The role of hip arthroscopic intervention for femoroacetabular impingement on the quality of life and deferring the need for hip replacement

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A thesis submitted in partial fulfilment of PhD

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Declaration

This is to declare that this thesis and the work presented in it are my own and have been generated by me as the result of my own original research.

1. Where any part of this thesis has previously been submitted for a degree or any other qualification at this university or any other institution, this has been clearly stated;

2. Where I have consulted the published work of others, this is always clearly attributed;

3. Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work;

4. I have acknowledged all main sources of help;

5. Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;

Signed:

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Date: 10/01/2016

Dedication

I would like to dedicate this thesis to my parents, Om Prakash Malviya and Chandrakala Malviya who always believed in me, and mentored and supported me in all the decisions I have made in my life.

Acknowledgement

This thesis would not have been possible without the guidance and support of Mr Richard Villar and the Richard Villar Practice; which has been the foundation of the papers used to prepare this work.

I would like to express my thanks to my supervisors, Scott Wilkes and Eddie Bradley, for their time, patience and indeed flexibility in changing the dates and times for our monthly meetings, sometimes at the last moment and occasionally even having to wait when I was running late!

I am grateful to all my co-authors for allowing me to use the papers for completion of this thesis; in particular Giles Stafford, with whom I have shared several curries, usually in pleasant, but occasionally in tough circumstances, in Cambridge, during my fellowship.

This list would certainly be incomplete without acknowledgment of the support I have received at home, particularly from my wife Parul, who is the cornerstone of my sustenance, allowing me to work over and beyond my normal commitments. Tasha and Nisna, you are the twinkle of my eyes, the beats of my heart and the motivation to succeed.

Abstract

Background

The role of hip arthroscopic intervention for Femoroacetabular impingement (FAI) is evolving with increasing ability to deal with impingement lesions and repair the chondrolabral tears. Initially, the procedure was thought to be most appropriate for treatment of athletes but the objective benefits in terms of return to sport at the same level were not considered. Moreover, any benefit in terms of overall quality of life, and potential efficacy of arthroscopic treatment in non-athletes has not been clarified. Currently, this procedure is still very new, and most published studies involve retrospective analysis of small numbers of patients and do not give an accurate picture of the frequency and severity of complications, in particular the potential to delay the need the have hip replacement.

Aim

The aim of this thesis is to establish the benefit of hip arthroscopic intervention for FAI by answering pertinent questions about the procedure:

- Is it effective in terms of improvement in quality of life?
- Is it beneficial for non-athletes?
- Is it possible for athletes to return to sport at the same level?
- What is the short-term complication rate?
- Does it defer the need to have hip replacement in the future?

Methods

This thesis is based on four original published papers in various peer-reviewed journals that address the above questions.

Results

Does hip arthroscopic intervention improve quality of life (QoL) of patients with FAI?

This publication reported the largest single-surgeon series, at the time of publication, and was the first to consider QoL outcomes. In a series of 612 patients at a mean follow-up of 3.2 years, we found that the QoL improved significantly after surgical intervention in 77%, remained unchanged in 14% and deteriorated in 9% of patients. The significant predictors of change in QoL were preoperative QoL scores and female gender.

Is hip arthroscopic intervention for FAI only for athletes?

In this prospective comparative study the trend for improvement in hip scores after surgery was compared between athletes and non-athletes and we found that, while the athletes had a significantly better score at six weeks, there were no significant differences between the two groups after one year. This study was the first prospective comparative study to look at these two groups of patients and demonstrated that arthroscopic surgery may be an appropriate treatment for FAI in both athletes and non-athletes.

Does hip arthroscopic intervention for FAI improve the outcome in athletes?

In this prospective comparative study we noted that both the training and time in competition improved approximately three-fold after surgery, with a mean time to return to sport at the same level of 5.4 months. Professional athletes (4.2 months) recovered more quickly than recreational athletes (6.8 months). A greater proportion of the professional athletes (88%) returned to their pre-injury level of sport than the recreational athletes (73%). Prior to this study, objective measures of return to sport were lacking, and there had been no prospective comparative studies of recovery time in professional and recreational athletes.

What is the short-term complication rate?

The national hospital episode statistics data on short-term complications after hip arthroscopy showed that, in 6395 hip arthroscopies performed in England between April 2005 and Jan 2013, the 30-day readmission rate was 0.5%; the 90-day incidence of deep vein thrombosis (DVT) was 0.08% and of pulmonary embolus (PE) 0.08%; and the 90-day mortality rate was 0.02%.

Does it defer the need to have hip replacement in the future?

In this series of 6395 hip arthroscopies, 680 patients (10.6%) underwent total hip replacement (THR), at a mean of 1.4 years after the index operation. Female patients had a 1.68 times (95% CI, 1.41 to 2.01) higher risk of conversion to THR than male patients, and patients aged 50 years or older had a 4.65 (95% CI, 3.93 to 5.49) times higher risk of requiring hip replacement than patients younger than 50 years. Kaplan-Meier survival analysis revealed an eight-year survival of 82%; while Cox proportional hazard analysis, adjusting for age, gender and Charlson comorbidity score, revealed an eight-year survival of 86%.

Conclusion

Arthroscopic surgery for FAI improves QoL, is beneficial for non athletes as well as athletes, enables athletes to return to their professional level of function and may delay the need for total hip replacement. These papers have helped, not only in establishing the outcome of surgery but also in identifying the patients who would benefit from intervention. This information is critical to the clinicians' understanding of both the success of the intervention and limitations of the technique. Important information has been generated from this work that will be helpful during preoperative counselling, when it is imperative to obtain properly informed consent.

Published papers on which this thesis is based

1. Malviya A, Stafford GH, Villar RN. Impact of arthroscopy of the hip for femoroacetabular impingement on quality of life at a mean follow-up of 3.2 years. J Bone Joint Surg Br. 2012 Apr;94(4):466-70
   Impact factor: 2.801

   Novel question: What proportion of patients have an improvement in their quality of life after hip arthroscopy for femoroacetabular impingement and what are the factors that determine this

   Original finding: 77% patients have improvement in quality of life scores after hip arthroscopy with female gender and lower preoperative scores being predictors of poorer outcome

2. Malviya A, Stafford GH, Villar RN. Is hip arthroscopy for femoroacetabular impingement only for athletes? Br J Sports Med. 2012 Nov;46(14):1016-8.
   Impact factor: 4.17

   ***Novel question*:** Is the outcome after hip arthroscopy for femoroacetabular impingement similar in athletes and non-athletes?

   Original finding: In this prospective comparative study we have demonstrated that apart from early 6-week outcome score both groups performed equally well.

3. Malviya A, Paliobeis CP, Villar RN. Do Professional Athletes Perform Better Than Recreational Athletes After Arthroscopy for Femoroacetabular Impingement? Clin Orthop Relat Res. 2013;471:2477-2483

Impact factor: 2.882

Novel question: Is the outcome after hip arthroscopy for femoroacetabular impingement similar in professional and recreational athletes?

Original finding: In this prospective comparative study we have demonstrated that professional athletes have a quicker return to sports than recreational athletes but the hip scores and rate of return to sports are similar.

4. Malviya A, Raza A, Jameson S, James P, Reed MR, Partington PF. Short-term complications and survival analyses of hip arthroscopies performed in the UK NHS – a review of 6395 cases. Journal of Arthroscopy and Related Surgery 2015;31:836-42

Impact factor: 3.191

Novel question**:** What is the mid-term survival of hip arthroscopy in terms of deferring the need to have hip replacement?

Original finding: The eight-year survival of hip arthroscopy is 86% after adjusting for all the confounding variables.

List of abbreviations

DVT – Deep vein thrombosis

EQ-5d – Euroqol – 5d

FAI - Femoroacetabular impingement

HOOS - Hip disability and osteoarthritis outcome score

HOS – Hip outcome score

ICD – International classification of disease

ICER – Incremental cost-effectiveness ratio

MHHS - Modified Harris hip score

NAHS - Non arthritic hip score

NICE – National Institute of Health and Clinical Excellence

OPCS – Office of population census and surveys

PROM – Patient reported outcome measure

PA – Professional athlete

PE – Pulmonary embolism

QALY – Quality adjusted life years

QoL – Quality of life

RA – Recreational athlete

SF-12 – Short form 12

SF-36 – Short form 36

THA – Total hip replacement

VAS – Visual analogue score

CONTENTS

Chapter One: Femoroacetabular impingement (FAI)

Normal hip anatomy

The hip joint is a congruent articulation of the femoral head (ball) and the acetabulum (socket) (Figure 1) while the acetabular labrum (Figure 2) is a ring of fibrocartilage that is attached around the circumference of the acetabulum. The labrum increases the depth of the acetabulum, effectively increasing the surface area of contact and thereby provides stability to the joint. Another important function of the acetabular labrum is to maintain the synovial fluid and the fluid pressure by sealing the joint and acting as a lubricator between the femoral head and acetabular cartilage. A tear in the labrum could result in a loss of this suction-seal effect increasing in the joint forces, which could potentially put the acetabular cartilage at a high risk of degeneration. Injuries to the acetabular labrum can occur from chronic trauma due to repetitive hip motion or from acute trauma as, for example, from a direct blow to the hip or a forceful abnormal movement of the hip.

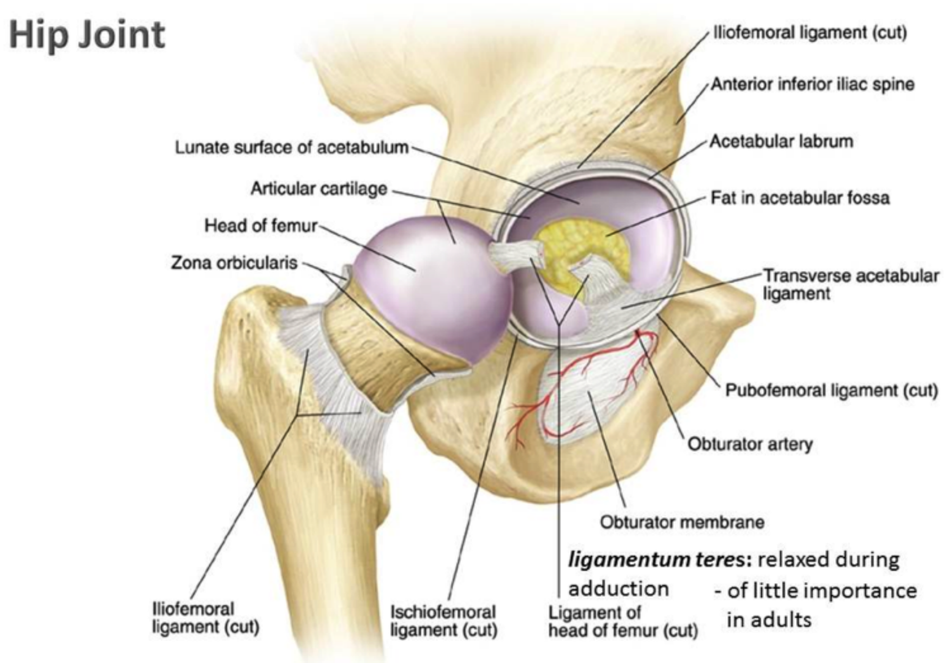

Figure 1 – Normal anatomy of the hip joint with soft tissue attachment

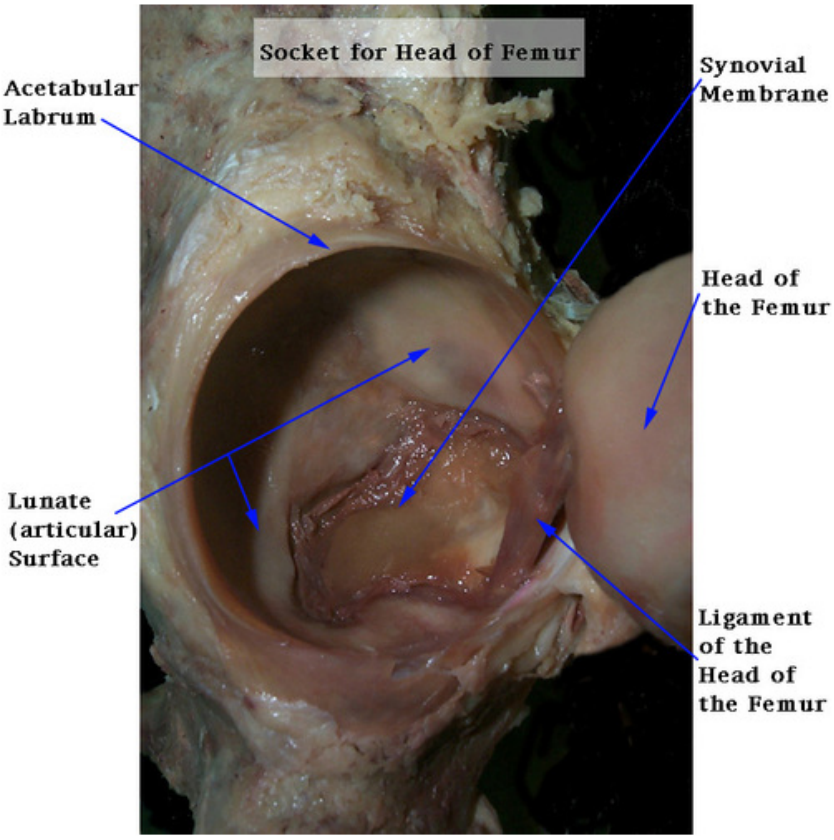

Figure 2 – Cadaveric dissection of the hip joint with different parts labelled – note the labrum is attached to the acetabular rim and increases the depth of the acetabulum

Arthroscopic anatomy

Arthroscopically the hip joint can be divided into two compartments: the central compartment or iliofemoral joint (Figure 3) and the peripheral compartment (Figure 4), which includes structures in the capsule and lateral to the labrum. The central compartment can only be accessed with hip distraction.

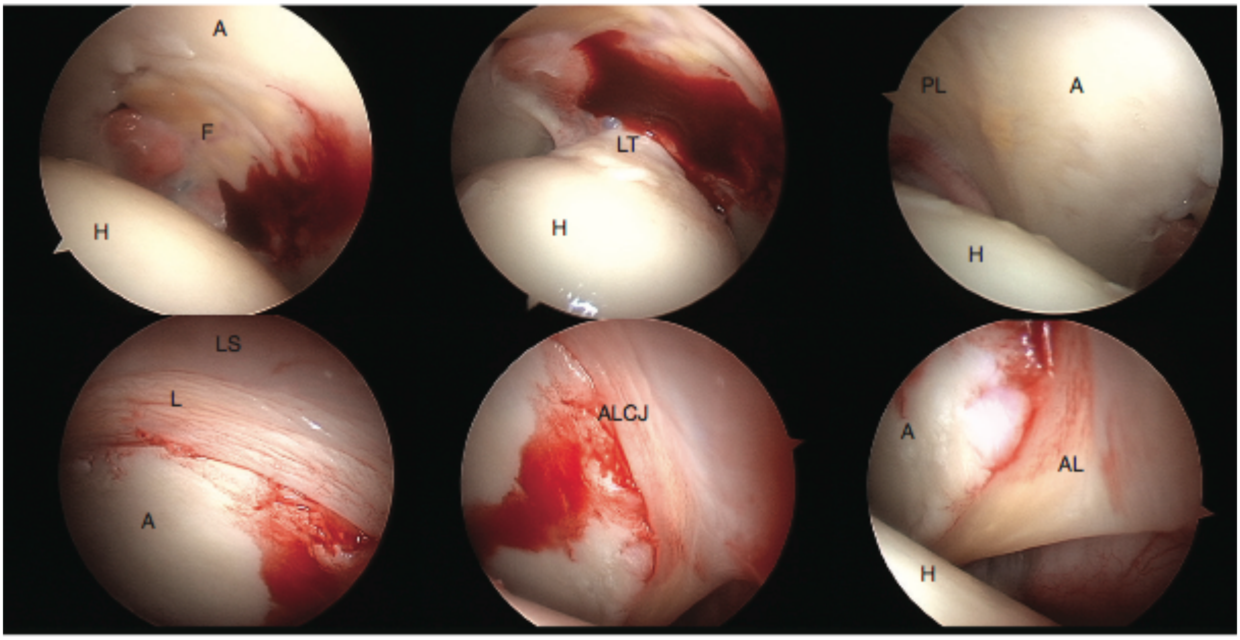

Figure 3 – Central compartment – can be viewed only with hip distraction

A, Acetabulum; AL, anterior labrum; ALCJ, anterior labrocartilaginous junction; F, fossa; H, head; L, labrum; LS, lateral sulcus; LT, ligamentum teres; PL, posterior labrum.

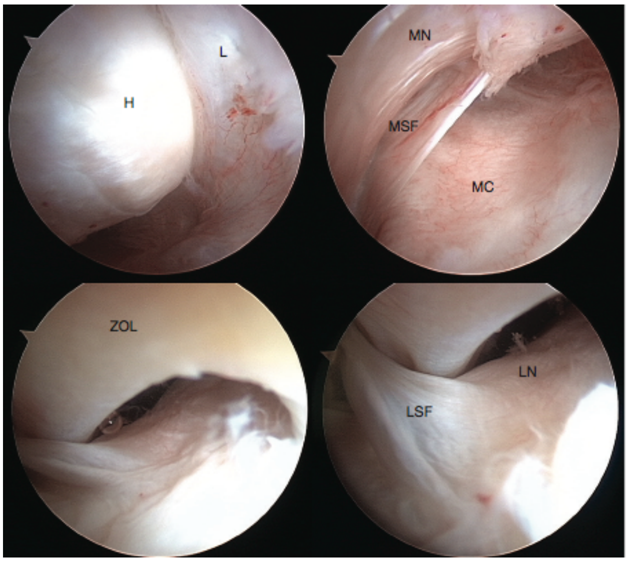

Figure 4 – Peripheral compartment **-** Arthroscopic view of right hip

H, Head; L, labrum; LN, lateral neck; LSF, lateral synovial fold; MC, medial capsule; MN, medial neck; MSF, medial synovial fold; ZOL, zona orbicularis lateral portion.

What is femoroacetabular impingement?

An incongruity of the shape of the hip can lead to impingement of the labrum and chondrolabral junction between the femoral head and acetabular rim during hip movements, in particular deep flexion and internal rotation. These abnormalities can be grouped as femoroacetabular impingement (FAI) and may be caused by an aspherical femoral head (cam impingement lesion) or prominent acetabular rim (pincer lesion) or a combination of the two (Figure 5 a-d). Repetitive forceful impact of the femoral head neck junction at or against the acetabular rim causes damage, exposing the articular cartilage to abnormal shear stress resulting in chondral cleavage and delamination which over a period of time leads to progressive chondral loss and more advanced degeneration.

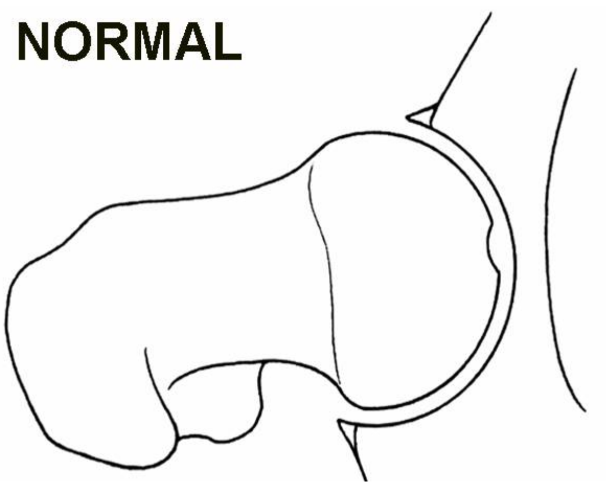

Figure 5a – Congruent ball and socket joint (axial profile)

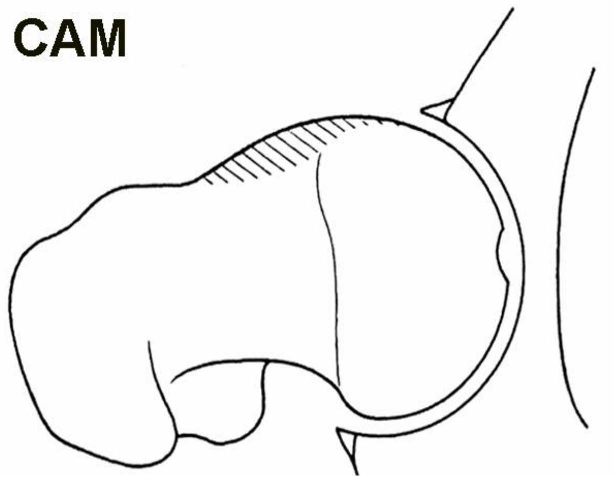

Figure 5b – Incongruent hip caused by abnormal prominence of the femoral head (Cam lesion)

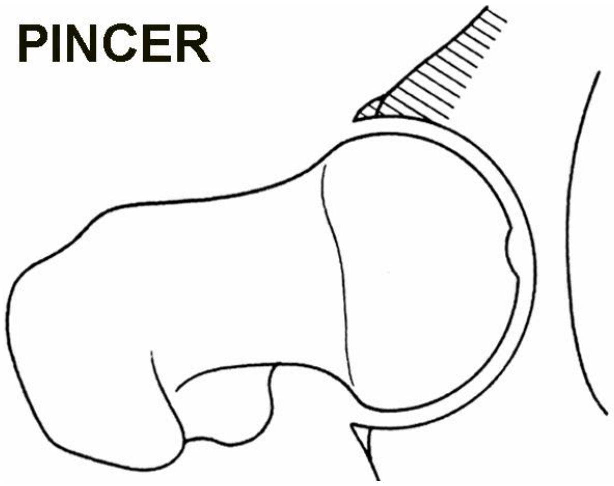

Figure 5c – Incongruent hip caused by abnormal prominence of the acetabular rim (Pincer lesion)

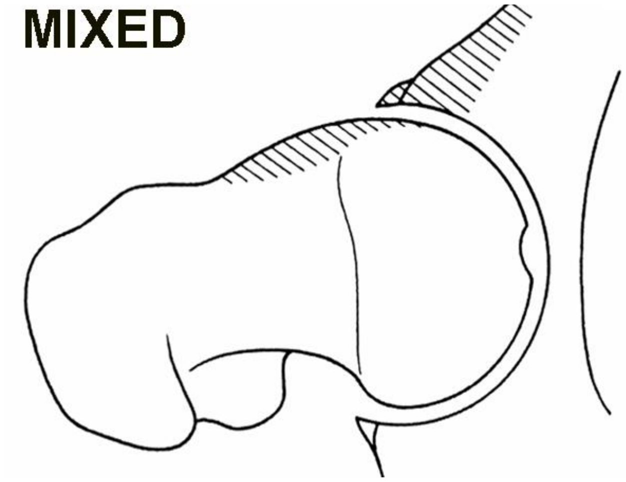

Figure 5d – Incongruent hip caused by mixed Cam and Pincer lesion

Cam lesion can be secondary to other pathologies in the hip like slipped capital femoral physis or perthes or idiopathic pistol grip deformity (Figure 6) leading to lack of anterior clearance and reduced femoral head-neck offset and high alpha angle (Figure 7).

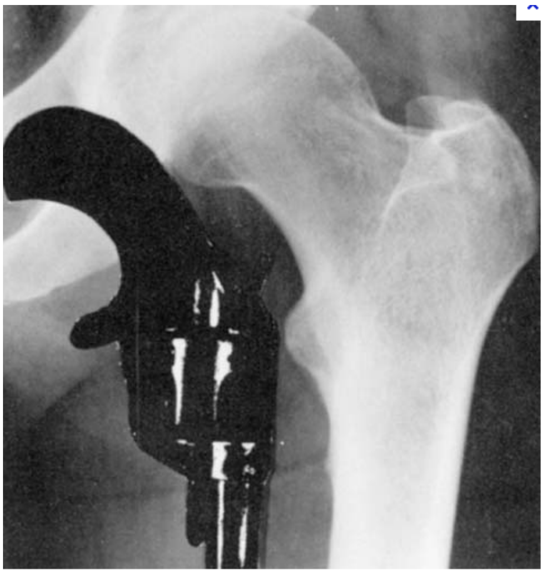

Figure 6 - Cam lesion leading to pistol grip deformity

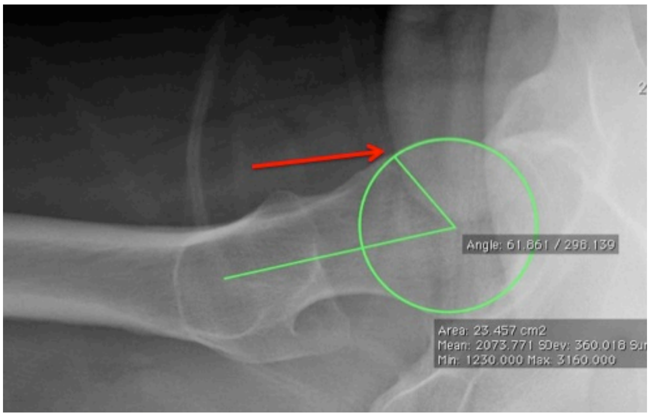

Figure 7 – Cam lesion leading to increased alpha angle (angle between the line along the femoral neck and another joining the point where the sphericity is lost to the centre femoral head), reduced femoral head-neck offset and decreased anterior clearance

Pincer lesion can be secondary to deep sockets as in coxa profunda and protrusion acetabuli or acetabular retroversion (Figure 8) leading to acetabular overcoverage by the anterior acetabular wall.

