FEMOROACETABULAR IMPINGEMENT: THE PURSUIT OF EVIDENCE

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Femoroacetabular Impingement:
The pursuit of evidence

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ABSTRACT

Femoroacetabular Impingement (FAI) is an important cause of hip pain in the young adult. It is the result of abnormal contact between the femoral head and neck junction and the acetabular rim. Although FAI has only recently been recognized as a medical and surgical condition, there has been a dramatic rise in diagnosis, treatment and scientific publications addressing this entity. Despite initial promising reports of outcomes following surgical management of this condition, controversy remains about the best approach of diagnosing and managing. This thesis aims to evaluate the current state of the evidence, the global perceptions of the condition from clinicians and world experts, as well as provide a study design that can definitively evaluate the efficacy of surgical intervention.

Study 1 is a survey of 202 surgeon members of the Canadian Orthopaedic Association, evaluating their perceptions of the evidence for the management of FAI. The majority of surgeons were unsure of the existence of evidence supporting the best clinical test for FAI, the use of a diagnostic intra-articular injection for diagnosis of FAI, and for non-operative management of FAI.

Study 2 is a survey of international surgeons from global organizations evaluating the state of opinions in terms of the diagnosis and treatment of FAI as well as exploring the current demographic characteristics of surgeons performing FAI surgery. The survey was completed by 900 respondents. Surgeons performing a higher volume of FAI surgery (> 100 cases per year) were significantly more likely to have practiced for more than 20 years, to be practicing at an academic hospital, and to have formal arthroscopy training. High-volume surgeons were over two-fold more likely to practice in North America and Europe than the rest of the world.

Study 3 is a systematic review of the literature that assesses the quality of the literature addressing FAI over the 5-year span of 2011-2015. The review demonstrated that in comparison with previous work, there has been 3.5-fold increase in the number of publications over the past 5 years with a shift towards improving the level of evidence available guiding the arthroscopic management of FAI.

Study 4 is a systematic review of the world's English literature to assess the current strategies used to diagnose and treat FAI. We identified 105 studies reporting surgical interventions for FAI. Most studies were completed in North America and in Europe. Asia and Oceania had smaller contributions. There were no studies from South America or Africa. Most research performed in North America, Europe, and Oceania investigated arthroscopic FAI surgery followed by surgical dislocation, and mini-open and combined approaches. Methods of diagnosis were consistent worldwide, with radiography being the mainstay of diagnostic evaluation.

Study 5 is a systematic review of the literature that evaluated the reporting of non-hip score related outcomes following FAI surgery. The most common non-hip score outcomes reported included; patient satisfaction, symptom improvement, pain improvement, hip range of motion. The most frequently reported standardized hip outcome scores used were the modified Harris Hip Score (mHHS) and Non-Arthritic Hip Score (NAHS).

Study 6 is a systematic review of the literature evaluating the consistency of reporting clinical and radiographic outcomes follow FAI surgery. There was a lack of consensus and consistency with regard to reported outcomes (clinical and radiographic) after arthroscopic treatment of FAI.

Study 7 is a narrative review with global content and research experts evaluating the current state of the evidence pertaining to FAI as well as proposing critical questions that needs addressing with rigorous scientific investigation.

Study 8 is a study protocol for investigating the surgical efficacy of FAI surgery with a randomized controlled trial. This study has received ethics approval at the primary site as well as other international sites. This study demonstrates the feasibility of a prospective randomized controlled trial addressing FAI.

Keywords: femoroacetabular impingement, evidence based medicine, hip, systematic review, survey.

SAMMANFATTNING PÅ SVENSKA

Femoroacetabulär impingement (FAI) är en vanlig orsak till höftsmärta hos unga vuxna, som uppkommer på grund av en onormal kontakt mellan lårbenet och den acetabulära ledskålen i höftleden. FAI blev nyligen erkänt som ett medicinskt tillstånd och under de senaste åren har det skett en dramatisk ökning av vetenskapliga publikationer avseende detta tillstånd. Initiala rapporter av resultat efter kirurgisk behandling är lovande men det kvarstår ändå osäkerhet avseende det bästa sättet att behandla FAI.

Denna avhandling är uppdelad i åtta delarbeten och syftar till att belysa evidensen kring FAI och uppfattningen av operatörer och världsledande experter rörande diagnostik och behandling. Avhandlingen visar även en studiedesign som definitivt kan utvärdera effektiviteten av kirurgisk behandling i en randomiserad studie.

Studie 1 utvärderar uppfattningen av evidensen för behandling av FAI hos medlemmar i den kanadensiska ortopediska föreningen. Svarsfrekvensen låg på 20%, med 202 svarande. Majoriteten av operatörerna var osäkra på förekomsten av bevis som stöder det bästa kliniska testet, samt användningen av en diagnostisk intraartikulär injektion för diagnos av FAI.

Studie 2 undersöker de nuvarande demografiska egenskaperna hos operatörer som utför kirurgisk behandling av FAI. Detta visar på att de som främst opererade FAI var operatörer som utfört många operationer för FAI (> 100 operationer per år), hade praktiserat i mer än 20 år, arbetade på ett universitetssjukhus, samt hade en formell artroskopiutbildning.

Studie 3 är en systematisk översikt vilken bedömer kvaliteten på litteraturen avseende FAI från 2011 till 2015. Översikten visar att det har skett en 3,5-faldig ökning av antalet publikationer under de senaste fem åren med en tydlig riktning till att etablera ökad evidens för artroskopisk behandling av FAI.

Studie 4 är en systematisk översikt med syfte att kunna bedöma de nuvarande strategierna som används för att diagnostisera och behandla FAI. 105 studier som beskriver operativ behandling av FAI identifierades. De flesta studierna utfördes i Nordamerika och i Europa. Ett litet antal studier var utförda i Asien eller Oceanien. Inga studier var från Sydamerika eller Afrika. De flesta studier undersökte artroskopisk behandling av FAI följt av osteotomier, mini-artrotomi alternativt kombinerade metoder. Diagnostiska metoder var överensstämmande över hela världen, med röntgenundersökning som viktigaste grunden för diagnos.

Studie 5 är en systematisk översikt som utvärderar rapportering av resultat efter FAI-operation. De vanligaste utfallsmåtten som användes i de inkluderade studierna var; patienttillfredsställelse och förbättring av symtom, smärta och rörlighet. De vanligaste mätmetoderna som användes var den modifierade Harris Hip Score (mHHS) och Non Arthritic Hip Score (NAHS).

Studie 6 är en systematisk översikt som utvärderar rapportering av kliniska och radiologiska resultat efter operation för FAI. Den visar brist på konsensus med avseende på rapporterade resultat (kliniska och radiologiska) efter artroskopisk behandling av FAI.

Studie 7 är en studie där experter från hela världen utvärderar diagnostiken av FAI, samt ger förslag på vidare forskningsfrågeställningar, som är i behov av ytterligare vetenskaplig utredning.

Studie 8 är ett studieprotokoll för utförandet av en randomiserad kontrollerad studie med syfte att studera effekten av operativ behandling av FAI .

Sammantaget visar avhandlingen att FAI är en relativt ny diagnos, som många unga lider av. De senaste årens forskning har visat att antalet operationer har ökat markant. Kunskapen har ökat, men ytterligare studier krävs för att ge fördjupad insikt i temat.

Nyckelord: femoroacetabulär impingement, evidensbaserad medicin, höft, systematisk översikt.

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ABBREVIATIONS

ANCOVA: Analysis of Co–Variance

CONSORT: Consolidated Standards of Reporting Trials

COA: Canadian Orthopaedic Association

CT: Computerized Tomography

DGEMRIC: Delayed Gadolinium Enhanced Magnetic Resonance Imaging of Cartilage

EQ-5D: Euro Qol 5 Dimensions

FADIR: Flexion Adduction Internal Rotation

FAI: Femoroacetabular Impingement

FIRST: Femoroacetabular Impingement Randomised Controlled Trial

FSFI: Female Sexual Function Index

HAGOS: Copenhagen Hip and Groin Outcome Score

HOS: Hip Outcome Score

ICIQ-FLUTS: International Consultation on Incontinence Modular Questionnaire-Female Lower Urinary Tract Symptoms

ICIQ-MLUTS: International Consultation on Incontinence Modular Questionnaire-Male Lower Urinary Tract Symptoms

IHOT: International Hip Outcome Tool

IIEF: International Index of Erectile Function

INFOCUS: International Femoroacetabular Impingement Optimal Care Update Survey

ISHA: International Society for Hip Arthroscopy

MCID: Minimal Clinically Important Difference

MINORS: Methodological Index for Non-Randomized Studies

MHHS: Modified Harris Hip Score

MRI: Magnetic Resonance Imaging

NAHS: Non-Arthritic Hip Score

OA: Osteoarthritis

PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses

PROCESS: Perception of Femoroacetabular Impingement by Surgeons Survey

QUADAS: Quality Assessment of Diagnostic Accuracy Studies

QUIPS: Quality in Prognostic Studies

RCT: Randomized Controlled Trial

VAS: Visual Analogue Scale

WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index

BRIEF DEFINITIONS

Content Validity: refers to how well a test measures the behavior for which it is intended.

Construct Validity: the degree to which a test measures what it claims to measure

CAM: a subtype of FAI that is the result of prominence at the head and neck junction of the femur.

Case Series: a study that tracks patients with a known exposure to an intervention or treatment.

Case-Control Study: a study design that compares subjects with a condition or outcome of interest to those who do not have the condition or outcome of interest.

Cohort Study: a group of patients is followed over time until an outcome or disease occurs. It can be prospective and retrospective in design.

Evidence Based Medicine: judicious use of current best evidence to make clinical decisions about individual patients.

Femoroacetabular impingement (FAI): refers to abutment or abnormal contact between the femoral head/neck and acetabular rim causing pain.

Face Validity: extent to which a test is subjectively viewed as covering the concept it purports to measure. It is a more superficial and subjective assessment than content validity.

Intention to Treat Analysis: patients who were enrolled and randomly allocated to treatment are included in the analysis and are analysed in the groups to which they were randomized.

Inter observer Agreement: comparing observations from 2 independent reviewers of the same event.

Meta-Analysis: statistical procedure for pooling the results of multiple studies together, particularly when treatment effect is consistent from one study to the next.

MIXED FAI: a combination of CAM and PINCER type morphologies

Narrative Review: a broad review of opinions from content experts in consultation with current literature to address an area of potential investigation or state of the current research.

Nonresponse bias: is the bias that results when respondents differ in meaningful ways from non-respondents

PINCER: a subtype of FAI that is the result of focal or global over coverage of the acetabular rim.

Randomized controlled trial: a study design that involves randomly allocating subjects to different treatment groups. It is considered the gold standard of scientific investigation.

Systematic Review: a methodological search of the literature (databases) to select well-designed studies whose results summarized to answer a defined research question.

I. INTRODUCTION

I.I HISTORICAL BACKGROUND

Femoroacetabular Impingement (FAI) as a cause of hip pain in young adults has become an increasingly diagnosed and investigated clinical entity[1]. Origins of the concept of FAI were first proposed by Smith-Petersen in 1936[2]. In his seminal paper, patients with hip pain were treated surgically to minimize "impingement" or contact between the femoral head and neck junction and the acetabulum. The proposed surgery involved resecting bone to minimize contact between the femoral head and neck junction and the acetabulum. Other investigators also proposed that subtle anomalies in morphology at the hip joint may predispose individuals to the development of hip osteoarthritis (OA)[3,4]. Almost five decades later, Ganz formerly stated that FAI or abnormal contact between the femoral head and neck junction and the acetabular rim leads to intra-articular damage and the subsequent degeneration of the hip joint[5]. The final stage degeneration of both cartilage and labrum is the resultant hip OA.

In this theory, FAI is the result of two distinct types of deformities: An abnormally shaped femoral head neck junction due to osseous prominence termed, "CAM type" impingement or a focal or global over coverage of the hip by osseous prominence on the acetabular rim termed "PINCER type" impingement (See Figure 1). Typically, the CAM type deformity results in damage to the chondro-labral junction of the anterior superior acetabulum and the PINCER type deformity results in intra substance damage to the labrum[5,6]. In PINCER type impingement, compression of hip cartilage during flexion may lead to the development of "contre coup" lesions in the femoral head and posterior inferior acetabular cartilage[6]. Nonetheless, most patients have a combination of both CAM and PINCER type impingement and this is termed "mixed" impingement. It follows that surgical intervention for this condition consists of resecting the osseous lesions and treating the intra articular lesion concurrently (labral tears and/or cartilage lesions).

This way, the abnormal contact between bony surfaces or impingement is minimized. More recently, a multidisciplinary group of international experts who treat FAI has defined FAI syndrome in a consensus statement (Warwick Agreement of FAI) as follows: a motion-related clinical disorder of the hip with a triad of symptoms, clinical signs and imaging findings[7,8]. It represents symptomatic premature contact between the proximal femur and the acetabulum. It is proposed that the recognition of all determinants of FAI (clinical and radiographic) will result in more consistent and standardized diagnosis and communication about the condition. Subsequently, both treatment and research that is generalizable while addressing the condition will follow.

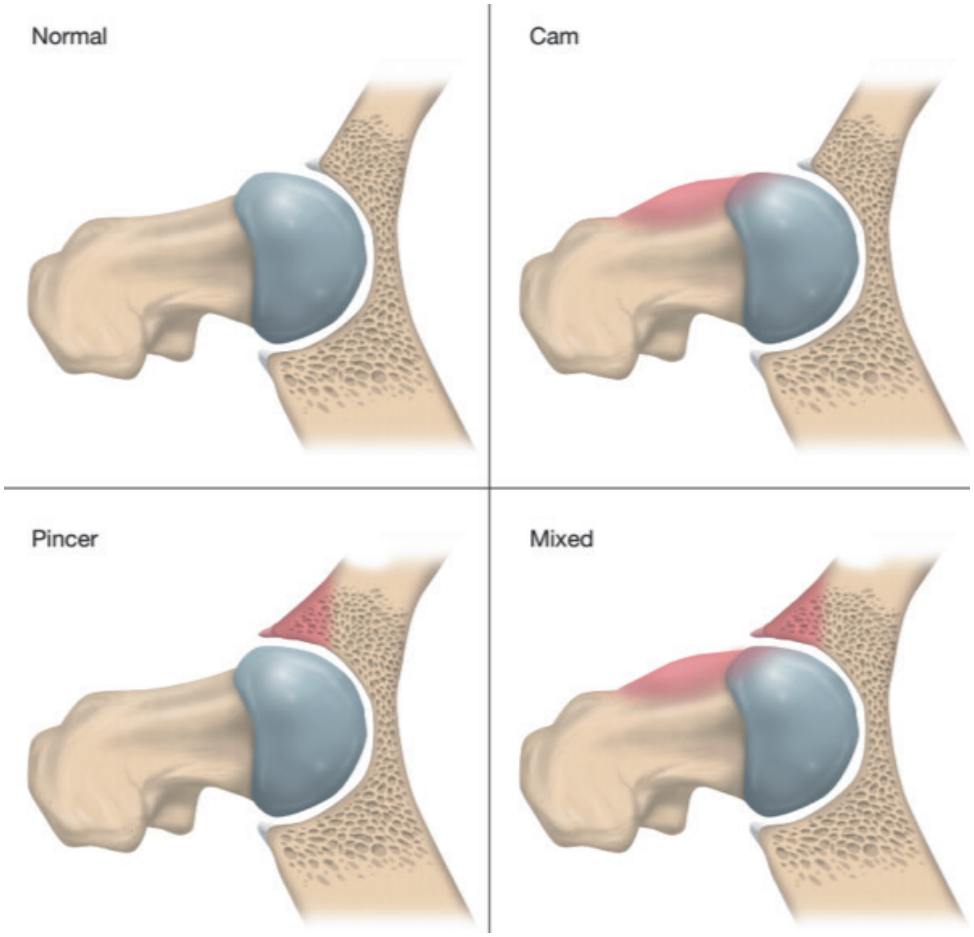


Figure 1. FAI schematic of the varying sub types: Normal hip shows no abnormality CAM depicts bony prominence (in red) at the head and neck junction of the femur, pincer depicts bony over coverage and prominence (in red) of the acetabulum, mixed depicts a combination of both cam and pincer morphology (in red).

I.2 ETIOLOGY OF FAI

There are several proposed causes of FAI including residual or subtle pediatric hip disease, genetic predisposition and activity related physeal hip injury during adolescence. Some investigators have proposed that pediatric hip disease, particularly slipped capital femoral epiphysis (SCFE), may contribute to the development of FAI and osteoarthritis[9]. However, others refute this theory of SCFE leading to FAI and propose that FAI is a distinct clinical entity[10]. As such, this debate about the relationship between pediatric hip disease and FAI has not been resolved. The contribution of genetics to clinical FAI has been evaluated by Pollard et al. In a case-control study, these researchers compared 96 siblings (cases) of 64 patients with symptomatic FAI to 77 spouses (controls) of patients with FAI. These investigators found that there is an increased relative risk of 2.8 for siblings compared with controls of having the same CAM morphology (alpha angle >62.5°) as the patients. Also, the siblings of patients with a PINCER morphology had a relative risk of 2.0 of also having PINCER morphology[11]. To date, most of the research has been focused on the development of the CAM morphology and much less is known about the PINCER morphology. One of the increasingly recognized possibilities is that the CAM morphology develops as a result of subtle injuries (caused by repetitive activities) to the physis or growth plate of the proximal femur. It follows that adolescents exposed to high-level sports involving repetitive hip movements during training may be at risk for developing this deformity. It also follows that there may be a critical period during hip development (after age 13) when athletic activity may impact the development of CAM type deformities. Ayeni et al, compared 20 elite level hockey players to

20 non-hockey players using MRI and clinical examination.

They reported a significant difference in the alpha angle, a measure of CAM deformity, between athletes and non-athlete[12]. Non-athletes measured 43.2 degrees and athletes 54.2 degrees, SD 12 ($p = 0.003$) and there were no differences noted in PINCER morphology. Similarly, Agricola et al. prospectively evaluated pre-professional soccer players (age 12,13) and noted a change in the incidence of CAM morphology from 13.6% at baseline to 50% at final follow up[13].

In other studies, end of range hip internal rotation in elite ice hockey goaltenders was suggested to be the pivotal motion that served as a precursor to the development of symptomatic FAI (See Figure 2).[14,15]

Finally, Siebenrock et al. noted an increase in CAM morphology measured by epiphyseal extension in elite basketball players compared age matched non athletes[16]. These findings suggest that during adolescence there may be a critical period of hip development in which the volume of repetitive activity may alter the development of the femoral head and neck junction. Nevertheless, investigators also recognize that the morphological characteristics that are found on imaging can occur frequently.

In a systematic review of multiple studies by Frank et al., the prevalence of FAI morphology in reported studies was; CAM 7%-100% and PINCER 61%-76%. Not surprisingly, high level athletes have common radiographic findings of FAI without symptoms[17]. Similarly, labral pathology on MRI is also common particularly in athletes and older adults[18-20]. For example, Gallo et al., found that 64% of collegiate or professional hockey players had positive findings of cartilage or labral damage on MRI despite being asymptomatic[21]. These findings highlight the fact that FAI is not simply a radiological finding but a condition that also requires patient symptoms and associated positive clinical tests.

