samples again amplified our outcomes. The limited number of published studies could be attributed to the low prevalence of THA in SCFE patients.^{35,36} The mismatch between the prevalence of SCFE in adolescents and the low reported inci-

Table 2. Primary outcomes of the included studies.

Author	Surgical Approach* (%)	Survival rate**	Type of Fixation* (%)	Functional outcomes ***	Other outcomes/ complications
Schoof <i>et al.</i> 2013 ⁷	Posterior (100)	81% (11.2)	Cemented (42) Hybrid (35.4) Uncemented (22.6)	HHS (47-92.3) SF-36 (improved significantly)	No complications LLD improved (mean preop 13,5mm -mean postop 4,5mm)
Traina <i>et al.</i> 2012 ²⁴	Anterolateral (96.8) Direct lateral/ trochanteric osteotomy (3.2)	92.8% -9	Cementless (90,5) Hybrid (9,5)	HHS (48.3-86)	HO in 15 hips LLD (mean preop 12 mm -mean postop 6 mm)
Larson <i>et al.</i> 2010 ¹³	NA	82% (10)	NA	HHS (51-85)	
Nizard <i>et al.</i> 2008 ²⁷	NA	64.9% (8)	NA	NA	
Engesaeter <i>et al.</i> 2012 ³¹	NA	-	NA	NA	No difference in revision rate compared to Perthes
Boyle <i>et al.</i> 2012 ²²	Posterolateral (52.1) Anterolateral (41.0) Anterior (2.5)	94.8% (4.4)	Cementless (65) Hybrid (29,9) Cemented (5,1)	OHS	No difference in OHS and revision rates between SCFE and OA patients
Thillemann <i>et al.</i> 2008 ³²	NA	90,70% (11)	Cementless (61) Hybrid (22) Cemented (17)	NA	No difference in the revision rate between SCFE and OA patients
Hannouche <i>et al.</i> 2016 ²⁸	NA	83.3 % (10)	NA	NA	2/12 aseptic loosening at ten years
Taheriazam <i>et al.</i> 2018 ²⁹	Hardinge (100)	-	NA	MHHS (49.6-81.2). OHS (18.1-31.2) PMA (8.2-15.4) VAS (6,7-3,6)	
Lehmann <i>et al.</i> 2012 ³⁰	NA	-	NA	EQ-5D	Significantly higher reported EQ-5D score for SCFE compared to Perthes and hip dysplasia

SCFE: Slipped Capital Femoral Epiphysis, OA: osteoarthritis, HHS: Harris Hip Score, LLD: limb length discrepancy, HO: heterotopic ossification, MHHS: Modified Harris Hip Score, OHS: Oxford Hip Score, PMA: Postel-Merle d'Aubigné, VAS: Visual Analogue Score, NA: Not Answered. * Results are given as the type with the percentages in parentheses. ** Results are given as percentages with the last follow up (years) in parentheses. *** Results are given as the evaluated test with the mean preop and postop score in parentheses.

dence of THA in these patients needs further elucidation.

Demographics and preoperative disease characteristics

New Zealand Joint Registry demonstrated that at the time of surgery SCFE patients were significantly younger, more often male and had a lower American Society of Anaesthesiologists score compared to the OA control.²³ The mean reported age per study at the time of arthroplasty ranged between 26-50 years old. The majority of SCFE patients will undergo THA at a relatively young age, mainly between the fourth and fifth decade of life.^{7,15} The latter renders them a high demanding group of patients undergoing THA. Unfortunately, the majority of studies did not mention the severity and type of management of SCFE during adolescence as well as the time from SCFE to THA. However, in three studies that mentioned the type of initial therapy, the vast majority of the patients had surgical management.^{7,13,24}

Type of implants

There are several challenges when performing THA for the sequelae of SCFE. Even mild slips can lead to cartilage degeneration, femoroacetabular impingement and early onset of degenerative joint disease symptoms in young adults.^{37,38} Except for the young age of patients, the loss of head-neck offset, the distorted proximal femoral anatomy and the femoroacetabular impingement are crucial anatomic considerations to restore hip kinematics.²⁴ Although standard THA usually allows recovery of hip biomechanics in SCFE, custom made prostheses, or modular necks may further increase the possibility to restore the proximal femoral anatomy and metaphyseal bone contact or leg length and the appropriate femoral neck anteversion, respectively.²⁴ Traina *et al.* used modular necks in 19 of the 32 THAs in SCFE patients with promising results.²⁴ Leg length was restored in the majority of cases; however, a fracture of the modular neck was reported. The cumulative survival rate, using revision for any reason as the endpoint, was 92,8% at nine years postoperatively.