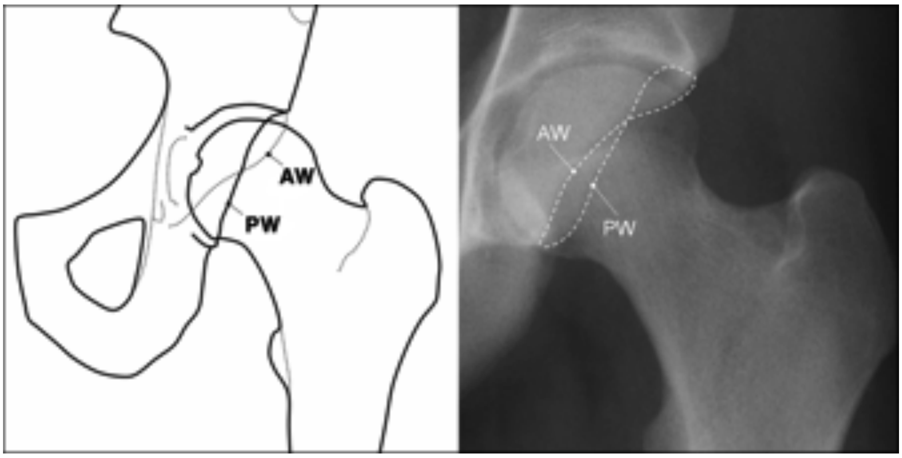

Figure 8 - Acetabular retroversion causing crossing over of anterior (AW) and posterior (PW) acetabular walls, will lead to pincer type pathology

Natural history of Femoroacetabular impingement (FAI)

The concept of FAI is relatively new and was first introduced when Ito *et al.* in 2001, working under the supervision of Professor Reinhold Ganz, published a dynamic MRI-based study looking at the morphology of the femoral head/neck junction. They hypothesised that asphericity of the femoral head, with decreased anterior offset, may cause impingement between the femur and acetabular margin, causing labral tears(1). Subsequently, Ganz *et al.,* 2003, reviewed over 600 non-dysplastic patients who had a surgical dislocation for the treatment of FAI, mapping the areas of cartilage damage or loss and expanded on the concept of FAI, proposing that the condition was a precursor of osteoarthritis (OA)(2). Similarly, Tanzer *et al*., 2004, (3) linked osseous abnormality caused by FAI with early OA. They linked patients from three separate studies and found a common aetiology between patients requiring hip arthroscopy for labral tear, hip cheilectomy for FAI and hip replacement for idiopathic arthritis. They found that repetitive anterior FAI resulted in groin pain, labral tear and chondral damage, leading to arthritis. Pistol grip deformity caused impingement in 97% of patients in the arthroscopic labral tear study and 100% of cases in idiopathic arthritis. These studies concluded that FAI leads to osteoarthritis.

How common is FAI?

Hip shape abnormalities characteristic of FAI are, however, common in the young adult population (4). The prevalence of hip shape abnormality is reported to be higher in asymptomatic athletes than in the general population; the reasons for this remaining unclear. A recent systematic review(5) identified 26 studies for inclusion, comprising 2,114 asymptomatic hips. The prevalence of an asymptomatic cam deformity was 37%; 54.8% in athletes versus 23.1% in the general population. The prevalence of asymptomatic hips with pincer deformity was 67%. Only 7 studies reported on labral injury, which was found on MRI without intra-articular contrast in 68.1% of hips.

It is not yet understood why some people develop symptoms (FAI syndrome) while others do not. The mechanism of development probably involves a combination of factors; with hip shape abnormality combining with the level and type of activity to provoke impingement (6). There may also be a genetic predisposition to shape abnormality and/or soft tissue damage in these patients. The natural history of FAI and long-term progression to OA remain topics of much debate and ongoing research. Although Ganz *et al*. (2) and Tanzer *et al.* (3) have proposed a link between arthritis of the hip and FAI, it is too soon to conclude whether surgery will delay the progression of osteoarthritis (7).

Chapter Two: The Evolution of Hip Arthroscopy

2.1 Introduction

Over a period of approximately 30 years, hip arthroscopy has evolved from an experimental technique, performed by a handful of surgeons worldwide, to a widely recognised and increasingly popular procedure. The arthroscope may be used in the treatment of many disorders in and around the hip joint, the indications for its use constantly expanding and being refined.

Michael Samuel Burman, 1929, (Figure 9) a resident at the Hospital for Joint Diseases in New York, first conceived the idea that it might be possible to view the interior of a joint with a special device (8). He commissioned the design and fabrication of the instrument from Reinhold Wappler, at the American Cystoscope Manufacturing Institute, and this was completed in 1930. A description from Wappler follows;

'the arthroscope consists of a sheath with a point serving as a trocar. An extremely small lens system with illuminator fits within the said sheath. It permits visualising of narrow spaces, either air or water filled. The removal of the telescope permits washing out of opaque fluid contained in hollow bodies to be examined, until the distending fluid is clear and a good view can be had. The front lens is shaped so that the inlet pupil is on the periphery and the little lamp on the end is just on the outside of the field of vision.'

He goes on to describe the diameter of the trocar as 4mm, with a 3mm telescope (Figure 10).

'Note should be made of the space between the trocar and the telescope, which allows irrigation of the joint examined. The faucets are attached to the trocar and may be used as either as inlet or as an outlet'.

Figure 9 - Dr Michael Samuel Burman (1901-1975)

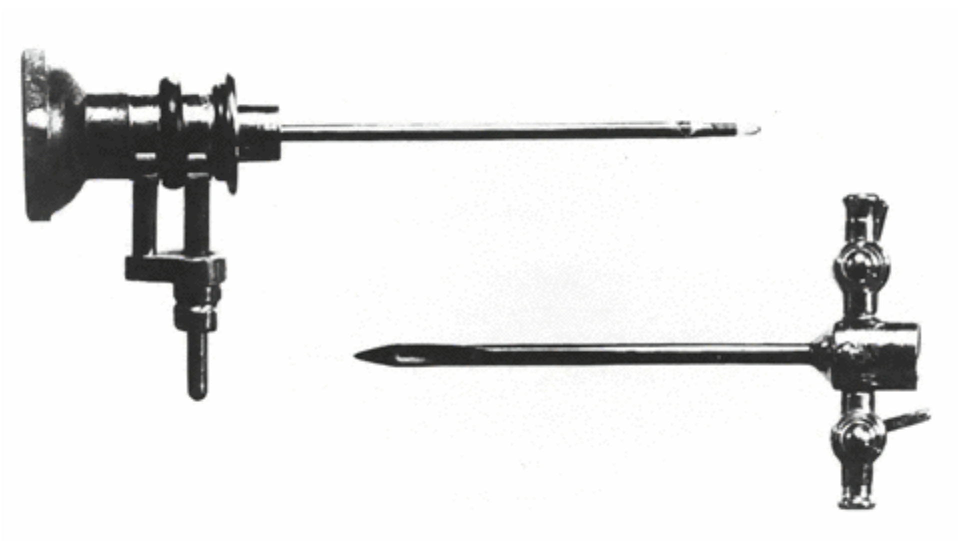

Figure 10 – Arthroscopic instruments developed by Reihnold Wappler and used by Dr Burman in his study. The upper portion is the telescope (measuring 3mm in diameter) and the lower portion is the trocar sheath (4mm in diameter)

Unfortunately, there were not enough cadavers available at the New York Medical School for further research, and so Burman set sail for Germany on a travelling scholarship. He resumed work at the Krankenhaus der Freidrichstadt-Dresden under the supervision of Dr Georg Schmorl. Following his return to New York, Burman published a comprehensive study; describing the arthroscopic appearances of the hip, knee, ankle, shoulder, elbow and wrist. Burman decided that arthroscopy of smaller joints was not advisable because of the diameter of the instrument. After the completion of his study, he became aware of earlier work from Bircher (9) and his publication acknowledges this work.

Burman was, however, the first to describe hip arthroscopy. He stated:

‘visualization of the hip joint is limited to the intracapsular part of the joint. It is manifestly impossible to insert a needle between the head of the femur and acetabulum.’

However, he determined that the visualisation of what we now call the "peripheral compartment" to be an unusual success (Figure 11). He emphasised that:

‘it is not at all difficult to see into the hip joint and that it is the neck of the femur which here commands our interest.’

More than 70 years later the peripheral compartment is a major working field in hip arthroscopy for the treatment of femoroacetabular impingement.

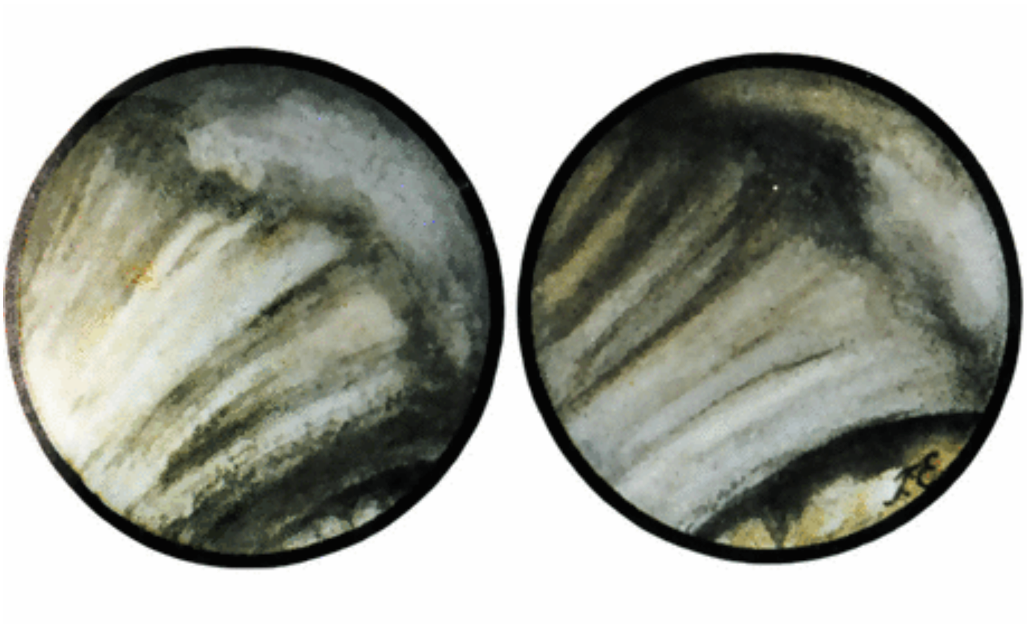

Figure 11 – Burman's illustration of the arthroscopic view of the hip (peripheral compartment) showing the ridging of the femoral neck, junction of the femoral head and neck and a portion of the articular surface of the femoral head.

Burman does not describe attempting distraction of the hip, but does say:

'we have found it difficult to move the joint because of rigor mortis fixing the joint solidly'. Burman also describes his preferred portal placement for hip arthroscopy as 'anterior paratrochanteric', a portal much used today. He also states that:

'a special long trocar, with a correspondingly long telescope'

at least 15cm in length, should be used for the hip joint. Michael Burman completed his residency, and subsequently spent his entire career as an orthopaedic surgeon at the Hospital for Joint Diseases. The undisputed originator of the technique of hip arthroscopy, he continued his work but it was never published. Further development of hip arthroscopy stagnated because of perceived difficulties in introduction of a straight arthroscope into the hip joint.(10)

2.2 Introductory period (Pre 1990)

Aignan, in the mid-1970s, was the first to describe clinical introduction of an arthroscope into the hip for arthroscopic synovial biopsy (11). Other early pioneers of the technique, Johnson and Eriksson, (12, 13), were working independently of each other in the USA and Sweden. Johnson ran the first course on hip arthroscopy, in Michigan, in 1976. He used a knee arthroscope, with the patient in the supine position and discovered that, by injecting fluid into the hip, less distraction was necessary to gain safe access. Methylene blue was used in the hip to facilitate visualisation of degenerative articular cartilage. While the arthroscope was mainly being used for diagnostic purposes, being able to visualise the whole hip, including the *ligamentum teres*, some therapeutic procedures were performed via a second portal; such as loose body removal, osteophyte debridement, chondroplasty and iliopsoas debridement.

Richard Gross, 1977, published the first paper in English, describing hip arthroscopy in children post slipped upper femoral epiphysis (14). Shifrin and Reis, 1980, described the use of an arthroscope to remove a loose body in the acetabular component of an irreducible total hip replacement (THR) (15). Vakili, Salvati and Warren also used an arthroscope to remove a foreign body within the acetabular cup of a THR (16). Holgersson *et al*., 1981, used hip arthroscopy to diagnose juvenile chronic arthritis in children (17). Johnson, 1981, published ‘Hip joint in diagnostic and surgical arthroscopy’, where he described his technique (18).

Eriksson and Sebik, 1982, discussed the benefits of gas over fluid media, and were also the first to describe the ‘suction seal’ of the hip joint (19). Eriksson, Arvindsson and Arvindsson, 1986, also measured the forces need to distract the hip to allow access to the area between the femoral head and acetabulum (300-500 Newtons (N) in an anaesthetised patient, and up to 900 N if awake(13)). Eriksson, discussing the benefits of gas and fluid media, concluded that, while gas was preferable for diagnosis, fluid was better for operative procedures (7).

These early procedures were carried out with the patient supine, using a fracture table for distraction of the hip. Glick and Sampson, 1982, were the first to convert to the lateral position. They hypothesised that, in the lateral position, the skin to joint distance would decrease as a result of gravity and adopted this approach partially because the standard arthroscope was of insufficient length to enter the hip joint of a particularly well-covered patient. Glick used a combination of weights and pulleys for distraction, and helped to develop this design for the first specific hip arthroscopy distractor (Figure 12), subsequently manufactured by Arthronix (Arthronix, New City, NY, USA) in 1986.

Figure 12 – The Hip Distraktor (Arthronix). A rack supported the leg preventing valgus forces on the knee and the foot piece was attached to the traction hand-driven screw, which could be positioned at various degrees of flexion, abduction and rotation. A tensiometer measured the relative force.

When hip arthroscopy was in its infancy, surgeons had no choice but to use the standard 30-degree knee arthroscope to visualise the inside of the hip joint. Only a few surgeons were performing hip arthroscopy and it was not thought to be commercially viable to manufacture specific instruments. The 70-degree arthroscope was developed by J.W. Thomas Byrd, in conjunction with Dyonics. Byrd used both the standard length arthroscope and then the extra-long instrument that had been manufactured for him and has now become the standard for arthroscopic access to the hip (20). He also went on to help design the first specific hip arthroscopy instruments. Both Glick and Byrd were involved in the design of hip arthroscopy specific instruments; the 'Glick Hip Set' (Figure 13) was manufactured by Stryker (Stryker Endoscopy, San Jose, CA, USA) while Smith & Nephew developed and produced the 'Byrd set'.

Figure 13 – Glick hip set with long arthroscope and sheath

Glick *et al.*, 1987, described the anatomy, techniques and the instruments used in a series of 11 hip arthroscopies, with the patients in the lateral decubitus position(20). However, the best approach, supine or lateral decubitus remains open to debate among hip arthroscopists. Byrd argued for the supine position when describing a series of 20 cases (21). In this position, the surgeon can still use the standard fracture table and the orientation is easier for surgeon and staff. Both approaches have merits and drawbacks, and the choice is down to the preference and training of the operating surgeon.

The majority of papers at this time were occasional case reports. Hawkins, 1989, published a series of 12 cases of hip arthroscopy, following a mini-arthrotomy (22). At this time, the indications for hip arthroscopy were mainly diagnostic, with therapeutic procedures being limited largely to removal of loose bodies, biopsy and synovectomy.

2.3 Consolidation period (1990 – 2000)

Growing interest in hip arthroscopy led to the need for further understanding of the arthroscopic anatomy and pathology. Dvorak, Duncan and Day, 1990, published the 'Arthroscopic anatomy of the hip', describing the views from the different portals in use at the time (23). The first textbook followed, describing hip arthroscopy and the conditions that may be treated (24). Keene and Villar, 1994, described more detailed anatomical features visible using the arthroscope (25). The potential for iatrogenic injury was of concern and emphasis was being given to portal placement. Byrd, Pappas and Pedley demonstrated that, hip arthroscopy should be safe if the portals were properly placed in relation to the neurovascular structures (26). Elsaidi *et al.,* 2004, in a further cadaver study, showed that traction of up to 64 kg on the lower limb failed to produce evidence of labral or capsular injury(27), thus confirming Byrd's conclusions. Furthermore, traction of 23 kg resulted in little change in the position of adjacent neurovascular structures relative to the standard arthroscopic portals(27).

Adoption of the Seldinger technique, used for central venous access, was posited in the early 1990s, by Dr Amo Oduro, an anaesthetist, and Colin Dunling, an operating department practitioner, working with Richard Villar in Cambridge, UK, as a means of simplifying cannula access to the hip joint. A guide wire (Figure 14) was used first to access the hip joint under fluoroscopic control, before sliding the cannulated obturator over it. This technique, replacing the use of either sharp or blunt trocars to enter the joint, has made arthroscopic access to the hip joint much safer and easier (20).The first cannulated hip obturators were subsequently manufactured in 1995, by Smith & Nephew.

Figure 14 – Set showing different size sheaths, nitinol guide wires and switching stick

Motorised shavers were introduced in the late 1970s. Smith & Nephew acquired Dyonics in 1986 and developed and introduced curved shaver blades in 1997. These blades were originally designed for use in the knee and shoulder, but were also used in the hip for many years. Hip-specific motorised burrs were also developed for the excision of bone around the femoral head/neck junction, including various non-spherical burr shapes. However, many different portals and approaches to hip arthroscopy were being developed and the only shape that would accommodate them all was spherical.

Dorfmann and Boyer were teaching arthroscopy of the peripheral compartment of the hip joint as far back as the early 1980s. They divided the hip joint into two distinct regions, the ‘central’ and ‘peripheral’ compartments (28). The ‘central compartment’ is described as that inside the labrum, between the femoral head and acetabulum; the peripheral compartment is the intracapsular part of the joint, but outside of the ball and socket. Both Dorfmann and Boyer are rheumatologists and their work was mainly for diagnostic or synovial biopsy purposes, following on from the early work of Aignan (11). Dienst, Gödde and Seil furthered the work of Dorfmann and Boyer, publishing a review of a technique using arthroscopy in the peripheral compartment, without traction (29). Dienst, Seil and Kohn, 2005, went on to describe the technique of entering the central compartment from the peripheral compartment (30).

Hip arthroscopy is known to be a technically demanding procedure, and pudendal nerve neuropraxia was a well-known complication, described by both Lyon *et al., 1993,* and Rodeo, Forster and Weiland, 1993 (31, 32). Sciatic, femoral and lateral cutaneous nerve injuries have also been reported (13). These injuries can be caused by prolonged traction and direct compression and both the techniques of hip arthroscopy and the methods of distraction have been refined. It is suggested that the perineal post is a minimum of 9 cm in diameter in order to distribute the forces in the perineal area more evenly. Hip distractors available now all have wide padded posts (Figure 15) in an attempt to avoid iatrogenic injury to the perineal region and the risks of complications have been shown to reduce. Excessive traction should also be avoided and the early Arthronix distractor had an in-built tensiometer.

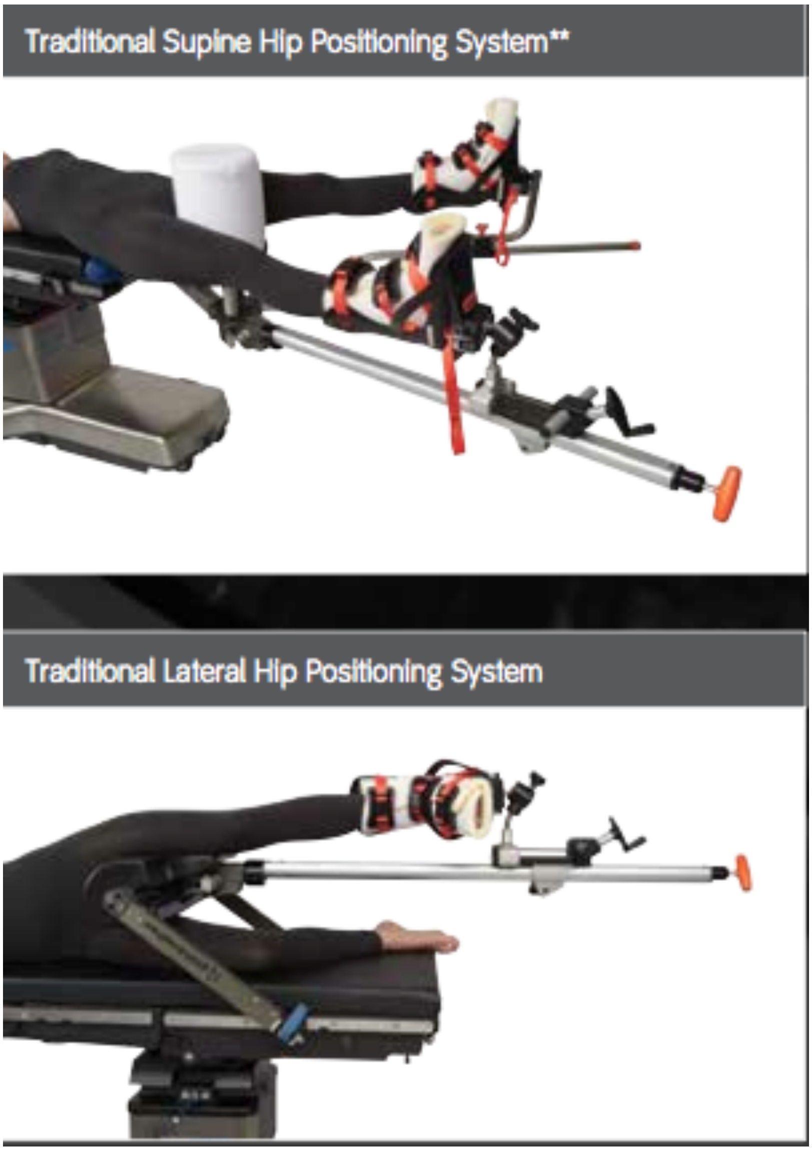

Figure 15 – Hip distractors (Smith and Nephew) – supine and lateral position with well-padded perineal posts

Funke and Munzinger, 1996, produced an algorithm for avoidance of complications after reviewing data from 19 patients (33). Griffin and Villar expanded on this by reviewing the complication rate in 640 consecutive cases (34). They showed an overall complication rate of 1.6%, none of which had long-term sequelae. Dorfmann and Boyer, 1996, published the results of 12 years' work (35). They considered 413 cases and found occasional scuffing of the articular surface, but otherwise no other adverse events. Clarke, Arora and Villar, 2003, reviewing over 1000 hip arthroscopies, described a complication rate of 1.4% (36).

Ilizaliturri described published complications of hip arthroscopy in a recent review of the literature (37). All sciatic, pudendal and femoral nerve injuries related to traction were reported to have resolved; but use of an anterior portal could damage a branch of the lateral cutaneous nerve of the thigh permanently. No incidences of post-operative DVT or PE have been reported. The main complications appear to be related to instrument breakage, inadequate bony resection and cartilage scuffing. There have been isolated case reports of postoperative heterotopic ossification, avascular necrosis, femoral neck fracture, hip instability and problems with excessive fluid extravasation.

2.4 Expansion period (post 2000)

One of the major advances in the instrumentation of hip arthroscopy was the introduction of the slotted cannula, originally designed by James Glick (Figure 16) and manufactured by Stryker (Stryker Endoscopy, San Jose, CA, USA) (38). This allowed both safe introduction of curved instruments and also easier removal of loose bodies.

Ilizaliturri went on to refine the slotted cannula design (Figure 17), with his design being manufactured by Smith & Nephew in 2004, and updated in 2007.

Figure 16 – Original slotted cannula to allow curved instruments to be passed through

Figure 17 – Refined slotted cannula designed by Victor Ilizaliturri

The holmium:yttrium-aluminium-garnet (YAG) laser for intra-articular debridement was also popular for a time in the 1990s . The pinpoint nature of the YAG laser was both its strength and major problem. The debridement of anything but the smallest of lesions would take too long. Radiofrequency ablation probes (Figure 18) were first introduced in 2001 and flexible probes, giving the surgeon the opportunity to resect tissue otherwise unreachable with straight instruments, designed and manufactured by Smith & Nephew, in conjunction with Dr Philippon, were introduced in 2002.

Figure 18 – Radiofrequency ablation system

The Arthronix hip distractor already mentioned was the only specific hip distractor available to those who wished to perform arthroscopy in the lateral position. Traction tables for fracture fixation appeared adequate for those whom the supine position was preferred. Innomed (Innomed, Savannah, GA, USA) manufactured a hip distractor to McCarthy's improved design, and this instrument is still available. However, the McCarthy design does not allow for dynamic hip motion, and requires a member of the operating room staff to detach the boot and hold the leg in flexion, with or without rotation as required. Therefore, Smith & Nephew developed the 'Hip Positioning System' (Figure 15) that allowed the leg to be flexed and rotated without the need for the foot to be uncoupled from the distractor; whether the patient was in either the lateral or the supine position. The position can be 'locked out'. Therefore, although a member of the team needs to be available to move the leg, it does not have to be supported for the duration of the procedure.

A review of the status of hip arthroscopy published by Kelly, Williams and Philippon, 2003, described the indications as:

‘the presence of symptomatic acetabular labral tears, hip capsule laxity and instability, chondral lesions, osteochondritis dissecans, ligamentum teres injuries, snapping hip syndrome, iliopsoas bursitis, and loose bodies (for example, synovial chondromatosis). Less common indications include management of osteonecrosis of the femoral head, bony impingement, synovial abnormalities, crystalline hip arthropathy (gout and pseudogout), infection, and posttraumatic intra-articular debris (33)’.(39)

Clearly in 2003, there were multiple pathologies that could be dealt with but no primary indication for the procedure existed. Hip arthroscopy was a procedure waiting for an indication.

2.5 Hip arthroscopy for Femoroacetabular impingement

Alongside the time when hip arthroscopic techniques were being refined, studies by Ganz et al (2) and Tanzer et al (3) linked FAI to OA. At the time, open surgical dislocation was the standard treatment for FAI (40, 41). They concluded that the identification of anterior hip impingement as a cause of labral tears and idiopathic arthritis may allow early surgical correction and delay or prevent end-stage OA. Demand for surgery for FAI increased in the wake of this study and, although Ganz *et al.* had proposed open surgical hip dislocation to deal with the pathology, arthroscopic techniques were modified to deal with FAI. Subsequently arthroscopic techniques have developed in line with the increased understanding of treatable hip pathology and a large proportion of hip arthroscopic practice is now dedicated currently to the treatment of FAI. Hip arthroscopy, therefore, found its primary indication (Figure 19 and 20).