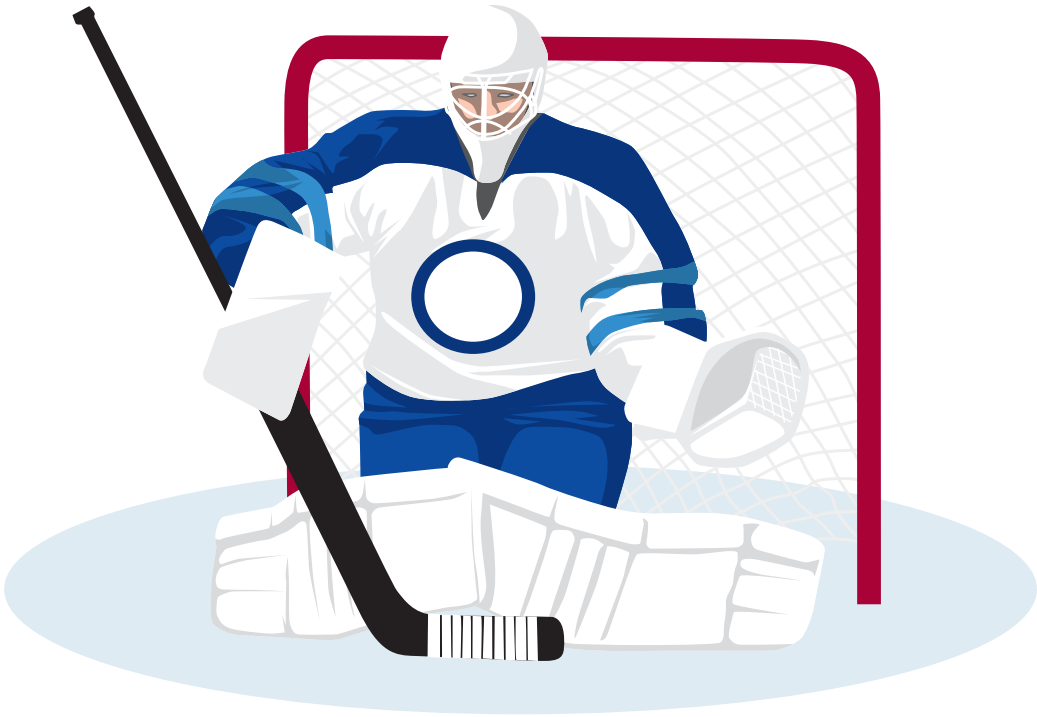


Figure 2. Picture of the "butterfly position." This depicts end of range hip internal rotation in an ice hockey goal tender, the repetitive placement of hips in this position may be a precursor to symptomatic FAI.

1.3 DIAGNOSIS OF FAI

The diagnosis of FAI is typically obtained by documenting a history of hip and/or groin pain[22]. Patients may cup their palm and hand around the hip girdle just above the greater trochanter in what's been described as the "C-sign"[23]. Subsequently, provocative testing for FAI on physical examination should also yield positive results.

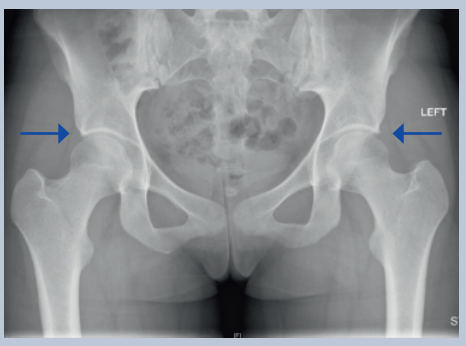
This test typically involves examining a patient in multiple positions (standing, seated, supine, lateral decubitus and prone), however, a loss of flexion and rotation of the affected hip is most common when assessing range of motion of the hip[24]. To date, one the commonest tests used to diagnose FAI is the: Flexion-ADduction-Internal Rotation or FADIR test[25,26]. To conduct this exam maneuver, the hip is flexed 90 degrees, internally rotated 10 degrees and adducted approximately 10 degrees (Figure 3). With further and gradual internal rotation, hip pain is elicited. Despite the inherent limitations of physical examination maneuvers in the hip, this test has been shown to be one of the most sensitive tests for FAI in a comparative cohort study of 77 patients by Tijssen et al.[22]. Subsequently, imaging results can confirm the radiographic presence of a CAM and PINCER morphology (Figure 4A and 4B). These bony lesions can be identified on imaging such as radiographs, computerized tomography (CT) scan, and magnetic resonance imaging (MRI), (with or without dye).

Radiographic findings that are typical of FAI are:
1.) a loss of femoral head and neck offset measured by an elevated alpha angle (greater than 50 degrees) for CAM type impingement[27,28],
2.) For PINCER type impingement, a focal or global over coverage quantified by the presence of a figure of sign, ischial spine sign or elevated center edge angle (greater than 40 degrees)[28,29].

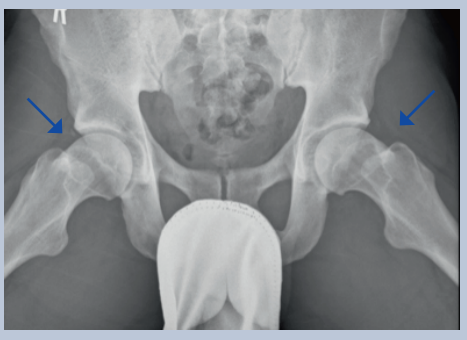
Finally, a diagnostic intra articular injection with documented relief of the typical hip pain has both diagnostic and therapeutic value. Byrd et al., demonstrated that relief with an intra articular hip injection was 90% accurate for predicting the presence intra articular findings at time of hip arthroscopic surgery[31]. Interestingly, in a prospective cohort study by Ayeni et al., no relief from an injection was a negative predictor of short term outcome following FAI surgery[32,33]. Upon the completion of these diagnostic steps, symptomatic patients with positive provocative testing may be offered corrective FAI surgery. In accordance, with the Warwick Agreement, those candidates for intervention are symptomatic, have positive clinical testing and positive radiographic findings[7].

Figure 3. FADIR TEST: Flexion of the hip (90 Degrees) followed by adduction (10 degrees) and internal rotation (10 degrees) to recreate the patient's symptoms

Figure 4: FAI 4A (BILATERAL PINCER) AND 4B (BILATERAL CAM).



4A: Bilateral PINCER Type FAI with crossover morphology of the acetabulum shown by arrows.



4B: Bilateral CAM Type FAI with prominence of the femoral head-neck junction show by arrows.

1.4 MANAGEMENT OF FAI

Initially, the surgical hip dislocation technique pioneered by Ganz was the gold standard of treatment. This technique involved a controlled surgical dislocation of the hip while preserving blood supply to the femoral head[34]. Beck et al., treated 19 patients using this technique and at a mean follow up of 4.7 years, and found that 13 patients had good to excellent scores based on the Merle d'Aubigne scoring, with 6 requiring arthroplasty for symptomatic degenerative changes[35]. In their series, Beaule et al., reported on 34 patients that underwent open surgical hip dislocation and osteochondroplasty. At a mean follow up of 3.1 years post operatively, the Western Ontario and McMaster Universities Index (WOMAC) increased from 61.2 to 81.4 (P<0.001) with no additional surgery required. However, with the recent advancements in hip arthroscopic surgery, hip arthroscopy is increasingly being utilized to treat FAI successfully (Figure 5 A and 5 B).

Recent studies have also documented that the arthroscopic technique is associated with fewer complications, less pain and less resource utilization[36,37].

Philippon et al., prospectively evaluated 122 patients undergoing arthroscopic FAI surgery with a minimum of 2 year follow up. They reported a mean improvement in modified Harris hip score 58 to 84 (mean difference = 24 (95% CI 19 to 28) and the median patient satisfaction was 9 (1 to 10)[38]. Ten patients had treatment failures and underwent total hip replacement within the follow-up period.

Similar results of clinical improvement have also been reported in the pediatric population[37]. Philippon et al, evaluated 16 adolescents and noted an improvement of 35 points in the modified Harris hip score at a mean follow up of 1.4 years.

Overall, the surgical efficacy of FAI treatment, regardless of surgical approach (open or arthroscopic) is supported by clinical evidence that is limited to case series and cohort studies as reported by a systematic review by Ng et al.[40].

The goals of surgery remain to remove the impingement bony lesions and treat any intra-articular damage concurrently.

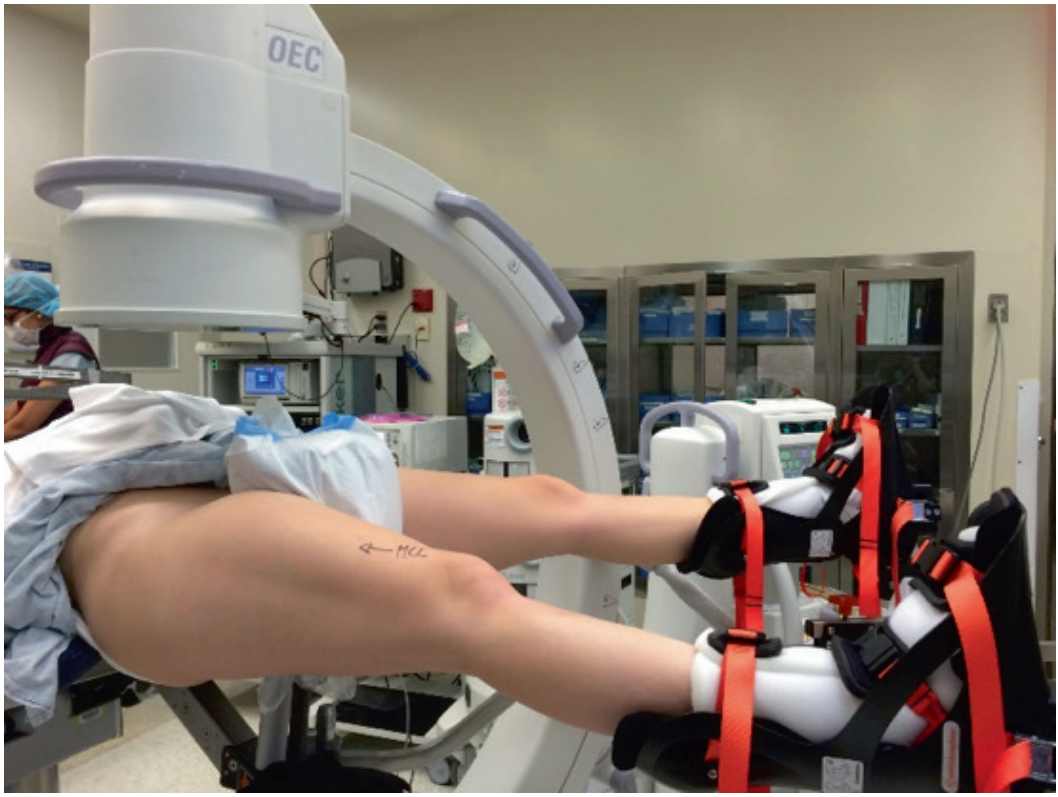


Figure 5A. Supine positioning for hip arthroscopy.

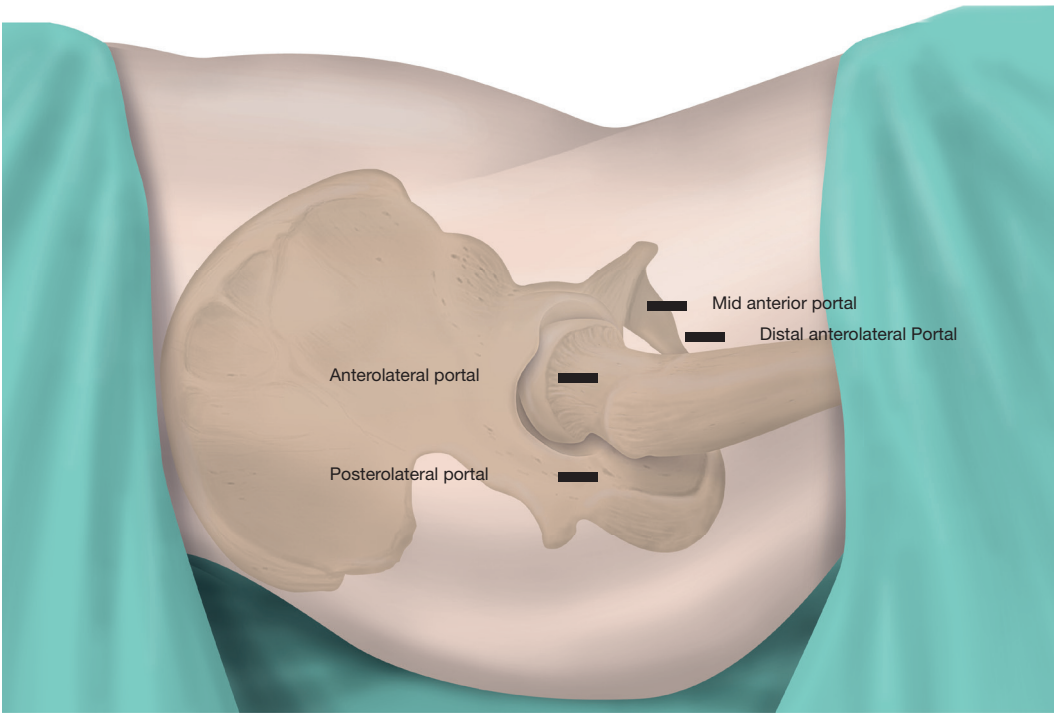


Figure 5B. Standard hip arthroscopic portals for FAI surgery. (AL-anterolateral, MAP-Mid Anterior Portal, DALA-Distal Antero Lateral Portal).

Nevertheless, the potential of this intervention to alleviate hip pain and prevent the development of osteoarthritis has led to rapid adoption of surgical intervention globally. However, the supporting evidence about the diagnosis and treatment of FAI is still to a great degree limited. Most studies documenting successful management of FAI consist of case series and single surgeon studies with limited follow-up. These studies of lower methodological quality are often limited by various biases[41]. As such there is a need to evaluate the current state of the literature addressing FAI, identify areas that need clarity and propose a definitive surgical trial that evaluates the efficacy of surgical management of FAI.

I.5 STATE OF THE EVIDENCE

The recent increase in publications related to FAI has been exponential1. Ayeni et al., demonstrated a 5-fold increase in FAI related publications from 2005-2010[1]. This is because the reported successful surgical intervention has the potential to reduce pain, improve function and possibly prevent the development of degenerative changes such as OA in selected patients (Figure 6)[42]. Moreover, the elegant theory of FAI and mechanical hip pain makes inherent sense to clinicians. However, despite the impressive increase in available information, there have been no high quality clinical trials evaluating the effectiveness of surgical intervention for FAI[1]. Most surgical studies addressing FAI have been single surgeon case series or limited cohort studies with short term follow-up. In addition, the widespread availability of information on FAI surgery to patients regardless of the scientific quality has fueled demand from symptomatic patients[43]. This lack of definitive surgical trial is likely due to the known barriers to conducting clinical trials in surgery. Such barriers include, cost of randomized trials, inability to blind surgeons as well as pre-existing surgeon and patient preferences[44]. Nevertheless, a well-conducted, multi-centered trial evaluating the efficacy of surgical intervention is warranted to determine who may benefit from FAI surgery. Such a trial would serve as a transition from the current understanding largely based on lower level evidence to one based on research of the strongest methodology. The necessity for evidence-based medicine has been well documented as it allows for the use of the best available evidence in conjunction with medical expertise and patient input to make clinical decisions.

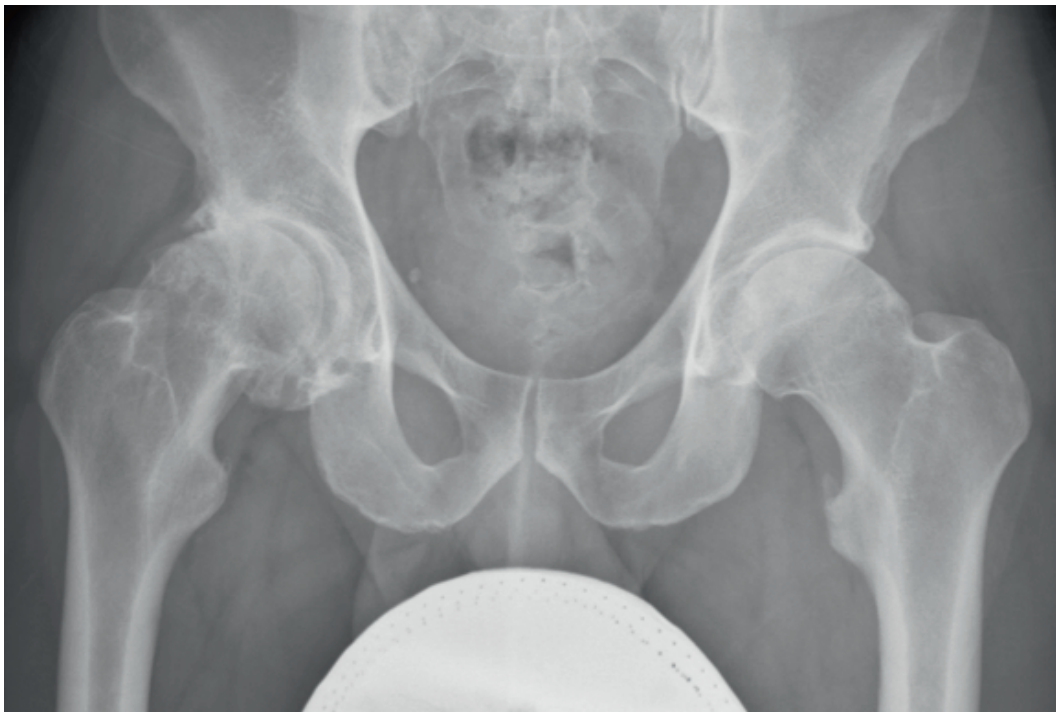


Figure 6. Example of severe OA and FAI: Right hip, Mild OA and FAI: Left Hip.

I.6 THE OVERALL PROBLEM

Femoroacetabular impingement is a cause of hip pain in the young adult. It is recognized by the combination of clinical symptoms, clinical examination and radiological findings. It is increasingly being diagnosed globally and treated surgically despite a lack of high level or high quality evidence to evaluate the effectiveness of surgical treatment. The potential of preventing or limiting damage to the hip joint in the young adult has increased the interest in diagnosis of and intervention for FAI. There remain important questions about how effective the intervention, notably surgery is for symptom relief and limitation of the disease progression.

I.7 WHY IS THIS THESIS NEEDED

This thesis effort demonstrates the preparatory work completed using comprehensive systematic reviews of the literature and surveys to determine the critical research components of a randomized controlled trial evaluating efficacy of the surgical management of FAI. Overall, this body of research aims to evaluate the quality of current evidence pertaining to the diagnosis and management of FAI and identify gaps in the understanding of this condition. Specific questions include: what is the state of the global literature addressing FAI, what are the most comprehensive methods to assess patients with FAI pre and post operatively. Secondarily, it aims to propose a definitive randomized controlled trial evaluating the efficacy of surgical treatment of FAI. This thesis is needed because despite the improved understanding of the mechanics of the hip joint, notably FAI, there has not been a comprehensive evidence based approach to investigate the effectiveness of treating this condition surgically. The amount of FAI-related literature to date has grown rapidly with associated improvement in diagnosis and treatment. However, the ability to make definitive statements about FAI using most of the available literature is limited by the current state of research/evidence[45,46]. As such, there is a critical need to proceed with managing this condition effectively using an evidence-based approach.