Implant fixation

Although less than half of the studies reported on implant fixation, the cementless and hybrid fixation were more commonly used.^{22,24,32} This is mainly attributed to the young age and good bone stock in SCFE patients and the inferior reported results of cemented THA in young patients in the past years.³⁹ Torchia *et al.* demonstrated a high failure rate of cemented THA in young patients reaching 45% at 15 years postoper-

atively.³⁹ However, excellent survival rates were reported in patients younger than 50 years old using fully cemented hips. Lewthwaite *et al.* showed 92.6% survivorship of the Exeter universal fully cemented hip from all causes at an average of 12.5 years.⁴⁰ The use of cemented implants in SCFE patients may be also another option to restore hip kinematics and stem version.

Bearing surface

Unfortunately, a limited number of studies reported on the bearing surface in THA for SCFE patients. Although the best technique for implantation of ceramic hips has not been clarified, the outstanding tribological properties of ceramic on ceramic THAs is an option for young patients. Traina *et al.*, using ceramic on ceramic bearing surface in 72% of THAs performed in SCFE patients showed favourable mid-term survival results.²⁴

Survival of THA

THA for SCFE patients was initially mentioned to have inferior results compared to OA demonstrating a mean reported per study survival rate between 64.9% to 82%;^{7,13,27} the main reason for revision was the aseptic loosening of the acetabular or femoral component. This was more or less attributed to the old implant designs, the inconsistent and various surgical techniques and the extended time period of studies.^{7,13,27} However, recent studies from national registries demonstrated more favourable results.^{22,31,32} In the largest so far national registry study, Engesaeter *et al.* found no difference in THA survivorship between SCFE and age-matched OA patients.³¹ Similarly, the Danish National Registry reported comparable relative risk for revision between SCFE and primary OA during the early and later postoperative period.³²

Functional outcomes of patients

The clinical outcomes and patient satisfaction were consistently improved in the majority of the studies.^{7,13,24,29} The improvement was quite similar to what happened in THA for OA patients. Boyle *et al.* reported comparable functional outcomes of THA between SCFE and primary OA patients at six months postoperatively.²² Data from the Norway arthroplasty registry supported that following THA the SCFE group had a better quality of life than the other groups of pediatric diseases, namely Perthes and DDH.³⁰ Although remained uncertain, it was hypothesized that the main reason was the involvement in the course of the disease of only the head and not the acetabulum.

Complications

With regard to complications, a limited number, namely for infection, periprosthetic fracture and dislocation was reported in the studies involved in this review. The most commonly described complications in the literature were aseptic loosening, heterotopic ossification and leg length discrepancy. Larson *et al.* found a high revision rate due to aseptic loosening.¹³ In a study with 28 THAs in SCFE patients, there were 14 hips requiring revision due to aseptic loosening at 11,6 years follow up. Heterotopic ossification was present in 15 out of 32 cases as reported by Traina *et al.*²⁴

Conclusions

In conclusion, SCFE patients seem to be younger, more often male and healthier than OA patients undergoing THA. Cementless implants are most commonly used for this young group of patients. Modern THA-studies in SCFE patients showed improvement of survivorship, clinical outcomes and patient satisfaction. With the advance of technology and new implant designs, survivorship of THA in SCFE patients is expected to be prolonged. This review supports the use of THA to relieve hip pain and functional abilities in patients suffering from hip OA due to SCFE disease. Future higher-quality studies, however, are necessary to estimate long-term postoperative outcomes better.

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