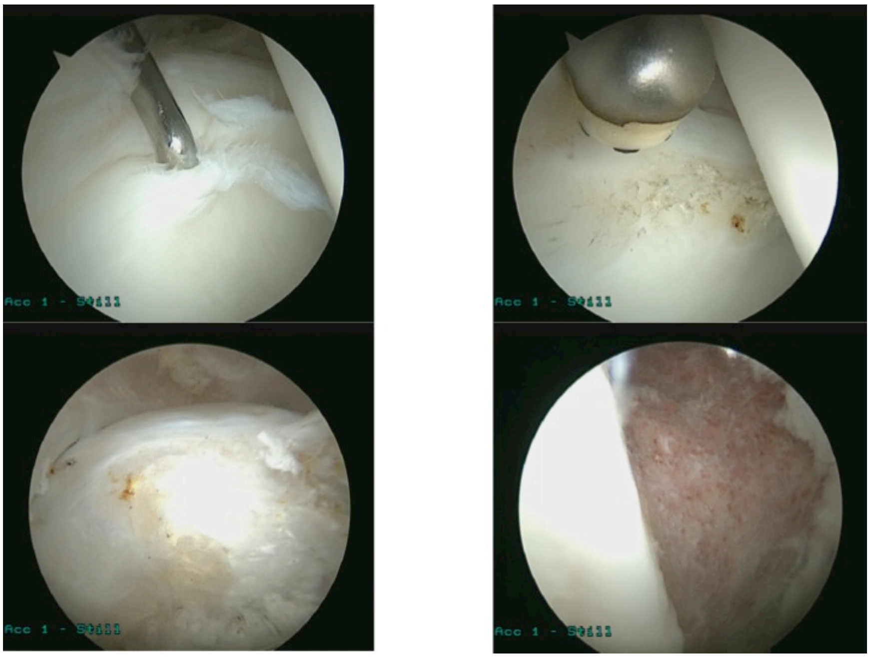

Figure 19 – Chondrolabral junction tear treated with radiofrequency ablation; Cam lesion treated with femoral osteochondroplasty

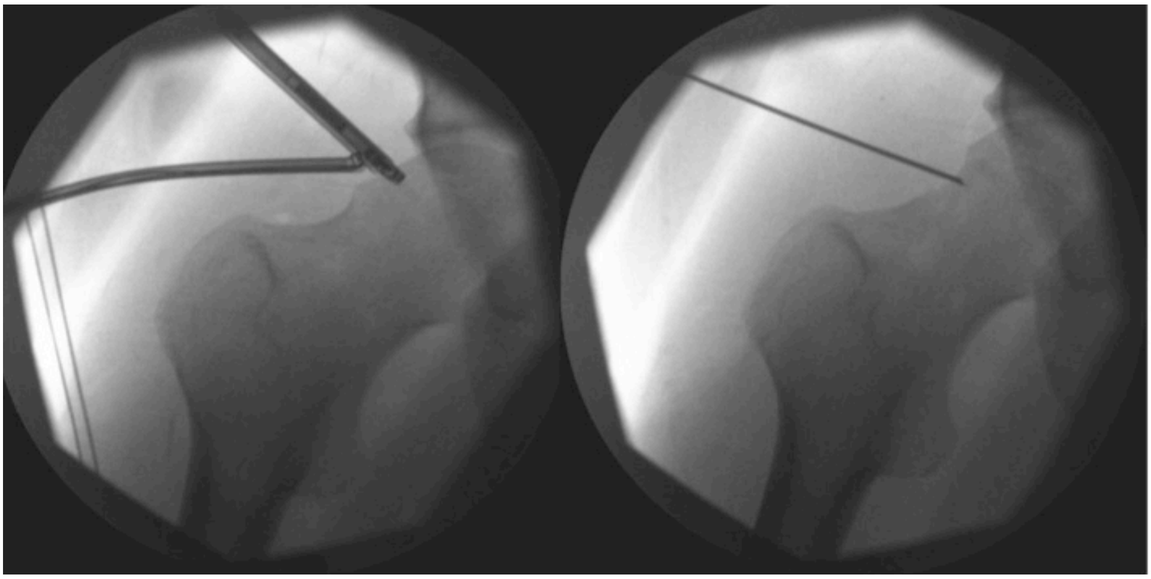

Figure 20 – Femoral cam lesion removed arthroscopically to achieve a round femoral head

Arthroscopic treatment for FAI and other conditions became more widely accepted over time and indicators for the need for hip arthroscopy were clarified (42). Procedures such as labral debridement and/or repair had been described and early results reported (43), and Steadman's microfracture technique had been adapted from the knee, in an attempt to treat chondral lesions (44, 45). Guanche and Bare, 2006, described the current role of arthroscopic treatment for FAI, including resection of the cam at the femoral head/neck junction (46). Sampson, 2006, published his early results of arthroscopic treatment for FAI; results comparing favourably with using open surgery(47). Philippon and Ganz, 2007, also described the arthroscopic treatment of patients with FAI (48).

Prior to 2007, the majority of published papers regarding hip arthroscopy were biased towards technique over results. This was to be expected, owing to the ever-changing nature of the procedure and the novelty of conditions recognised and thus treated. Larson and Giveans, 2008, published a review of 100 hips treated arthroscopically for FAI between 2004 and 2007 with a minimum of one-year follow-up (49). Their results were encouraging, with 75% reporting a good or excellent outcome. Ilizaliturri *et al.*, 2008, described two-year results from a smaller study, also demonstrating good outcomes from the technique (50). Bardakos, Vasconcelos and Villar, 2008, demonstrated the importance of excision of the cam (51). Botser *et al*. (52) reviewed the results of surgery (open surgical dislocation, arthroscopy and combined approach) for FAI in all groups of patients and found 26 articles reporting the results for a total of 1462 hips (1409 patients). They noted that 62% of the literature focused on arthroscopic management and reported that the mean improvement in modified Harris hip score (MHHS) after arthroscopic surgery was 26.4 as compared with 20.5 for open surgical dislocation and 12.3 for the combined approach. They suggested that the outcome of surgery in professional athletes may be better with the arthroscopic approach, compared with open surgical dislocation, with a higher rate of return to sport

(52). The complication rate is lowest for the arthroscopic group (1.7%) compared with 9.2% for open surgical dislocation and 16% for the combined approach. Therefore, the arthroscopic approach has both the lowest complication rate and the quickest rehabilitation. These findings are consistent with another independent systematic review by Matsuda *et al*. (53), who reported that the historical 'gold standard', open surgical dislocation, had a comparatively high major complication rate. The mini-open method had a significant incidence of lateral femoral cutaneous nerve injury and the arthroscopic technique had a surgical outcome equal to or better than the other methods, with a lower rate of major complications, when performed by experienced surgeons.

2.6 Current issues

Currently, the most common indication for hip arthroscopy is FAI (54). The question as to how best to treat the labrum still remains unanswered. Philippon had described labral re-fixation, but a number of papers describing the arthroscopic treatment of FAI have described labral debridement as the primary intervention for a tear. Larson and Giveans, 2009, addressed this, publishing results from 75 hips that had either had debridement or re-fixation (55). At minimum of one-year follow-up, this cohort of patients reported a significantly better outcome following labral re-fixation compared with debridement. Similarly, another retrospective comparative study of 96 patients, Schilders *et al.* (56) reported improved outcomes for labral refixation compared with debridement/resection.

Techniques for labral grafting have now been developed to replace an absent or irreparable labrum; resection having been shown to produce worse outcomes than reconstruction. Tissues used so far include the *ligamentum teres* and part of the iliotibial band (51, 57, 58). Early results appear favourable (59). However, Haddad *et al*. (60), in a systematic review, compared labral repair with labral debridement, in 1631 hips and found no difference in outcome. They recommended that an unstable good quality labrum with good potential to heal should be repaired. However, a degenerate labrum may be a source of discomfort and its preservation may result in persistent pain and failure of reattachment. Treatment of an unstable cartilage flap is also difficult, with the option of debridement along with microfracture for exposed subchondral bone. Fixation of cartilage flaps is a surgical challenge, although early results from one study using fibrin glue-assisted fixation of unstable cartilage flaps are encouraging (61).

The emphasis on published outcomes continues to gain momentum. Byrd and Jones have published ten-year results of hip arthroscopy in general, not specifically in patients with FAI, and further longer-term studies are eagerly awaited (62). However, two contemporary independent reviews of the current literature conclude that, when compared with open surgical techniques, hip arthroscopy confers faster recovery and fewer complications, while being equivalently efficacious (52, 53).

Chapter Three: Contemporary literature review

3.1 National Guidelines on Osteoarthritis and FAI

A recent report by Arthritis Research UK on 'Osteoarthritis in General Practice' has found that more than 30% of people aged over 45 have presented to their GP with suspected OA, with almost 8.75 million people suffering from degenerative joint disease (63). Twenty four per cent of 2.12 million people with hip pathology had confirmed OA of the hip. It was projected that more than 50% of patients undergoing hip and knee replacement in the USA would be under the age of 65 by 2011 and 2016 respectively (64). Increasing need for surgery will be compounded by the effects of obesity on the condition, specifically on weight-bearing joints, and by the aging population. These observations emphasise the need for increased understanding of the underlying causes of early arthritis and early intervention to ameliorate the condition.

The National Institute for Health and Clinical Excellence (NICE) guidelines on the treatment of OA in adults (65) have been amended recently, with referral thresholds to specialists being dictated by patient symptoms and clinicians rather than by scoring tools. NICE also recommend early referral for surgery, before there is prolonged and established functional limitation and severe pain (65). Hip arthritis can cause significant problems in the working-age population and lead to reduced quality of life (QoL), change in employment or unemployment (66, 67). The 10th National Joint Registry reported that 18-20% of patients undergoing hip and knee replacement in England and Wales were under the age of 60 years (68). Joint replacement may enable patients to continue working, a more cost-effective long term solution, (69) as patients remain economically productive members of the society. However, the young population carry a higher risk of revision surgery, with the Swedish joint registry (70) reporting a doubled risk for revision in patients under the age of 50 years while risk is four times higher in patients under the age of 30.

Therefore, there is merit in avoiding hip replacement in this young age group and alternative approaches like activity modification, analgesia, physiotherapy and hip preserving surgery should be explored. Although non-arthritic hip pain is not a life- or limb-threatening condition, some causes, particularly FAI, are associated with an increased risk of OA. Therefore, it is advisable to obtain a specialist referral in a timely manner if symptoms do not improve with conservative management. In particular, early referral may be indicated in athletes, where the prevalence of hip shape abnormality has been shown to be substantially higher than in the general population (71, 72). At present, there is no evidence that patients with asymptomatic incidental findings of FAI benefit from any intervention but they should be advised to present early if symptoms develop.

Physical therapy and activity modification appear to confer benefit to some patients as an alternative to operative treatment for FAI (73). Non-operative treatment regimens, particularly physical therapy, need to be evaluated more extensively and rigorously, preferably against operative care, to determine the true clinical effectiveness. Many patients respond to a course of non-operative care, particularly physical therapy, and there is no evidence that such treatment is harmful (73). Therefore, for young adults with persistent hip pain, it would be reasonable to commence a course of physical therapy and only offer surgery should this treatment fail (74). Exercise-based physical therapy is probably the most effective form of non-operative care, but it is also reasonable to consider a short course of non-steroidal anti-inflammatory drugs (NSAIDs), activity modification, education and advice, although evidence for the efficacy of these regimens is limited (75). Forty-four percent of patients with hip pain caused by prearthritic, intraarticular disorder of the hip can be improved with conservative care alone while 56% may choose to have surgery after receiving conservative care (76). People with a more active lifestyle were more likely to choose surgery.

NICE issued full guidance to the NHS in England, Wales, Scotland and Northern Ireland on arthroscopic femoro-acetabular surgery for hip impingement syndrome in September 2011 (77). Contemporaneous evidence for the efficacy and safety of arthroscopic femoro–acetabular surgery for hip impingement syndrome was found to be adequate in terms of symptom relief, in the short and medium term. They noted well-recognised complications and outlined safe procedures that may be used; provided that normal arrangements are in place for clinical governance, consent and audit, with local review of outcomes. NICE recommended that arthroscopic femoro–acetabular surgery for hip impingement syndrome should only be carried out by surgeons with specialist expertise in arthroscopic hip surgery and that the clinicians should submit details of the patients undergoing this procedure to the non-arthroplasty hip register established by the British Hip Society. The prime purpose of the register is to provide information about long-term outcomes. It is important that both the register and other studies report details of patient selection to allow clear understanding of these outcomes.

3.2 Outcome and quality of life after surgery for FAI

Quality of life (QoL) is a multidimensional concept measuring the physical, social and psychological health of individuals. Generic and specific instruments are available to measure QoL after surgical intervention (78, 79). A review of disease-specific measures and instruments used to assess the generic QoL and physical activity levels of patients with FAI found no conclusive evidence to support a single disease-specific questionnaire (80). Very few studies have reported on QoL outcome after hip arthroscopy.

Beaule *et al*. (81) reported that, surgical dislocation of the hip and femoral osteochondroplasty led to a significant improvement in QoL in 34 patients. QoL was measured by generic health score (SF-12), with improvement in both physical ($\rho<0.001$) and mental component scores ($\rho=0.031$). Sink *et al*. reported a similar improvement in SF-12 scores in a series of 71 adolescents, younger than 21 years, who underwent open surgical hip dislocation for FAI. Only 15% of patients reported improvement in function, range of movement and QoL while symptoms remained unchanged for 10%; an outcome inadequate to be deemed either good or excellent (82).

Impellizzeri *et al*. (83) report that early outcome of surgery for FAI depends on how success is measured. Feeling better does not always equate with feeling good and improvement in outcome scores, even if large, should be deemed clinically important. The minimum clinically important change for EQ-5D index, a QoL outcome measure, after surgical treatment for FAI should be ≥ 0.16. Statistically significant improvement in all scores was reported at six months but only 55% had achieved an acceptable level of improvement in symptoms.

Shearer *et al*. (84) studied the impact of hip arthroscopy on health related QoL among younger patients with symptomatic FAI, after constructing a Markov model, and comparing two strategies: observation and hip arthroscopy. This model suggests hip arthroscopy in patients with FAI, without arthritis, may result in a favourable incremental cost-effectiveness ratio (ICER), compared with other health interventions. Clement *et al*. (85) also published a cost effectiveness analysis of hip arthroscopy for FAI, in a prospective cohort of 58 patients. The short form, 12 six dimension health utility score (SF12-6D) was used; both preoperatively and one year after surgery. Three time points (one, two, and 10 years) from operation were used to calculate the quality-adjusted-life-years (QALYs) gained. Predicted need for conversion to THR and diminishing gain with time (5% per year) was incorporated into the two-year and 10-year models. The Scottish Tariff was used to assign the cost of surgery. The number of QALYs gained one year after surgery was 0.159 and this equated to a cost per QALY of £19,335. This cost decreased to £10,118 per QALY gained at two years, and further still to £2,677 per QALY gained at 10 years. Multivariate regression analysis found that a worse preoperative SF12-6D was an independent predictor of greater QALYs gained one year after surgery ($R2 = 0.51$, $\rho<0.001$). At no point in time, from one year onwards, does hip arthroscopy for FAI cost more than £20,000 per QALY, making it a cost-effective intervention, as per NICE guidelines.

3.3 Outcome in non-athletes

While the outcome after surgery for FAI has focused on the results in athletes, contemporary literature has not considered the outcome in young non-athletes. However, in the general population, Byrd *et al*. (86) have reported an average improvement in HHS of 20 points, at a mean follow-up of 16 months, with a conversion to THR in 0.5%.

Clohisy *et al*. (87), in a systematic review of 496 patients (198 treated arthroscopically), found that 68-96% of patients had reduced pain and improved function after surgical treatment for FAI. Polsello *et al.* reported on one of the longest follow-up series of patients after arthroscopic treatment of FAI, showing that, of the 24 patients with a mean follow-up of 6.1 years (minimum 5 years), three required reoperation but were satisfied with their outcome and 11 (42.3%) had no pain. Dippman *et al.* (88), 2014, reported that a significant improvement in score (20.2 on MHHS) occurs between three and six months after surgery, but there is no further improvement from six to twelve months in 87 patients undergoing hip arthroscopy and labral repair for FAI. Ben Tov *et al*. (89) have also demonstrated the benefit of labral repair in patients over 50 years of age without significant OA (Tonnis of one or less). Philippon *et al*. (90) recruited a group of 122 patients prospectively and these people underwent arthroscopic intervention for FAI, with a mean follow-up of 2.3 years (2-2.9 months). They reported significant improvement in mean MHHS of 24 points with a median patient satisfaction of 9. The predictors of good results were the pre-operative modified HHS ($r = 0.018$), joint space narrowing ≥ 2 mm ($r = 0.005$), and repair of labral pathology instead of debridement ($r = 0.032$).

Byrd and Jones (86) reported similar promising results at two years (mean 16 months, range 12-24 months) in a prospective analysis of 207 hips in 200 patients with cam (163 hips) or combined cam-pincer (44 hips) FAI. The authors reported a mean improvement in MHHS of 20 points with 83% of patients demonstrating a benefit. Scores were maintained at the 12-month values in those patients followed up for longer. Byrd and Jones (91) have also reported on two-year outcome after primary labral repair in 37 patients (38 hips), of whom 4 (10%) required repeat arthroscopy. They reported an improvement of MHHS of 18.9 points with 35 hips (92%) showing good to excellent improvement. Interestingly, a total of 1574 hip arthroscopies were performed during this period; with 439 requiring labral refixation (refixation to repair ratio of 11.6:1). However, only 38 were seen at two-year follow-up.

3.4 Outcome in athletes

Outcome of hip arthroscopy for FAI in athletes has been the subject of a recently published review (92). The review highlights the importance of recognition of athletes with symptomatic FAI, in order to ensure prompt treatment and therefore preserve hip function and maintain activity level. The bony structural abnormality leading to FAI and its associated pathology potentially leads to pain and a progressive decline in athletic performance. Alradwan *et al*., 2012, (93) found nine suitable articles on return to pre-injury levels of activity after surgical management of FAI, using stringent inclusion and exclusion criteria. Of these, two studies had employed open surgical dislocation and the rest arthroscopy, three being from the same centre. The longest mean follow-up for the arthroscopic group was 2.4 years and there was no consistency in the type of sport or outcome measure used in most studies. This study included a total of 418 athletes, with a rate of return to sport of 92% and a return to previous level of competition of 88%.

Lovett Carter *et al*. (94) have used qualitative techniques to study the perceptions of athletes of rehabilitation outcome one year after hip arthroscopy. The athletes were relatively satisfied with their outcome, despite having some limitation in sporting ability and requiring some adaptation of their sporting activities. However, the study highlighted dissatisfaction with the rehabilitation offered and a desire for more physiotherapy. Amenabar *et al*. (95) found a 96% return to elite-level sport and a durable increase in the hip scores (Modified Harris Hip score [MHHS], Non-arthritic hip score[NAHS]) in a retrospective review of return to sport for 34 professional Australian Football League players. A minimum of two years follow-up was available for 26 of 27 patients. Philippon *et al*. (96) reported a 92% (42 of 45 patients) return to competition for professional athletes with FAI after arthroscopic treatment, while 78% (35 patients) remained active in professional sport at an average follow up of 1.6 years (range 6 months to 5.5 years). A separate series of 28 professional hockey players, found that the mean time to return to skating/hockey drills was 3.4 months (97). Two of these 28 patients required repeat hip arthroscopy after a re-injury; but all returned to sport.

Byrd *et al*., 2010, (98, 99) reviewed the techniques and management of FAI in athletes and reported a significant improvement in functional scores for 172 athletes of various grades (19 professional, 51 intercollegiate and 102 recreational). At average follow-up of one year, around 90% of professional and intercollegiate athletes had been able to return to their previous level of competition. These findings were corroborated in a separate publication by the same group (100). Nho *et al*. (101), reported significant improvement in MHHS and hip outcome score (HOS), in a retrospective review of 47 high-level athletes,; with 79% of patients able to return to sport at a mean of 9.4 months (4-26 months) and 73% able to play sport after two years. 92.3% of those who returned to sport were able to play at the same level. Byrd *et al*. (100) found that, from a cohort of 200 patients participating in athletic activities at various levels, 95% of professional athletes returned to sport and 85% of intercollegiate athletes returned to their previous level of competition after surgery. At two-year follow-up, the median improvement in MHHS was about 21 points for 58% (116) of patients. A similar improvement in MHHS after hip arthroscopy for FAI was reported by Fabricante *et al*. (102) at a minimum follow-up of one year, for a group of 27 adolescent hips (21 patients) under the age of 19 years. This finding is consistent with the systematic review by Philippon *et al*., demonstrating a mean improvement in MHHS of 20.4, in five studies using this outcome measure (103).

3.5 Complications

Most complications after hip arthroscopy are preventable and related to patient positioning and fluid management (37).Complications have been the subject of several reviews (37, 104-106), and can be graded as minor (iatrogenic chondrolabral damage, temporary nerve palsy, superficial infection, hypothermia, deep vein thrombosis, broken instrumentation, heterotopic ossification) or major (deep infection, skin damage, pulmonary embolus, intra-abdominal or intrathoracic extravasation [requiring surgical decompression drainage], large vessel vascular injury, avascular necrosis, femoral neck fracture, dislocation, death)(105).

Modified Clavien classification has also been used to grade complications after hip arthroscopy (107-109). The adapted classification system shows high interobserver and intraobserver reliabilities for grading of complications when applied to orthopaedic surgery looking at complications of hip preservation surgery (109). This grading scheme may standardise the reporting of complications and thus render outcomes more comparable.

Grade I—alterations from the ideal postoperative course that are not life-threatening and result in no lasting disability.

Grade II—potentially life-threatening complications; but without residual disability.

Grade III—complications that can result in residual disability.

Grade IV—complications that can result in death

Oak *et al*. (107), using this classification system, have reported a complication rate of 6.9% with 88.7% of these being Grade I, 5.6% Grade II, 4.2% Grade III and 1.4% Grade IV.

Gupta *et al*., 2014, (104) identified 81 studies (6277 hips) that had reported a total of 285 complications (4.5%) after hip arthroscopy ; with 26 major (0.41%) complications and the rest (4.1%) minor complications. The reoperation rate was 4.03% with 150 patients (2.4%) requiring hip arthroplasty and 94 (1.6%) requiring repeat hip arthroscopy. The most frequent major complication was abdominal fluid extravasation (13 hips, 0.2%), with abdominal compartmental syndrome seen in 2 patients (1% of complications). Clearly this complication is potentially catastrophic (110). The risk of DVT (4; 0.06%), PE (2; 0.03%) and infection (1; 0.015%) is low.

Harris *et al*. (105), reviewed complications and reoperation rate after hip arthroscopy in 92 suitable studies, that included 6134 patients. The major complication rate was 0.58% and the minor complication rate 7.5%, with chondral injury being the most common complication. The reoperation rate was 6.3% at 16 months, with hip replacement being the most common reoperation (2.9%). The infection rate was low (n=8; 0.13%) with the majority (n=7) being superficial and one requiring arthrotomy. The rate of DVT (n=7; 0.11%) and PE (n=1; 0.02%) was also low. There was one case of fatal PE. Extra-articular fluid extravasation was reported in 22 patients (0.35%), with the majority (n=19) being intra-abdominal and the remaining three intra-thoracic.

Papavasiliou and Bardakos (106) have also analysed the reported complications and made recommendations for their minimisation, based on both the literature review and personal experience. Most complications are transient with an incidence of between 0.5% and 6.4%. During surgery, the complications can be traction-related, portal-related or iatrogenic and due care is needed to minimise such issues at each step. In order to prevent traction-related injury, they recommend that the perineal post and boot should be well padded; the perineal post should be more than 9 cm in diameter, the hip should be in slight abduction, and traction time should be less than two hours with a force less than 50lbs; lateral force should not be excessive, especially in women and the perineal area should be inspected before and after application of traction to ensure that there is no entrapment of scrotum, penis or any other soft tissue. Portal-related complications can be avoided by ensuring neutral rotation of the limb, identifying and marking bony landmarks such as anterior superior iliac spines, anterior and posterior borders of greater trochanter and lateralising the anterior portal to avoid the lateral cutaneous nerve of the thigh. Iatrogenic complications such as chondral and labral injury can be avoided by ensuring distraction of more than 10mm, using visual and tactile feedback, and using the instrument carefully.

Leakage of irrigation fluid into anatomical spaces adjacent to the joint, especially into the abdominal or thoracic cavities, can be a potentially dangerous complication (110-117). It is common for the fluid to escape through capsular incisions, in particular if psoas tenotomy is being performed, or in the presence of a recent acetabular fracture. Length of the operation, pressure of the fluid pump and extent of capsular dissection are directly related to leakage (106). It is difficult to determine the volume fluid leakage into the soft tissues accurately because irrigation fluid will also escape from the portals onto the operating area and the theatre floor.

3.6 Does surgery for FAI defer the need for total hip replacement?

Shearer *et al*. (84) constructed a Markov model including possible health states for 36-year-old patients with FAI, using decision analysis software and compared two strategies: observation and hip arthroscopy; followed by THR with disease progression. They estimated the ratio of the incremental cost to the incremental benefit (reflected by health related QoL) of both strategies and identified studies reporting Harris hip scores and complications after arthroscopy to estimate health state preferences and their probabilities. A sensitivity analysis was performed on 30 input variables over a plausible range of estimates, to determine the influence of uncertainty on the ICER with particular emphasis on the magnitude and duration of benefit. Among patients with FAI but no radiographic evidence of arthritis, the estimated ICER of hip arthroscopy was $21,700/QALY while the ICER for patients with preoperative arthritis was $79,500/QALY. Alteration of the natural history of arthritis by hip arthroscopy improved the ICER to $19,200/QALY and resulted in cost savings if THR was not performed until at least 16 years after arthroscopy. Clearly, the main benefit of hip arthroscopy for FAI in cost terms would be to delay the need for THR.

Ng *et al*., 2010, (7) reviewed 23 case series, with 970 patients, including both open surgery and the arthroscopic approach, one of the primary aims of surgical treatment for FAI being to explore the efficacy of surgery in altering the natural progression of OA. Only a minority of these patients had progression of their OA. Up to 30% of patients required THR, with worse outcomes being seen in those patients with Outerbridge grade III or IV cartilage damage, seen intraoperatively or with preoperative radiographs showing greater than Tonnis grade I OA. They concluded that, although surgical treatment improved the symptoms in a majority of patients without advanced OA, it was too soon to predict if surgery would delay the progression of OA and consequent need for THR.

Larson *et al*. (118) explored the failure rate (defined as MHHS of < 70 or conversion to THR) in a prospective comparative study between patients with no pre-existing OA and those with established radiological OA. They found that the group with FAI alone had a failure rate of 12%, those with FAI and mild to moderate OA (<50% joint space narrowing or > 2mm joint space) had a failure rate of 33% while the group with advanced OA (≥ 50% joint space narrowing or ≤ 2 mm joint space) had a failure rate of 82% (ρ<0.001).

A review covering the period from 1950 to 2012, Harris *et al*., 2013, (105) reported a reoperation rate of 6.3% in 6134 procedures at a mean of 16.4 months; with progression to THR in 2.9%. Clohisy *et al*. (87) reported a conversion to THR in 0-26% of cases with progression of OA in 0-33%, after 496 procedures for FAI, including open surgery. Gupta *et al*. (104) reported a reoperation rate of 4.03% in 6277 hip arthroscopies, with hip replacement/resurfacing in 2.4%, conducted between 1999 and 2013.