This evidence-based approach should include input from clinicians (surveys), input from thought leaders (narrative review), as well as a thorough assessment of the literature to identify key clinically relevant questions (systematic reviews)[47]. All of this work as conducted in this thesis should lead to the development of a definitive clinical trial to provide answers to important questions.

2. AIMS

- A survey was developed and administered to evaluate the current state of knowledge of the diagnosis and treatment of FAI amongst Canadian orthopaedic surgeons.
- An international survey of surgeons to assess the perceptions of orthopaedic surgeons in terms of the diagnosis and management of FAI.
- A systematic review to explore the current trends in the literature over the last 5 years (2011-2015) in FAI and evaluate the quality and sources of publications.
- A systematic review to assess the global patterns in the diagnosis, surgical treatment and outcome assessment following FAI surgery.
- A systematic review to evaluate the reporting of non-hip score outcomes following surgical management of FAI.
- A systematic review to evaluate the consistency of the reporting of clinical and radiographic outcomes after arthroscopic management of femoroacetabular impingement.
- This narrative review with global content experts evaluated the critical questions needing addressing with regards to FAI as well as future areas of scientific investigation.
- The Femoroacetabular Impingement RandomiSed controlled Trial (FIRST) compares outcomes following surgical correction of the impingement morphology (arthroscopic osteochondroplasty) with/without labral repair versus arthroscopic lavage of the hip joint in adults aged 18 to 50 diagnosed with FAI. The aim is to evaluate the efficacy of surgical management of FAI.

3. METHODS

STUDIES I AND 2:

Research ethics board approval was obtained from Hamilton Integrated Research Ethics Board prior to the commencement of both surveys: PROCESS (11-429) and INFOCUS (12-404)

QUESTIONNAIRE DEVELOPMENT

The investigators formed a focus group consisting of an international group of orthopaedic surgeons who treat young adults with hip pain to determine key parameters and indices to be included in the survey. The investigators also reviewed prior surveys addressing related surgical interventions to develop the survey. Finally, websites of governing bodies and organizations that address FAI were reviewed for item generation. Questions were tailored to address the current state of knowledge among orthopaedic surgeons in terms of FAI treatment. The final survey was translated when appropriate to local languages.

Questions were tailored to examine respondent's demographic characteristics, surgical indications, and management preferences, as well as perceptions of the current available evidence for FAI surgery. We used the "sample-to redundancy" approach, by which new surgeons were surveyed until no new items for the questionnaire emerged. The surveys were pretested to ensure face and content validity with an independent group of orthopaedic surgeons specializing in managing hip pathology.

PRETESTING AND VALIDITY ASSESSMENTS

During pre-testing the following sections were identified and refined after feedback: (1) demographics, (2) diagnosis, (3) treatment, (4) evidence and diagnosis, (5) evidence and treatment, (6) outcomes, and (7) impressions. The surgeons also made comments on the content, ease of understanding, comprehensiveness, and time consumption related to the survey. The final questionnaire framed responses using both Likert and Nominal Scales. In addition, commentary and open responses were permitted in certain sections of the survey.

QUESTIONNAIRE ADMINISTRATION:

Electronic surveys by email after obtaining consent from the governing bodies for email access. In the PROCESS survey, those without valid email addresses or who did not have an email address listed with the COA were sent mailed surveys for manual entry. All electronic responses were collected and stored on a secure, password-protected server. The responses from mailed surveys were transcribed and recorded on the same electronic server. All responses were voluntary, and ethics approval was obtained prior to administering the survey.

STUDIES 3, 4, 5 AND 6

SEARCH STRATEGY

Two reviewers conducted a librarian-assisted search of multiple databases (EMBASE, MEDLINE and PubMed) of the English literature of the research topic relating to FAI. The research question and individual study inclusion and exclusion criteria were established a priori.

STUDY SCREENING

Two reviewers independently screened the titles, abstracts and full texts of the retrieved studies. If at any point during the title and abstract screening phases, one reviewer believed an article should proceed to the next stage, it was included to ensure thoroughness. At the full text stage, any disagreements were first discussed by the two reviewers and unresolved conflicts mediated by a third reviewer until a consensus was reached. The references of included studies were further searched to capture any articles that may have been missed by the initial search strategy.

QUALITY ASSESSMENT OF INCLUDED STUDIES.

The following scales were used to assess the quality of the included studies (see appendix for details):

- MINORS checklist for nonrandomized studies[48]
- Coleman Methodology Score for RCT[49]
- Newcastle-Ottawa Scale for observations studies (cohort and case-control)[50]
- Modified Yang checklist for case series[51]
- CONSORT checklist for prospective comparative studies[52]
- QUADAS for diagnostic accuracy Studies[53]
- QUIPS (Hayden) Tool[54]

DATA ABSTRACTION

Two reviewers independently abstracted study data from the final pool of included articles and recorded this data in a Microsoft Excel (2013) File.

DATA ANALYSIS

Interobserver agreement for reviewers' assessments of study eligibility was calculated with the Cohen kappa (k) coefficient.

COMPILATION OF RESULTS:

Results are compiled and reported in appropriate categories and tables to answer the research questions. No meta-analysis is performed due to the heterogeneity in the exiting data precluding a synthesis of data.

STUDY 7

This narrative review focused on FAI, summarizes the findings and conclusions of several important papers addressing the diagnosis and treatment of FAI while highlighting areas of needed investigation. Leading experts in the clinical medicine and research also provide their opinions to provide a comprehensive clinically oriented approach to address FAI.

STUDY 8

RANDOMIZED CONTROLLED TRIAL

FIRST (Femoroacetabular Impingement Randomized Controlled Trial) is an ongoing multicenter, blinded RCT of 220 patients who have been diagnosed with FAI and are selected for surgical intervention. Research ethics board approval was obtained from the Hamilton Integrated Research Board (12-396). Pre-defined inclusion and exclusion criteria were applied to screen patients and those who are eligible are approached by a research assistant for consent into the trial.

RANDOMIZATION (FIGURE 7)

A centralized 24 hour computerized randomization system that allows for automated internet based randomization to allocate patients to the control or intervention group in random block sizes of 4 and 8 prior to surgery is utilized. Patients are stratified based on centre and impingement sub-type (CAM or Mixed) and randomization is concealed.

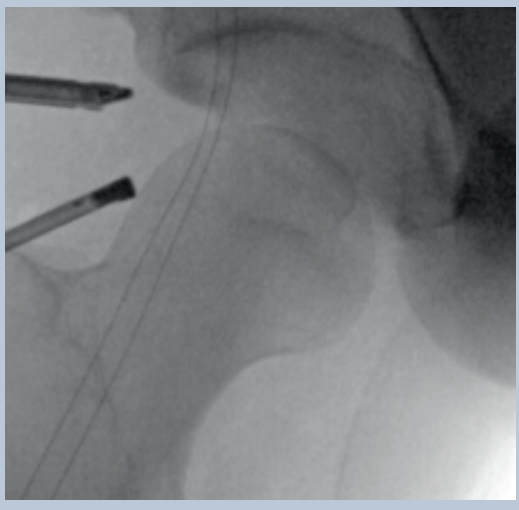
Figure 7. Process of Randomization: assigning a treatment group in a study by chance to reduce bias.

STUDY INTERVENTIONS:

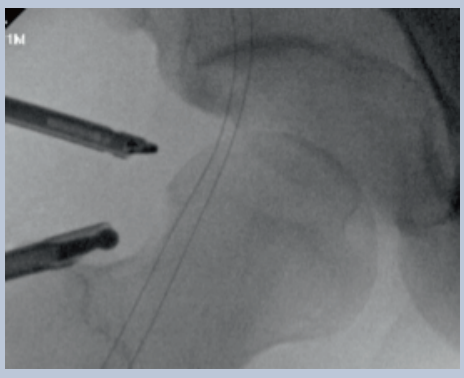
OSTEOCHONDROPLASTY (INTERVENTION GROUP)

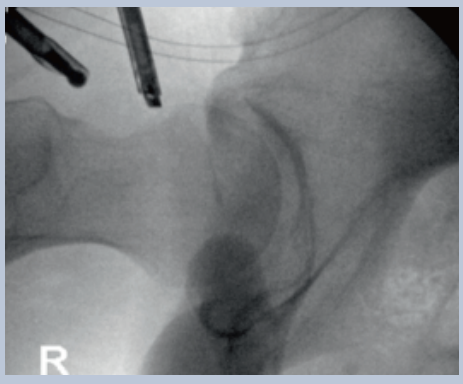
Patients in the intervention group (osteochondroplasty with/without labral repair) undergoing an initial hip evaluation using hip arthroscopy. Three standard hip arthroscopy portals are used during the entire procedure to assess and treat the patient[55,56]. Significant and obvious labral tears and cartilage damage are addressed concurrently[57,58]. The pincer lesion is resected using an arthroscopic burr under fluoroscopic guidance[59-61]. The head-neck junction of the femoral neck is visualized and the CAM lesion is resected (See Figure 8). Intraoperative fluoroscopy is used to guide the osteochondroplasty and resection of the impingement lesions (See Figure 8)[62-63].

Figure 8. Stages of FAI management.

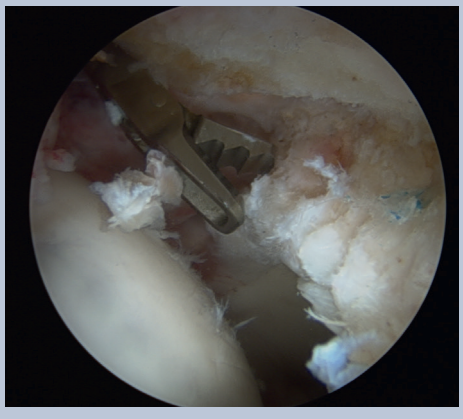


8A. Pre CAM resection.

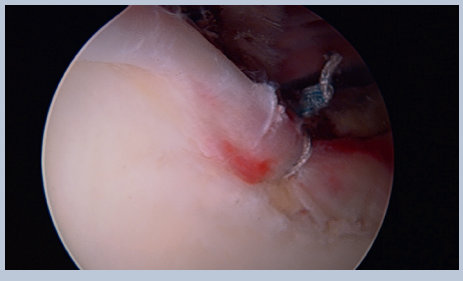




8B. Post CAM Resection in ap & lateral views.



8C. Acetabular rim decompression (arthroscopic image).



8D. Labral repair with suture anchors (arthroscopic image).

ARTHROSCOPIC LAVAGE (CONTROL GROUP)

Patients in the control group (arthroscopic lavage) have the same three hip portals with limited capsulotomy allowing for a complete assessment of the hip joint. A diagnostic arthroscopy and lavage of the hip joint with three litres of normal saline is completed. No osteochondroplasty or rim resection is completed in the control group. The labrum or cartilage is only repaired if it is mechanically unstable once probed with visible displacement or significant chondro labral separation (See Figure 9).

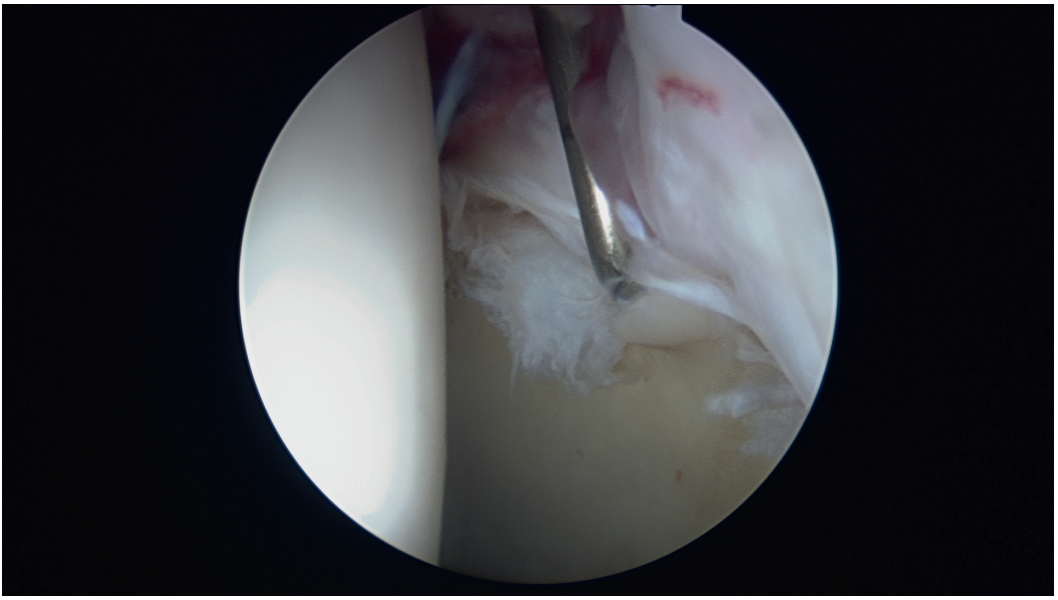


Figure 9. Chondro-labral damage (separation) in the hip joint (arthroscopic image).

STUDY OUTCOMES:

PRIMARY OUTCOME

The primary outcome is the change in pain scores between intervention and control patients at 12 months, as rated using a Visual Analog Scale (VAS).

SECONDARY OUTCOMES

Secondary outcomes include: Questionnaires include a generic health status measurement instrument (SF-12), hip function questionnaires (HOS, iHOT-12), a health utility measure (EQ-5D), and urinary (ICIQ-MLUTS/FLUTS) and sexual function questionnaires (IIEF/FSFI). Patient cost data, complication and revision surgery rates, as well as secondary procedures such as anti-inflammatory hip injections are also collected.

ADJUDICATION

An independent, blinded Adjudication Committee will review patient eligibility (e.g. preoperative radiographic alpha angle), intraoperative arthroscopic findings, and all reported complications. Disagreements between the Adjudication Committee members are resolved during regular conference calls.

SAMPLE SIZE CALCULATION

The FIRST trial is powered to detect a minimal clinically important improvement (MCII) in the VAS pain score (improvement of at least 13 points) between hip osteochondroplasty and lavage. The estimates of MCII were based upon Norman et al. and estimates from our pilot clinical trial[64]. To achieve 80% power and using at two-sided Type I error rate (5%), the trial requires 73 patients per study arm. For the secondary outcomes, the two-tailed Type I error rate to 1% to account for multiple comparisons was set. Therefore, for adequate study power across all our planned outcome measures, 192 patients are needed to recruit and follow. To account for potential loss to follow up (5%) and potential crossovers (5%), FIRST will recruit 107 patients per treatment arm, rounded to a total of 220 patients.

DATA MANAGEMENT:

The Case Report Forms (CRFs) are the primary data collection tool for the study (See Appendix). An Electronic Data Capture system (iDataFax) is being used to submit data to the Methods Centre located at McMaster University.

DATA SAFETY AND MONITORING COMMITTEE:

The purpose of the Data Safety and Monitoring Committee (DSMC) is to advise the FIRST Investigators in terms of the continuing safety of the trial participants. The DSMC is comprised of a clinical expert with prior trial experience, a clinical trial methodologist, and a biostatistician. All members are independent of the trial investigators, and have neither financial nor scientific conflicts of interests related to the trial.

4. STATISTICAL METHODS

STUDIES 1 AND 2

Summary statistics were calculated as dichotomous or categorical variables and presented as percentages. In the INFOCUS survey, we conducted a multinomial logistic regression analysis of demographic characteristics of surgeons performing no FAI surgery, a low volume of FAI surgery (1 to 100 cases per year), and a high volume of FAI surgery (> 100 cases per year)

STUDIES 3, 4 ,5 AND 6

Interobserver agreement for reviewers' assessments of study eligibility was calculated with the Cohen's k coefficient. On the basis of the recommendations of Landis and Koch, a k of 0 to 0.2 represents slight agreement; 0.21 to 0.40, fair agreement; 0.41 to 0.60, moderate agreement and 0.61 to 0.80, substantial agreement. A value greater than 0.80 is considered to indicate almost complete agreement.

Descriptive statistics were used to summarize the data. All analyses were performed using Microsoft Excel (version 15.2, Microsoft Corporation, Redmond, WA,USA) and SPSS Statistics (version 21, IBM, Armonk, NY, USA).

STUDY 7

No statistical analysis

STUDY 8

PRIMARY ANALYSES

The intention to treat principle is adopted for all analyses that is, patients will be retained in the group to which they were randomized. The baseline characteristics of the patients will be summarized by group, reported as a mean (standard deviation) or median (first quartile, third quartile) for continuous variables and count (percent) for categorical variables. An analysis of covariance (ANCOVA) will be used to compare the mean pain scores (VAS) at 12 months post-surgery adjusting for baseline scores. The treatment effect will be quantified with an absolute difference in rate of pain reduction with the associated 95% confidence interval (CI) and p-value. All p-values will be reported to 3 decimal places with those less than 0.001 reported as p<0.001. The criterion for statistical significance will be set at alpha =0.05. Multiple regression models will be used to determine variables and factors related to improvement in pain and quality of life scores.

SECONDARY ANALYSES

The effect of arthroscopic osteochondroplasty (intervention) versus lavage (control) on FAI patient quality of life (SF-12), function (HOS, iHOT-12), health outcome (EQ-5D), and sexual/urinary function (ICIQ-MLUTS/FLUTS, FSFI, IIEF) at 12 months with ANCOVA will be estimated using the following covariates: 1) baseline scores and 2) impingement sub-type. Multiple imputation will be used to handle missing data to enable an intention to treat analysis[64]. The results will be reported as means with 95% CIs. The Bonferroni method will be used to adjust the p-value for multiple secondary outcomes.