At a minimum of two year follow-up, the majority of a group of 19 patients requiring hip arthroscopy for FAI improved but two patients deteriorated and one required THR (50). A larger group of 112 patients, studied prospectively over a period of 2.2 years (2 to 2.9 years), found 10 patients (9%) to need THR at a mean of 16 months (8 to 26) after hip arthroscopy(90). The predictors of a better outcome were the pre-operative MHHS ($\rho = 0.018$), joint space narrowing ≥2 mm ($\rho = 0.005$), and repair of labral pathology instead of debridement ($\rho = 0.032$). Javed and O'Donnell looked at their outcome in a group of 40 older patients, over the age of 60 years, and a majority had reduction in both hip pain and mechanical symptoms after hip arthroscopy but seven required THR at a mean of 12 months (2-24 months) follow-up (119). THR was also indicated in 5% (4 of 110 patients) at a mean of 10 month (6-18 month) follow-up in a multi-centred prospective study (120); patients with preoperative arthritis were associated with poorer outcome.

McCarthy *et al*. (121) reported the survival of hip arthroscopy at a minimum follow-up of 10 years (mean 13 years) in a group of 106 (111 hips) patients. Although this study predates the era of arthroscopic FAI surgery, it has relevance to the overall effectiveness of hip arthroscopy. They reported a survival of 63% at 10 years, with age at arthroscopy and Outerbridge grades as independent predictors. Gender and the presence of labral tear did not influence long-term survival. Thus patients aged less than 40 years with Outerbridge grade 0 to II had a 10% risk of conversion to THA over

10 years while patients older than 40 years with higher Outerbridge grade (III-IV) had a risk of 99%.

Laude *et al*. (122) retrospectively reviewed 97 patients (100 hips) who underwent arthroscopic assisted mini-open osteochondroplasty and, at a mean follow-up of 58 months, reported an 11% conversion to THR. The best results were obtained in patients younger than 40 years with no preexisting OA. A study of 153 older patients (over 53 years of age) investigated outcome after hip arthroscopy; to determine how long patients avoided THR (103). Twenty per cent of patients required THR. At three years, data were available for 64 patients with a Kaplan-Meier survival of 90% in patients with more than 2 mm joint space and 57% in those with 2 mm or less joint space (ρ=0.01).

3.7 Critical analyses of contemporary literature

Most of the published literature on FAI uses quantitative research methods and follows the positivistic paradigm. There is less enthusiasm for interpretivism and there are few publications where qualitative work has considered patient experiences and expectations after surgery for FAI. One qualitative report (94) has explored the athletes' perceptions, to gain an insight into factors that influence the process of return to sport. Three main themes were identified: ability to participate in sports, perception of hip problems and perception of rehabilitation. However, there has been no qualitative research on the impact of surgery in the general population, in particular the non-athletes and its role in return to normal employment after such intervention; the perception of patient, family or indeed the employers.

One of the primary issues with research on FAI has been the lack of adequately powered randomised controlled trials in the published literature. This is highlighted in a recent Cochrane review (123) that has concluded that there is no high quality evidence examining the efficacy of surgery for FAI. The criteria for selection for this review were; randomised and quasi-randomised clinical trials, assessing surgical intervention compared with placebo treatment, non-operative treatment or no treatment, in adults with FAI. Following detailed review it was concluded that out of 11 studies, none met the inclusion criteria. Currently, there are four randomised controled studies ongoing that may provide evidence for the benefit and safety of this type of surgery in the future, the results of which will be probably available in the next 2-5 years.

Moreover, there are only a small number of prospective analytical cohort studies in the literature (86, 90, 124). It is therefore clear that even the simplest type of prospective studies are limited by issues like small sample size, limited followup and lack of appropriate control group. Most other work, relating to both open and arthroscopic treatment outcomes, involves small retrospective case series and thus yields less reliable data than the larger prospective studies. In addition, no comparative data exist that examine the relative efficacy of the different treatment modalities, whether by prospective comparative case series or by randomised controlled trials (125). Arthroscopic intervention as a treatment for FAI is a recent development and so, all the current published studies have relatively short durations of follow-up.

Systematic review articles have repeatedly highlighted this lack of robust evidence. The one performed by Clohisy *et al*. (87) revealed that nine of the eleven suitable studies were retrospective analyses (level IV evidence)(126) and two retrospective comparative studies or case control studies (level III). Of these, six had looked at open surgery, one mini-open (minimally invasive open impingement surgery) and four arthroscopic surgery. *Ng et al.*, 2010, (7) also reviewed 23 studies (970 patients) of surgery for FAI and found one level II, two level III and 20 level IV studies. More work is needed, involving larger numbers of patients, longer follow-up, prospective comparative trials and subsequently randomised controlled trials.

Byrd and Jones, 2014, (91) reported the two-year outcome in only 38 of 439 procedures performed during the study period of this paper. Although this study was focusing on primary repair of the labrum and compared it with the group which required repair after removal of pincer lesion the authors did not compare the outcome scores of both groups and only reported on the 38 patients requiring primary repair. The field of hip arthroscopy is rapidly evolving with modern generation instrumentation allowing more to be performed inside the hip joint with key holes than ever before. In the past similar repair would be only possible using open dislocation approach, which would create more surgical insult and longer rehabilitation time for the patient. Therefore the study has added to the knowledge base because of the novelty of the procedure even though it lacked the scientific robustness. It clearly highlights the problem of working in a rapidly-developing field, where the literature is trying to keep pace with technical developments.

Chapter Four: Aims and objectives

The papers presented in this commentary describe the role of hip arthroscopy for FAI, with the aim of determining whether it is an effective and safe intervention, and whether arthroscopy can delay the onset of arthritis.

The four papers included in this work answer the following key questions about the procedure:

- Is it effective in terms of improvement in quality of life?(127)
- Is it beneficial for a non-athletic population?(128)
- Is it possible for athletes to return to sport at the same level?(129)
- What is the frequency of short-term complications?(130)
- Does it defer the need for hip replacement in the future? (130)

Little relevant prior data exist to answer these questions. Most studies have involved retrospective analysis of small numbers of patients and trials without adequate controls. In this thesis, a compilation of my published work, I have addressed the questions posed using large patient cohorts, and data collected in a prospective manner.

Chapter Five: Materials and Methods

Study of the literature has helped to construct the ontology of FAI, giving a better understanding of the pathology and possible options for treatment. Such knowledge is key to the construction of a research programme. Most of the research into orthopaedic conditions, tends to follow the positivistic research paradigm; the literature concentrating on quantitative analyses to determine the laws that govern behaviour. Little research adopts the interpretivistic paradigm, relying on qualitative analysis to help determine an understanding from an insider's perspective. Quantitative research tends to use experiments, surveys and questionnaires while, on the other hand, qualitative research employs ethnographic studies, in-depth interviews and focus groups that necessitate different skills and tend to generate theories and hypotheses.

The perspectives of patients, family or employers on the extent to which surgery helps relieve symptoms secondary to FAI could be better determined using qualitative studies. Qualitative research aims to develop theories on individual decision making or behaviour by gathering in-depth interview data; prioritising the views of a small number of patients or groups. In addition, qualitative approaches can develop an understanding of the experiences of patients with FAI and its treatment, and highlight the particular significance the treatment may have for different categories of patient at different stages.

5.1 Methods used for the papers

5.1.1 Setting

Majority of this work was performed in the Richard Villar Practice in Cambridge. This practice performs the largest number of hip arthroscopies in the UK for FAI and other indications. All patients undergoing hip arthroscopic surgery under the Richard Villar Practice were invited to participate and provided informed consent. The data were collected prospectively as part of the routine follow-up process for service evaluation. Patient-reported validated outcome measures were used. For the last paper, national data were obtained by extracting records for patients having elective hip arthroscopies from the administrative hospital admissions database (hospital episode statistics).

5.1.2 Patients and intervention

All surgical procedures were performed in the Richard Villar Practice, Cambridge, UK, by the senior surgeon, who has extensive experience of hip arthroscopy. Alpha-angle and Tonnis grade of OA were measured as described previously. All patients were assessed by the senior surgeon and those with evidence of an impingement lesion were counselled for surgery. Surgery was performed on patients with progressively increasing pain that affected QoL; following failure of a trial of non-operative treatment. The patient was anaesthetised and surgery performed in the lateral position, using image intensifier control and traction. The central compartment was accessed as described by the senior surgeon (131), followed by the peripheral compartment; after releasing the traction. Surgery involved removal of the impingement lesion (femoral and/or acetabular) and labral preservation with, where appropriate, repair of chondral/ labral/ chondrolabral lesions. Chondral and labral lesions were treated using thermal ablation with radiofrequency probe, labral reattachment, or chondrolabral repair using either sutures or fibrin adhesive, as necessary; microfracture was performed for grade IV chondral defects. All patients received an identical, standardised physiotherapy regimen in the post-operative period and were mobilised using crutches for the first four weeks, to facilitate partial weight bearing. A documented rehabilitation plan involved four months of formal physiotherapy, from one week after surgery, and regular follow-up at six weeks, three months, one year and annually thereafter. Patients were asked to complete the outcome measures at follow-up.

5.1.3 Design and database

The data were collected prospectively, including intraoperative details, radiological abnormalities and outcome scores. All patients undergoing surgery in the practice were recruited as part of service evaluation. The patients were asked to complete the outcome booklet on the day of surgery and the postoperative outcome was collected by either postal questionnaire or, where appropriate, via email. The outcome measures used include MHHS (Appendix 1)(132), NAHS (Appendix 2)(133), and a patient satisfaction score using a visual analogue scale (VAS – Appendix 3) from 0 (no pain relief) to 100 (maximum pain relief)(134, 135). The Rosser Index Matrix was used to create QoL scores from the responses from the MHHS (136-138). Qualitative responses were translated to Rosser distress (pain) and disability (function) categories (Appendix 4), and then applied to the Rosser Index Matrix (139, 140) (Appendix 5) to derive QoL scores. The Rosser index matrix allocates scores from -1.486 to 1.000. There are 29 possible health states, each with a numerical score for QoL. A score of 1.000 indicates complete normality while death is given a score of 0.000. Negative scores indicate health states thought to be worse than death. The patients were also asked to respond in “yes” or “no” if they were satisfied with the results of the surgery.

All the patients were asked to complete a sports module questionnaire before surgery (Appendix 6), to determine their engagement in sport and their current level of sporting activities over the previous three months. This questionnaire included information both on the time spent training and also in competition.

All the data are maintained in a secure database in the treating hospital. The database includes demographic details, information collected at the time of surgery including intraoperative details, findings at the time of the operation, length of surgery, type of procedure, radiological parameters (degree of osteoarthritis, alpha angle, centre edge angle), degree of chondral damage on acetabular and femoral side, associated pathologies like loose bodies, ligamentum teres tear, presence of cam lesion, pincer lesion, procedure performed (excision of cam lesion, rim recession, labral repair, acetabular microfracture, chondroplasty, labroplasty, chondral repair with fastfix, chondral gluing with fibrin, ligamentum teres debridement) and any intraoperative complications.

The database also includes the preoperative scores (NAHS, MHHS, VAS) and responses to the sports questionnaire collected on the day of surgery. Postoperative scores (NAHS, MHHS, VAS for pain and satisfaction after surgery) were collected at six weeks, six months, one year, and annually thereafter and entered in the database.

5.1.4 Analyses

The statistical analysis was performed using the SPSSv15 statistical programme (SPSS Inc. Chicago, Illinois). In order to determine whether the data were significantly different from a normal distribution, the Kolmogorov-Smirnov test was used. If $\rho<0.05$, the data were treated as non-parametric. To compare continuous variables, two sample t-tests were used for parametric data and the Mann-Whitney U test was used for non-parametric data. All the tests were two tailed and a significance level of $\rho<0.05$ was maintained throughout. Categorical data were compared using the Chi-squared test.

A linear regression analysis was performed to determine the predictors of functional results with the change in QoL score at one year being the dependent variable. The independent variables were age, gender, pre-operative scores, associated pathologies (OA, osteochondral defect, chondral delamination, psoas tendonitis, loose bodies, tear of ligamentum teres, trochanteric bursitis), type of impingement lesion (femoral, acetabular or combined) and type of chondrolabral repair (thermal treatment, repair with suture anchors or fast-fix or chondral repair with fibrin glue). Data were entered if $\rho<0.05$ and removed if $\rho>0.10$.

Power analysis revealed that, to be able to detect a difference in the mean MHHS or NAHS of five, with SD of five for a 90% power and ρ value set at 0.05, 22 patients would be required in each group. A change of five points was chosen to show a minimum clinically important difference in hip scores; thus improving the robustness of the analysis compared with the seven to ten point change suggested in the literature (141, 142).

5.2 Quality of life paper – Prospective cohort study

This study is a report of the change in QoL for 612 patients with FAI after hip arthroscopic surgery. The two main criticisms of this study are that the Rosser-Index matrix was chosen as an outcome measure and the data were not used to estimate the QALY.

Arguably, EQ-5d is the most well-known and commonly used generic measure of health internationally(143) of the QoL measures available. It is quick, simple, reliable and validated and now has been recommended by NICE for use in appraisal of health technology (144). However, the previous three-level version of the EQ-5d was considered to lack sensitivity and failed to capture certain aspects of health, leading to the introduction of the relatively new five-level version, in 2011 (145).

The SF-36 is another generic health measurement tool (146) and consists of eight scaled scores that are the weighted sums of the questions in their section. These consider vitality, physical functioning, bodily pain, general health perceptions, physical role functioning, emotional role functioning, social role functioning and mental health and each scale is directly transformed into a 0-100 scale. Although comprehensive, this tool has the disadvantage of being complex and time consuming to complete. Patients are also being assessed for other outcomes and the complexity of this tool makes it less likely that it will be completed properly.

This study did not use a contemporary QoL outcome measure such as EQ-5d or SF-36 but relied on the Rosser-Index matrix. However, use of the Rosser-Index matrix over contemporary outcome measures can be justified in that EQ-5d was not a popular outcome measure time in 2005, when the database was set up. Additionally, SF-36 is a complex measurement tool and data collection is difficult if it is combined with other outcome measures. By contrast, at one point, the Rosser-Index matrix was the most commonly-used outcome measure in the United Kingdom (139, 140, 147-149); making the results of this study directly comparable with QoL outcomes for other interventions. Moreover, it is possible to translate the findings of MHHS, in terms of pain and function, into a QoL score comparable with the Rosser Index matrix and so conduct this study effectively.

NICE, 2013, recommended (144) that the principal measures of health outcome(s) used should be relevant to the estimation of clinical effectiveness and should measure health benefits and adverse effects that are important to patients and/or their carers. In addition, when EQ-5d data are not available, these data can be estimated by mapping other health-related QoL measures or health-related benefits observed in the relevant clinical trial(s) to EQ-5d. The mapping function chosen should be based on data sets containing both health-related QoL measures and its statistical properties should be fully described, its choice justified, and it should be demonstrated adequately how well the function fits the data. Sensitivity analyses to explore variation in the use of the mapping algorithms on the outputs should be presented. Use of the Rosser-Index matrix for this work can be justified in line with the NICE guidelines.

Measures of clinical outcomes usually quantify an impact on survival or health-related QoL and, if recorded over a period of some years, can be translated into QALYs to determine the cost effectiveness of this procedure relative to its impact on QoL. Evaluation of the QALY score for this cohort of patients was not feasible owing to a current lack of long-term follow-up data. Over time, these data will become available and this evaluation will be possible.

5.3 Athletes and non-athletes paper – Prospective comparative study

This is a consecutive series of 122 patients with FAI with a minimum follow-up of one year. The outcome for 80 athletes was compared with that for 42 non-athletes, all of who were comparable and demographically similar. This study is not a randomised control trial because one cannot randomise patients to be either athletes or non-athletes. The main criticism of the study that the athletes were self-reported and there may be an element of error in completion of the sports module questionnaire. Also, MHHS (Appendix 1), the outcome measure used, may have a ceiling effect. This is possibly because the MHHS does not include questions on sports and higher-level activities. This is however not the case with NAHS (Appendix 2) which includes detail questions on high and low demand sports, jogging and walking for exercise and heavy and light household duties. Lodhia *et al*. (150) reviewed the content and clinimetric evidence (rigor of rating scales and indexes for the description of clinical phenomena) for the published patient-reported outcome (PRO) instruments used to assess FAI and labral hip pathology. They concluded that the NAHS showed evidence for validity and lack of a floor/ceiling effect while demonstrating clinimetric evidence to support its use to measure outcomes in FAI and labral pathology patients. Therefore combining MHHS with NAHS would circumvent the problem of floor and ceiling effect.

Moreover, the International hip outcome measurement tool (iHOT-12)(151), a validated measure of both health-related QoL and changes after treatment in young, active patients with hip disorders and now the recommended scoring system to use was not available for use when the study was set up. The iHOT-12 is an abridged version of the iHOT-33 and is a shorter, more clinically applicable tool and has been shown to be valid, reliable and responsive to change without losing any information despite being one-third the length. In retrospect, hip disability and OA outcome score (HOOS)(152, 153), another validated tool that does not have a ceiling effect and was available at the time of the study, would have been a better outcome measure. The HOOS score and the modified Western Ontario and McMaster Universities Osteoarthritis Index also demonstrated supporting evidence to justify their use.

The potential for bias in the evaluation of postoperative results is well recognised. Significant differences between patient reported outcome and physicians' evaluation can exist; with the physicians' evaluation being more favourable particularly in patients with more inferior surgical results(154, 155).

Interestingly, Hetaimish *et al*., 2013, (156) have identified a lack of consensus with regard to reported outcomes (clinical and radiographic) after arthroscopic treatment of FAI. Of the 29 eligible studies included in their systematic review the Harris hip score was the commonest outcome measure used (45%) and the NAHS was the next most popular (28%). Our data collection process was therefore in keeping with the contemporary literature at the time the study was setup, although in the current climate better tools are available.

5.4 Professional versus recreational athletes paper – Prospective comparative study

This is a consecutive series of 80 athletes with a minimum follow-up of one year. The groups were further divided into professional athletes (PA), including those who engage in competitive sport representing their country, region or local club and recreational athletes (RA), who were involved only in recreational sport.

Similar concerns to those expressed with regard to the previous studies also apply in this case. In addition, errors may be introduced through smaller sample size, especially because we did not find any statistically significant differences at follow-up at 6 and 12 months. However, power analysis revealed that, to be able to detect a difference in the mean MHHS or NAHS of five, with SD of five for a 90% power and ρ value set at 0.05, 22 patients would be required in each group. A change of five points was chosen to show a minimum clinically important difference in hip scores; thus improving the robustness of the analysis compared with the seven to ten point change suggested in the literature (141, 142).

5.5 Complications and survival analyses study - Therapeutic case series

We extracted records for patients undergoing hip arthroscopy from the administrative hospital admissions database (hospital episode statistics), covering all admissions to the NHS hospitals in England using ICD-10 and OPCS-4 codes. There are several limitations to this methodology and these have been highlighted in the paper. The data suggest that a total of 6395 hip arthroscopies were performed in the English NHS between 1st April 2005 and 31st January 2013. This is clearly an underestimation of the number of procedures performed annually as the database did not include patients operated on in the private sector. Also, some patients may be coded inappropriately. The reliability of the codes and data collected may be in question and so, some cases were excluded to improve the accuracy of the data captured. The short-term complication rate would apply only to patients admitted to NHS hospitals and would not include any complications arising in the private sector.

Moreover, we have not looked at the primary indication of hip arthroscopy in individual cases or details of intraoperative findings, and thus it is difficult to establish the outcome based on the diagnosis or, indeed, in the group that underwent THR, the relation with the presence and degree of arthritis. The procedures were performed by surgeons of different levels of experience and it may be that the outcome is dependent on this key factor especially considering the steep learning curve of hip arthroscopic intervention. Crucially the indication for surgery and threshold for revision to hip replacement is also dependent on surgeon related factors.

Nevertheless, the effects of this inaccuracy would be negated by the large number of patients included in the study, the largest series reported out with systematic reviews. More importantly adding different levels of surgeon is a true reflection of results of surgery in the general population and standard orthopaedic practice.

Chapter Six: Findings

Hip arthroscopy is technically a new procedure, the scope of which is evolving rapidly. The demand for the surgery is increasing worldwide. In the USA, there was an 18-fold increase in the number of hip arthroscopies performed by candidates of the American Board of Orthopaedic Surgery between 1999 and 2009(157) and a 600% increase between 2006 and 2010(158). A total of 11 329 hip arthroscopies were performed in NHS hospitals in England between 2002 and 2013(159). There was a statistically significant increase of 727% (p<0.0001) during this period and there is a projected increase of 1388% by 2023. This increasing trend has been noticed in all regions of England. Several factors are likely to be driving the increasing number of hip arthroscopies. Conditions such as femoracetabular impingement and labral tears are increasingly recognised as a source of pain and future osteoarthritis(160) by both clinicians and patients. Demands are buoyed by outcomes from cohort studies, which report good short-term and medium-term outcomes for a wide range of arthroscopic hip procedures. Guidance from the National Institute for Health and Clinical Excellence (NICE) may have played a role. In 2011, NICE concluded that there was adequate evidence of symptom improvement in the short and medium term.

This section summarise the key findings of the papers and how the papers have over a period of time contributed to the growing knowledge base about the procedure.

Quality of life paper

At the time the study was being set up there were several case series with small number of patients, which showed that the functional outcome improves after hip arthroscopy for FAI. These measures showed that the various outcome scores improve after surgery but it was not clear how this would be in real life term. Quality of life is probably a better way to assess this as any change is QoL would equate to a real life benefit of any intervention. No published work was available looking at this aspect of hip arthroscopic intervention, making this particular paper very strong. A systematic review published in 2010 had a total of 970 patients in 23 papers(7) found suitable for inclusion, half of who had hip arthroscopic intervention while the rest open surgery making the QoL paper one of the largest single-surgeon series published at that time.

It was also the first to consider QoL outcome after hip arthroscopic surgery for FAI. In a series of 612 patients at a mean follow-up of 3.2 years, we found that the QoL improved significantly after surgical intervention in 77%, remained unchanged in 14% and deteriorated in 9% of patients. The significant predictors of change in QoL were preoperative QoL scores and female gender.

Subsequently there have been other papers with similar numbers but without looking at QoL as outcome measure and therefore this paper continues to contribute to literature and has already been cited 33 times.

Athletes versus non-athletes paper

The initial literature on FAI and its surgical treatment mainly looked at athletes undergoing corrective procedure and indeed this benefitted the patients to return to their sporting activity. What was not clear was whether it is a surgery reserved for athletes or also for the general population.

In this prospective comparative study (Level 2 evidence – Appendix 7) the trend for improvement in hip scores after surgery was compared between athletes and non-athletes and we found that, while the athletes had a significantly better score at six weeks, there were no significant differences between the two groups after one year. This study was the first prospective comparative study to look at these two groups of patients and demonstrated that arthroscopic surgery may be an appropriate treatment for FAI in both athletes and non-athletes.

The paper was quoted in a recent supplement of Orthopaedic Today (April 2015) to confirm that it remains the only study to have looked at this aspect of hip arthroscopic surgery in a prospective comparative design.

Professional versus recreational athletes paper

While the athletes are able to return to their sporting activity, do they return to the same level? There are no studies that have looked at the objective evidence with regards this. We created a sports questionnaire (Appendix 6) that looked at objective measures like the time spent in training, time spent in competition and number of competitions participated in to have a more objective measure of return to sports. We also compared the performance of professional athletes with recreational athletes.

We noted that both the training and time in competition improved approximately three-fold after surgery, with a mean time to return to sport at the same level of 5.4 months. Professional athletes (4.2 months) recovered more quickly than recreational athletes (6.8 months). A greater proportion of the professional athletes (88%) returned to their pre-injury level of sport than the recreational athletes (73%). Prior to this study, objective measures of return to sport were lacking, and there had been no prospective comparative studies (Level 2 evidence – Appendix 7) of recovery time in professional and recreational athletes.

A review of studies (93) looking at return to sports in athletes after surgery for FAI was published in 2012 with similar conclusion. Interestingly this review(93) included 9 articles with a total of 418 athletes and did not include any objective measure of return to sports as we have been able to perform in our study.

Complications and survival analyses

The exponential increase in hip arthroscopies being performed worldwide has coincided with rapidly growing number of papers in the published domain, especially over the last three four years. Whilst there is benefit in knowing the results of surgery by individual surgeons there is always a risk of publication bias, with most studies being performed, reported and published by high output surgeon. It is therefore imperative to understand and explore the results in "non-expert" hands. The ultimate goal of surgery for FAI is to preserve the hip and delay hip replacement.

The national hospital episode statistics data on short-term complications after hip arthroscopy showed that, in 6395 hip arthroscopies performed in England between April 2005 and Jan 2013, the 30-day readmission rate was 0.5%; the 90-day incidence of deep vein thrombosis (DVT) was 0.08% and of pulmonary embolus (PE) 0.08%; and the 90-day mortality rate was 0.02%. In this series of 6395 hip arthroscopies, 680 patients (10.6%) underwent total hip replacement (THR), at a mean of 1.4 years after the index operation. Female patients had a 1.68 times (95% CI, 1.41 to 2.01) higher risk of conversion to THR than male patients, and patients aged 50 years or older had a 4.65 (95% CI, 3.93 to 5.49) times higher risk of requiring hip replacement than patients younger than 50 years. Kaplan-Meier survival analysis revealed an eight-year survival of 82%; while Cox proportional hazard analysis, adjusting for age, gender and Charlson comorbidity score, revealed an eight-year survival of 86%.

No paper exists that has looked at survival analyses in large cohorts of patients with mixed surgeon experience. The National database study has been able to address this problem and remains a paper, which will be cited several times in the future and has contributed immensely to our knowledge of these interventions. It has also been able to demonstrate the short-term complication rate and revision rate for a surgery, which is rapidly gaining popularity despite its steep learning curve. It has been able to identify the patient groups where surgery is going to be of greater benefit and has provided information that is crucial for an informed consenting process.

Chapter Seven: Results: papers

7.1 Quality of life paper

Impact of arthroscopy of the hip for femoroacetabular impingement on quality of life at a mean follow-up of 3.2 years

A. Malviya,
G. H. Stafford,
R. N. Villar

From The Richard Villar Practice, Cambridge, United Kingdom

The benefit of arthroscopy of the hip in the treatment of femoroacetabular impingement (FAI) in terms of quality of life (QoL) has not been reported. We prospectively collected data on 612 patients (257 women (42%) and 355 men (58%)) with a mean age at the time of surgery of 36.7 years (14 to 75) who underwent arthroscopy of the hip for FAI under the care of a single surgeon. The minimum follow-up was one year (mean 3.2 years (1 to 7)). The responses to the modified Harris hip score were translated using the Rosser Index Matrix in order to provide a QoL score. The mean QoL score increased from 0.946 (-1.486 to 0.995) to 0.974 (0.7 to 1) at one year after surgery ($p < 0.001$). The mean QoL score in men was significantly higher than in women, both before and one year after surgery (both $p < 0.001$). However, the mean change in the QoL score was not statistically different between men and women (0.02 (-0.21 to 0.27) and 0.04 (-0.16 to 0.87), respectively; $p = 0.12$). Linear regression analysis revealed that the significant predictors of a change in QoL score were pre-operative QoL score ($p < 0.001$) and gender ($p = 0.04$). The lower the pre-operative score, the higher the gain in QoL post-operatively ($\rho = -0.66$; $p < 0.001$). One year after surgery the QoL scores in the 612 patients had improved in 469 (76.6%), remained unchanged in 88 (14.4%) and had deteriorated in 55 (9.0%).

Interest in the assessment of health-related quality of life (QoL) for outcome studies in orthopaedic surgery is increasing.[1] The assessment of quality of life is a broad concept representing individual responses to the physical, mental and social effects of illness and its treatment. Health-related QoL outcome measures are often used in research trials but less so in routine clinical practice.[2] However, in order to make a complete assessment of the benefits of an intervention, it is essential to provide evidence of the impact on the patient in terms of QoL,[3] as it allows the patient's health status to be expressed independently of technical concerns and diagnosis.[4,5]

Evidence has emerged over the past decade that femoroacetabular impingement (FAI) may lead to early osteoarthritis of the hip, and that patients with FAI may be successfully treated by addressing the underlying pathomorphology.[6,7] Hip arthroscopy, femoral osteochondroplasty and acetabuloplasty are established interventions for the treatment of FAI.[8-12] Many outcome measures have been used, although studies have not specifically examined whether arthroscopic surgery for FAI improves the patients' QoL.

The usefulness of measuring QoL is not confined to assessing clinical outcome but also has implications for resource allocation,[13] as healthcare authorities can purchase interventions that best meet the needs of the population they serve. Evidence of cost-effectiveness is therefore crucial to purchasing decisions,[13,14] and QoL outcomes can be potentially used to determine this cost-effectiveness.

The aim of this study was to quantify the impact of arthroscopy of the hip on the QoL of patients with FAI. We also wished to explore the influence of possible confounding variables on the QoL. Our hypothesis was that the QoL outcome measures would improve after surgery and would not be influenced by age, gender, associated pathology, or the type of intervention for an impingement lesion and/or labral tear.

Patients and Methods

This is a single-surgeon prospective series of patients with a minimum follow-up of one year who underwent arthroscopy for FAI, assessed from a QoL perspective. All the patients were asked to respond to questionnaires in order to provide a modified Harris hip score (HHS)[15,16] and their view of their satisfaction with surgery. Data on intra-operative findings and the procedure performed were meticulously recorded at the time of the operation. The

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scores were collected immediately pre-operatively on the day of surgery, and post-operatively at six weeks, six months and one year. All information was entered into a prospectively maintained database.

Between January 2005 and December 2009, 612 patients with FAI were operated on by the senior author (RNV). We excluded bilateral arthroscopies to reduce the impact of the contralateral side on the scores. The mean age of the patients at the time of surgery was 36.7 years (14 to 75), and there were 257 women (42%) and 355 men (58%). Surgery involved removal of the impingement lesion (femoral and/or acetabular) and labral preservation with, where appropriate, repair of chondral/labral/chondrolabral lesions. Femoral osteochondroplasty alone was performed in 537 hips (88%), combined femoral osteochondroplasty with acetabular recession was performed in 61 hips (10%) and acetabular recession alone in 14 hips (2%). Chondral and labral lesions were treated using thermal treatment with radiofrequency probe, labral reattachment, or chondrolabral repair using either sutures or fibrin adhesive. Thermal treatment alone was performed in 469 hips (77%), labral or chondrolabral repair with suture anchors (Bioraptor; Smith & Nephew UK Ltd, London, United Kingdom) or the Fast-Fix meniscal repair system (Smith & Nephew UK Ltd) was performed in 78 hips (13%), and fibrin glue was used in 65 hips (10%). All patients had FAI and a labral tear, with a wide range of associated pathologies (osteoarthritis in 137 hips, osteochondral lesions in 132, chondral delamination in 66, psoas tendonitis in 39, ligamentum teres tear in 51, loose bodies in 23 and trochanteric bursitis in eight). Post-operatively all patients undertook a standardised regimen. Briefly, for the first four weeks patients were asked to be partially weight-bearing with crutches. Formal physiotherapy was started one week after surgery and continued for four months, using a documented rehabilitation plan.

Table I. The Rosser Index[17]

Index	Description
Disability	
I	No disability
II	Slight social disability
III	Severe social disability and/or slight impairment of performance at work
IV	Choice of work or performance at work severely limited. Housewives and old people able to do light housework only, but able to go shopping
V	Unable to undertake any paid employment. Unable to continue any education. Old people confined to home except for escorted outings and short walks and unable to do any shopping
VI	Confined to chair or wheelchair or able to move around in the house only with support from an assistant
VII	Confined to bed
VIII	Unconscious
Distress	
A	No distress
B	Mild
C	Moderate
D	Severe

Table II. The Rosser Index Matrix[21] showing a quality of life (QoL) score for each disability/distress combination

	Distress			
Disability	A	B	C	D
I	1.000	0.995	0.990	0.967
II	0.990	0.986	0.973	0.932
III	0.980	0.972	0.956	0.912
IV	0.964	0.956	0.942	0.870
V	0.946	0.935	0.900	0.700
VI	0.875	0.845	0.680	0.000
VII	0.677	0.564	0.000	-1.486
VIII	-1.028			

We used the answers from the modified HHS to translate it to a Rosser Index Matrix-created QoL score[17] using previously reported techniques.[18-20] The qualitative nature of the questions from the modified HHS[18-20] allows them to be translated to Rosser distress (pain) and disability (function) categories (Table I), which can be applied to the Rosser Index Matrix[21] (Table II) to derive QoL scores. The Rosser Index Matrix allocates scores from -1.486 to 1.000, and there are 29 possible health states, each with a numerical score for QoL.[21] A score of 1.000 indicates normality, whereas death is given a score of 0.000. Negative scores indicate health states thought to be worse than death. The patients were also asked whether they were satisfied with the results of the surgery, and to respond 'yes' or 'no'.

The pre-operative and one year post-operative QoL scores are reported in the study. Complete data were available for all patients.

Statistical analysis. Statistical analysis was performed using the SPSS v15 statistical programme (SPSS Inc., Chicago, Illinois). In order to determine whether the data were significantly different from the normal distribution, a Kolmogorov–Smirnov test was used. If $p < 0.05$, the data were treated as non-parametric. In order to compare continuous variables, two-sample *t*-tests were used for parametric data and the Mann-Whitney U test for non-parametric data. All the tests were two-tailed and $p < 0.05$ was considered statistically significant throughout. A chi-squared test was used to compare categorical data. A linear regression analysis was performed to determine the predictors of functional results, with the change in QoL score at one year being the dependent variable and age, gender, pre-operative scores, associated pathologies (osteoarthritis, osteochondral defect, chondral delamination, psoas tendonitis, loose bodies, tear of ligamentum teres, trochanteric bursitis), type of impingement lesion (femoral, acetabular or combined) and type of chondrolabral repair (thermal treatment, repair with suture anchors or fast-fix or chondral repair with fibrin glue) as the independent variables. Data were entered if $p < 0.05$ and removed if $p > 0.10$.

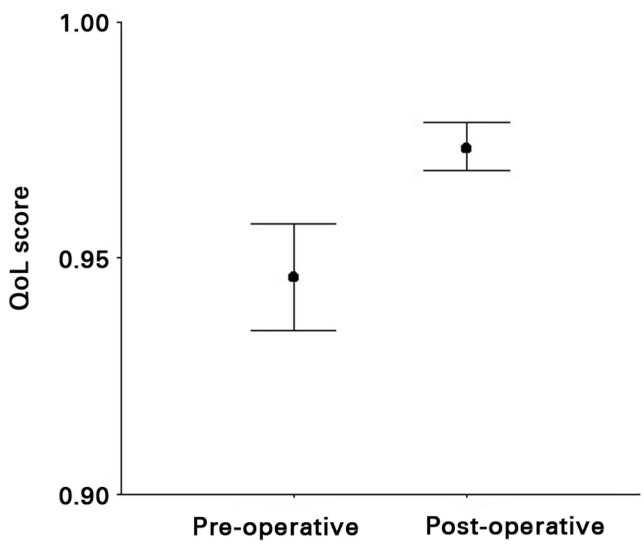

Fig. 1

Plot for the whole group depicting the pre-operative and one-year post-operative quality of life (QoL) scores. The error bars show the 95% confidence intervals.

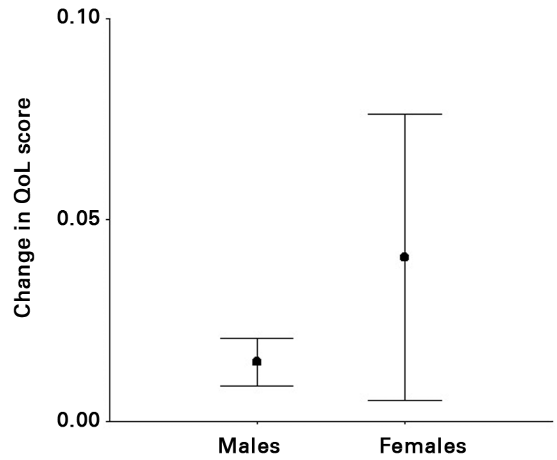

Fig. 3

Plot showing the gender difference in the change in quality of life (QoL) scores at one year after surgery. The error bars show the 95% confidence intervals.

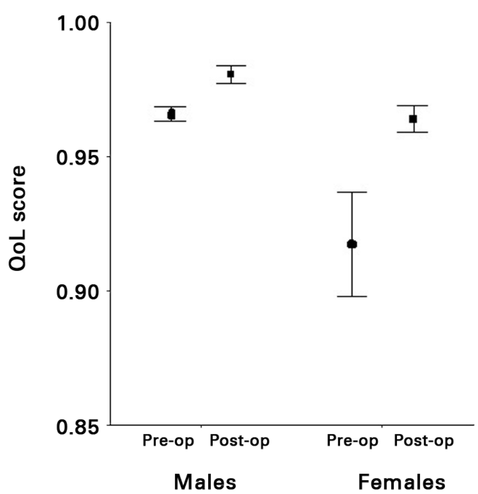

Fig. 2

Plot showing the gender difference between the pre-operative (Pre-op) and one-year post-operative (Post-op) quality of life (QoL) scores. The error bars show the 95% confidence intervals.

Results

The mean follow-up was 3.2 years (1 to 7).

Outcome for the whole group. The mean QoL score increased from 0.946 (-1.486 to 0.995) pre-operatively to 0.974 (0.7 to 1) at one year after surgery (p < 0.001, *t*-test) (Fig. 1).

At one-year follow-up the QoL score showed at least a one-grade improvement in 469 patients (76.7%), no change in 88 (14.4%), and in 55 (8.9%) the score deteriorated.

At one year after surgery 450 patients (73.5%) were happy with the results. All the patients who were pleased with the results of the surgery had an improvement in QoL score. In all, 19 patients were not pleased with the surgery despite an improvement in QoL score, either because it did not match their expectations or because of the prolonged rehabilitation involved.

Influence of gender difference. The mean QoL score for men was significantly better than for women, both before surgery (0.962 (0.7 to 0.99) *versus* 0.924 (0 to 0.99); p < 0.001, *t*-test) and at one year (0.982 (0.7 to 1) *versus* 0.964 (0.7 to 1); p < 0.001, *t*-test) after surgery (Fig. 2). However, the mean change in the QoL score was greater for women (0.02 (-0.21 to 0.27) for men, 0.04 (-0.16 to 0.87) for women), although this was not statistically significant (p = 0.12, *t*-test) (Fig. 3).

Influence of difference in age. The groups were split into those patients ≤ 50 years of age (n = 540) and those > 50 (n = 72). The mean QoL score for the two groups (Fig. 4) did not show any significant difference either before surgery (≤ 50 years: 0.944 (0.7 to 0.99); > 50 years: 0.952 (0.7 to 0.986); p = 0.67, Mann-Whitney U test) or at one year after surgery (≤ 50 years: 0.974 (0.7 to 1); > 50 years: 0.967 (0.7 to 1); p = 0.37, Mann-Whitney U test).

The mean change in QoL score (Fig. 5) was greater for the patients ≤ 50 years of age (≤ 50 years: 0.04 (-0.21 to 0.87); > 50 years: 0.01 (-0.1 to 0.13)), but the difference was not statistically significant (p = 0.39).

Predictors of change in QoL scores. Linear regression analysis was performed to look at the predictors of change in QoL

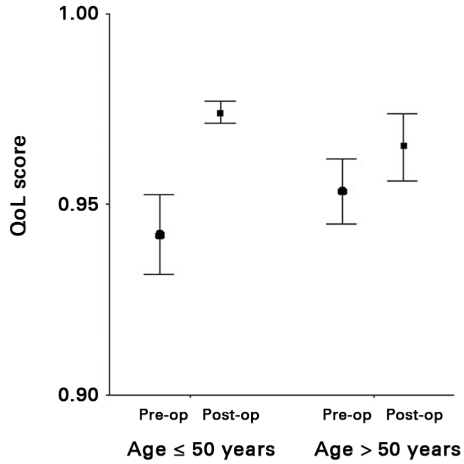

Fig. 4

Plot showing the influence of difference in age between the pre-operative (Pre-op) and one-year post-operative (Post-op) quality of life (QoL) scores. The error bars show the 95% confidence intervals.

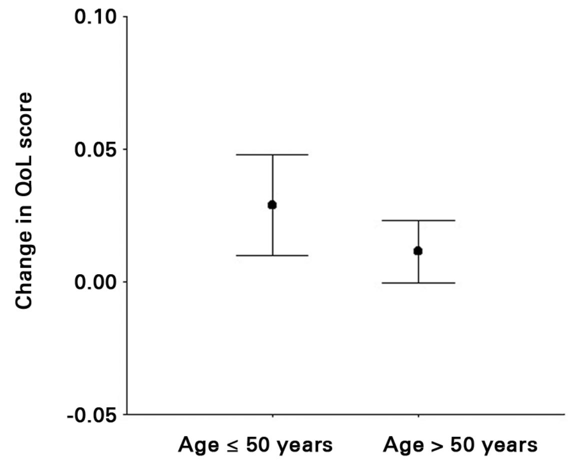

Fig. 5

Plot showing the influence of difference in age (in years) on the change in quality of life (QoL) score at one year after surgery. The error bars show the 95% confidence intervals.

Table III. Results of the linear regression analysis with change in quality of life (QoL) as dependent variable and age, gender, pre-operative QoL score, associated pathologies, type of impingement and type of intervention as independent predictors

Predictors	Standardised coefficient (β)	Zero-order correlation coefficient (r)	p-value
Age	-0.02	-0.09	0.31
Gender	-0.04	0.09	0.04
Pre-operative QoL	-0.95	-0.94	< 0.001
Associated pathologies	-0.03	-0.06	0.15
Type of impingement	0.05	0.03	0.18
Type of intervention for chondrolabral tear	0.04	-0.003	0.89

scores (Table III). The significant predictors were pre-operative QoL score ($p < 0.001$) and gender ($p = 0.04$). The age of the patient, type of impingement lesion, type of chondrolabral repair and the presence of associated pathologies (osteoarthritis, osteochondral defect, chondral delamination, psoas tendonitis, loose bodies, ligamentum teres tear, trochanteric bursitis) did not have a significant influence on the change of QoL score at one year (Table III).

The change in QoL score showed moderate ($\rho = -0.66$, $p < 0.001$) negative correlation with the pre-operative QoL score, indicating that the lower the pre-operative score, the higher the gain in QoL post-operatively.

Discussion

In a large prospective series we found that QoL improves after hip arthroscopy, labral preservation, femoral osteochondroplasty and acetabuloplasty in patients with FAI. The QoL scores improved in 469 patients (76.7%) and 450 (73.5%) were happy with the outcome of surgery at one year. We noted that the QoL scores were significantly ($p < 0.001$) lower in women, both pre- and post-operatively. A linear regression analysis revealed that the best predictor of change in QoL score is the pre-operative QoL score ($p < 0.001$) followed by the gender of the patient ($p = 0.04$).

We generated the QoL scores from a patient-derived classification of health states called the Rosser Index Matrix.[17] The index is the most commonly used in United Kingdom, making the results of this study comparable with studies that look at QoL outcome for other interventions.[22-24] The translation of pre-existing scores to the Rosser Index Matrix can be a source of error and subjectivity.[24] However, the modified HHS is closely comparable to the Rosser categories, allowing the two parameters (pain and function) to be translated and thereby quantified to a QoL score.[18-20,25] Whereas the modified HHS has values ranging from 0 to 100, the change in QoL score will fall into one of 29 categories (26 different scores, after excluding some common scores). Therefore, a minor change in the modified HHS does not equate to a change in QoL, whereas a major change does. Any change in QoL can therefore be considered to be more clinically relevant in the overall health status of an individual.

The age of the patient and the presence of associated diagnoses such as osteoarthritis, osteochondral defects, chondral delamination, ligamentum teres tear, psoas tendonitis, loose bodies and trochanteric bursitis did not have a bearing on the QoL score. Those patients over the age of 50 had statistically similar scores to patients under the age of 50 ($p = 0.39$), although the mean change in score was lower for the former, older group (Fig. 5). Others have also reported the irrelevance of older age when predicting outcome after arthroscopic surgery for FAI. Javed and O'Donnell[26] reported the results of arthroscopic femoral osteochondroplasty for cam FAI in patients over the age of 60 and found an overall satisfaction rate of 75%.

In our study, the pre- and post-operative QoL scores were significantly lower for women ($p < 0.001$) than for men. Although the change in score was higher for women, this was not statistically different ($p = 0.12$). We could not find such a difference in outcome in previous reports. We established by linear regression analysis that the gender of the patient was a significant predictor ($p = 0.04$) of a change in QoL score. However, the best predictor of change in QoL was the pre-operative QoL score: the lower the pre-operative QoL score, the greater the change in QoL after surgery ($\rho = -0.66$, $p < 0.001$). This information is crucial for the purpose of informed consent.

When considering our whole study group, at one year after surgery the QoL scores improved in 76.7% of patients, remained unchanged in 14.4%, but deteriorated in 8.9%. This is similar to other studies in the general population, which have revealed that arthroscopic management of FAI leads to a good-to-excellent result in up to 75% of patients at one year.[27,28] Even in patients with milder degrees of pre-operative degenerative change on their radiographs, osteochondroplasty for FAI can lead to an improvement in pain and function at short-term follow-up.[29] In a series of 200 patients, Byrd and Jones[30] reported that 83% of patients had an improvement in their HHS at a mean follow-up of 16 months. In a series of 34 patients with FAI treated by open surgical dislocation, labral debridement and femoral osteochondroplasty, Beaulé, Le Duff and Zaragoza[31] demonstrated that QoL, in terms of Short Form-12 scores, improved after surgery in 82% of patients. However, studies on the arthroscopic management of FAI have not measured the improvement in terms of change in QoL, which is essential for complete assessment of the benefit of an intervention.[3]

This study has a selection bias owing to the nature of the tertiary referral pattern. However, it is nevertheless a prospective study of a large cohort of patients operated upon by a single surgeon. We looked uniquely at the impact of surgery on QoL, which has not been explored previously, and found that arthroscopic surgery for FAI improves QoL in 76.7% of patients. The pre-operative QoL score and gender were significant predictors of the change in QoL.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References

1. **Naughton MJ, Anderson RT.** Outcomes research in orthopaedics: health-related quality of life and the SF-36. *Arthroscopy* 1998;14:127–129.
2. **Walters SJ, Brazier JE.** What is the relationship between the minimally important difference and health state utility values?: the case of the SF-6D. *Health Qual Life Outcomes* 2003;1:4–5.
3. **Garratt A, Schmidt L, Mackintosh A, Fitzpatrick R.** Quality of life measurement: bibliographic study of patient assessed health outcome measures. *BMJ* 2002;324:1417.
4. **Bowling A.** *Measuring health: a review of quality of life measurement scales.* Buckingham: Open University Press, 1992.
5. **Gartland JJ.** Orthopaedic clinical research: deficiencies in experimental design and determinations of outcome. *J Bone Joint Surg [Am]* 1988;70-A:1357–1364.
6. **Leunig M, Beaulé PE, Ganz R.** The concept of femoroacetabular impingement: current status and future perspectives. *Clin Orthop* 2009;467:616–622.
7. **Sierra RJ, Trousdale RT, Ganz R, Leunig M.** Hip disease in the young, active patient: evaluation and nonarthroplasty surgical options. *J Am Acad Orthop Surg* 2008;16:689–703.
8. **McCarthy JC, Lee JA.** Arthroscopic intervention in early hip disease. *Clin Orthop* 2004;429:157–162.
9. **Bardakos NV, Vasconcelos JC, Villar RN.** Early outcome of hip arthroscopy for femoroacetabular impingement: the role of femoral osteoplasty in symptomatic improvement. *J Bone Joint Surg [Br]* 2008;90-B:1570–1575.
10. **Byrd JW, Jones KS.** Hip arthroscopy in athletes: 10-year follow-up. *Am J Sports Med* 2009;37:2140–2143.
11. **Keogh MJ, Batt ME.** A review of femoroacetabular impingement in athletes. *Sports Med* 2008;38:863–878.
12. **Singh PJ, O'Donnell JM.** The outcome of hip arthroscopy in Australian football league players: a review of 27 hips. *Arthroscopy* 2010;26:743–749.
13. **Torrance GW, Thomas WH, Sackett DL.** A utility maximization model for evaluation of health care programs. *Health Serv Res* 1972;7:118–133.
14. **Donaldson C, Mooney G.** Needs assessment, priority setting, and contracts for health care: an economic view. *BMJ* 1991;303:1529–1530.
15. **Harris WH.** Traumatic arthritis of the hip after dislocation and acetabular fractures: treatment by mold arthroplasty: an end-result study using a new method of result evaluation. *J Bone Joint Surg [Am]* 1969;51-A:737–755.
16. **Byrd JWT, Jones KS.** Hip arthroscopy in the presence of dysplasia. *Arthroscopy* 2003;19:1055–1060.
17. **Rosser RM, Watts VC.** The measurement of hospital output. *Int J Epidemiol* 1972;1:361–368.
18. **Chan CL, Villar RN.** Obesity and quality of life after primary hip arthroplasty. *J Bone Joint Surg [Br]* 1996;78-B:78–81.
19. **Norman-Taylor FH, Palmer CR, Villar RN.** Quality-of-life improvement compared after hip and knee replacement. *J Bone Joint Surg [Br]* 1996;78-B:74–77.
20. **Papavasiliou AV, Villar RN.** Quality of life in different age groups after metal-on-metal hip resurfacing arthroplasty. *Hip Int* 2008;18:307–312.
21. **Gudex C, Kind P.** *The QALY Toolkit.* York: Centre for Health Economics University of York, 1988. (Discussion paper 38).
22. **Bryan S, Parkin D, Donaldson C.** Chiropody and the QALY: a case study in assigning categories of disability and distress to patients. *Health Policy* 1991;18:169–185.
23. **Williams A.** Economics of coronary artery bypass grafting. *Br Med J (Clin Res Ed)* 1985;291:326–329.
24. **Coast J.** Reprocessing data to form QALYs. *BMJ* 1992;305:87–90.
25. **Robinson AH, Palmer CR, Villar RN.** Is revision as good as primary hip replacement? A comparison of quality of life. *J Bone Joint Surg [Br]* 1999;81-B:42–45.
26. **Javed A, O'Donnell JM.** Arthroscopic femoral osteochondroplasty for cam femoroacetabular impingement in patients over 60 years of age. *J Bone Joint Surg [Br]* 2011;93-B:326–331.
27. **Larson CM, Giveans MR.** Arthroscopic management of femoroacetabular impingement: early outcomes measures. *Arthroscopy* 2008;24:540–546.
28. **Gedouin JE, May O, Bonin N, et al.** Assessment of arthroscopic management of femoroacetabular impingement: a prospective multicenter study. *Orthop Traumatol Surg Res* 2010;96(Suppl):59–67.
29. **Larson CM, Giveans MR, Taylor M.** Does arthroscopic FAI correction improve function with radiographic arthritis? *Clin Orthop* 2011;469:1667–1676.
30. **Byrd JW, Jones KS.** Arthroscopic femoroplasty in the management of cam-type femoroacetabular impingement. *Clin Orthop* 2009;467:739–746.
31. **Beaulé PE, Le Duff MJ, Zaragoza E.** Quality of life following femoral head-neck osteochondroplasty for femoroacetabular impingement. *J Bone Joint Surg [Am]* 2007;89-A:773–779.

7.2 Athletes versus non-athletes paper

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Is hip arthroscopy for femoroacetabular impingement only for athletes?

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ABSTRACT

Purpose The aim of this study was to compare the outcome of hip arthroscopy for femoroacetabular impingement (FAI) between athletes and non-athletes.
Methods The authors prospectively collected data on 122 patients, the largest comparative series reported, who underwent hip arthroscopy for FAI. Of these, 80 actively participated in sporting activities (athletes), while 42 did not (non-athletes). Patients were asked to complete questionnaires for the modified Harris hip score (MHHS), non-arthritic hip score (NAHS), patient satisfaction on a visual analogue scale (VAS). This was collected immediately before surgery, and at 6 weeks, 6 months and 1 year after the procedure. The responses to the MHHS questionnaire were used to calculate the quality-of-life (QoL) score using the Rosser index matrix.
Results A significant improvement in the MHHS, NAHS and QoL was observed at 6 weeks, 6 months and 1 year after surgery ($p<0.001$). The 6-week MHHS ($p=0.01$) and NAHS ($p=0.04$) for the athletes were significantly better as compared with non-athletes. However, the 6-month and 1-year MHHS, NAHS and QoL scores were statistically similar for both groups.
Conclusions In this large, prospective series of patients we have demonstrated the positive impact of arthroscopic surgery for FAI in both the athletic and non-athletic population. Arthroscopic management of FAI is thus not the sole domain of the athletic patient. Non-athletes can do just as well.