SENSITIVITY AND SUBGROUP ANALYSES

The following sensitivity analyses are conducted:
1) centre-effects: investigators will redo both primary and secondary analyses adjusting for centre as fixed and random effects;
2) per-protocol analysis: we will also redo the analyses including patients who received the interventions as allocated; and
3) adjusted analyses: adjusted analyses will be performed to address any residual baseline imbalance between groups. A subgroup analysis will be completed comparing the treatment effects in patients with severe (alpha angle greater than 83 degrees), moderate (alpha greater than 60 degrees), and mild (alpha angle of less than 60 degrees) impingement at baseline. ANCOVA models will be used and include treatment by subgroup interactions to assess whether the magnitude of the treatment effect is significantly different between subgroups

5. SUMMARY OF STUDIES AND RESULTS

STUDY I:

A survey focused on the perceptions of FAI by surgeon members of the COA was developed with help of focus groups, online subject reviews and successful pre-testing. Electronic and mailed surveys were sent to members of the COA (in both English and French). Responses were coded and summary statistics were calculated as dichotomous or categorical variables. Two hundred and two surveys were obtained (20 % response rate), of which 74.3 % of respondents manage patients under age 40 with hip pain. Fifty-nine percent of respondents worked in academic centers with 37% and 29% completing fellowship training in arthroplasty and sports medicine respectfully (See Table 1). The majority of respondents made the diagnosis of FAI by considering groin pain (81.7 %) and 74% use the FADIR test to make the diagnosis. Most surgeons use magnetic resonance imaging (MRI) (70.8 %) and 66.3% use radiographs to confirm radiographic diagnosis of FAI. Approximately half of all surgeons responded that physiotherapy was their initial treatment for FAI. Most surgeons (62%) considered failure of non-operative management as the most important indication for the surgical management of FAI, usually by treating both bony and soft tissue damage (54.4 %). The majority of surgeons agreed that there is evidence supporting positive outcomes following FAI surgery (42.1 %), 40.1% believed that evidence for a positive association between FAI and the development of hip osteoarthritis existed. Over half of the respondents believed that reduced pain was the most important patient outcome following FAI surgery (58.4 %) and 40.6% believed that pre-operative OA was a negative predictor for outcomes. The majority of surgeons were unsure of the existence of evidence supporting the best clinical test for FAI, the use of a diagnostic intra-articular injection for diagnosis of FAI, and for non-operative management of FAI. One in four respondents supported a sham surgery (24.8 %) control arm for a trial evaluating the impact of surgical intervention on FAI.

Take Home Points: The totality of the results of this survey highlight the need for a well conducted clinical trial to inform the best evidence based management of FAI. The respondents believed that surgical intervention is warranted for FAI once non operative management fails, however, their responses show that higher level studies are needed to evaluate the efficacy of FAI intervention.

TABLE 1: Demographic data of study respondents for Study 1

Characteristics	N (%)
Age (years)	
<30	1 (0.5)
30-40	62 (30.6)
41-50	54 (32.1)
51-60	42 (20.8)
Over 60	32 (15.8)
Years in practice	
<5	40 (19.8)
5-10	44 (21.8)
11-15	27 (13.4)
16-20	20 (9.9)
Over 20	68 (33.7)
Not currently practicing	2 (0.99)
Did not respond	1 (0.50)
Practice environment	
Academic	119 (58.9)
Community Based	79 (39)
Private hospital	2 (0.99)
Did not respond	2 (0.99)

STUDY 2:

This study focused on assessing demographic characteristics of FAI surgeons as well perceptions regarding the diagnosis and management of FAI. This survey was developed using previous literature, focus groups, and a sample-to-redundancy strategy. The survey was administered to multiple sports medicine and related organizations. Nine hundred orthopaedic surgeons from 20 national and international organizations and across 6 continents completed the survey. Most respondents were from Europe (40.7%), South America (29.3%), and North America (14.0%). Most of the North American respondents were in private practice (66.7%), followed by a university-affiliated position (31.7%). The overwhelming majority of respondents (96.8%) regularly treated patients with hip pathology. Most international respondents completed fellowship training in arthroplasty (53.1%), followed by sports medicine (35.6%). North American respondents' fellowship training results were similar with 47.6% in arthroplasty and 34.1% in sports medicine. Dedicated or formal training in hip arthroscopy was received by 36.4% of international and 48.0% of North American respondents (see Table 2). The essential finding on clinical history for FAI was reported to be pain with hip rotation (73.6%) and the FADIR clinical test was considered necessary by 87.9% of respondents. Most respondents (97.9%) routinely ordered plain radiographs, with the anteroposterior pelvis radiograph (69.7%) and cross-table lateral radiograph (37.0%) most commonly used. The most important radiographic measurement for CAM type FAI was the alpha angle (48.7%) and for pincer type FAI was the crossover sign (49.4%). Internationally, the annual FAI diagnosis was fewer than 30 cases for 70.4% of respondents and over 50 cases for 9.8%. Fewer than 10 arthroscopic cases annually were performed by 37.8% of international surgeons and over 100 cases by 12.9%. In comparison, 59.0% of North American surgeons diagnosed fewer than 30 cases annually and 13.1% diagnosed more than 50 cases annually. Among North American surgeons, 22.2% performed fewer than 10 cases annually and 13.0% performed over 100 cases. Respondents performing a high volume of FAI surgery were significantly more likely to have practiced for more than 20 years (OR, 1.91; 95% CI, 1.01 to 3.63), to be practicing at an academic hospital (OR, 2.25; 95% CI, 1.22 to 4.15), to have formal arthroscopy training (OR, 46.17; 95% CI, 20.28 to 105.15), and to be practicing in North America or Europe (OR, 2.26; 95% CI, 1.08 to 4.72).

Respondents indicated that the initial treatment after a diagnosis of FAI should consist of physiotherapy (69.7%) and rest (43.9%). The use of a confirmatory intra-articular hip injection was more widespread among North American sports fellowship trained surgeons (51.4%) in comparison to international respondents (21.0%). FAI was treated by all-arthroscopic approaches by 33.3% of respondents, either arthroscopic or open approaches by 24.7%, and open surgical dislocation by12.2%. North American surgeons managed FAI arthroscopically in 44.5% of cases compared with 31.5% of international surgeons, and 25.2% performed open management compared with 32.2% internationally (Figure 10). Isolated and complete labral tears were managed with suture repair by 56.8% of respondents and with debridement

by 19.4%. Clinical outcome scores should be used to evaluate FAI surgical outcomes according to 80.7% of responding surgeons. The most commonly used clinical parameter to assess successful operative management was pain relief (76.3%). The most commonly used outcome scores were the Western Ontario and McMaster Universities Arthritis Index (21.1%) and Harris Hip Score (22.6%). Evidence supporting the best clinical test and the best radiographic parameter for the diagnosis of FAI was rated as moderate by 35.8% and 38.9% of respondents, respectively. Evidence supporting the treatment effect of a corrective osteoplasty for CAM impingement and a PINCER lesion resection was believed to be moderate by 34.8% and 38.2% of respondents, respectively. Evidence suggesting positive outcomes after FAI surgery was rated as moderate by 41.0% of respondents. Evidence related to the commonly described association between FAI and future development of hip osteoarthritis was considered moderate by 33.6% of respondents and strong by 32.6%.

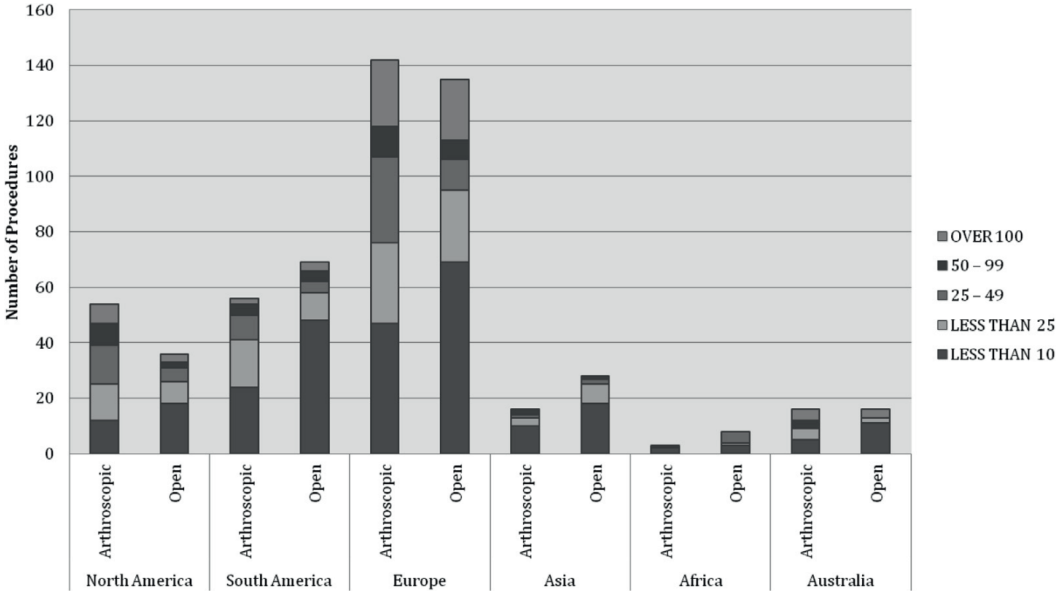
Take Home Points: The exponential rise in the diagnosis and surgical management of FAI appears to be driven largely by experienced surgeons in developed nations. Significant variability exists regarding the diagnosis and management of FAI. This analysis suggests that although arthroscopic FAI management is early in the innovation cycle, we are at a tipping point toward wider uptake and use.

TABLE 2: Demographic data of study respondents for Study 2

	North America	South America	Europe	Asia	Africa	Australia
Years in practice	126 respondents	263 respondents	366 respondents	88 respondents	4 respondents	31 respondents
<5	13 (10.3%)	3 (1.1%)	18 (4.9%)	2 (2.3%)	3 (12.5%)	4 (12.9%)
5	25 (19.8%)	44 (16.7%)	47 (12.8%)	14 (15.9%)	4 (16.7%)	8 (25.8%)
5-10	14 (11.1%)	41 (15.6%)	65 (17.8%)	9 (10.2%)	3 (12.5%)	4 (12.9%)
11-20	17 (13.5%)	73 (27.8%)	112 (30.6%)	33 (37.5%)	6 (25.0%)	5 (16.1%)
21-25	10 (7.9%)	40 (15.2%)	50 (13.7%)	16 (18.2%)	4 (16.7%)	5 (16.1%)
>25	47 (37.3%)	62 (23.6%)	74 (20.2%)	14 (15.9%)	4 (16.7%)	5 (16.1%)
Practice type	126 respondents	263 respondents	366 respondents	88 respondents	24 respondents	31 respondents
Academic	40 (31.8%)	63 (24.0%)	177 (48.4%)	39 (44.3%)	10 (41.7%)	11 (35.5%)
Private	84 (66.7%)	179 (68.1%)	167 (45.6%)	43 (48.8%)	12 (50.0%)	15 (48.4%)
Other	2 (1.6%)	21 (8.0%)	22 (6.0%)	6 (6.8%)	2 (8.3%)	5 (16.1%)
Subspecialty training	126 respondents	263 respondents	366 respondents	88 respondents	24 respondents	31 respondents
Arthroplasty	60 (47.6%)	95 (36.1%)	239 (65.3%)	42 (47.7%)	12 (50.0%)	22 (71.0%)
Sports	43 (34.1%)	86 (32.7%)	140 (38.3%)	23 (26.1%)	10 (41.7%)	16 (51.6%)
None	20 (15.9%)	15 (5.7%)	18 (4.9%)	9 (10.2%)	3 (12.5%)	3 (9.7%)
Trauma	13 (10.3%)	93 (35.4%)	115 (31.4%)	36 (40.9%)	9 (37.5%)	7 (22.6%)
Pediatrics	5 (4.0%)	18 (6.8%)	17 (4.6%)	10 (11.4%)	2 (8.33%)	2 (6.5%)
Formal training in hip arthroscopy	123 respondents	253 respondents	356 respondents	85 respondents	22 respondents	30 respondents
Yes	59 (48.0%)	69 (27.8%)	159 (44.5%)	13 (15.3%)	5 (22.7%)	13 (43.3%)

No	64 (52.0%)	184 (72.7%)	197 (55.5%)	72 (84.7%)	17 (77.3%)	17 (56.7%)
Type of formal training	59 respondents	69 respondents	158 respondents	12 respondents	5 respondents	13 respondents
Fellowship	35 (59.3%)	9 (13.0%)	43 (27.2%)	3 (25.0%)	2 (40.0%)	10 (76.9%)
Residency	23 (39.0%)	16 (23.2%)	43 (27.2%)	1 (8.3%)	1 (20.0%)	3 (23.1%)
Courses	40 (67.8%)	58 (84.1%)	126 (79.8%)	8 (66.7%)	3 (60.0%)	8 (61.5%)
Mentor visits	24 (40.7%)	27 (39.1%)	90 (57.0%)	3 (25.0%)	2 (40.0%)	4 (30.8%)
Annual FAI diagnosis	122 respondents	250 respondents	354 respondents	84 respondents	22 respondents	30 respondents
None	12 (9.8%)	15 (6.0%)	34 (9.6%)	17 (20.2%)	8 (36.4%)	3 (10.0%)
1-30	72 (59.0%)	191 (76.4%)	241 (68.1%)	60 (71.4%)	12 (54.6%)	18 (60.0%)
31-50	22 (18.0%)	24 (9.6%)	35 (9.9%)	4 (4.8%)	1 (4.6%)	4 (13.3%)
>50	16 (13.1%)	20 (8.0%)	44 (12.4%)	3 (3.6%)	1 (4.6%)	5 (16.7%)
Perform arthroscopic FAI surgery	122 respondents	249 respondents	354 respondents	84 respondents	22 respondents	30 respondents
Yes	54 (44.2%)	56 (22.5%)	142 (40.0%)	16 (19.1%)	3 (13.6%)	16 (53.3%)
No	68 (55.7%)	193 (77.5%)	212 (60.0%)	68 (81.0%)	19 (86.4%)	14 (46.7%)
Perform open FAI surgery	115 respondents	247 respondents	330 respondents	84 respondents	22 respondents	26 respondents
Yes	29 (25.2%)	68 (27.5%)	112 (33.9%)	28 (33.3%)	8 (36.3%)	12 (46.2%)
No	86 (74.8%)	179 (72.5%)	218 (66.0%)	56 (66.7%)	14 (63.6%)	14 (53.9%)

FIGURE 10: Distribution of global open and arthroscopic hip procedures amongst study respondent (Study 2).



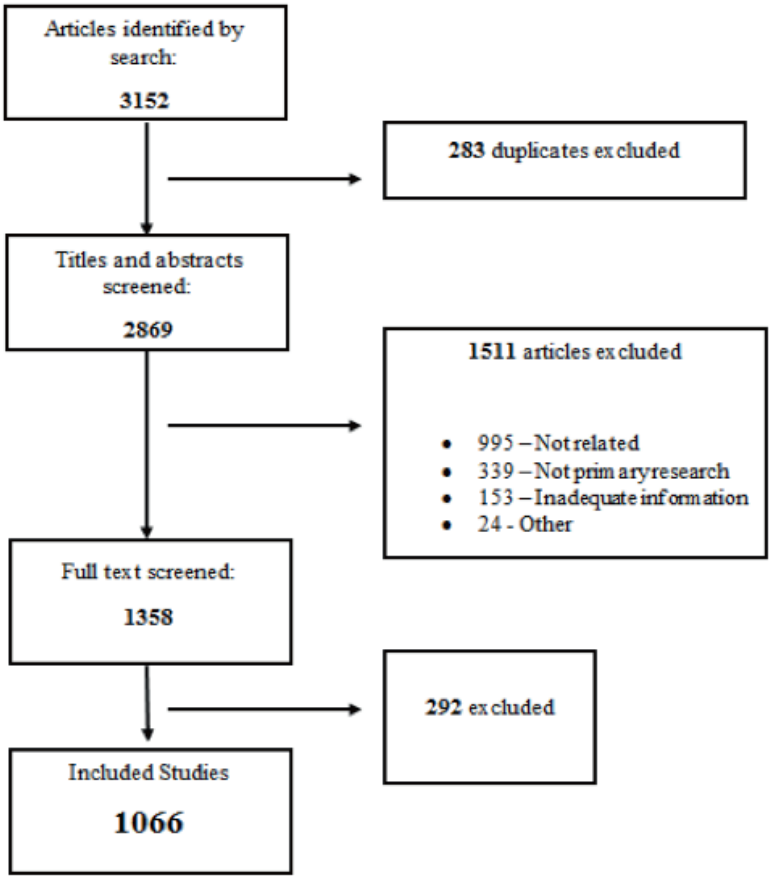
STUDY 3:

This study was conducted according to the methods of the Cochrane Handbook and is reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement. Relevant studies were identified by 2 reviewers with data extracted by the multiple reviewers. Inter observer agreement was calculated for study inclusion. The investigators identified 1,066 relevant studies including 186,572 patients (See Figure 11B). The kappa for overall agreement between reviewers for final eligibility decision was 0.50 (95 % CI 0.47–0.53) indicating moderate agreement. The number of publications increased during the reviewed time period with the most dramatic increase from 2011 to 2013 (See Figure 11 A). Seventy-three percent (n=786) of all studies were of levels 4 and 5 quality evidence. The percent of publications which were levels 1, 2 and 3 increased by almost twofold from 16.1 % (n=26) to 28.7 % (n=51) between 2011 and 2015. Seventy-three percent (n=786) of all studies were of levels 4 and 5 quality evidence. Specifically, there were 522 level 4 studies (48.9 %) and 264 level 5 studies (24.7 %), 169 level 3 studies (15.8 %), 105 level 2 studies (9.8 %) and six level 1 studies (0.6 %) of which there were five randomized control trials identified. The majority of articles published were clinical (538, 50.4 %), followed by review articles (232, 21.7 %), radiographic studies (208, 19.5 %) and cadaveric studies (88, 8.2 %). The majority of publications were performed in the USA (601; 56.4 %) followed by the UK (150; 14.1 %), and Germany (96; 9.0 %).

Take Home Point: Overall, there has been 3.5-fold increase in the number of publications over the past 5 years with a shift towards improvement of the level of evidence available guiding the arthroscopic management of FAI (Figure 11 A).

FIGURE 11 A: Number of included publications and level of evidence over 2011-2015 (Study 3).

FIGURE 11 B: PRISMA flowchart of included studies for Study 3.



STUDY 4:

In this study, electronic databases (MEDLINE, EMBASE, and Cochrane Library) were searched for surgical FAI studies from 1946 up to June 2013 (when the search was performed). After applying inclusion and exclusion criteria, 105 studies reporting surgical interventions for FAI were identified (Figure 12 A). Descriptive statistics concerning the numbers of randomized controlled trial publications and total sample population studied, sex ratio, type of diagnostic imaging used, reported outcome measures, and level of evidence used were computed by continent. Most studies were completed in North America (52 studies, 3,629 patients) and in Europe (44 studies, 3,745 patients). Asia (3 studies, 49 patients) and Oceania (6 studies, 394 patients) had smaller contributions (see Figure 12 B). There were no studies from South America or Africa. A total of 7,880 patients with FAI were managed surgically across all included studies. Most studies investigated arthroscopic intervention (57 studies), followed by open surgical dislocation (34 studies), mini open approaches (16 studies), combined approaches (8 studies), and periacetabular osteotomy (2 studies). Most studies investigated arthroscopic intervention (57 studies, 5,059 patients), followed by open surgical dislocation (34 studies, 1,437 patients), mini-open approaches (16 studies, 890 patients), combined approaches (8 studies, 254 patients), and periacetabular osteotomy (2 studies, 73 patients). In North America, 73% (2,648 patients) of patients underwent arthroscopic intervention, compared with 11% (407 patients) who underwent surgical dislocation, 10% (372 patients) who underwent mini-open procedures, 7% (253 patients) who underwent combined procedures, and 2% (73) who underwent periacetabular. In Europe, 57% (2,075 patients) of patients underwent arthroscopic

intervention, 26% (933 patients) underwent open surgical dislocation, 16% (566 patients) underwent mini-open procedures, and 2% (59 patients) underwent combined procedures. In Oceania, 88% (346 patients) underwent arthroscopic intervention and 12% (46 patients) underwent open surgical dislocation. All patients in studies from Asia (49 patients) underwent surgical hip dislocation. Of the North American studies, 48 studies (92%) reported use of radiography, whereas 33 studies (63%) reported MRI use, and 15 (29%) reported the use of CT. In Europe, 34 studies (77%) reported the use of radiography, 26 studies (59%) reported the use of MRI, and 5 studies (11%) reported CT use. The overall sex ratio of the entire study population was 61:39 male to female patients. The North American population had a sex ratio of 60:40. In Europe, the male to female ratio was 59:41. The most commonly used reported outcome measure in all studies was the Harris Hip Score (HHS), with the modified Harris Hip Score (mHHS) used in 32 studies (30.5%) and the original HHS used in 17 studies (16.2%). Common radiologic outcomes were the alpha angle, used in 30 studies (28.6%), degenerative changes, reported in 20 studies (19.0%), and head-neck offset, used in 8 studies (7.6%).In North America, the most commonly used outcome measures were the mHHS score, used in 21 studies (40%), and the HHS, used in 7 studies (13%). European studies most commonly used WOMAC and NAHS 15 (34.9%) and 14 (32.6%) of studies, respectively. Oceania most commonly used mHHS and NAHS; each was used in 5 studies (83.3%). Asia used HHS in all 3 studies from the region. Most of the 105 studies located were case series of Level IV evidence (76%), whereas retrospective cohorts (Level III evidence), prospective cohorts (Level II evidence), and randomized controlled trials (Level 1 evidence) were less common.