INTRODUCTION

Hip arthroscopy is an established intervention for the treatment of hip pathologies in the sporting and general population.[1–9] An acetabular labral tear is described as the most common pathology for which hip arthroscopy may be indicated, and selective debridement of these tears, without addressing the impingement, leads to satisfactory 10-year results in more than 80% of patients.[10] Although there is no evidence on the prevention of osteoarthritis, the early clinical data suggest that by resolving bony impingement, prevention of further labral and chondral damage is possible, and the progression of osteoarthritis may be delayed.[11] Even in the patients with milder degrees of preoperative degenerative change on their radiographs, after osteochondroplasty for femoroacetabular impingement (FAI), an improvement in pain and function has been demonstrated at short-term follow-up.[12]

Labral preservation with osteochondroplasty for FAI in a professional sportsperson can lead to a high patient satisfaction rate and prompt return to sports.[13 14] In a 10-year follow-up of 15 athletes, Byrd and Jones[7] reported that 87% returned to sports, but five of these patients required hip replacement at a mean of 6 years. In the general population, arthroscopic management of FAI leads to a good or excellent result in up to 75% of patients at 1 year.[15 16]

However, most studies have been within an athletic population. No studies exist for the non-athlete who, in reality, represents a significant portion of the community. In particular, there is no comparative study looking into the difference in outcome between the athletes and non-athletes. This was an area we considered to be critical to the development of hip arthroscopic surgery and we wished to investigate the issue further. Our null hypothesis was that there is no difference between athletes and non-athletes after arthroscopic labral preservation and osteochondroplasty for FAI.

METHODS

We report the results from a single surgeon's prospective series of patients. We wished to explore the benefits of hip arthroscopic intervention for FAI and associated pathology, with particular attention to the difference in outcome between those who engage in sporting activities (athletes) and those who do not (non-athletes). We have prospectively collected the modified Harris hip score (MHHS), the non-arthritic hip score (NAHS)[17] and a patient satisfaction score using a visual analogue scale (VAS) from 0 (no pain) to 100 (maximum pain). We used previously described techniques to calculate quality-of-life (QoL) scores from the responses from the MHHS.[18 19] The qualitative nature of responses allows them to be translated to Rosser distress (pain) and disability (function) categories (box 1), which can be applied to the Rosser index matrix[20] (table 1) to derive QoL scores. The Rosser index matrix[20] allocates scores from −1.486 to 1.000. A score of 1 indicates complete normality while death is given a score of 0. Negative scores indicate health states thought to be worse than death. The scores were collected immediately preoperatively on the day of surgery and postoperatively at 6 weeks, 6 months and 1 year.

This is a consecutive series of 122 patients with FAI with a minimum follow-up of 1 year. The patients were asked before surgery to declare if they participated in sporting activities or not. We have excluded patients who had surgical indications other than FAI and re-arthroscopies. The diagnosis of FAI was made on the basis of the clinical findings corroborated by the radiographic and MRI imaging. Hip arthroscopy was offered to patients who had symptoms, which were restricting their life style and affecting their day-to-day activities. The surgery was performed in the lateral position with the patient

Box 1 The Rosser index[20]

Disability

I. No disability
II. Slight social disability
III. Severe social disability and/or slight impairment of performance at work
IV. Choice of work or performance at work severely limited
  ▶ Housewives and old people able to do light housework only, but able to go shopping
V. Unable to undertake any paid employment
  ▶ Unable to continue any education
  ▶ Old people confined to home except for escorted outings and short walks and unable to do any shopping
VI. Confined to chair or wheelchair or able to move around in the house only with support from an assistant
VII. Confined to bed
VIII. Unconscious

Distress

A. No distress; B. Mild; C. Moderate; D. Severe.

under general anaesthesia, under image intensifier control and traction. The central compartment was accessed first followed by the peripheral compartment after releasing the traction. Details of the senior author's surgical technique have been described elsewhere.[21] Surgery involved removal of the impingement lesion (femoral and/or acetabular) and, where appropriate, repair of chondral/labral/chondrolabral lesions. This was by microfracture, labral reattachment or chondrolabral repair using either sutures or fibrin adhesive. Labral preservation was the central philosophy in dealing with all the cases. All patients received an identical, standardised physiotherapy regimen in the postoperative period.

STATISTICAL ANALYSIS

The statistical analysis was performed using the SPSS V.15 statistical program (SPSS Inc., Chicago, Illinois, USA). In order to determine whether the data were significantly different from the normal distribution, a Kolmogorov-Smirnov test was used. If $p<0.05$, the data were treated as non-parametric. To compare continuous variables, two sample t-tests were used for parametric data and the Mann-Whitney U test for non-parametric data. All the tests were two tailed and a significance level of $p<0.05$ was maintained throughout. A χ^2 test was used to compare categorical data.

RESULTS

The mean age of the patients at the time of surgery was 35.4 (14–59) years. There were 74 (61%, N=122) male patients, 80 athletes and 42 non-athletes.

Table 2 outlines the demographics of the two groups.

Outcome

The MHHS increased from a mean of 61 (6 to 91) before surgery to a mean of 73 (34 to 91) at 6 months ($p<0.001$) and 80 (42 to 91) at 1 year ($p<0.001$) after surgery. The trend of mean MHHS and the difference between the two groups is depicted in figure 1. The 6-week postoperative score was significantly ($p=0.01$) better for the athletes as compared with non-athletes; however, the 6-month ($p=0.54$) and 1-year ($p=0.30$) scores for both groups were statistically similar.

Table 1 The Rosser index matrix (Gudex and Kind, 1988) showing a quality of life (QoL) score for each disability/distress combination[31]

	Distress			
Disability	**A**	**B**	**C**	**D**
I	1.000	0.995	0.990	0.967
II	0.990	0.986	0.973	0.932
III	0.980	0.972	0.956	0.912
IV	0.964	0.956	0.942	0.870
V	0.946	0.935	0.900	0.700
VI	0.875	0.845	0.680	0.000
VII	0.677	0.564	0.000	−1.486
VIII	−1.028			

The NAHS increased from a mean of 67 (21 to 97) before surgery to 80 (41 to 100) at 6 months ($p<0.001$) and 85 (44 to 100) ($p<0.001$) at 1 year after surgery. The trend of the mean NAHS and the difference between the two groups is depicted in figure 2. The 6-week postoperative score was significantly better ($p=0.04$) for the athletes as compared with non-athletes; however, the 6-month ($p=0.39$) and 1-year ($p=0.79$) scores after surgery for both groups were statistically similar.

The overall patient satisfaction for surgery improved on a VAS (0 to 100) from 74% at 6 weeks to 79% at 6 months and 82% at 1 year after surgery. There was no statistical difference ($p>0.05$) between the two groups at any stage of follow-up.

Quality of life

The QoL scores improved from a mean of 0.961 (0.7 to 1) preoperatively to 0.979 (0.87 to 1) at 6 months ($p<0.001$) and 0.982 (0.9 to 1) at 1 year ($p<0.001$) after surgery. The trend of the mean QoL score and the difference between the two groups is depicted in figure 3. The QoL scores at 6 months ($p=0.77$) and 1 year ($p=0.12$) after surgery for both groups were statistically similar.

DISCUSSION

In a large prospective single-surgeon series of patients, we have shown that the overall outcome (MHHS, NAHS) and QoL improves after arthroscopic intervention for FAI. We have found that the scores for athletes were significantly ($p<0.05$) better than for non-athletes at 6 weeks' follow-up but similar ($p>0.05$) at 6 months and 1 year.

FAI and any associated labral pathology is a common cause of hip discomfort in young adults.[22] It has been blamed on the abnormal axial or torsional forces placed on the hip during high-output athletic activities. Recently, a better understanding of the pathomechanics and morphological abnormalities in the hip has implicated FAI as a possible factor in early osteoarthritis.[23–26] Although the literature is replete with short-term evidence to support surgical treatment, there are currently no long-term prospective data or natural history studies examining the implications of FAI and effects of early intervention.[22] The role of early intervention in preventing the progression of disease[2] and its benefit in an early return to sporting activities has been recognised.[8 27 28] When compared with open surgical

Table 2 Demographics of the two groups

	Athletes	Non-athletes	*p* Value
N	80	42	
Mean age (years)	35.7 (16 to 59)	34.9 (14 to 57)	0.58
Gender (M:F)	50:30	24:18	0.57

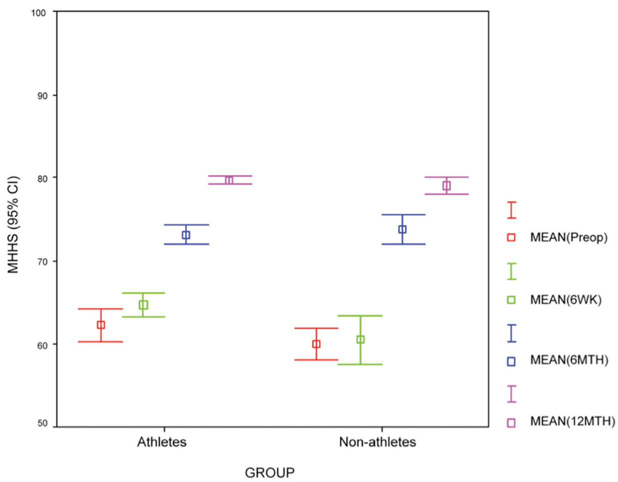

Figure 1 Trend of mean modified Harris hip score (MHHS) and bar graph showing the difference between the two groups. MHHSPreop, preoperative MHHS; MHHS6wk, 6-week postoperative MHHS; MHHS6mth, 6-month postoperative MHHS; MHHS1yr, 1-year postoperative MHHS. This figure is only reproduced in colour in the online version.

dislocation, arthroscopic treatment has a lower complication rate and faster rehabilitation.[29] A descriptive epidemiological study[30] of adults under the age of 50 years presenting with mechanical hip pathology in the French population has revealed that 62% of patients have osteoarthritis of the hip, 70% participate in sports with 30% being high-level athletes. This may not be consistent with other population groups, and possibly is different for the other populations, but is clearly indicative of the fact that the problem is not confined to the athletes. Work to date, however, has not established if the outcome after surgery is better for the athletic population as compared with non-athletes. This was the issue that led to our present study being performed.

We have noted that although the recovery is quicker for the athletes (better scores at 6 weeks), non-athletes have a similar outcome at the 6-month and 1-year follow-up. The physiotherapy regimen for both the groups was identical. The difference in early outcome is perhaps because of the preoperative level of fitness of the two groups.

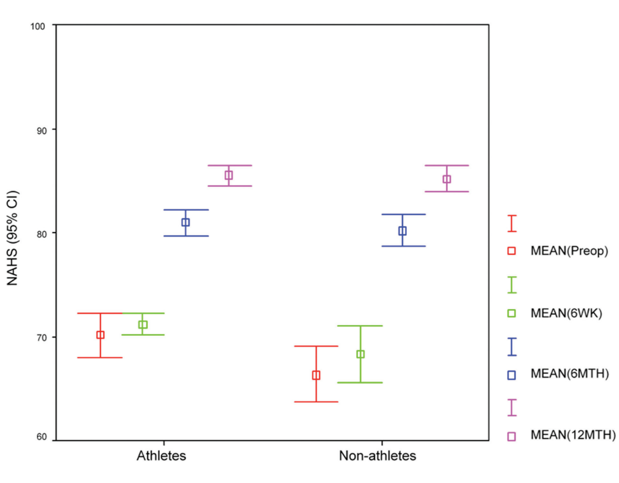

Figure 2 Trend of mean non-arthritic hip score (NAHS) and bar graph showing the difference between the two groups. NAHSPreop, preoperative NAHS; NAHS6wk, 6-week postoperative NAHS; NAHS6mth, 6-month postoperative NAHS; NAHS1yr, 1-year postoperative NAHS. This figure is only reproduced in colour in the online version.

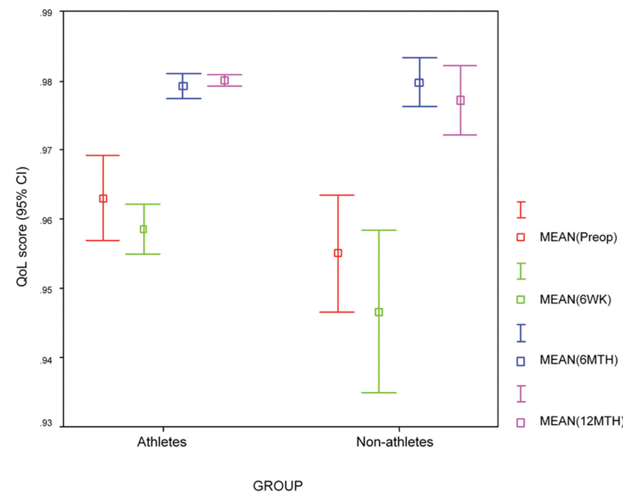

Figure 3 Trend of mean QoL scores and bar graph showing the difference between the two groups. QoLPreop, preoperative QoL score; QoL6mth, 6-month postoperative QoL score; QoL1yr, 1-year postoperative QoL score. This figure is only reproduced in colour in the online version.

Hip arthroscopy with labral preservation and osteochondroplasty improves the QoL of patients with FAI. The functional scores (MHHS, NAHS and QoL scores) continue to improve up to 1 year after surgery. On a VAS from 0 to 100, 82% patient satisfaction was noted at 1 year after hip arthroscopy. We believe this information to be crucial during the consenting process for arthroscopic surgery for FAI.

Our study is limited by a relatively short follow-up of 1 year, but our intention was to compare the trend of recovery during the early phase of rehabilitation between athletes and non-athletes. In addition, this is a single-surgeon series of a high-volume hip arthroscopy surgeon, and may not necessarily reflect the practice of low-volume or less-experienced surgeons.

CONCLUSIONS

In a prospective series of 122 patients comparing athletes and non-athletes, the largest reported to date, we have demonstrated the positive impact of arthroscopic surgery for FAI in both athletes and non-athletes. There was no significant difference in the outcome between these two groups at 6 months and 1 year after surgery although better scores were seen in the athletes during the early period of rehabilitation. However, what is clear as a conclusion is that hip arthroscopic FAI surgery is not solely the domain of the athlete. Non-athletes can do just as well. This finding is critical to the future development and expansion of hip arthroscopic surgery for FAI.

What this study adds

- Only comparative study looking at difference in outcome between athletes and non-athletes.
- Results at 1 year similar in both groups.
- Six-week functional scores better for athletes.

Contributors AM analysed the data and prepared the first draft. GHS analysed the data, did literature search and helped in preparing the final draft. RNV conceived the idea, contributed the cases and approved the final draft.

Competing interest None.

Provenance and peer review Not commissioned; externally peer reviewed.

REFERENCES

1. **McCarthy J,** Barsoum W, Puri L, *et al*. The role of hip arthroscopy in the elite athlete. *Clin Orthop Relat Res* 2003;**416**:71–4.
2. **McCarthy JC,** Lee JA. Arthroscopic intervention in early hip disease. *Clin Orthop Relat Res* 2004;**429**:157–62.
3. **Byrd JW,** Jones KS. Prospective analysis of hip arthroscopy with 2-year follow-up. *Arthroscopy* 2000;**16**:578–87.
4. **Bardakos NV,** Vasconcelos JC, Villar RN. Early outcome of hip arthroscopy for femoroacetabular impingement: the role of femoral osteoplasty in symptomatic improvement. *J Bone Joint Surg Br* 2008;**90**:1570–5.
5. **Larson CM.** Arthroscopic management of pincer-type impingement. *Sports Med Arthrosc* 2010;**18**:100–7.
6. **McCarthy JC,** Busconi B. The role of hip arthroscopy in the diagnosis and treatment of hip disease. *Orthopedics* 1995;**18**:753–6.
7. **Byrd JW,** Jones KS. Hip arthroscopy in athletes: 10-year follow-up. *Am J Sports Med* 2009;**37**:2140–3.
8. **Keogh MJ,** Batt ME. A review of femoroacetabular impingement in athletes. *Sports Med* 2008;**38**:863–78.
9. **Singh PJ,** O'Donnell JM. The outcome of hip arthroscopy in Australian football league players: a review of 27 hips. *Arthroscopy* 2010;**26**:743–9.
10. **Byrd JW,** Jones KS. Hip arthroscopy for labral pathology: prospective analysis with 10-year follow-up. *Arthroscopy* 2009;**25**:365–8.
11. **Ellis HB,** Briggs KK, Philippon MJ. Innovation in hip arthroscopy: is hip arthritis preventable in the athlete? *Br J Sports Med* 2011;**45**:253–8.
12. **Larson CM,** Giveans MR, Taylor M. Does arthroscopic FAI correction improve function with radiographic arthritis? *Clin Orthop Relat Res* 2010;**469**:1667–76.
13. **Philippon MJ,** Weiss DR, Kuppersmith DA, *et al*. Arthroscopic labral repair and treatment of femoroacetabular impingement in professional hockey players. *Am J Sports Med* 2010;**38**:99–104.
14. **Philippon M,** Schenker M, Briggs K, *et al*. Femoroacetabular impingement in 45 professional athletes: associated pathologies and return to sport following arthroscopic decompression. *Knee Surg Sports Traumatol Arthrosc* 2007;**15**:908–14.
15. **Larson CM,** Giveans MR. Arthroscopic management of femoroacetabular impingement: early outcomes measures. *Arthroscopy* 2008;**24**:540–6.
16. **Gedouin JE,** May O, Bonin N, *et al*. Assessment of arthroscopic management of femoroacetabular impingement. A prospective multicenter study. *Orthop Traumatol Surg Res* 2010;**96**(Suppl 8):S59–67.
17. **Christensen CP,** Althausen PL, Mittleman MA, *et al*. The nonarthritic hip score: reliable and validated. *Clin Orthop Relat Res* 2003;**406**:75–83.
18. **Chan CL,** Villar RN. Obesity and quality of life after primary hip arthroplasty. *J Bone Joint Surg Br* 1996;**78**:78–81.
19. **Norman-Taylor FH,** Palmer CR, Villar RN. Quality-of-life improvement compared after hip and knee replacement. *J Bone Joint Surg Br* 1996;**78**:74–7.
20. **Rosser RM,** Watts VC. The measurement of hospital output. *Int J Epidemiol* 1972;**1**:361–8.
21. **Khanduja V,** Villar RN. Arthroscopic surgery of the hip: current concepts and recent advances. *J Bone Joint Surg Br* 2006;**88**:1557–66.
22. **Samora JB,** Ng VY, Ellis TJ. Femoroacetabular impingement: a common cause of hip pain in young adults. *Clin J Sport Med* 2011;**21**:51–6.
23. **Ganz R,** Parvizi J, Beck M, *et al*. Femoroacetabular impingement: a cause for osteoarthritis of the hip. *Clin Orthop Relat Res* 2003;**417**:112–20.
24. **Leunig M,** Beaule PE, Ganz R. The concept of femoroacetabular impingement: current status and future perspectives. *Clin Orthop Relat Res* 2009;**467**:616–22.
25. **Leunig M,** Beck M, Dora C, *et al*. [Femoroacetabular impingement: trigger for the development of coxarthrosis]. *Orthopaedics* 2006;**35**:77–84.
26. **Parvizi J,** Leunig M, Ganz R. Femoroacetabular impingement. *J Am Acad Orthop Surg* 2007;**15**:561–70.
27. **Vaughn ZD,** Safran MR. Arthroscopic femoral osteoplasty/chielectomy for cam-type femoroacetabular impingement in the athlete. *Sports Med Arthrosc* 2010;**18**:90–9.
28. **Bohnsack M,** Lekkos K, Borner CE, *et al*. [Results of hip arthroscopy in sports related groin pain]. *Sportverletz Sportschaden* 2006;**20**:86–90.
29. **Botser IB,** Smith TW Jr., Nasser R, *et al*. Open surgical dislocation versus arthroscopy for femoroacetabular impingement: a comparison of clinical outcomes. *Arthroscopy* 2011;**27**:270–8.
30. **Nogier A,** Bonin N, May O, *et al*. Descriptive epidemiology of mechanical hip pathology in adults under 50years of age. Prospective series of 292 cases: clinical and radiological aspects and physiopathological review. *Orthop Traumatol Surg Res* 2010;**96**:S53–8.
31. **Gudex C,** Kind P. The QALY Toolkit, *University of York: Centre for Health Economics*. 1988. Discussion paper 38.

7.3 Professional versus recreational athletes paper

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SYMPOSIUM: ADVANCED HIP ARTHROSCOPY

Do Professional Athletes Perform Better Than Recreational Athletes After Arthroscopy for Femoroacetabular Impingement?

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Abstract

Background Although a large number of athletes' returns to sports after hip arthroscopic surgery for femoroacetabular impingement (FAI), it is not clear if they do so to the preinjury level and whether professional athletes (PA) are more likely to return to the preinjury level compared with recreational athletes (RA).

Questions/purposes We therefore compared (1) the time taken to return to the preinjury level of sport between professional and recreational athletes; (2) the degree of improvement in time spent in training and competitive activities after arthroscopic surgery for FAI; and (3) the difference in trend of improvement in hip scores.

Methods We prospectively followed 80 athletes (PA = 40, RA = 40; mean age, 35.7 years; males = 50, females = 30; mean followup, 1.4 years; range, 1–1.8 years) who underwent hip arthroscopy for FAI. We measured the time to return to sports; training time and time in competition; and the modified Harris hip score and the nonarthritic hip score.

Results There was a 2.6-fold improvement in the training time (from 7.8 to 20 hours per week) and a 3.2-fold increase in time in competition (from 2.5 to 7.9 hours per week) 1 year after surgery. The mean time to return to sporting activities was 5.4 months, which was lower for PA (4.2) as compared with RA (6.8). Eighty-two percent (66) (PA = 88% [35] versus RA = 73% [29]) returned to their preinjury level of sport within 1 year of surgery.

Conclusions The data suggest PA may show quicker return to sports than RA but the hip scores and rate of return to sports are similar.

Level of Evidence Level IV, therapeutic study. See Guidelines for Authors for a complete description of levels of evidence.

Each author certifies that he or she, or a member of his or her immediate family, has no funding or commercial associations (eg, consultancies, stock ownership, equity interest, patent/licensing arrangements, etc) that might pose a conflict of interest in connection with the submitted article.
All ICMJE Conflict of Interest Forms for authors and *Clinical Orthopaedics and Related Research* editors and board members are on file with the publication and can be viewed on request.
Each author certifies that his or her institution approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.
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Introduction

Hip arthroscopy is an established intervention for the treatment of hip disorders in the sporting and general population [1, 2, 6, 9, 15, 17, 21–23, 27]. Labral repair with osteochondroplasty for femoroacetabular impingement (FAI) in a professional sportsperson can lead to a high patient satisfaction rate and prompt return to sports [1, 10, 25, 26]. In the general population, arthroscopic management of FAI leads to pain and preoperative scores in

75% to 77% of patients at 1 year [14, 18, 20]. Botser et al. [4] in a review comparing arthroscopy with open surgical dislocation and a combined approach for FAI found consistent improvement in modified Harris hip score (mHHS) for all with a lower complication rate and higher return to sports for professional athletes with the arthroscopic approach. The arthroscopic approach has the benefit of less soft tissue damage leading to quicker rehabilitation and also is safer for the patients [4]. Even in patients with milder degrees of preoperative degenerative change on their radiographs, after osteochondroplasty for FAI, an improvement in pain and function has been demonstrated at followup from 12 to 60 months [19]. An acetabular labral tear is described as the most common pathology for which hip arthroscopy may be indicated and selective débridement of these tears leads to improvement in HHS at 10 years in 83% of patients without associated arthritis [8]. Although there is no evidence surgery prevents osteoarthritis, Ellis et al. in a review conclude that by resolving bony impingement, prevention of further labral and chondral damage is possible, and the progression of osteoarthritis may be delayed [13]. Most studies of the sporting population have been retrospective in nature or in a small series of patients ranging from 10 to 45 patients [21, 24–27, 29]. Furthermore, when it is reported that a patient has returned to sport after surgery, what does this mean? Does this imply a return to sport in general or a return to preinjury levels of activity? The latter is clearly important. Objective criteria like time spent in training and competition would directly indicate if the pain limits the duration of time these patients can spend in high-output activity and therefore will be one way to measure this. It is also unknown if there is a difference in the rate of return to the same level of sports, hip scores, and satisfaction scores between individuals engaged in competitive sports (professional athletes) as compared with recreational sports (recreational athletes).

We therefore determined (1) the time taken to return to the preinjury level of sport; (2) the degree of improvement in time spent in training and competitive activities after arthroscopic surgery for FAI; and (3) the difference in trend of improvement in hip scores between professional and recreational athletes.

Patients and Methods

We prospectively followed all 80 athletes who underwent arthroscopy for FAI from November 2009 to August 2010. The indications for arthroscopy for the cohort of patients included in the study were (1) pain and limitation of activity; (2) positive impingement test; and (3) radiographically proven impingement lesion (cam, pincer, or both). We did not perform arthroscopy in patients with unrestricted activity. We excluded six patients with Tönnis 2 or 3 osteoarthritis treated during the study time. All patients were asked to complete a sports module questionnaire (Fig. 1), which required them to declare before surgery if they actively engaged in sporting activities or not and the level at which they participated. We defined the patients as professional athletes (PAs; n = 40), which included those who engage in competitive sports representing their country, region, or local club, and recreational athletes (RAs; n = 40) who were involved only in recreational sports. The mean age of the patients at the time of surgery was 35.7 years (range, 14–59 years). There were 50 (63% [N = 80]) males. Of the 40 PA patients, six (7%) represented their country, 11 (14%) their region, and 23 (29%) their club. The type of sporting activity varied widely (Fig. 2). Bilateral symptoms were present in 12 patients (15%). Forty-six patients (58%) had presented primarily because their hip pain was restricting their sporting activities. The responses to the sports questionnaire are included in Figure 1. Patients felt that their performance at the time of presentation was reduced to a mean of 50% (0%–80%) of their usual activity before the beginning of symptoms. The PA participated in a mean of 31 events/year (range, 0–64 events/year) before the onset of symptoms and had to miss a mean of 52% (0%–100%) of events because of their hip symptoms. There were 75 (94%) patients who had to reduce their exposure to sports before surgery and 51 (64%) who had modified their style in sport to accommodate their hip condition. For eight patients (10%), sport was their only source of income, whereas for four patients (5%), sport was an additional source of income. No patients were lost to followup. The minimum followup was 1 year (mean, 1.4 years; range, 1–1.8 years). No patients were recalled specifically for this study; all data were obtained from medical records.

Power analysis revealed that to detect a difference in the mean mHHS [7] or nonarthritic hip score (NAHS) [11] of five points with a SD of 5 for a 90% power with p value set at 0.05, 22 patients would be required in each group. A change 7 to 10 points has been suggested to show a minimum clinically important difference in hip scores [3, 12]. We chose a value of 5 to improve the robustness of the analyses.

The two groups were comparable by all preoperative measures (Table 1). There was no statistical difference between the two groups in terms of age, sex, or preoperative alpha angle.

The senior author (RNV) assessed all the patients and those who had a positive impingement sign and MRI-proven impingement lesion were counseled for surgery. Those who had progressively increasing pain affecting the quality of life despite a trial of nonoperative treatment underwent surgery. The senior author directly performed all the procedures. The surgery was performed in the lateral

Fig. 1 Sports module questionnaire relating to the impact of the hip problem on the preferred sport. If someone played more than one sport, patients were requested to answer with respect to the activity that was most important to them.

Please record *the one* sport which is most important to you: ____________.

1. Does your hip condition involve one or both hips?	12(15%) bilateral
2. Is the impact of the hip on your sport the main reason why you saw an orthopaedic surgeon?	Yes = 46 (58%)
3. With 100% being your performance the day before symptoms began, at what percentage would you presently rate yourself?	Mean = 50(0-80%)
4. Is your sport a source of income? (Options: ***A: only source. B: additional source. C: no income received***)	A = 8(10%) B = 4(5%) C = 68(85%)
5. What is your level of competition? (Options: ***A: representing country. B: representing region, e.g. county(ies)/state(s). C: representing local club. D: no affiliation***)	A = 6(7%) B = 11(14%) C = 23(29%) D = 40(50%)
6. How many hours per week did you *train* for your sport in the last 3 months?	7.8 hours (mean)
7. How many hours per week did you *compete* in your sport in the last 3 months?	2.5 hours (mean)
8. How many competitive events were you attending per year before hip symptoms started?	31 (0-64)
9. What percentage of the competitions you had planned for this year have you missed as a result of your hip condition?	Mean = 52(0-100)%
10. Have you stopped or reduced exposure to your sport because of your hip condition?	Yes = 75(94%)
11. Have you changed your style in your sport to accommodate your hip condition?	Yes = 51(64%)

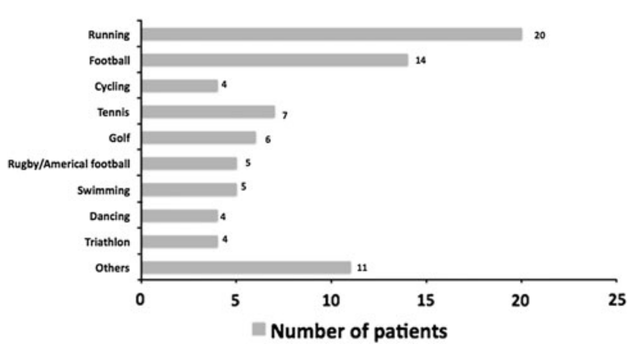

Fig. 2 Bar chart depicting the type of sporting activity most important to the patients. Others included badminton, basketball, boxing, cricket, handball, hockey, martial arts, skiing, squash, table tennis, and volleyball.

position with the patient under general anesthesia under image intensifier control and traction. The central compartment was accessed first followed by the peripheral compartment after releasing the traction. Details of the senior author's surgical technique have been described elsewhere [16]. Surgery involved removal of the impingement lesion (femoral and/or acetabular) and, where appropriate, repair of chondral/labral/chondrolabral lesions. This was by microfracture, labral reattachment, or chondrolabral repair using either sutures or fibrin adhesive. The procedures were similar in both groups (Table 1). Labral preservation was the central philosophy in dealing with all the cases.

All patients received an identical, standardized physiotherapy regimen in the postoperative period. The patients

Table 1. Comparison of the two groups

Parameters	Professional athletes	Recreational athletes	p value
Number	40	40	
Mean age (years)	36 (range, 16–59)	35 (range, 14–57)	0.58
Sex (male:female)	26:14	24:16	0.57
Alpha angle	60° (range, 48°–66°)	59° (range, 49°–65°)	0.48
Tönnis grade			
0	23	25	0.47
1	13	11	0.47
2	4	4	0.93
3	0	0	
Surgical procedure			
Cam lesion	39	37	0.85
Pincer lesion	8	8	0.62
Microfracture	6	8	0.91
Labral fixation	11	9	0.67

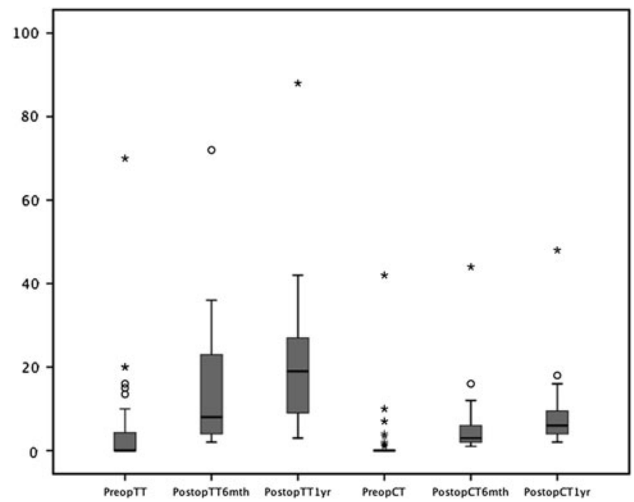

Fig. 3 Box plot (data within 95% CI) showing the change in training time (hours per week) and the time spent in competition (hours per week). PreopTT = preoperative training time; PostopTT6mth = postoperative training time (6 months); PostopTT1yr = postoperative training time (1 year); PreopCT = preoperative competition time; PostopCT6mth = postoperative competition time (6 months); PostopCT1yr = postoperative competition time (1 year). The central line is a measure of median; a minor outlier (denoted by a "o") is an observation 1.5 × interquartile range (IQR) outside the central box; a major outlier (denoted by an asterisk) is an observation 3.0 × IQR outside the central box.

were asked to partially weightbear for the first 4 weeks with the help of crutches. Formal physiotherapy was started 1 week after surgery and continued for a period of 4 months after surgery using a documented rehabilitation plan.

The patients were followed up at 6 weeks, 3 months, 1 year, and annually thereafter. We prospectively collected the mHHS and the NAHS. The scores were collected immediately preoperatively on the day of surgery and at each followup visit. The sports module questionnaire included information on the training time (in hours per week) and also competitive activity (hours per week).

To determine whether the data normally distributed, we used a Kolmogorov-Smirnov test. If $p < 0.05$, the data were treated as nonparametric. To compare the training time, time in competition, mHHS, and NAHS, we used two-sample t-tests for parametric data and the Mann-Whitney U test for nonparametric data. All the tests were two-tailed. A chi-square test was used to compare the number of patients returning to sporting activities in the two groups. The statistical analysis was performed using the SPSS Version 15 statistical program (SPSS Inc, Chicago, IL, USA).

Results

The mean time to return to sporting activities was 5.4 months (range, 3–10 months) for the entire group. This was lower ($p = 0.03$) for PA (4.2 months) compared with RA (6.8 months). At 6 months followup, 57 (72%) had returned to their preferred sporting activity. This tended to be higher ($p = 0.21$) in PA (31 of 40 [78%]) as compared with RA (26 of 40 [65%]). At 1-year followup, 66 (82% [N = 80]) had returned to their preferred sporting activity. This again tended to be higher ($p = 0.09$) in PA (35 of 40 [88%]) as compared with RA (29 of 40 [73%]).

There was a 2.6-fold improvement in the training time after surgery and a 3.2-fold increase in the time in competition 1 year after surgery. For the entire study group, there was an improvement in the training time (hours per week) from a mean of 7.8 hours before surgery to 16 hours 6 months after surgery ($p < 0.001$) and 20 hours 1 year after surgery ($p < 0.001$) (Fig. 3). An improvement in the time in competition was also noted from a mean of 2.5 hours before surgery to 5.2 hours 6 months after surgery ($p = 0.02$) and 7.9 hours 1 year after surgery ($p < 0.001$). We did not find any sex difference in the training time and time in competition both before and after surgery.

The mHHS increased from a mean of 61 before surgery to a mean of 73 at 6 months ($p < 0.001$) and 84 at 1 year ($p < 0.001$) after surgery. Similarly, the NAHS increased from a mean of 68 before surgery to 79 at 6 months ($p < 0.001$) and 88 ($p < 0.001$) at 1 year after surgery. We found no difference between the two groups in terms of the change of mHHS at 6 months (PA = 12.8, RA = 11.7; $p = 0.38$) and 1 year (PA = 22.6, RA = 23.4; $p = 0.23$) and also the NAHS at 6 months (PA = 11.3, RA = 10.7; $p = 0.42$) and 1 year (PA = 20.2, RA = 19.8; $p = 0.46$).

Discussion

Hip arthroscopic treatment of FAI leads to a high patient satisfaction rate and return to sports [1, 2, 6, 9, 15, 17, 21–23, 25–27] with improvement in pain and preoperative scores in up to 75% of patients at 1 year [14, 18, 20]. Most studies of the sporting population have been retrospective in nature or in a small series of patients and do not report objective criteria to assess their level of activity. It is not clear to what extent these patients improve and whether they are able to return to their preinjury level of sports. The motivation to return to sports is multifactorial and the evidence is limited to show if this is expected to be different for athletes in competitive sports as compared with those who do it just as a hobby. In our cohort of athletes undergoing hip arthroscopic intervention for FAI, we questioned if training time and time in competition improve after surgery and whether the hip scores and time to return to preinjury level of sports were different for PA as compared with RA.

We acknowledge limitations to our study. First, the patient population may be biased by the tertiary referral pattern of the service. We cannot ensure these findings would apply to all athletes, although it is a relatively large cohort. Second, we have a relatively short-term followup, but it is expected that the majority of improvement in pain and hip scores would occur during the first year of surgery. Third, we had no control group in which patients received no treatment or where patients were treated using an open surgical dislocation; however, Botser et al. [4], in a review of the literature on patients having treatment for FAI, suggested those with hip arthroscopy alone had similar or better improvement than those having open approaches. Fourth, the measurement of training time and time in competition has not been described or validated, but we believe this is the only objective way to measure a change in the extent to which these patients can be involved in sporting activities. We have also deliberately not elected to contrast the two groups in terms of training time and time in competition because it would have been an unfair comparison because of the different level of sports between the two groups. Fifth, the patients in this study group engaged in a wide variety of sports with their different intensities, but we believe that using the total time for these in terms of training time and time in competition would control for this limitation.

The mean time to return to the preinjury level of sporting activities in this study was 5.4 months with 82% having returned to sports by 1 year. In a recent systematic review of patients with FAI in athletes considering open surgical dislocation apart from hip arthroscopic intervention, rate of return to sports was 92% with 88% returning to the preinjury level of sports [1]. Philippon et al. [26] reported a high patient satisfaction rate with a return to sports at a mean of 3.4 months (Table 2). In a separate report on 45 professional athletes, Philippon et al. [25] also found that 78% remained in active professional sport at a mean of 1.6 years after surgery. In contrast, Nho et al. [24] reported a mean time to return to sports of 9.4 months. Singh and O'Donnell, in a series of 24 Australian Football League players who underwent arthroscopic treatment for various hip abnormalities, reported that the improved function was maintained for up to 4 years followup [27]. In a 10-year followup of 15 athletes, Byrd and Jones reported that 87% returned to sports, but five of these patients required hip arthroplasty at a mean of 6 years [9].

At 1 year after surgery, we found a 2.6-fold improvement in the training time after surgery and a 3.2-fold increase in the time in competition. We could not find comparative data in the literature looking into these parameters. Using a sports frequency score (SFS) to look at the rate and level of sporting activities after hip arthroscopic intervention for FAI, Brunner et al. [28] reported an increase of the SFS from 0.78 to 1.84 at a mean of 2.4 years after surgery in a series of

Table 2. Review of literature on return to sports

Author	Number	Followup	Return to sports	Time to return to sports (months)
Byrd and Jones, 2011 [10]	200	19 (12–60) months	95% of professional athletes and 85% of intercollegiate athletes	
Nho et al., 2011 [24]	33	27 months	79%	9.4
Philippon et al., 2010 [26]	28	24 (12–42) months	100%	3.8
Singh and O'Donnell, 2010 [27]	24	22 (6–60) months	96%	
Brunner et al., 2009 [5]	53	2.4 (2–3.2) years	69%	
Byrd and Jones, 2009 [9]	15	10 years	87%	
Philippon et al., 2007 [25]	45	1.6 years (6 month to 5.5 years)	78%	
Current study	80	1.4 (1–1.8) years	83%	5.4

Ranges shown in parentheses.

53 patients [5]. The SFS graded patients as per their level of sporting activities from Grade 0 (no sports) to Grade 4 (professional level of activity, elite athlete). Philippon et al. [26] attempted to quantify activities using the number of games played after surgery.

We found the mHHS and NAHS continued to improve 1 year after surgery but found no difference in these outcome measures between the PA and RA. The proportion of athletes that returned to preinjury level of sports was also similar in the two groups, although we did notice that a higher proportion of PA returned to sporting activities as compared with RA (78% versus 65% at 6 months and 88% versus 73% at 1 year). This finding is similar to that of Byrd and Jones [10] who reported 95% of PA return to their previous level of competition as compared with 85% of intercollegiate athletes. Alradwan et al. [1] in a systematic review found a return to preinjury level of sports of 92% for PA as compared with 84% for RA. The return to sports was quicker for PA (4.2 months) as compared with RA (6.8 months). This may be secondary to motivational or fitness issues because all our patients received an identical postoperative rehabilitation protocol. This information can be useful in an informed consenting process to explain the prognosis and expected recovery.

In a prospective series of 80 athletes, we demonstrated the majority of the athletes (72%) return to sports within 6 months of arthroscopic surgery for FAI, increasing to 82% at 1 year. The duration of time that athletes are able to engage in training and competitive sports shows a threefold improvement after arthroscopic surgery for FAI. There is a trend that suggests PA and RA have similar improvement in mHHS and NAHS and ability to return to their preinjury level of sports, although the PA may return to sports sooner than RA.

References

1. Alradwan H, Philippon MJ, Farrokhyar F, Chu R, Whelan D, Bhandari M, Ayeni OR. Return to preinjury activity levels after surgical management of femoroacetabular impingement in athletes. *Arthroscopy.* 2012;28:1567–1576.
2. Bardakos NV, Vasconcelos JC, Villar RN. Early outcome of hip arthroscopy for femoroacetabular impingement: the role of femoral osteoplasty in symptomatic improvement. *J Bone Joint Surg Br.* 2008;90:1570–1575.
3. Beaton DE. Simple as possible? Or too simple? Possible limits to the universality of the one half standard deviation. *Med Care.* 2003;41:593–596.
4. Botser IB, Smith TW Jr, Nasser R, Domb BG. Open surgical dislocation versus arthroscopy for femoroacetabular impingement: a comparison of clinical outcomes. *Arthroscopy.* 2011;27:270–278.
5. Brunner A, Horisberger M, Herzog RF. Sports and recreation activity of patients with femoroacetabular impingement before and after arthroscopic osteoplasty. *Am J Sports Med.* 2009;37: 917–922.
6. Byrd JW, Jones KS. Prospective analysis of hip arthroscopy with 2-year follow-up. *Arthroscopy.* 2000;16:578–587.
7. Byrd JW, Jones KS. Hip arthroscopy in the presence of dysplasia. *Arthroscopy.* 2003;19:1055–1060.
8. Byrd JW, Jones KS. Hip arthroscopy for labral pathology: prospective analysis with 10-year follow-up. *Arthroscopy.* 2009;25: 365–368.
9. Byrd JW, Jones KS. Hip arthroscopy in athletes: 10-year follow-up. *Am J Sports Med.* 2009;37:2140–2143.
10. Byrd JW, Jones KS. Arthroscopic management of femoroacetabular impingement in athletes. *Am J Sports Med.* 2011;39(Suppl): 7S–13S.
11. Christensen CP, Althausen PL, Mittleman MA, Lee JA, McCarthy JC. The nonarthritic hip score: reliable and validated. *Clin Orthop Relat Res.* 2003;406:75–83.
12. Costa ML, Achten J, Parsons NR, Edlin RP, Foguet P, Prakash U, Griffin DR. Total hip arthroplasty versus resurfacing arthroplasty in the treatment of patients with arthritis of the hip joint: single centre, parallel group, assessor blinded, randomised controlled trial. *BMJ.* 2012;344:e2147.
13. Ellis HB, Briggs KK, Philippon MJ. Innovation in hip arthroscopy: is hip arthritis preventable in the athlete? *Br J Sports Med.* 2011;45:253–258.
14. Gedouin JE, May O, Bonin N, Nogier A, Boyer T, Sadri H, Villar RN, Laude F. Assessment of arthroscopic management of femoroacetabular impingement. A prospective multicenter study. *Orthop Traumatol Surg Res.* 2010;96(Suppl):S59–67.
15. Keogh MJ, Batt ME. A review of femoroacetabular impingement in athletes. *Sports Med.* 2008;38:863–878.
16. Khanduja V, Villar RN. Arthroscopic surgery of the hip: current concepts and recent advances. *J Bone Joint Surg Br.* 2006;88: 1557–1566.
17. Larson CM. Arthroscopic management of pincer-type impingement. *Sports Med Arthrosc.* 2010;18:100–107.
18. Larson CM, Giveans MR. Arthroscopic management of femoroacetabular impingement: early outcomes measures. *Arthroscopy.* 2008;24:540–546.
19. Larson CM, Giveans MR, Taylor M. Does arthroscopic FAI correction improve function with radiographic arthritis? *Clin Orthop Relat Res.* 2011;469:1667–1676.
20. Malviya A, Stafford GH, Villar RN. Impact of arthroscopy of the hip for femoroacetabular impingement on quality of life at a mean follow-up of 3.2 years. *J Bone Joint Surg Br.* 2012;94:466–470.
21. McCarthy J, Barsoum W, Puri L, Lee JA, Murphy S, Cooke P. The role of hip arthroscopy in the elite athlete. *Clin Orthop Relat Res.* 2003;406:71–74.
22. McCarthy JC, Busconi B. The role of hip arthroscopy in the diagnosis and treatment of hip disease. *Orthopedics.* 1995;18: 753–756.
23. McCarthy JC, Lee JA. Arthroscopic intervention in early hip disease. *Clin Orthop Relat Res.* 2004;429:157–162.
24. Nho SJ, Magennis EM, Singh CK, Kelly BT. Outcomes after the arthroscopic treatment of femoroacetabular impingement in a mixed group of high-level athletes. *Am J Sports Med.* 2011; 39(Suppl):14S–19S.
25. Philippon M, Schenker M, Briggs K, Kuppersmith D. Femoroacetabular impingement in 45 professional athletes: associated pathologies and return to sport following arthroscopic decompression. *Knee Surg Sports Traumatol Arthrosc.* 2007;15:908–914.
26. Philippon MJ, Weiss DR, Kuppersmith DA, Briggs KK, Hay CJ. Arthroscopic labral repair and treatment of femoroacetabular impingement in professional hockey players. *Am J Sports Med.* 2010;38:99–104.
27. Singh PJ, O'Donnell JM. The outcome of hip arthroscopy in Australian football league players: a review of 27 hips. *Arthroscopy.* 2010;26:743–749.

28. Valderrabano V, Pagenstert G, Horisberger M, Knupp M, Hintermann B. Sports and recreation activity of ankle arthritis patients before and after total ankle replacement. *Am J Sports Med.* 2006;34:993–999.

29. Vaughn ZD, Safran MR. Arthroscopic femoral osteoplasty/chielectomy for cam-type femoroacetabular impingement in the athlete. *Sports Med Arthrosc.* 2010;18:90–99.

7.4 Complications and survival analyses

Complications and Survival Analyses of Hip Arthroscopies Performed in the National Health Service in England: A Review of 6,395 Cases

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Purpose: Our study aimed to identify the complications of hip arthroscopies with particular emphasis on the 30-day readmission rate; 90-day deep vein thrombosis (DVT) and pulmonary embolism (PE) rate and mortality rate; revision hip arthroscopy rate; and in particular, survivorship with conversion to total hip replacement (THR) as the endpoint. **Methods:** The records of patients undergoing hip arthroscopy were extracted from the administrative hospital admissions database covering all admissions to the National Health Service hospitals in England using ICD-10 (*International Statistical Classification of Diseases and Related Health Problems, 10th Revision*) and OPCS-4 (Office of Population Censuses and Surveys Classification of Surgical Operations and Procedures, fourth revision) codes. **Results:** A total of 6,395 hip arthroscopies were included in the study period. The 30-day readmission rate was 0.5%; both the 90-day DVT rate and PE rate were 0.08%; and the 90-day mortality rate was 0.02%. THR was performed in 680 patients (10.6%) at a mean of 1.4 years after the index operation, and 286 patients (4.5%) underwent revision hip arthroscopy at a mean of 1.7 years. Kaplan-Meier survival analysis showed an 8-year survival rate of 82.6% (95% confidence interval [CI], 80.9% to 84.2%), whereas Cox proportional hazard analysis adjusting for age, gender, and Charlson comorbidity score showed an 8-year survival rate of 86%. Female patients had a 1.68 times (95% CI, 1.41 to 2.01) higher risk of conversion to THR than male patients, and patients aged 50 years or older had a 4.65 (95% CI, 3.93 to 5.49) times higher risk of requiring hip replacement than patients younger than 50 years. **Conclusions:** In this large series of 6,395 hip arthroscopies looking at the national data from the English National Health Service, our null hypothesis has been supported, and we have determined that the rate of short-term complications, in particular the risk of DVT and PE after this operation, is low. Higher age and female gender are significant predictors of conversion to THR, with Cox proportional hazard analyses showing a survivorship rate of 86% at 8 years after adjustment for confounding variables. **Level of Evidence:** Level IV, therapeutic case series.

Hip arthroscopic surgery is a safe and less invasive alternative for the diagnosis and treatment of several hip disorders compared with conventional open surgery.[1-3] The technique, however, continues to remain challenging and demands considerable surgical experience.[4,5] Although the evidence related to hip arthroscopy continues to expand, there is still a general lack of long-term longitudinal studies[6] and those that are published predate the era of arthroscopic impingement surgery.[7-10] Cost-effectiveness analyses have shown that alteration of the natural history of arthritis by hip arthroscopy would lead to substantial cost saving if total hip replacement (THR) was not performed until at least 16 years after hip arthroscopy.[11] However, there is no robust evidence regarding whether hip arthroscopy can delay conversion to THR.

The procedure is typically performed as a day case, although data on length of stay and readmission rate

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are sparse in contemporaneous literature. A low incidence of thromboembolic events has been reported[12]; however, the lack of clear guidelines on the use of prophylactic agents in patients undergoing hip arthroscopy has been identified, and with surgical time exceeding 1 hour on a regular basis, the risk of thromboembolic events may be higher.[13,14] Although the mortality rate is expected to be low in this group of young patients, mortality data are not available and may be important in the current climate of open communication about surgeon-level mortality figures.

Our study aimed to identify the complications of hip arthroscopies with particular emphasis on the 30-day readmission rate; 90-day deep vein thrombosis (DVT) and pulmonary embolism (PE) rate and mortality rate; revision hip arthroscopy rate; and in particular, survivorship with conversion to THR as the endpoint. Our null hypothesis was that the short-term complication rates after hip arthroscopy are low.

Methods

We extracted records of patients undergoing hip arthroscopy from the administrative hospital admissions database (Hospital Episode Statistics). The Hospital Episode Statistics database covers all admissions to English hospitals providing care for National Health Service (NHS) patients and includes diagnosis (coded using ICD-10 [*International Statistical Classification of Diseases and Related Health Problems, 10th Revision*] codes) and surgical procedure fields (coded using OPCS-4 [Office of Population Censuses and Surveys Classification of Surgical Operations and Procedures, fourth revision] codes). Patients are identified and linked by the Information Centre for Health and Social Care. In this way, independent data analysis providers have no access to patient identifiable information. Institutional review board approval was therefore not required for this study. Demographic data on age and gender were recorded. The data related to comorbidities were quite comprehensive and included hypertension, atrial fibrillation, ischemic heart disease, hypothyroidism/hyperthyroidism, diabetes, chronic obstructive pulmonary disease, psoriatic arthropathy, rheumatoid arthritis, peripheral vascular disease, and history of DVT/PE. The Charlson Comorbidity Index score, representing comorbidity-adjusted life expectancy, was also recorded for all the patients.[15] This index predicts the long-term prognosis of patients with comorbidities. It is a point-scoring system with scores ranging from 0 to 40 calculated from age and associated comorbidities. The cumulative score for comorbidities is calculated, and 1 point is added for every 10 years above the age of 40 years. This scoring system has been validated for age-adjusted patient mortality based on comorbidities.

Table 1. Demographic Data

	Data
Total	6,395
Mean age, yr (range)	38 (11-83)
Gender, n	
Male	2,381
Female	4,014
Median follow-up period, yr (range)	2.4 (0.5-8.2)
Charlson score, n (%)	
0	5,685 (88.9)
1	649 (10.1)
2	54 (0.8)
≥3	7 (0.2)

Data obtained regarding complications included inpatient 90-day DVT and PE rates, 90-day hospital mortality rate, chest infection, 30-day readmission rate, revision hip arthroscopy rate, and rate of conversion to THR. From the data obtained, the time to conversion to THR was calculated from the date of the initial arthroscopic procedure until the date of arthroplasty.

Descriptive statistical analysis was performed using Microsoft Excel (Microsoft, Redmond, WA). Kaplan-Meier survival analysis was performed using IBM SPSS software (version 19.0; IBM, Armonk, NY), with THR as the common endpoint. Furthermore, Cox proportional hazard analysis adjusting for age, gender, and Charlson Comorbidity Index was performed to emphasize the effect of these 3 variables on survival. The α level was set to .05, with $P \leq .05$ considered significant. Logistic regression analysis was performed with conversion to THR as the dependent variable and age, gender, and Charlson Comorbidity Index as the independent variables.

Results

A total of 6,395 hip arthroscopies performed in the English NHS from April 1, 2005, to January 31, 2013, were included in the study from a total of 7,280 procedures. Patients with incomplete datasets were excluded. Bilateral cases were treated as individual episodes. Table 1 shows the demographic data. The mean age of the patients was 38 years (range, 11 to 83 years); the majority of patients were female patients (2,381 male patients *v* 4,014 patients), with a male-female ratio of 1:1.7. The median follow-up period was 2.4 years (range, 0.5 to 8.2 years).