Take Home Points: Global surgical trends for FAI show a predominance of North American and European studies, studies of lower level evidence, and inconsistent use of outcome measures. However, patterns of diagnostic imaging, sex proportions, and predominance of arthroscopic techniques are consistent worldwide. Future research should focus on the development of reliable validated outcome measures and international collaboration to conduct high-quality research to improve the understanding of FAI diagnosis and management.

FIGURE 12A: PRISMA flowchart of included studies for Study 4.

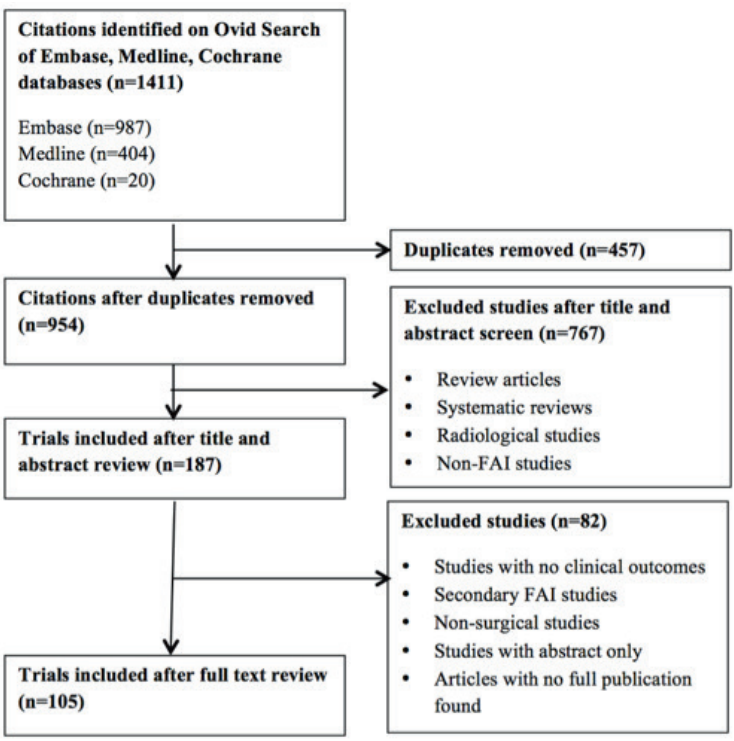


FIGURE 12B: Global distribution of published FAI studies (Study 4).

Sample Size (patients enrolled by city)

- 50.0
- 200.0
- 400.0
- 600.0
- 800.0
- 900.0

Map based on Longitude (generated) and Latitude (generated). Size shows sum of Sample. Details are shown for Country and City.

STUDY 5:

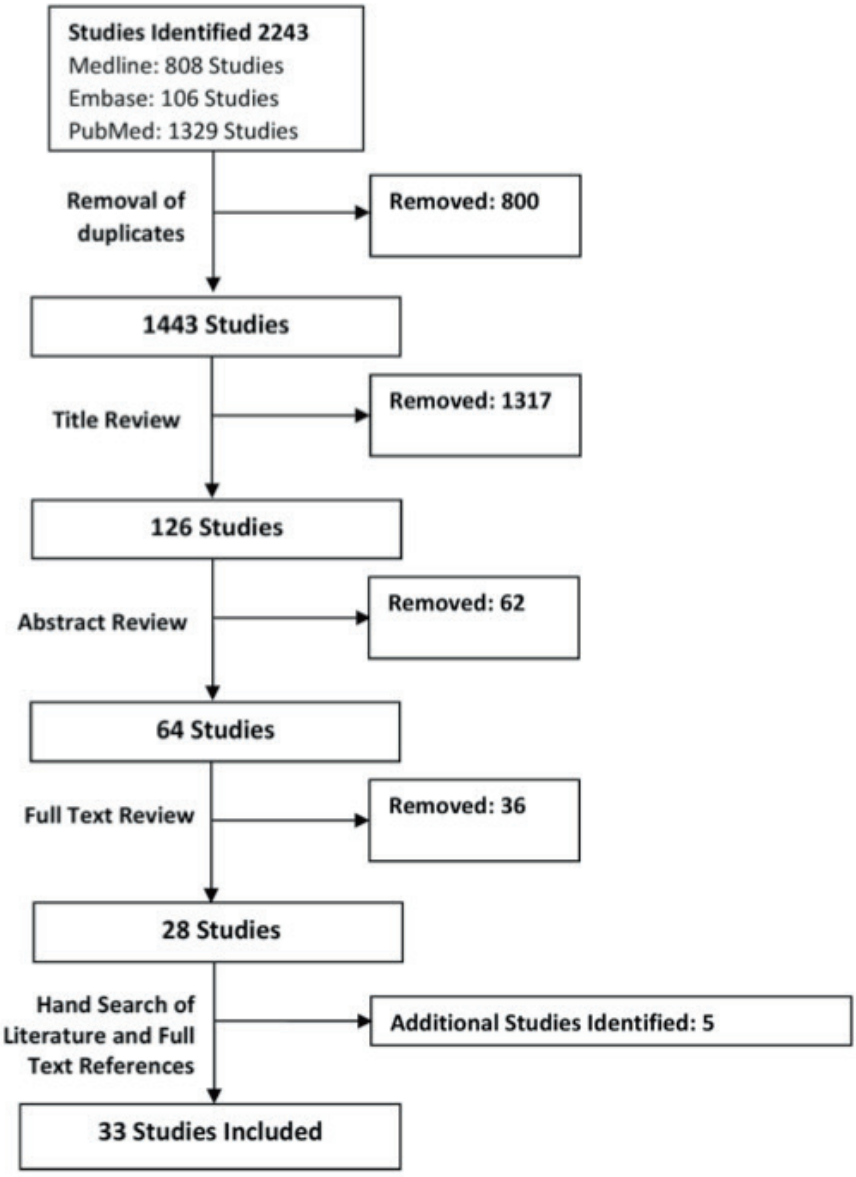
In this study, two reviewers searched EMBASE, MEDLINE and PubMed for literature related to non-hip score outcomes after surgical treatment of FAI. The database search was conducted on 15 October 2014 and retrieved articles from database inception to the search date. The pre-determined inclusion and exclusion criteria were applied and data was extracted by 2 reviewers. A weighted k (kappa) was calculated for each stage of article screening in order to evaluate inter-reviewer agreement. Thirty-three studies involving 3198 patients were included in this review (see Figure 13). There was an excellent agreement among reviewers at the title (k 0.81; 95% CI, 0.78– 0.84), abstract (k 0.76; 95% CI, 0.71–0.82) and full-text screening (k 1.0). This included a total of 3198 patients, with 281 patients treated by surgical hip dislocation, 33 mini-open procedures and 2422 arthroscopic procedures. A remaining 462 patients were treated with either arthroscopy, mini-open or combined procedures that were not otherwise specified. The majority of these studies were of level IV evidence (27 case series). Two studies were level III evidence, three studies were of level II evidence and a single arthroscopic study comparing labral debridement with labral repair was of level I evidence.

The most common non-hip score outcomes reported included, patient satisfaction (72.7%), symptom improvement (24.7%), pain improvement (12.4%), hip range of motion (12.3%) and return to sport (6.8%). The most frequently reported standardized hip outcome scores used were the modified Harris Hip Score (mHHS) (41.2%), Non- Arthritic Hip Score (NAHS) (29.4%), Hip Outcome Score - Activities of Daily Living (HOS-ADL) (26.5%), the Western Ontario McMaster Universities Index of Osteoarthritis (WOMAC) (17.6%), the HOS Sport-Specific Subscale (SSS), (17.6%). The majority (55–70%) of patients stated they had an 'acceptable state' of symptoms with only 12–17.6% of patients reported being unsatisfied with outcomes in post-operative surveys. No clear relationship between standardized hip outcome scores and non-hip score outcomes was able to be established due to the inconsistency of outcome reporting between studies.

The most commonly reported non-hip score outcomes are patient satisfaction, symptom improvement and pain improvement. Patients report high levels of satisfaction when surveyed post-operatively. The most commonly reported non-hip score outcomes are patient satisfaction, symptom improvement and pain improvement. Patients report high levels of satisfaction when surveyed post-operatively.

Take Home Points: Based on this study, a discrepancy exists between what outcomes the literature suggests should be reported and what outcomes are actually reported. Pain improvement and return to sport is often held as a major patient-important outcomes yet both are seldom (12.4% and 6.8% respectively) reported in studies assessing the efficacy of FAI surgery. More efforts are needed to encourage the reporting of hip outcome score that have been validated in the young adult population (IHOT, HOS, HAGOS).

FIGURE 13: PRISMA flowchart of included studies for Study 5.

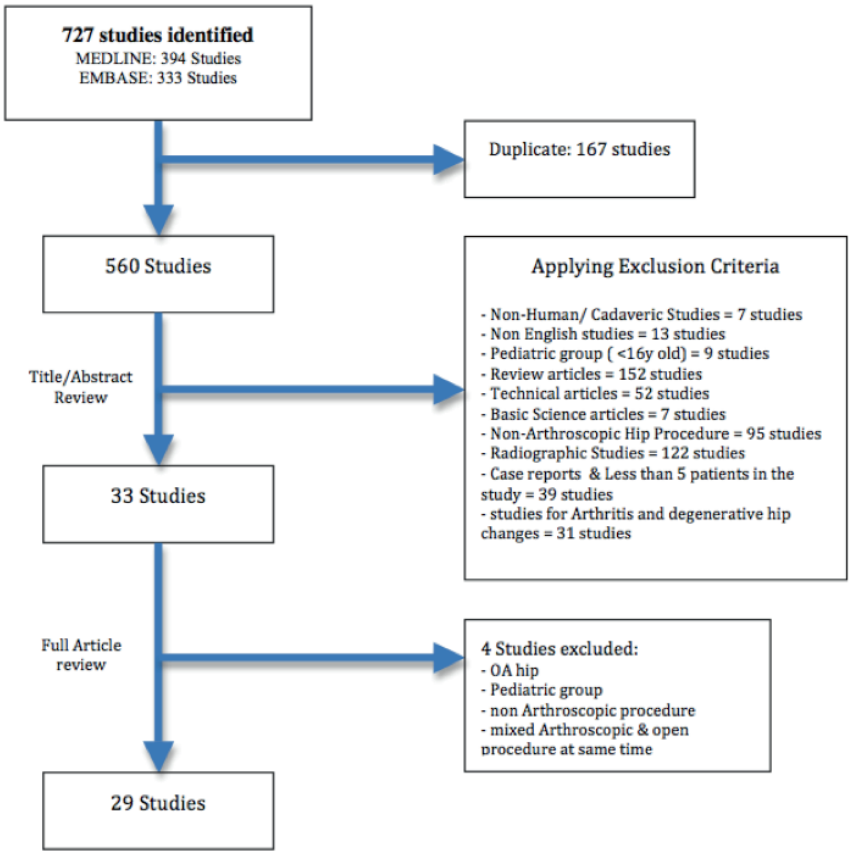


STUDY 6:

In this study, two reviewers searched Medline and EMBASE (1946 to June 2012) for clinical studies reporting on outcomes after arthroscopic FAI surgery. The focus was the reporting of clinical and radiographic outcomes following surgery. After applying inclusion and exclusion criteria, data was extracted and methodological quality of included studies assessed. The investigators identified 29 eligible studies involving 2,816 patients. 14 were conducted in the United States and 4 in Switzerland. The remaining studies were conducted in the United Kingdom, Mexico, Germany, France, Israel, and Australia (Figure 14). The mean sample size was 95 patients. The mean follow-up was 25.8 months. Twenty-two Level IV studies were identified (case series), (76%), 3 Level III studies (1 case-control study and 2 cohort studies), (10%), and 4 Level II studies (1 prospective comparative study, 1 diagnostic accuracy study, and 2 retrospective prognostic studies) (14%) based on the criteria of Wright et al.11 There were no Level I studies identified. The 3 most commonly reported outcome measures were the modified Harris Hip Score (MHHS) (3 studies, 45%), the Non-Arthritic Hip Scale (NAHS) (8 studies, 28%), and the Western Ontario McMaster Osteoarthritis Index (WOMAC) score (4 studies, 14%). The alpha angle was the most frequently reported postoperative radiographic outcome (11 studies, 38%). Apparent degenerative changes on postoperative radiographs were used in 6 studies (21%). Head-neck offset parameters were reported in 4 studies (14%). The center-edge angle plus anterior and lateral acetabular coverage was used in 3 studies (10%).

Take Home Points: There is significant variation in reported clinical and radiographic outcomes after arthroscopic treatment of FAI. This study highlights the need for consistent outcome reporting after arthroscopic FAI surgery.

FIGURE 14: PRISMA flowchart of included studies for Study 6.

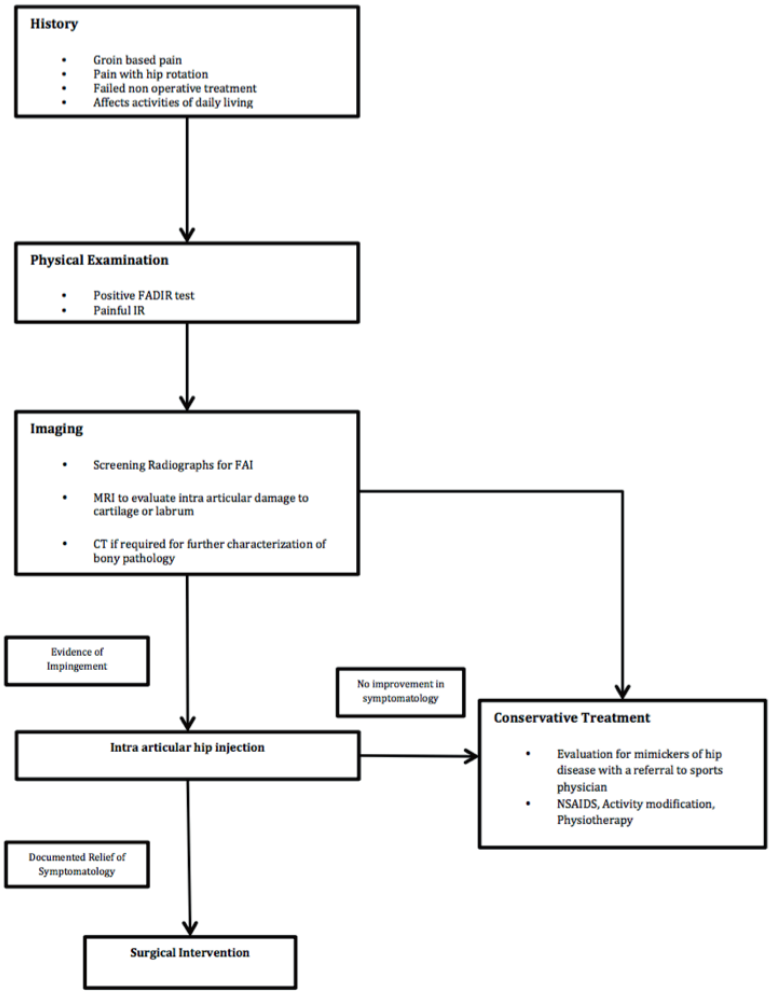


STUDY 7:

In this review, interviews and discussions regarding the current state of the evidence addressing FAI was completed with experienced and noted investigators. Current literature was evaluated to assess the gaps in the knowledge pertaining to FAI and future directions in the management of FAI. From this effort, it was clear that arthroscopic treatment has become the preferred method of management of FAI owing to its minimally invasive approach. The diagnosis uses a combination of clinical and radiographic parameters (see suggested algorithm Figure 15). Particularly important is the clinical history of groin pain and a positive FADIR test. Surgical correction involves resection of impinging osseous structures as well as concurrent management of the associated chondral and labral pathology with improved outcomes noted following labral repair compared with labral debridement. The relationship between FAI and OA remains an association but causation has not been proven. Research is underway to improve cartilage assessment by using innovative imaging techniques and biochemical tests to inform predictors of prognosis.

Take Home Points: FAI is a clinical entity that is increasingly diagnosed in the young adult, the diagnosis and management of FAI is evolving and will be impacted by ongoing studies. Current studies show satisfactory clinical results following surgical intervention and additional clinical studies will help identify those best suited for intervention as well as the best diagnostic and therapeutic strategies.

FIGURE 15: Flowchart of diagnostic approach to FAI (Study 7).



STUDY 8:

In this randomized controlled trial comparing arthroscopic lavage to arthroscopic osteochondroplasty for FAI; 100% enrolment was completed in October 2017. At the time of this thesis publication, the available demographic and baseline data for the enrolled patients is presented (See Tables 3 & 4). Final data tabulation will be completed at 1 year.

Take Home Point: The FIRST trial is complete and will add high level evidence to the growing body of FAI related literature.

TABLE 3: Demographic data and characteristics of Study 8 participants (September 2017)

		Total
Total Number of Patients		193
Gender, N (%)		
	Missing	0 (0.0)
	Male	124 (64.2)
	Female	69 (35.8)
Age		
	Missing, n (%)	0 (0.0)
	Mean (SD)	35.9 (8.6)
	Median	36.4
	Maximum	50.7
	Minimum	18.6
Height in inches		
	Missing, n (%)	0 (0.0)
	Mean (SD)	68.5 (4.5)
	Median	69.3
	Maximum	77.2
	Minimum	52.0
Weight in pounds		
	Missing, n (%)	0 (0.0)
	Mean (SD)	182.5 (36.5)
	Median	180.8
	Maximum	300.0
	Minimum	105.0
Race/Ethnicity, n (%)		
	Missing	0 (0.0)
	Native or Aboriginal	3 (1.6)
	South Asian	5 (2.7)
	White/Caucasian	177 (91.7)

	Hispanic or Latino	0 (0.0)
	Black (African or Caribbean)	3 (1.6)
	Other	5 (2.6)
Tobacco Use, n (%)		
	Missing	0 (0.0)
	No	152 (78.8)
	Yes, current use	29 (15.0)
	Yes, but quit	12 (6.2)
Alcohol Consumption, n (%)		
	Missing	0 (0.0)
	No	46 (23.8)
	Yes	147 (76.2)
Treatments Tried at Time of Baseline Assessment, n (%)		
	Missing	0 (0.0)
	Physical therapy	169 (87.6)
	NSAIDS	127 (65.8)
	Hip injection	158 (81.9)
	Massage therapy	11 (5.7)
	Chiropractic	9 (4.7)
	Acupuncture	6 (3.1)
	Ultrasound therapy	1 (0.5)
	Other	0 (0.0)
Affected Hip, n (%)		
	Missing	0 (0.0)
	Left	83 (43.0)
	Right	110 (57.0)
Location of Pain, n (%)		
	Missing	0 (0.0)
	Groin only	116 (60.1)
	Lateral sided only	14 (7.3)
	Posterior only	3 (1.6)
	Groin & Lateral only	30 (15.5)
	Groin & Posterior only	9 (4.7)
	Lateral & Posterior only	0 (0.0)
	Groin & Lateral & Posterior	21 (10.9)

Onset of Symptoms, n (%)		
	Missing	0 (0.0)
	Acute	19 (9.8)
	Subacute	35 (18.1)
	Insidious	89 (46.1)
	Traumatic	24 (12.4)
	Non-traumatic	26 (13.5)
Patient Activity Level Reported at Baseline, n (%)		
	Missing	0 (0.0)
	None	34 (17.6)
	Light	52 (26.9)
	Moderate	72 (37.3)
	Vigorous	35 (18.1)
Comorbid Conditions, n (%)		
	Missing	0 (0.0)
	Osteopenia	0 (0.0)
	Osteoporosis	0 (0.0)
	Lung Disease	3 (1.6)
	Diabetes	5 (2.6)
	Ulcers or Stomach Disease	8 (4.1)
	Kidney Disease	0 (0.0)
	Anemia or Other Blood Disease	5 (2.6)
	Depression	19 (9.8)
	Cancer	0 (0.0)
	Osteoarthritis, Degenerative Arthritis	6 (3.1)
	Back Pain	29 (15.0)
	Rheumatoid Arthritis	3 (1.6)
	Heart Disease	2 (1.0)
	High Blood Pressure	9 (4.7)
	Genitourinary	0 (0.0)
	Previous Lower Extremity Injury	13 (6.7)
	Dementia	0 (0.0)
	Other*	18 (9.3)

* Hypothyroidism, pyslipidemia, asthma, thyroid surgery, whiplash injury, Crohn's disease, hyperlipidermy, migraines, myasthenia gravis, hyperthyreosis, reflux, herpes, polycystic ovarian syndrome, arnold chiari syndrome, vertigo, supraventricular tachycardia.

TABLE 4: Radiographic baseline data of Study 8 participants

		Total
Total Number of Patients		199
Anterior Impingement Test, n (%)		
	Missing	2 (1)
	Positive	193 (97)
	Negative	4 (2)
Posterior Impingement Test, n (%)		
	Missing	50 (25.1)
	Positive	21 (10.6)
	Negative	128 (64.3)
Log Roll Test, n (%)		
	Missing	4 (2)
	Positive	63 (31.7)
	Negative	132 (66.3)
Crossover sign, n (%)		
	Missing	6 (3)
	Positive	46 (23.1)
	Negative	147 (73.9)
Coxa profunda, n (%)		
	Missing	6 (3)
	Positive	7 (3.5)
	Negative	186 (93.5)
Coxa protrusio, n (%)		
	Missing	6 (3)
	Positive	2 (1)
	Negative	191 (96)
Tonnis and Heinecke Cartilage Classification, n (%)		
	Missing	7 (3.5)
	Grade 0	90 (45.2)
	Grade 1	82 (41.2)
	Grade 2	18 (9)
	Grade 3	2 (1)
Centre-edge Angle		
	Missing, n (%)	6 (3)
	Mean (SD)	34.4 (6.9)

	Median	33.7
	Maximum	63.0
	Minimum	21.0
Alpha Angle		
	Missing, n (%)	6 (3)
	Mean (SD)	65 (12.1)
	Median	63.0
	Maximum	96.8
	Minimum	32.0
Neck Shaft Angle		
	Missing, n (%)	6 (3)
	Mean (SD)	119.1 (35.2)
	Median	130.0
	Maximum	145.0
	Minimum	12.0
Femoral Offset Ratio		
	Missing, n (%)	12 (6)
	Mean (SD)	0.31 (0.43)
	Median	0.12
	Maximum	2.00
	Minimum	0.00

6. DISCUSSION

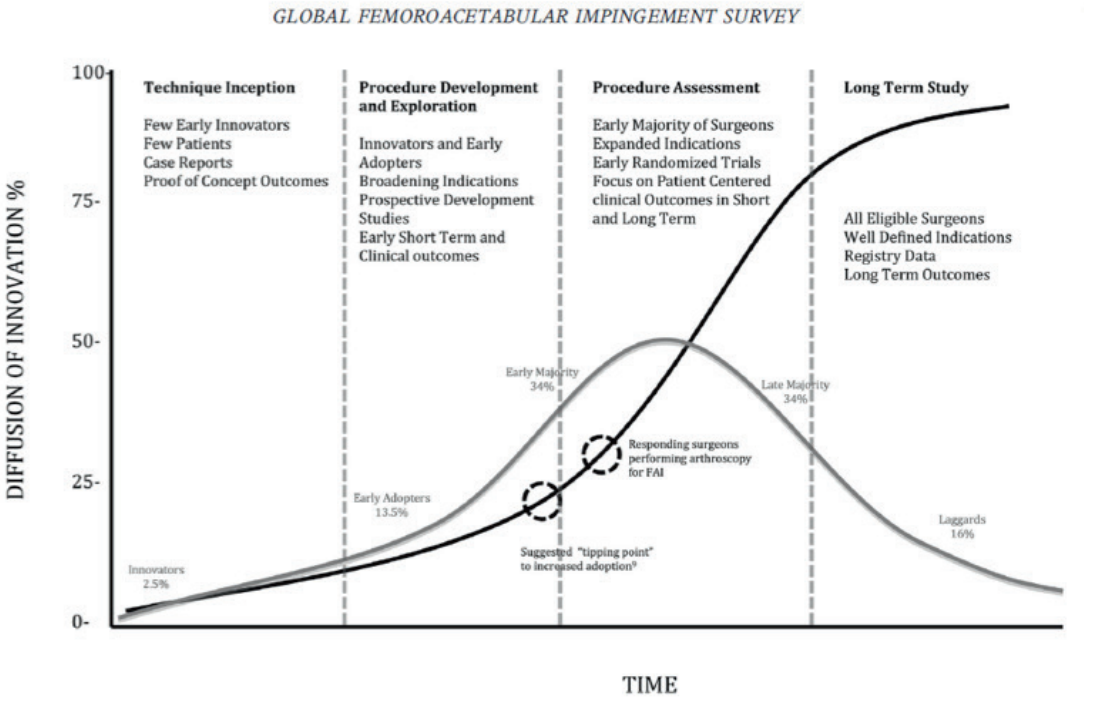
The body of knowledge related to FAI has grown rapidly both in terms of peer reviewed publications and publications on non-medical electronic media[43,65].

Despite the increase in FAI literature, the level of evidence has generally remained low. As such, the ability for clinicians to make evidence based treatment decisions is limited[1, 66].

The results of study 1 showed that 45% of respondents were not sure if the current evidence supported the need for osteochondroplasty for FAI and a majority of surgeons were not aware of the best diagnostic approach for FAI[67]. Moreover, 25% and 20% of respondents believed that placebo surgery or physical therapy, respectively, would be appropriate comparative groups in a clinical trial[67]. As such, the need for a well-conducted trial that evaluates the surgical management of FAI would provide much needed evidence. Based on the survey of Canadian orthopaedic surgeons, 74% of whom see young adult hip patients, it is apparent that surgical intervention readily available[67]. However, the ability to assess efficacy of the diagnostic procedures and surgical treatment using current evidence is limited. It is interesting to note that almost 5% of non-respondents declined to participate, citing a lack of knowledge about FAI due to the novelty of the condition[67]. Given the novel nature of the condition, moving forward with best evidence to guide diagnosis as well as developing appropriate surgical indications is critically important.

The increase in the adoption of hip arthroscopy for treating FAI is occurring at a rapid rate as shown in study 2 (see Figure 16). More widespread adoption of this technique is projected to happen in the next few years as we are likely approaching a "tipping point"[68]. This is thought to be due to both an increased understanding of the pathophysiology of FAI as well as improved access to hip arthroscopic intervention. With a better understanding of the learning curve for hip arthroscopy, more surgeons are adopting arthroscopic surgery to treat FAI[69]. Moreover, in certain healthcare systems, hip arthroscopic intervention is a more cost effective option than open hip surgery due to reduced stay in hospital[32]. Unfortunately, despite the recognition and increased adoption of FAI, there is a demonstrated lack of high level evidence to guide treatment. The available evidence was noted to be weak to moderate in support of surgical management of FAI by most respondents[68]. As such, the key to safe adoption of this emerging technology is guidance by well conducted studies. Through high level studies, the potential for safe dissemination of arthroscopic FAI surgery is increased. Despite the inherent limitations and potential biases in administering a survey in English and electronically, this diverse group of 900 surgeons represented a large cohort of clinicians who treat this condition. The results of this survey also re-affirm the need for a well-conducted trial that may answer questions such as: what are the best indications and contra indications; what is the prognosis following surgery; what are the predictive values of diagnostics and clinical tests; and finally, what is the efficacy of surgical intervention.

FIGURE 16: Global adoption of hip arthroscopy as a treatment for FAI an illustration of the "tipping point" or increased adoption over time.



Study 3 shows that there continues to be steady growth in the English literature in terms of studies addressing FAI. In the recent past (2011-2015), there has also been an increase in the quality of published studies reflected in the by the numerical increase in level 2 and 3 studies[66]. Although most studies were clinical and reported in orthopaedic journals, there is also an increase in peer reviewed publications in general medicine and radiology journals. As diagnosing FAI includes positive clinical and radiographic findings, there will likely be continued interest and investigations in medical specialties such as radiology, sports medicine, and orthopaedics. Moreover, allied health-care providers such as physical and athletic therapists who also treat FAI will likely contribute to future knowledge of FAI. This diverse multi-specialty interest is likely to continue as FAI becomes are more commonly diagnosed and recognized. A critical step in the future will be ensuring that all clinicians diagnose FAI using similar criteria as it has been shown that often there is disagreement on the radiographic criteria for FAI[70]. Finally, the encouraging trend towards higher quality research is not surprising and follows the generally positive trend that has been recognized in specialty organizations such as ISHA that addresses hip joint conditions[71].

The available studies reviewed in study 4 demonstrated that there was a consistent global pathway for diagnosing FAI and this typically involved the assessment of radiographs (84%)[70]. Moreover, the gender ratios of patients were generally similar across the globe. However, the type of surgical intervention and the reporting of outcomes following surgery varied across the globe. For example, 73% of North American studies reported an arthroscopic approach compared with 57% of European studies. These regional differences in surgical approach (open or arthroscopic approaches) may reflect differences in expertise, access to technology or philosophical approaches to managing FAI. The overall dominance of North American and European literature could be for several reasons. First, it is possible that populations of European descent are more prone to FAI and secondary OA as has been previously suggested[71,72]. Also, it is possible that the nations in Europe/North America have higher research expenditures that allow for research in this field[75]. Whereas nations with less significant research resources have a focus on more acute medical conditions. Finally, FAI may also be a condition of

"affluence" in which recreation or professional sports or even obesity plays a role and these factors may be more prominent in Europe or North America.

Study 5 focused on non-hip score or subjective results that are often most important to the patient. Patient satisfaction (73%) and symptom improvement (25%) were most commonly reported in studies. Given that FAI is a condition that impacts the quality of life of the young adult, it was interesting to find that other key outcomes measures such as pain improvement and return to sport were reported at low levels (12% and 7% respectively)[76]. Several investigators have demonstrated that pain improvement is most important to the patient following FAI surgery as such more attention should be paid to documenting this symptom[77,78]. The most frequently reported standardized hip outcome score were the modified Harris Hip Score (41.2%) and Non-Arthritic Hips Score (29.4%). Interestingly, the mHHS, was adapted to evaluate the young adult hip from the Harris Hip Score that was originally designed to evaluate outcomes following intervention for OA, like total hip arthroplasty (THA)[79]. As such, more contemporary hip outcome instruments such as the IHOT, HAGOS and HOS are likely more relevant as they were validated in a FAI related population. The increased use of these newer tools will capture the subjective and objective aspects of hip function. Future studies should continue to report relevant clinical outcomes that are most important to patients.

There remains a lack of consistency of reporting clinical and radiographic outcomes following FAI surgery. As shown in study 6, the clinical and radiographic outcomes reported following surgical intervention vary tremendously. Although the WOMAC (45%), NAHS (28%) and MHHS (14%) were reported the most commonly outcome measures, they may not reflect the best outcome measure for young adults who typically present with FAI[80]. This is because these outcomes were developed in populations with conditions such as OA that affected a different (older population) than FAI. More contemporary outcome tools such as the IHOT, HAGOS, and HOS have been validated and should be used when assessing FAI in this population (young adult hip)[81-83]. Likewise, radiographic outcomes such as the alpha angle (38%) and degenerative changes (21%) were most commonly reported but often not measured or reported in a standardized fashion. Different modalities and views/planes (CT, MRI and radiographs) were used to record and measure these results. As such, there remains a continued need to encourage the adoption of reliable and validated tools that exist and use of to consistently report all outcomes following FAI surgery. This effort can be encouraged by societies such as ISHA, editorial boards of peer reviewed publications and consensus statements by experts. Collectively, the adoption validated tools and consistent reporting of outcomes will improve communication about FAI and allow for more collaborative and comparative studies across the globe.

The formulation of the theory of FAI by Ganz was an important step in the understanding the pathophysiology of FAI[5]. Now there is a need for high level evidence to supplement this theory and enable clinicians to direct treatment when appropriate. Study 7 highlights the dramatic rise in the diagnosis and treatment of FAI and the continued need to refine indications for treatment based on well-conducted trials some of which are under way. The experts involved in this review understand that there is a need to treat the patients despite the limitations of the current evidence. As such following an algorithm that includes the appropriate clinical tests and imaging findings are suffice (See Figure 13)[33]. Nevertheless, the existence of current treatment approaches should not preclude the attempts to improve upon current treatment strategies. As such the pursuit of studies including randomized controlled trials is needed.

There is a need for a definitive trial addressing the management of FAI, and the FIRST trial (Study 8) is an effort to establish this important goal[64]. The principles of evidence-based medicine involve clinical decision making as a combination of using best available evidence, clinical judgement/experience and patient values and preferences[84]. Despite a growing amount of clinical experience, it is important to establish well conducted trials to guide treatment of FAI. With the completion of recruitment this year and the 1 year data requirement, it is anticipated that this trial will have published results reported November, 2018. More importantly, this effort highlights the impact the potential that global collaborative effort can have on treatment on medical conditions. Despite the logistical challenges of conducting multi-centered randomized controlled trials, the recruitment to date shows they are possible when an important question is addressed.

LIMITATIONS

SURVEY STUDIES

These survey studies were conducted and administered for the most part in the English language (Study 1, PROCESS survey was in French as well). Although, English is considered the universal language of science, there is the potential to miss information for non-English speakers[85]. In any survey, the potential exists for non-responder bias in which those who respond to the survey are fundamentally different from those who do not respond to the survey[86]. Subsequently, it is possible that differing opinions and beliefs are not captured in the survey when compared to those who have responded.

These responses can also be affected by access to technology as those with and without internet resources may have different abilities to respond to electronic surveys such as these. Finally, with the IN FOCUS survey (Study 2), there are statistical challenges in determining the true response rate as there are multiple international organizations that were surveyed concurrently.

As such the response rate per organization was not a feasible calculation. However, the 900 respondents from the IN FOCUS survey provide a wealth of global data for a credible analysis. Despite these limitations, the rigorous design of the survey with development using a focus group as well as the aforementioned validity testing make this a robust method when obtaining information.

This is particularly true with a relatively novel condition such as FAI where treatment paradigms and approaches have the potential to change rapidly.

SYSTEMATIC REVIEWS

The systematic reviews in this thesis were completed using the rigorous PRISMA approach. Nonetheless, one must acknowledge that only English studies were included and may provide a source of bias despite English being recognized as the language of science[47]. Other sources of potential bias include publication bias in which positive results from intervention are published when compared to negative results from scientific investigation[87].

The studies included in each systematic review may have had overlapping study populations, though efforts were made to include only one study population per systematic review such as contacting authors for verification.

Finally, as in all systematic reviews, the quality of included primary studies plays a significant role in the quality of the overall systematic review[88]. This is particularly true in a studies addressing FAI, where high-level evidence for efficacy of treatment is limited.

7. CONCLUSIONS

- There is a gap in well conducted research addressing the best strategies for diagnosing and treating FAI. Areas of research that need further evaluation include: diagnostic strategy, efficacy or surgical intervention and relationship between FAI and OA. The results suggest that the current management of FAI by members of the COA is limited by the lack of awareness of high-level evidence.

- The exponential rise in the diagnosis and surgical management of FAI appears to be driven largely by experienced surgeons in developed nations. Significant variability exists in terms of diagnosis and management of FAI. The analysis in the present thesis suggests that although FAI management is early in the innovation cycle, we are at a tipping point toward wider uptake and use.

- In comparison to previous work, there has been 3.5-fold increase in the number of publications over the past 5 years with a shift towards improving the level of evidence available guiding the arthroscopic management of FAI.

- Global surgical trends for FAI show a predominance of North American and European studies, studies of lower level evidence, and inconsistent use of outcome measures. However, patterns of diagnostic imaging, sex proportions, and predominance of arthroscopic techniques are consistent worldwide. Future research should focus on development of reliable validated outcome measures and international collaboration to conduct high-quality research and improve the understanding of FAI diagnosis and management.

- A discrepancy exists between what outcomes the literature suggests should be reported and what outcomes are actually reported. Return to sport is often held as a major patient-important outcome yet it is seldom reported in studies assessing the efficacy of FAI surgery. Second, despite emerging evidence that outcome measures such as the HOS or IHOT evaluate the FAI patient population precisely, other standardized hip score outcomes (mHHS and NAHS) are still more commonly reported.

- There is significant variation in reported clinical and radiographic outcomes after arthroscopic treatment of FAI. This study highlights the need for consistent outcome reporting after arthroscopic FAI surgery.

- The current treatment paradigms for FAI are evolving along with the clinical evidence evaluating this condition. Several ongoing randomized controlled trials, including the Femoroacetabular Impingement Trial (FAIT) and the Femoroacetabular Impingement Randomized Controlled Trial (FIRST), will provide critical information in terms of the diagnosis, management and prognosis of patients undergoing arthroscopic management of FAI.

- The FIRST trial recruitment has being achieved as of October 2017. Efficacy of surgical intervention for FAI will be based on the results of this trial once follow-up is completed (2018). This effort demonstrates the potential for collaborative research in an emerging area when there is a lack of high level evidence to guide intervention.

OVERALL CONCLUSION

The overall conclusion of the 8 studies is that FAI as a cause of hip pain has become an increasingly common diagnosis particularly in Europe and North America. FAI is increasingly becoming a globally recognized condition in the young adult. The current evidence guiding diagnosis and management is limited by the overall quality of the literature addressing FAI, which is gradually improving. Significant variation exists when evaluating how FAI is diagnosed (physical examination and imaging). Moreover, the systematic reviews included demonstrate that further improvements are needed in consistently reporting diagnostic modalities and patient important outcomes. The existing studies are helpful and serve as a starting point for the development of more robust evaluation of FAI intervention. It is with development and dissemination of the results of well conducted randomized controlled trials that the best indications for this intervention will develop. Nonetheless, the overwhelming conclusion is that there is a need for a definitive clinical trial addressing the efficacy of surgical intervention for FAI.

8. FUTURE PERSPECTIVES

The diagnosis and management of FAI has progressed rapidly, but with each additional gain in knowledge it appears like more questions arise. The ability to detect those who are at risk for this condition via genetic testing will likely play a role in identifying those who may benefit from active surveillance. Although, there is no current role for prophylactic surgery for those with FAI morphology and no clinical symptoms, early detection will likely be an emphasis in the future[89].

Apart from great potential from genetic screening, cartilage sensitive imaging sequences will be able to help identify those who have sub-clinical disease or pre-arthritic changes despite a lack of symptoms. Modalities such as delayed gadolinium enhanced magnetic resonance imaging or cartilage (dGEMRIC[91,92]) and T2 mapping of cartilage sequences will continue to enhance the knowledge of disease progression and impact of treatment in the hip joint[92,93].

Other non-invasive tests such a serum or urine biomarkers of cartilage breakdown products from the hip joint will be more accessible[94-96]. Although the current versions of these tests are not sensitive or specific enough to detect FAI, research is underway to refine these diagnostic processes. These biomarkers will not only help with disease identification, they also have the potential to help monitor disease progress and perhaps response to treatment. Finally, as early RCTs are underway to address FAI, evidence-based approach to FAI management will likely become routinely adopted[97-99].

With the completion of these trials, the indications for surgery will be increasingly refined as more evidence emerges. Although, contemporary outcomes that are validated in the young adult population with hip dysfunction are increasingly being adopted, the possibility of developing a more comprehensive composite outcome that measure all aspects of hip function exists[100].

Finally, long term registry data will also play an important role in helping to identify prognostic and surgical factors that determine outcomes following FAI intervention[101-103].

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APPENDIX

CONSORT 2010 checklist of information to include when reporting a randomised trial*

Section/Topic	Item No	Checklist item	Reported on page No
Title and abstract			
	1a	Identification as a randomised trial in the title	
	1b	Structured summary of trial design, methods, results, and conclusions (for specific guidance see CONSORT for abstracts)	
Introduction			
Background and objectives	2a	Scientific background and explanation of rationale	
	2b	Specific objectives or hypotheses	
Methods			
Trial design	3a	Description of trial design (such as parallel, factorial) including allocation ratio	
	3b	Important changes to methods after trial commencement (such as eligibility criteria), with reasons	
Participants	4a	Eligibility criteria for participants	
	4b	Settings and locations where the data were collected	
Interventions	5	The interventions for each group with sufficient details to allow replication, including how and when they were actually administered	
Outcomes	6a	Completely defined pre-specified primary and secondary outcome measures, including how and when they were assessed	
	6b	Any changes to trial outcomes after the trial commenced, with reasons	
Sample size	7a	How sample size was determined	
	7b	When applicable, explanation of any interim analyses and stopping guidelines	
Randomisation:			
Sequence generation	8a	Method used to generate the random allocation sequence	
	8b	Type of randomisation; details of any restriction (such as blocking and block size)	
Allocation concealment mechanism	9	Mechanism used to implement the random allocation sequence (such as sequentially numbered containers), describing any steps taken to conceal the sequence until interventions were assigned	
Implementation	10	Who generated the random allocation sequence, who enrolled participants, and who assigned participants to interventions	
Blinding	11a	If done, who was blinded after assignment to interventions (for example, participants, care providers, those	

		assessing outcomes) and how	
	11b	If relevant, description of the similarity of interventions	
Statistical methods	12a	Statistical methods used to compare groups for primary and secondary outcomes	
	12b	Methods for additional analyses, such as subgroup analyses and adjusted analyses	
Results			
Participant flow (a diagram is strongly recommended)	13a	For each group, the numbers of participants who were randomly assigned, received intended treatment, and were analysed for the primary outcome	
	13b	For each group, losses and exclusions after randomisation, together with reasons	
Recruitment	14a	Dates defining the periods of recruitment and follow-up	
	14b	Why the trial ended or was stopped	
Baseline data	15	A table showing baseline demographic and clinical characteristics for each group	
Numbers analysed	16	For each group, number of participants (denominator) included in each analysis and whether the analysis was by original assigned groups	
Outcomes and estimation	17a	For each primary and secondary outcome, results for each group, and the estimated effect size and its precision (such as 95% confidence interval)	
	17b	For binary outcomes, presentation of both absolute and relative effect sizes is recommended	
Ancillary analyses	18	Results of any other analyses performed, including subgroup analyses and adjusted analyses, distinguishing pre-specified from exploratory	
Harms	19	All important harms or unintended effects in each group (for specific guidance see CONSORT for harms)	
Discussion			
Limitations	20	Trial limitations, addressing sources of potential bias, imprecision, and, if relevant, multiplicity of analyses	
Generalisability	21	Generalisability (external validity, applicability) of the trial findings	
Interpretation	22	Interpretation consistent with results, balancing benefits and harms, and considering other relevant evidence	
Other information			
Registration	23	Registration number and name of trial registry	
Protocol	24	Where the full trial protocol can be accessed, if available	
Funding	25	Sources of funding and other support (such as supply of drugs), role of funders	

*We strongly recommend reading this statement in conjunction with the CONSORT 2010 Explanation and Elaboration for important clarifications on all the items. If relevant, we also recommend reading CONSORT extensions for cluster randomised trials, non-inferiority and equivalence trials, non-pharmacological treatments, herbal interventions, and pragmatic trials. Additional extensions are forthcoming: for those and for up to date references relevant to this checklist, see www.consort-statement.org.

METHODOLOGICAL INDEX FOR NON-RANDOMIZED STUDIES (*MINORS*): DEVELOPMENT AND VALIDATION OF A NEW INSTRUMENT

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Table 2. The revised and validated version of MINORS

Methodological items for non-randomized studies	Score†
1. **A clearly stated aim:** the question addressed should be precise and relevant in the light of available literature 2. **Inclusion of consecutive patients**: all patients potentially fit for inclusion (satisfying the criteria for inclusion) have been included in the study during the study period (no exclusion or details about the reasons for exclusion) 3. **Prospective collection of data**: data were collected according to a protocol established before the beginning of the study 4. **Endpoints appropriate to the aim of the study**: unambiguous explanation of the criteria used to evaluate the main outcome which should be in accordance with the question addressed by the study. Also, the endpoints should be assessed on an intention-to-treat basis. 5. **Unbiased assessment of the study endpoint**: blind evaluation of objective endpoints and double-blind evaluation of subjective endpoints. Otherwise the reasons for not blinding should be stated 6. **Follow-up period appropriate to the aim of the study**: the follow-up should be sufficiently long to allow the assessment of the main endpoint and possible adverse events 7. **Loss to follow up less than 5%**: all patients should be included in the follow up. Otherwise, the proportion lost to follow up should not exceed the proportion experiencing the major endpoint 8. **Prospective calculation of the study size**: information of the size of detectable difference of interest with a calculation of 95% confidence interval, according to the expected incidence of the outcome event, and information about the level for statistical significance and estimates of power when comparing the outcomes *Additional criteria in the case of comparative study* 9. **An adequate control group**: having a gold standard diagnostic test or therapeutic intervention recognized as the optimal intervention according to the available published data 10. **Contemporary groups**: control and studied group should be managed during the same time period (no historical comparison) 11. **Baseline equivalence of groups**: the groups should be similar regarding the criteria other than the studied endpoints. Absence of confounding factors that could bias the interpretation of the results 12. **Adequate statistical analyses**: whether the statistics were in accordance with the type of study with calculation of confidence intervals or relative risk	

†The items are scored 0 (not reported), 1 (reported but inadequate) or 2 (reported and adequate). The global ideal score being 16 for non-comparative studies and 24 for comparative studies.

NEWCASTLE - OTTAWA QUALITY ASSESSMENT SCALE
CASE CONTROL STUDIES

Note: A study can be awarded a maximum of one star for each numbered item within the Selection and Exposure categories. A maximum of two stars can be given for Comparability.

Selection

1) Is the case definition adequate?
   a) yes, with independent validation ✵
   b) yes, eg record linkage or based on self reports
   c) no description

2) Representativeness of the cases
   a) consecutive or obviously representative series of cases ✵
   b) potential for selection biases or not stated

3) Selection of Controls
   a) community controls ✵
   b) hospital controls
   c) no description

4) Definition of Controls
   a) no history of disease (endpoint) ✵
   b) no description of source

Comparability

1) Comparability of cases and controls on the basis of the design or analysis
   a) study controls for _____ (Select the most important factor.) ✵
   b) study controls for any additional factor ✵ (This criteria could be modified to indicate specific control for a second important factor.)

Exposure

1) Ascertainment of exposure
   a) secure record (eg surgical records) ✵
   b) structured interview where blind to case/control status ✵
   c) interview not blinded to case/control status
   d) written self report or medical record only
   e) no description

2) Same method of ascertainment for cases and controls
   a) yes ✵
   b) no

3) Non-Response rate
   a) same rate for both groups ✵
   b) non respondents described
   c) rate different and no designation

NEWCASTLE - OTTAWA QUALITY ASSESSMENT SCALE
COHORT STUDIES

Note: A study can be awarded a maximum of one star for each numbered item within the Selection and Outcome categories. A maximum of two stars can be given for Comparability

Selection

1) Representativeness of the exposed cohort
   a) truly representative of the average _____ (describe) in the community ✵
   b) somewhat representative of the average _____ in the community ✵
   c) selected group of users eg nurses, volunteers
   d) no description of the derivation of the cohort

2) Selection of the non exposed cohort
   a) drawn from the same community as the exposed cohort ✵
   b) drawn from a different source
   c) no description of the derivation of the non exposed cohort

3) Ascertainment of exposure
   a) secure record (eg surgical records) ✵
   b) structured interview ✵
   c) written self report
   d) no description

4) Demonstration that outcome of interest was not present at start of study
   a) yes ✵
   b) no

Comparability

1) Comparability of cohorts on the basis of the design or analysis
   a) study controls for _____ (select the most important factor) ✵
   b) study controls for any additional factor ✵ (This criteria could be modified to indicate specific control for a second important factor.)

Outcome

1) Assessment of outcome
   a) independent blind assessment ✵
   b) record linkage ✵
   c) self report
   d) no description

2) Was follow-up long enough for outcomes to occur
   a) yes (select an adequate follow up period for outcome of interest) ✵
   b) no

3) Adequacy of follow up of cohorts
   a) complete follow up - all subjects accounted for ✵
   b) subjects lost to follow up unlikely to introduce bias - small number lost - > ____ % (select an adequate %) follow up, or description provided of those lost) ✵
   c) follow up rate < ____% (select an adequate %) and no description of those lost
   d) no statement

Appendix 1. Quality in Prognostic Studies (QUIPS) tool

Domains	Prompting items for Consideration	Ratings
Study Participation	a. Adequate participation in the study by eligible persons b. Description of the source population or population of interest c. Description of the baseline study sample d. Adequate description of the sampling frame and recruitment e. Adequate description of the period and place of recruitment f. Adequate description of inclusion and exclusion criteria	**High bias:** The relationship between the PF and outcome is very likely to be different for participants and eligible nonparticipants **Moderate bias**: The relationship between the PF and outcome may be different for participants and eligible nonparticipants **Low bias**: The relationship between the PF and outcome is unlikely to be different for participants and eligible nonparticipants
Study Attrition	a. Adequate response rate for study participants b. Description of attempts to collect information on participants who dropped out c. Reasons for loss to follow-up are provided d. Adequate description of participants lost to follow-up e. There are no important differences between participants who completed the study and those who did not	**High bias**: The relationship between the PF and outcome is very likely to be different for completing and non-completing participants **Moderate bias**: The relationship between the PF and outcome may be different for completing and non-completing participants **Low bias**: The relationship between the PF and outcome is unlikely to be different for completing and non-completing participants
Prognostic Factor Measurement	a. A clear definition or description of the PF is provided b. Method of PF measurement is adequately valid and reliable c. Continuous variables are reported or appropriate cut points are used d. The method and setting of measurement of PF is the same for all study participants e. Adequate proportion of the study sample has complete data for the PF f. Appropriate methods of imputation are used	**High bias**: The measurement of the PF is very likely to be different for different levels of the outcome of interest **Moderate bias**: The measurement of the PF may be different for different levels of the outcome of interest **Low bias**: The measurement of the PF is unlikely to be different for different levels of the outcome of interest

	for missing PF data	
Outcome Measurement	a. A clear definition of the outcome is provided b. Method of outcome measurement used is adequately valid and reliable c. The method and setting of outcome measurement is the same for all study participants	**High bias**: The measurement of the outcome is very likely to be different related to the baseline level of the PF **Moderate bias**: The measurement of the outcome may be different related to the baseline level of the PF **Low bias**: The measurement of the outcome is unlikely to be different related to the baseline level of the PF
Study Confounding	a. All important confounders are measured b. Clear definitions of the important confounders measured are provided c. Measurement of all important confounders is adequately valid and reliable d. The method and setting of confounding measurement are the same for all study participants e. Appropriate methods are used if imputation is used for missing confounder data f. Important potential confounders are accounted for in the study design g. Important potential confounders are accounted for in the analysis	**High bias:** The observed effect of the PF on the outcome is very likely to be distorted by another factor related to PF and outcome **Moderate bias:** The observed effect of the PF on outcome may be distorted by another factor related to PF and outcome **Low bias:** The observed effect of the PF on outcome is unlikely to be distorted by another factor related to PF and outcome
Statistical Analysis and Reporting	a. Sufficient presentation of data to assess the adequacy of the analytic strategy b. Strategy for model building is appropriate and is based on a conceptual framework or model c. The selected statistical model is adequate for the design of the study d. There is no selective reporting of results	**High bias**: The reported results are very likely to be spurious or biased related to analysis or reporting **Moderate bias**: The reported results may be spurious or biased related to analysis or reporting **Low bias**: The reported results are unlikely to be spurious or biased related to analysis or reporting

Source: Hayden JA, van der Windt DA, Cartwright JL, Côté P, Bombardier C. Assessing bias in studies of prognostic factors. Ann Intern Med. 2013;158(4):280-6

Abbreviation: PF prognostic factor

The QUADAS tool

Item		Yes	No	Unclear
1.	Was the spectrum of patients representative of the patients who will receive the test in practice?	( )	( )	( )
2.	Were selection criteria clearly described?	( )	( )	( )
3.	Is the reference standard likely to correctly classify the target condition?	( )	( )	( )
4.	Is the time period between reference standard and index test short enough to be reasonably sure that the target condition did not change between the two tests?	( )	( )	( )
5.	Did the whole sample or a random selection of the sample, receive verification using a reference standard of diagnosis?	( )	( )	( )
6.	Did patients receive the same reference standard regardless of the index test result?	( )	( )	( )
7.	Was the reference standard independent of the index test (i.e., the index test did not form part of the reference standard)?	( )	( )	( )
8.	Was the execution of the index test described in sufficient detail to permit replication of the test?	( )	( )	( )
9.	Was the execution of the reference standard described in sufficient detail to permit its replication?	( )	( )	( )
10.	Were the index test results interpreted without knowledge of the results of the reference standard?	( )	( )	( )
11.	Were the reference standard results interpreted without knowledge of the results of the index test?	( )	( )	( )
12.	Were the same clinical data available when test results were interpreted as would be available when the test is used in practice?	( )	( )	( )
13.	Were uninterpretable/ intermediate test results reported?	( )	( )	( )
14.	Were withdrawals from the study explained?	( )	( )	( )

Whiting P, Rutjes AW, Reitsma JB, et al. The development of QUADAS: a tool for the quality assessment of studies of diagnostic accuracy included in systematic reviews. BMC Med Res Methodol 2003;3:25

Appendix
Final Version of Instrument for Assessing Quality of Case Series Papers, and Instructions

Instrument for Evaluating the Quality of Case Series Studies in Chinese Herbal Medicine

Factor 1: Study aims and design
(1) The rationale/aim of the study is clear.
(2) The study design is appropriate for the aim of study.

Factor 2: Descriptions of treatment protocol
(3) Description of the disease/condition being treated is adequate.
(4) The rationale for the treatment protocol is clear.
(5) The treatment protocol (intervention and its duration, outcome measures: quantitative or qualitative, long-term vs. short-term, endpoints) is adequately described.

Factor 3: Descriptions of methods and therapeutic/side-effects
(6) Details of methods/procedures are adequate to allow the study to be repeated.
(7) Therapeutic effects and side-effects are defined.

Factor 4: Conduct of the study
(8) Inclusion/exclusion criteria (age range, disease/symptom duration, selection endpoints, diagnosis) are clear.
(9) The methods of patient recruitment are appropriate.
(10) Subject assessment was independent and objective.
(11) The data collected are relevant and complete.
(12) Data analysis is appropriate for the design of the study.
(13) The results for all outcome measures have been clearly reported.

FIRST #135 Plate #001 Visit #000

Patient Study ID Number [ ][ ][ ] [ ][ ][ ][ ] Patient Initials [ ][ ] Date of Screening [ ][ ] [ ][ ] [2][0][ ][ ]

Centre # Patient # F L DD MM YYYY

SCREENING FORM 1.1 (Page 1 of 1)

Please complete this form for all patients diagnosed with Femoroacetabular Impingement (FAI).

	YES	NO
1. Is this patient 18 to 50 years of age?	☐	☐
2. Has the patient had hip pain for greater than 6 months with no relief from non-operative means (physiotherapy, non-steroidal anit-inflammatory medication, rest)?	☐	☐
3. Does the patient have documented failed physiotherapy including core conditioning of the hip, back, and abdomen?	☐	☐
4. Does the patient have CAM or mixed type FAI that was diagnosed on x-rays or MRI/MRA?	☐	☐
5. Did the patient receive temporary pain relief from an intra-articular hip injection?	☐	☐
6. Has the patient provided written informed consent?	☐	☐
7. Does the patient speak, read and understand the language of the clinical site?	☐	☐

If you answered no to any items 1-7, the patient should be excluded from the FIRST trial.

	YES	NO
8. Has the patient previously been involved in a study involving FAI?	☐	☐
9. Does the patient have any evidence of hip dysplasia (centre edge angle less than 20°)?	☐	☐
10. Does the patient have advanced hip osteoarthritis (Tonnis Grade 2 or 3 - refer to the study protocol for a detailed description of the grade characteristics)?	☐	☐
11. Does the patient have other hip syndromes (concurrent non-FAI related pathology)?	☐	☐
12. Has the patient had any previous trauma to the affected hip?	☐	☐
13. Has the patient had any previous surgery on the affected hip or contralateral hip?	☐	☐
14. Does the patient have severe acetabular deformities (e.g. acetabular protrusion, coxa profunda, circumferential labral ossification)?	☐	☐
15. Has the patient used any immunosuppressive medication?	☐	☐
16. Does the patient have any chronic pain syndrome?	☐	☐
17. Does the patient have significant medical co-morbidities (requiring daily assistance for ADLs)?	☐	☐
18. Does the patient have a history of pediatric hip disease (Legg-Calve Perthes, slipped capital femoral epiphysis)?	☐	☐
19. Does the patient have any ongoing litigation or compensation claims secondary to the hip?	☐	☐
20. Are there any other reasons to exclude the patient? (specify): _____	☐	☐

If you answered yes to any items 8-20, the patient should be excluded from the FIRST trial.

Patient Status ☐ EXCLUDED ☐ MISSED ☐ INCLUDED (proceed to the Randomization Form)

If the patient is excluded from the FIRST trial, does the patient consent to participate in the FIRST Cohort study?

☐ No ☐ Yes → INCLUDED in Cohort Study (DO NOT RANDOMIZE)

FIRST #135 Plate #002 Visit #001

Patient Study ID Number [ ][ ][ ] [ ][ ][ ][ ] Patient Initials [ ][ ]

Centre # Patient # F L

RANDOMIZATION FORM 2.1 (Page 1 of 1)

Please complete the following questions for all patients included in the FIRST trial prior to randomization. You will need to have this information available when you randomize the patient.

1. Date of Randomization: [ ][ ] [ ][ ] [2][0][ ][ ]

DD MM YYYY

2. Impingement sub type:

- [ ] CAM
- [ ] Mixed

3. Patient randomized to:

- Group 1: [ ] Arthroscopic Osteochondroplasty
- Group 2: [ ] Arthoscopic Lavage

4. Initials of person who randomized patient: [ ][ ]

F L

FIRST #135 Plate #003 Visit #001

Patient Study ID Number ☐☐☐ ☐☐☐☐ Centre # Patient #

Patient Initials ☐☐ F L

BASELINE CHARACTERISTICS FORM 3.1 (Page 1 of 5)

Please complete the following questions for all included patients prior to surgery.

PART A: Visit Information

1. Date of baseline appointment: ☐☐ DD ☐☐ MM 2 0 ☐☐ YYYY

2. FOR EACH of the following, please indicate if the questionnaire was completed.

	Yes	No
VAS	☐	☐
HOS	☐	☐
iHOT-12	☐	☐
SF-12	☐	☐
EQ-5D	☐	☐
MLUTS/FLUTS	☐	☐
IIEF/FSFI	☐	☐

3. Visit Status:

☐ Complete: all required data collection forms and questionnaires completed

☐ Partially complete, please specify why: _____

4. At baseline, what is the patient's weight-bearing status? (check only one)

☐ Non-weightbearing

☐ Partial weightbearing

☐ Full weightbearing

5. What aid(s) is the patient using at this time? (check all that apply)

☐ None (patient is ambulatory)

☐ Wheelchair

☐ Walker

☐ Two crutches

☐ One crutch

☐ Cane

☐ Other (specify): _____

FIRST #135 Plate #004 Visit #001

Patient Study ID Number ☐☐☐ ☐☐☐☐ (Centre # / Patient #)

Patient Initials ☐☐ (F L)

BASELINE CHARACTERISTICS FORM 3.2 (Page 2 of 5)

6. What is the date of the most recent image taken of the affected hip?

☐ MRI → ☐☐ (DD) ☐☐ (MM) ☐☐☐☐ (YYYY)

☐ X-ray → ☐☐ (DD) ☐☐ (MM) ☐☐☐☐ (YYYY)

PART B: Demographic Information

7. Patient Date of Birth: ☐☐ (DD) ☐☐ (MM) ☐☐☐☐ (YYYY)

8. Sex: ☐ Male ☐ Female

9. Ethnicity:

☐ Native/Aboriginal ☐ Hispanic/Latino

☐ South Asian ☐ Black (African/Caribbean)

☐ White/Caucasian ☐ Other (specify): _____

10. Height: ☐☐☐ ☐ inches ☐ centimetres

11. Weight: ☐☐☐ ☐ pounds ☐ kilograms

12. Does the patient use tobacco products? (Includes cigarettes, cigars and chewing tobacco)

☐ No

☐ Yes → How long? ☐☐.☐ (years)

☐ Yes, quit → ☐☐ (Age began) ☐☐ (Age quit)

13. Does the patient consume alcohol? If yes, please specify the amount on average the patient drinks per week.

☐ No

☐ Yes → ☐☐.☐ Drinks per week

FIRST #135 Plate #005 Visit #001

Patient Study ID Number ☐☐☐ (Centre #) ☐☐☐☐ (Patient #) Patient Initials ☐☐ F L

BASELINE CHARACTERISTICS FORM 3.3 (Page 3 of 5)

14. Is the patient employed?

☐ No → If no,
- ☐ Retired
- ☐ Home-maker
- ☐ Student
- ☐ Doctor's Advice/Disabled
- ☐ Unemployed
- ☐ Other: _____

☐ Yes → If yes, which of the following job categories best describe their current position? (check all that apply)

- ☐ Management
- ☐ Business and Financial
- ☐ Computer and Mathematical
- ☐ Architecture and Engineering
- ☐ Life, Physical, and Social Science
- ☐ Community and Social Service
- ☐ Legal
- ☐ Education, Training and Library
- ☐ Arts, Design, Entertainment, Sports and Media
- ☐ Healthcare Practioners and Technical
- ☐ Protective Service
- ☐ Food Preparation and Serving
- ☐ Personal Care and Service
- ☐ Building, Grounds Cleaning and Maintenance
- ☐ Sales or Sales-related Occupations
- ☐ Office or Administrative Support
- ☐ Construction and Extraction
- ☐ Installation, Maintenance, and Repair
- ☐ Production and Assembly
- ☐ Transportation and Material Moving
- ☐ Healthcare Support

15. Does the patient currently have a pending claim (e.g. WSIB) or recieve payments for a disability or Worker's Compensation **not related to the affected hip**?

☐ No ☐ Yes → This patient is ineligible to participate in the trial and should be excluded. Please complete an Early Withdrawal Form.

16. Does the patient currently have a pending claim (e.g. WSIB) or recieve payments for a disability or Worker's Compensation **related to the affected hip**?

☐ No ☐ Yes

17. Has the patient undergone any other treatment modalities? Please provide details for all medications on Medication Log.

☐ Yes → Please specify all that apply
- ☐ Physical Therapy
- ☐ NSAIDS → Please note on Medication Log
- ☐ Hip Injection → Please note on Medication Log
- ☐ Other: _____ (If drug related, please note on Medication Log)

☐ No

18. Did you ask the patient about current medications and update the Medication Log appropriately?

☐ Yes ☐ No, there are no updates → Check appropriate visit box on Medication Log

FIRST #135 Plate #006 Visit #001

Patient Study ID Number [ ][ ][ ] [ ][ ][ ][ ] Patient Initials [ ][ ]

Centre # Patient # F L

BASELINE CHARACTERISTICS FORM 3.4 (Page 4 of 5)

PART C: Details of Diagnosis

19. Date of FAI diagnosis: [ ][ ] [ ][ ] [ ][ ][ ][ ]
DD MM YYYY

20. Please specify the hip affected: ☐ Left ☐ Right

21. Location of the pain: ☐ Groin ☐ Lateral sided ☐ Posterior Pain

22. Onset of symptoms: ☐ Acute ☐ Subacute ☐ Insidious
☐ Traumatic ☐ Non-traumatic

23. Please indicate sports activity level of patient:
☐ None ☐ Light ☐ Moderate ☐ Vigorous

24. Does the patient have any co-morbidities?

	Does this patient have the problem?		If yes	Do they recieve treatment for it?		Does it limit the patient's activities?	
	Yes	No		Yes	No	Yes	No
a) Osteopenia	☐	☐	→	☐	☐	☐	☐
b) Osteoporosis	☐	☐	→	☐	☐	☐	☐
c) Lung Disease	☐	☐	→	☐	☐	☐	☐
d) Diabetes	☐	☐	→	☐	☐	☐	☐
e) Ulcers or Stomach Disease	☐	☐	→	☐	☐	☐	☐
f) Kidney Disease	☐	☐	→	☐	☐	☐	☐
g) Anemia or Other Blood Disease	☐	☐	→	☐	☐	☐	☐
h) Depression	☐	☐	→	☐	☐	☐	☐
i) Cancer	☐	☐	→	☐	☐	☐	☐
j) Osteoarthritis, Degenerative Arthritis	☐	☐	→	☐	☐	☐	☐
k) Back Pain	☐	☐	→	☐	☐	☐	☐
l) Rheumatoid Arthritis	☐	☐	→	☐	☐	☐	☐
m) Heart Disease	☐	☐	→	☐	☐	☐	☐
n) High Blood Pressure	☐	☐	→	☐	☐	☐	☐
o) Genitourinary	☐	☐	→	☐	☐	☐	☐
p) Previous Lower Extremity Injury	☐	☐	→	☐	☐	☐	☐
q) Dementia	☐	☐	→	☐	☐	☐	☐
r) Other: _____	☐	☐	→	☐	☐	☐	☐

FIRST #135 Plate #007 Visit #001

Patient Study ID Number ☐☐☐ ☐☐☐☐ Centre # Patient #

Patient Initials ☐☐ F L

BASELINE CHARACTERISTICS FORM 3.5 (Page 5 of 5)

PART D: Hip Characterisitics

25. Anterior Impingement Test: ☐ Postive ☐ Negative
26. Posterior Impingement Test: ☐ Postive ☐ Negative
27. Log Roll Test: ☐ Postive ☐ Negative
28. Centre-edge angle: ☐☐☐.☐ (if less than 20 , patient should be excluded)
29. Alpha angle: ☐☐☐.☐
30. Neck Shaft angle: ☐☐☐.☐
31. Femoral offset ratio: ☐.☐☐
32. Crossover sign: ☐ Postive ☐ Negative
33. Coxa profunda: ☐ Postive ☐ Negative
34. Coxa protrusio: ☐ Postive ☐ Negative
35. Left Hip Range of Motion

Flexion:	☐☐☐.☐	Extension:	☐☐☐.☐
Abduction:	☐☐☐.☐	Adduction:	☐☐☐.☐
Internal Rotation (neutral):	☐☐☐.☐	External Rotation (neutral):	☐☐☐.☐
Internal Rotation (90 flexion):	☐☐☐.☐	External Rotation (90 flexion):	☐☐☐.☐

36. Right Hip Range of Motion

Flexion:	☐☐☐.☐	Extension:	☐☐☐.☐
Abduction:	☐☐☐.☐	Adduction:	☐☐☐.☐
Internal Rotation (neutral):	☐☐☐.☐	External Rotation (neutral):	☐☐☐.☐
Internal Rotation (90 flexion):	☐☐☐.☐	External Rotation (90 flexion):	☐☐☐.☐

37. Tonnis and Heinecke pre-operative cartilage classification (refer to the study protocol for a detailed description of each):

☐ Grade 0 ☐ Grade 1 ☐ Grade 2 ☐ Grade 3

38. Are any labral tears present?

☐ Yes → Please specify: ☐ Anterior ☐ Posterior ☐ Superior/Lateral

☐ No

39. Are any herniation pits present? ☐ Yes ☐ No

FIRST #135 Plate #008 Visit #001

Patient Study ID Number [ ][ ][ ] [ ][ ][ ][ ] Patient Initials [ ][ ]

Centre # Patient # F L

SURGICAL REPORT FORM 5.1 (Page 1 of 4)

Please complete the following questions for all included patients following the surgical procedure.

1. Date of surgery: [ ][ ] [ ][ ] [2][0][ ][ ]
DD MM YYYY

2. Name of attending surgeon: _____ _____
Surname Given Name

3. Who performed the majority of the surgery? ☐ Surgeon ☐ Resident ☐ Fellow

4. Does the surgeon meet the expertise threshold for the procedure the patient received?

We recommend that the surgeon/consultant has completed a minimum of 30 procedures of this type in thier career, as well we recommend that the surgeon/consultant has performed a minimum of 5 procedures of this type in the past year.

☐ Yes
☐ No → Please explain: _____

5. Was the surgeon present in the operating room for the critical aspects of this surgery?

☐ Yes
☐ No → Please explain: _____

6. Total operative time: [ ][ ][ ][ ]
(minutes)

7. Total traction time: [ ][ ][ ][ ]
(minutes)

8. Type of surgical preparation solution used (check all that apply):

☐ Iodine ☐ Alcohol
☐ Chlorhexidine ☐ Other (please specify): _____

9. Was there an operative adverse event or complication during this procedure?

☐ No ☐ Yes → Please complete an Adverse Event Form

10. Upon arthroscopic exploration, does this patient have FAI?

☐ Yes
☐ No → Please explain: _____

FIRST #135 Plate #009 Visit #001

Patient Study ID Number ☐☐☐ (Centre #) ☐☐☐☐ (Patient #) Patient Initials ☐☐ F L

SURGICAL REPORT FORM 5.2 (Page 2 of 4)

11. Which procedure was performed on this patient?

☐ Arthroscopic Osteochondroplasty
☐ Arthroscopic Lavage
☐ Neither → Please explain and complete as much of the remainig Surgical Report Form as as possible: _____

12. Was this the procedure that the patient was randomized to?

☐ Yes ☐ Not applicable - cohort study patient
☐ No → Please explain: _____

13. Amount of saline used: ☐☐.☐☐ Litres ☐ Not Applicable

14. Were any significant labral tears diagnosed (bucket handle tears) repaired or resected?

Labral Tear: ☐ Yes → ☐ Partial Tear → ☐ Linear Tear / ☐ Degenerative Tear
☐ Complete Tear
☐ No
☐ Anterior → ☐ Capsular Sided Tear / ☐ Articular Sided Tear
☐ Posterior

Labrum Injected: ☐ Yes → Edema: ☐ Focal / ☐ Diffuse
☐ No

15. Outerbridge intra-operative cartilage classification:

☐ Grade 0 ☐ Grade 1 ☐ Grade 2 ☐ Grade 3 ☐ Grade 4

16. Beck intra-operative <u>cartilage</u> classification:

☐ Grade 0 ☐ Grade 1 ☐ Grade 2 ☐ Grade 3 ☐ Grade 4

17. Beck intra-operative <u>labral</u> classification:

☐ Grade 0 ☐ Grade 1 ☐ Grade 2 ☐ Grade 3 ☐ Grade 4

18. Was a capsulotomy performed?

☐ Yes → ☐ Partial / ☐ Complete
☐ No

FIRST #135 Plate #010 Visit #001

Patient Study ID Number ☐☐☐ ☐☐☐☐ Patient Initials ☐☐

Centre # Patient # F L

SURGICAL REPORT FORM 5.3 (Page 3 of 4)

19. Was a capsular closure performed?

- ☐ Yes
- ☐ No

20. How much bone was debrided? (check one only)

- ☐ None
- ☐ Small amount (<1 cm^3)
- ☐ Moderate amount (1-5 cm^3)
- ☐ Large amount (>5 cm^3)

21. How much cartilage was debrided or repaired? (check one only)

- ☐ None
- ☐ Small amount (<1 cm^3)
- ☐ Moderate amount (1-5 cm^3)
- ☐ Large amount (>5 cm^3)

22. How much labrum was debrided or repaired? (check one only)

- ☐ None
- ☐ Small amount (<1 cm^3)
- ☐ Moderate amount (1-5 cm^3)
- ☐ Large amount (>5 cm^3)

23. How many anchors were used during repair? (check one only)

- ☐ Not applicable (no repair)
- ☐ 0
- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5
- ☐ 6

FIRST #135 Plate #011 Visit #001

Patient Study ID Number Centre # Patient # Patient Initials F L

SURGICAL REPORT FORM 5.4 (Page 4 of 4)

(S. Gokhale et al.)

24. **Presenting Complaint** (check all that apply):

- ☐ Hip Pain
- ☐ Hip Stiffnes/Inflexibililty
- ☐ Other: _____

25. **Pre-Op Diagnosis** (check only one):

- ☐ CAM Type Impingement
- ☐ Mixed Type Impingment
- ☐ Other: _____

26. **Intra-operative Findings:**

_____

_____

27. **Extra-articular tendon and bursal pathologies:**

_____

_____

28. **Preparations** (check all that apply):

- ☐ General anaesthetic and skin prep
- ☐ Traction with large bollard
- ☐ Traction time
- ☐ Lateral; antero-lateral approach

29. **Procedures** (check only one)**:**

- ☐ Arthroscopic Osteochondroplasty
- ☐ Arthroscopic Lavage
- ☐ Other: _____

30. **Post-op Plan** (check all that apply):

- ☐ No sutures
- ☐ Mobile FWB
- ☐ Home when able
- ☐ Follow up in 2 months with hip score on arrival

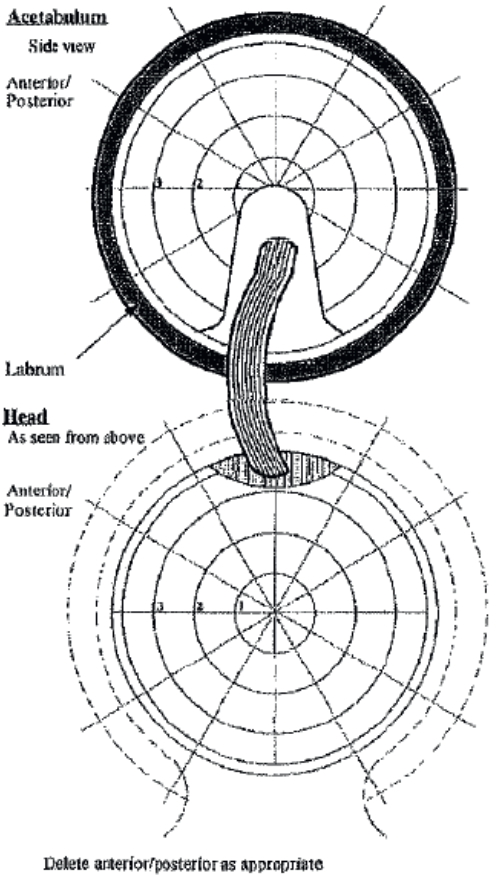

Figure 1: An arthroscopic hip documentation form. The documentation form maps the acetabulum from the side view and the femoral head from above. For orientation purposes, it also illustrates the head neck junction, part of the neck, and the ligamentum teres, extra-articular findings can be recorded in text format.

Grade I ☐ Grade II ▤ Grade III ■ Grade IV B Periosteal patch ▩