Comorbidities and Charlson Score

The most common comorbidity found among patients was hypertension (4.7%), followed by diabetes and hypothyroidism (1.7% each); 0.5% of patients had ischemic heart disease, whereas the incidences of chronic obstructive pulmonary disease and atrial fibrillation were 0.4% and 0.2%, respectively. The Charlson Comorbidity Index score was 0 in 88.9% of

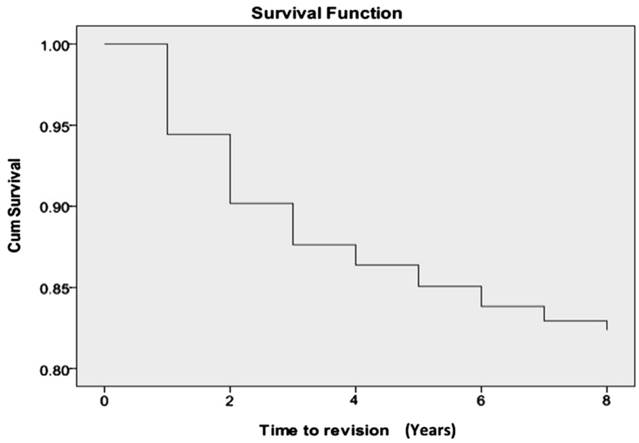


Fig 1. Kaplan-Meier survival analysis of the whole group showing the cumulative survival rate over a period of 8 years of 82.6% (95% confidence interval, 80.9% to 84.2%). The x-axis shows the time to revision in years, and the y-axis shows cumulative (Cum) survival.

patients (n = 5,685), 1 in 10.1% (n = 649), and 2 in 0.8% (n = 54), whereas the remaining patients had a score of 3 or more (n = 7). The mean Charlson score was 1.2 (range, 0 to 8), confirming that most patients undergoing hip arthroscopy are healthy with little or no comorbidity.

Length of Stay and 30-Day Readmission Rate

The mean length of stay was 0.88 days (median, 1 day), with 36.3% of patients (n = 2,324) going home the same day and 51.7% (n = 3,307) going home on day 1. The 30-day readmission rate was 0.5% (n = 32); in 0.22% of admissions (n = 14), the patients were admitted for wound-related reasons, of whom 4 (0.06%) required surgery, and 0.19% (n = 12) were admitted for pain.

Ninety-Day DVT and PE Rates and 90-Day Mortality Rate

Both the 90-day DVT and PE rates were 0.08% (n = 5). None of the patients who were admitted for a DVT within 90 days went on to have PE development in the hospital. Among those in whom DVT developed within 90 days, none progressed to having a PE or were readmitted. The 90-day inpatient mortality rate was 0.02% (n = 1). The mean Charlson Comorbidity Index score for the cohort was 0.12 (median, 0).

Revision Hip Arthroscopy

Revision hip arthroscopy was performed in 286 patients (4.5%) at a mean of 1.7 years (range, 3 days to 7.3 years). Revision hip arthroscopy was performed in 4 patients (0.06%) within 1 month of the index procedure, the indication for which could not be determined from the data available.

Conversion Rate to THR and Survival Analysis With Hip Replacement as Endpoint

THR was performed in 680 patients (10.6%) at a mean of 1.4 years after the index operation. The mean age of the patients who underwent THR (48 years) was significantly ($P < .001$) higher than that of the patients who did not undergo THR (36.7 years).

Kaplan-Meier survival analysis with conversion to THR considered a "failure" showed that at 8 years, 82.6% of patients (95% confidence interval [CI], 80.9% to 84.2%) did not require hip replacement (Fig 1). The life-table analysis is depicted in Table 2.

With gender taken into account, the survival analysis showed an 8-year survival rate of 87% (95% CI, 84.6% to 89.5%) for male patients versus 80% (95% CI, 77.8% to 82.2%) for female patients (Fig 2). Thus female patients are more likely to need hip replacement than male patients (12.4% of females patients *v* 7.3% of male patients, $P < .001$).

When adjusted for age, there was a negative relation between age and survival with THR as the failure point (Fig 3). Age-based analysis was performed by dividing patients into 4 age groups (<25 years, 25 to 49 years, 50 to 75 years, and >75 years). It showed that the younger the patient, the better the survival rate (and vice versa). Patients younger than 25 years had a survival rate of 94.3% (95% CI, 91.3% to 97.3%) over a period of 8

Table 2. Life Table With Hip Replacement as Endpoint

Interval Start Time	No. of Patients Entering Interval	No. of Terminal Events	Proportion Terminating	Proportion Surviving	Cumulative Proportion Surviving at End of Interval	SE of Cumulative Proportion Surviving at End of Interval
0 yr	6,395	319	0.06	0.94	0.94	0.00
1 yr	4,826	194	0.05	0.95	0.90	0.00
2 yr	3,594	88	0.03	0.97	0.88	0.00
3 yr	2,554	31	0.01	0.99	0.86	0.01
4 yr	1,742	22	0.02	0.98	0.85	0.01
5 yr	1,134	13	0.01	0.99	0.84	0.01
6 yr	641	5	0.01	0.99	0.83	0.01
7 yr	295	1	0.01	0.99	0.82	0.01

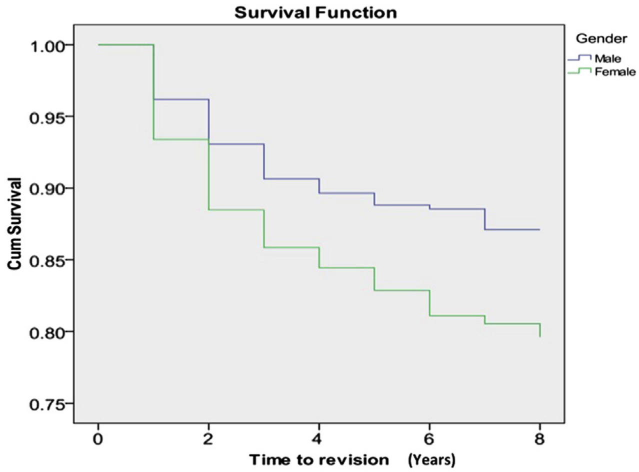


Fig 2. Kaplan-Meier survival analysis showing a higher cumulative survival rate over a period of 8 years of 87% (95% confidence interval, 84.6% to 89.5%) for male patients versus 80% (95% confidence interval, 77.8% to 82.2%) for female patients. The x-axis shows the time to revision in years, and the y-axis shows cumulative (Cum) survival.

years (6% conversion rate to THR), patients aged 25 to 49 years had a survival rate of 85.5% (95% CI, 83.6% to 87.4%), patients aged 50 to 75 years had a survival rate of 63.3% (95% CI, 58.7% to 67.9%), and patients older than 75 years had a survival rate of 69.8% (95% CI, 54.8% to 84.8%). Patients in the group aged between 50 and 75 years were at highest risk of conversion to THR (38% over a period of 8 years). Cox proportional hazard analysis adjusting for age, gender, and Charlson comorbidity score showed an 8-year survival rate of 86% (Fig 4).

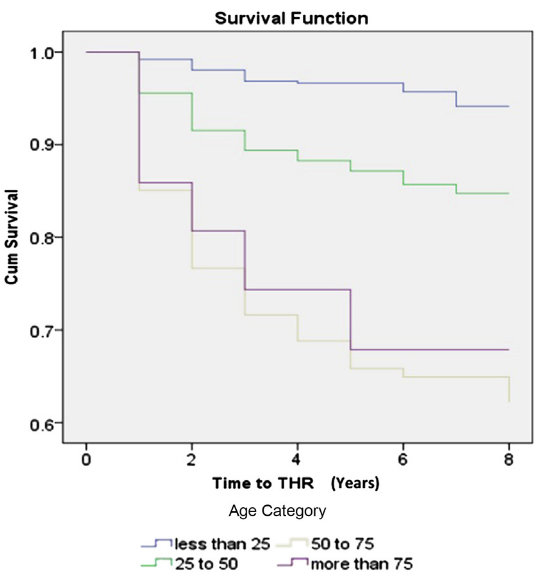


Fig 3. Kaplan-Meier survival analysis over a period of 8 years for various age groups: younger than 25 years, 94.3% (95% confidence interval [CI], 91.3% to 97.3%); 25 to 49 years, 85.5% (95% CI, 83.6% to 87.4%); 50 to 75 years, 63.3% (95% CI, 58.7% to 67.9%); and older than 75 years, 69.8% (95% CI, 54.8% to 84.8%). The x-axis shows the time to revision in years, and the y-axis shows cumulative (Cum) survival. (THR, total hip replacement.)

Regression Analysis

Logistic regression analysis showed that the significant predictors for a patient requiring THR are age ($P <$ .001) and gender ($P <$ .001), with age being the highest predictor. Female patients had a higher risk of conversion to THR (odds ratio, 1.68; 95% CI, 1.41 to 2.01). Patients aged 50 years or older had a higher risk (odds ratio, 4.65; 95% CI, 3.93 to 5.49) than patients younger than 50 years.

Discussion

The 30-day readmission rate after surgery is 0.5%, with the majority of patients being readmitted for pain and wound-related issues, a small proportion of whom have deep infection requiring washout (0.06%). The 90-day DVT and PE rates are low. Of the patients, 4.5% required revision hip arthroscopy whereas 10.6% underwent hip replacement at a mean of 1.4 years after hip arthroscopy. Cox proportional hazard analysis adjusting for age, gender, and Charlson comorbidity score showed an 8-year survival rate of 86%. Female patients had a 1.68 times higher risk of conversion to THR than male patients, and patients aged 50 years or older had a 4.65 times higher risk of requiring hip replacement than patients younger than 50 years. This information is unique and critical during the informed-consent process while discussing the possibility of success of this potentially hip-preserving procedure.

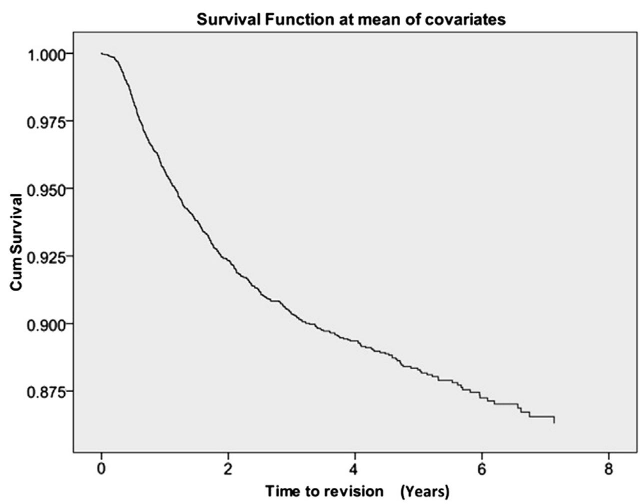


Fig 4. Cox proportional hazard analysis adjusting for age, gender, and Charlson score with a cumulative survival rate over a period of 8 years of 86%. The x-axis shows the time to revision in years, and the y-axis shows cumulative (Cum) survival.

The technique of hip arthroscopy has significantly evolved over the past decade with increasing indications and better outcomes. Most hip arthroscopies are now being performed for femoroacetabular impingement, with the arthroscopic approach offering a faster rehabilitation and similar clinical outcome in comparison with standard open surgical dislocation.[16-19] There is extensive literature on studies related to hip arthroscopy, with most being case series or case reports and nearly all having short-term follow-up. To our knowledge, there are only 2 long-term outcome studies with follow-up of more than 10 years and both predate the era of impingement surgery.[10,20] Several reviews have reported low complication rates[1,12,21] and a reoperation rate of 6.3% after hip arthroscopy.[1]

Our study sheds light on several aspects of hip arthroscopy: (1) 30-day readmission rate, (2) 90-day incidences of DVT and PE, (3) revision arthroscopy rate, and (4) rate of conversion to THR. No study has looked into the rate of readmissions and length of stay after hip arthroscopies. The readmission rate has important bearing in terms of patient morbidity and the financial constraints associated with any operative technique. Our study shows that a large majority of these patients (88%) can be discharged the same day or require an overnight admission with a low readmission rate (0.5%); most of the admissions were because of pain and wound-related issues, with a hip washout rate for infection of 0.06%.

The 90-day incidences of DVT and PE in this study were both 0.08%, findings consistent with previous studies and systematic reviews. In a review of over 5,500 cases of hip arthroscopy, the incidence of DVT was 0% and the authors recommended using prophylaxis only in individual high-risk cases.[13] Similarly, 2 recent systematic reviews have quoted very low incidences of DVT (0.11%) and PE (0.02%).[1,21] It is clear from our study that the large majority of patients undergoing hip arthroscopy have minimal or no comorbidities, with a mean Charlson score of 1.2. In addition, hip arthroscopy is associated with early mobilization and rehabilitation, thus further reducing the risk of DVT and PE. Fatal PE is a rarely reported complication.[13] Although there are no specific guidelines on the use of thromboprophylaxis in hip arthroscopy, one review article made recommendations in terms of early mobilization (ideally on the day of surgery); use of below-knee compression stockings on the contralateral leg during surgery; chemical thromboprophylaxis in high-risk cases; and wherever possible, discontinuation of oral contraceptive pills before surgery.[12] Routine use of chemical prophylaxis carries cost implications and the possibility of an increased risk of bleeding and wound infection. Analyses of national data confirm that the incidence is quite low, and this study provides no evidence that DVT and PE are major issues; moreover, routine prophylaxis is unlikely to be of benefit and may not be indicated except in high-risk groups.

In a recent systematic review, a reoperation rate of 6.3% has been reported after hip arthroscopy at a mean of 1.6 years, with conversion to THR in 2.9% of cases.[1] In our study the rate of revision hip arthroscopy is 4.5%. The efficacy of hip arthroscopy in delaying or preventing the need for THR has not yet been proven, and this is especially important in the era of an increasing number of hip impingement surgery procedures. There is evidence to suggest that patients with pre-existing arthritis and increasing age are at high risk of conversion to THR.[7,20,22-25] McCarthy et al.[20] reported a survival rate of 63% at 10 years in a group of 111 patients. Increasing age and higher Outerbridge grade of arthritis were associated with an increased risk of conversion to THR. Thus patients aged 40 years or younger with grade 0 to II Outerbridge grades had a 10% risk of conversion to total hip arthroplasty over a period of 10 years in comparison with patients older than 40 years with higher Outerbridge grades (III or IV), in whom the risk was 99%. Other authors found similar results for patients older than 40 years.[24,25] Philippon et al.[25] performed a survivorship analysis in a group of 153 patients aged 50 years or older based on joint space narrowing and showed a 57% survivorship rate in those with a joint space of 2 mm or less in comparison with 90% in those with greater than 2 mm of joint space over a period of 3 years ($P = .001$). Because of the poor outcome associated with pre-existing high-grade arthritis, a high Tönnis grade (grade 3) or joint space narrowing of 2 mm or less is considered by some authors to be a relative contraindication for hip arthroscopy.[22,23] Similarly, in a series of 564 patients with Tönnis grade 1 to 3 osteoarthritis, Haviv and O'Donnell[26] have reported conversion to THR in 16% of patients over a period of 7 years.

In our study of 6,395 patients, the ideal patient with the highest survivorship was a male patient younger than 25 years, with inferences drawn from the survivorship analysis based on gender and age. The poorest survivorship was observed in patients aged between 50 and 75 years, in whom the risk of conversion to THR over a period of 8 years was 37% ($P < .05$). Our study shows that female patients had a higher risk of conversion to THR (20%) than male patients (13%) over a period of 8 years. However, McCarthy et al.[20] did not notice the effect of gender on long-term survivorship. After we adjusted for age, gender, and Charlson score, our study showed a survivorship rate of 86% over a period of 8 years. Jameson et al.[27] have recently reported a rate of conversion to total knee replacement of 10.6% in 20,556 patients who underwent knee arthroscopy. These figures seem similar to the findings in our study, with female gender and age of 60 years or older being significant predictors of knee replacement after knee arthroscopy.[27]

Limitations

Our study is based on the data obtained from the hospital admissions database and thus suffers from certain limitations. It is based entirely on NHS data and excludes patients operated on in the private sector. This study may therefore underestimate the number of primary and repeat arthroscopies carried out nationally or the number of patients in the private sector who required hip replacement. The diagnosis of DVT/PE is based on clinical presentation and confirmed by further imaging; the rate of subclinical thromboembolism cannot be determined from the data available. Moreover, the true incidence of neurapraxia cannot be assessed because the coding would allow only the cases that underwent nerve conduction studies to have been recorded and this would have underestimated the risk. In addition, the records would not provide the ability to explore the nature of thromboprophylaxis that the patients received or perioperative antibiotics. We have not looked at the primary indication of hip arthroscopy in individual cases or details of intraoperative findings, and thus it is difficult to establish the outcome based on the diagnosis or, indeed, in the group that underwent THR, the relation with the presence and degree of arthritis.

Conclusions

In this large series of 6,395 hip arthroscopies looking at the national data from the English NHS, our null hypothesis has been supported, and we have determined that the rate of short-term complications, in particular the risk of DVT and PE after this operation, is low. Higher age and female gender are significant predictors of conversion to THR, with Cox proportional hazard analyses showing a survivorship rate of 86% at 8 years after adjustment for confounding variables.

References

1. Harris JD, McCormick FM, Abrams GD, et al. Complications and reoperations during and after hip arthroscopy: A systematic review of 92 studies and more than 6,000 patients. *Arthroscopy* 2013;29:589-595.
2. Ng VY, Arora N, Best TM, Pan X, Ellis TJ. Efficacy of surgery for femoroacetabular impingement: A systematic review. *Am J Sports Med* 2010;38:2337-2345.
3. Domb BG, Stake CE, Botser IB, Jackson TJ. Surgical dislocation of the hip versus arthroscopic treatment of femoroacetabular impingement: A prospective matched-pair study with average 2-year follow-up. *Arthroscopy* 2013;29:1506-1513.
4. Konan S, Rhee SJ, Haddad FS. Hip arthroscopy: Analysis of a single surgeon's learning experience. *J Bone Joint Surg Am* 2011;93:52-56 (suppl 2).
5. Lee YK, Ha YC, Hwang DS, Koo KH. Learning curve of basic hip arthroscopy technique: CUSUM analysis. *Knee Surg Sports Traumatol Arthrosc* 2013;21:1940-1944.
6. Lynch TS, Terry MA, Bedi A, Kelly BT. Hip arthroscopic surgery: Patient evaluation, current indications, and outcomes. *Am J Sports Med* 2013;41:1174-1189.
7. Meftah M, Rodriguez JA, Panagopoulos G, Alexiades MM. Long-term results of arthroscopic labral debridement: Predictors of outcomes. *Orthopedics* 2011;34:e588-e592.
8. Byrd JW, Jones KS. Hip arthroscopy in athletes: 10-year follow-up. *Am J Sports Med* 2009;37:2140-2143.
9. Byrd JW, Jones KS. Hip arthroscopy for labral pathology: Prospective analysis with 10-year follow-up. *Arthroscopy* 2009;25:365-368.
10. Byrd JW, Jones KS. Prospective analysis of hip arthroscopy with 10-year followup. *Clin Orthop Relat Res* 2010;468:741-746.
11. Shearer DW, Kramer J, Bozic KJ, Feeley BT. Is hip arthroscopy cost-effective for femoroacetabular impingement? *Clin Orthop Relat Res* 2012;470:1079-1089.
12. Papavasiliou AV, Bardakos NV. Complications of arthroscopic surgery of the hip. *Bone Joint Res* 2012;1:131-144.
13. Bushnell BD, Dahners LE. Fatal pulmonary embolism in a polytraumatized patient following hip arthroscopy. *Orthopedics* 2009;32:56.
14. Salvo JP, Troxell CR, Duggan DP. Incidence of venous thromboembolic disease following hip arthroscopy. *Orthopedics* 2010;33:664.
15. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: Development and validation. *J Chronic Dis* 1987;40:373-383.
16. Botser IB, Smith TW Jr, Nasser R, Domb BG. Open surgical dislocation versus arthroscopy for femoroacetabular impingement: A comparison of clinical outcomes. *Arthroscopy* 2011;27:270-278.
17. Buchler L, Neumann M, Schwab JM, Iselin L, Tannast M, Beck M. Arthroscopic versus open cam resection in the treatment of femoroacetabular impingement. *Arthroscopy* 2013;29:653-660.
18. Clohisy JC, St John LC, Schutz AL. Surgical treatment of femoroacetabular impingement: A systematic review of the literature. *Clin Orthop Relat Res* 2010;468:555-564.
19. Matsuda DK, Carlisle JC, Arthurs SC, Wierks CH, Philippon MJ. Comparative systematic review of the open dislocation, mini-open, and arthroscopic surgeries for femoroacetabular impingement. *Arthroscopy* 2011;27:252-269.
20. McCarthy JC, Jarrett BT, Ojeifo O, Lee JA, Bragdon CR. What factors influence long-term survivorship after hip arthroscopy? *Clin Orthop Relat Res* 2011;469:362-371.
21. Kowalczuk M, Bhandari M, Farrokhyar F, et al. Complications following hip arthroscopy: A systematic review and meta-analysis. *Knee Surg Sports Traumatol Arthrosc* 2013;21:1669-1675.
22. Horisberger M, Brunner A, Herzog RF. Arthroscopic treatment of femoral acetabular impingement in patients with preoperative generalized degenerative changes. *Arthroscopy* 2010;26:623-629.

23. Larson CM, Giveans MR, Taylor M. Does arthroscopic FAI correction improve function with radiographic arthritis? *Clin Orthop Relat Res* 2011;469:1667-1676.
24. Laude F, Sariali E, Nogier A. Femoroacetabular impingement treatment using arthroscopy and anterior approach. *Clin Orthop Relat Res* 2009;467:747-752.
25. Philippon MJ, Schroder ESBG, Briggs KK. Hip arthroscopy for femoroacetabular impingement in patients aged 50 years or older. *Arthroscopy* 2012;28:59-65.
26. Haviv B, O'Donnell J. The incidence of total hip arthroplasty after hip arthroscopy in osteoarthritic patients. *Sports Med Arthrosc Rehabil Ther Technol* 2010; 2:18.
27. Jameson SS, Rushton SP, Dowen D, et al. Increasing age and female gender are associated with early knee replacement following arthroscopy. *Knee Surg Sports Traumatol Arthrosc* 2014;22:2665-2671.

Chapter Eight: Discussion

8.1 Summary

Patients undergoing surgery for FAI have a significant improvement in QoL in the majority of cases. The outcome scores improve significantly for both athletes and non-athletes, with the earlier (six week) scores being slightly better for athletes but one year after surgery, the improvement is similar. Athletes have a significant increase in training time and time at competition, with a greater proportion of professional athletes returning to the same level compared with recreational athletes. Hip arthroscopic intervention for FAI is a safe procedure with low complication rates, with 86% of patients not requiring hip replacement after eight years. This section summarises the principal findings of each paper.

In the largest single-surgeon publication of 612 hip arthroscopic interventions for FAI, at a mean follow-up of 3.2 years, we have demonstrated the benefit of surgery in terms of improvement in QoL (127) and patient satisfaction. QoL improved significantly after surgical intervention in 77% of patients, remained unchanged in 14% and deteriorated in 9% of patients. The significant predictors of change in QoL were preoperative QoL scores and female gender. While standard outcome measures can demonstrate improvement in functional scores, these may not translate to clinically relevant benefit. Improvement in QoL measures the 'real-life' advantage of surgical intervention. At the time of publication, the only large studies available were two systematic reviews, one with 970 cases extracted from 23 independent studies (7), and the other including 496 cases from 11 publications (87). In both systematic reviews, the studies looked at a combination of hip arthroscopic intervention and open surgery. Therefore, the true number of hip arthroscopic interventions was even smaller. This observation clearly outlines the importance of the current publication to the scientific community. While the QoL improved in the majority of cases, it deteriorated in around 9% and this is a reflection of the unpredictability of the results in patients with more advanced degeneration of the hip. The application of hip preserving surgery is limited in this group of patients.

Generally, FAI and hip arthroscopic intervention have only been considered for people engaging in sporting activities and non-surgical treatment has been thought to be sufficient for people with a sedentary lifestyle. However, in a series of 52 patients (76) presenting with hip pain because of prearthritic intra-articular disorder, 44% (23) improved with conservative treatment and 56% (29) required surgery. The improvement in functional scores was similar in both groups after one year. Subjects who chose surgery had higher baseline activity scores compared with the conservative treatment group ($\rho = .02$). A natural expansion of our work was to look at the outcome in both the athletic group and the non-athletes.

We therefore compared the outcome between the athletes and non-athletes and published the results of a prospective comparative study (128). In this study we looked at the trend towards improvement in hip scores after surgery and found that the athletes had a significantly better score at 6 weeks but one year after surgery, there was no significant difference (128). Non-athletes showed equal benefit from surgery and therefore the procedure should be made available to them. Prior to this study, no work had compared outcomes in these two groups of patients and, to the best of our knowledge there have been no further reports comparing these two groups.

Return to sports had dominated the criteria for success in most studies looking at the athletic population, with little attempt to measure objectively whether the athletes were achieving to their pre-injury level of ability. We therefore decided to use training time and time in competition as measures of improvement after surgery and compared the outcomes between professional and recreational athletes in a prospective comparative study (129). The training and time in competition both improved approximately three-fold after surgery, pre-injury levels of performance being regained after an average of 5.4 months. Professional athletes regained their ability faster than recreational athletes. Greater proportion of the professional athletes (88%) returned to their pre-injury level of sport than the recreational athletes (73%).

The amount of fluid lost during hip arthroscopy is unknown and the amount of extravasation in the soft tissue is a cause for concern. Case reports have highlighted the potential problems that this may cause if the fluid tracks into the abdominal and thoracic cavities. We have measured the volume of fluid lost into the soft tissues during 36 consecutive routine uncomplicated hip arthroscopies (161) [Appendix 9]. We estimated in our study that a mean of 1132ml was lost in the periarticular soft tissues and recommended that the operating time should be minimised and intraoperative pressures should be kept low to reduce fluid loss.

Systematic reviews of a large number of patients have been performed, with the aim of collating the results and reporting on overall complications arising from arthroscopic surgery for FAI. Data collection was limited to hospital statistics compiled in England in order to ensure consistency in the methods of data collection. We extracted data from the national hospital episode statistics data for a series of 6395 hip arthroscopies performed in England between April 2005 and January 2013(130). The 30-day readmission rate was found to be 0.5% and the 30-day reoperation rate was 1%. The 90-day DVT rate was 0.08% and PE rate was 0.08%. The 90-day mortality rate was 0.02%.

Survival analysis with hip replacement as an endpoint has not been reported in a large group of patients. While systematic reviews have reported the number of cases that required conversion to THR no survival analysis has been performed. In our report on 6395 hip arthroscopies, we found that 680 patients (10.6%) underwent THR at a mean of 1.4 years after the index operation(130). The patients undergoing THR were significantly older (48 years, r<0.001) than the group who did not undergo THR (36.7 years). Females were more likely to need hip replacement than males (F=12.4%; M=7.3%; r <0.001). Female patients had a 1.68 times (95% CI, 1.41 to 2.01) higher risk of conversion to THR than male patients, and patients aged 50 years or older had a 4.65 (95% CI, 3.93 to 5.49) times higher risk of requiring hip replacement than patients younger than 50 years. Kaplan Meier survival analysis revealed an eight-year survival of 82% while Cox proportional hazard analysis, adjusting for age, gender and Charlson comorbidity score revealed an eight-year survival of 86%.

8.2 Strengths and limitations

In these papers, we have considered several important issues that make a significant contribution to the literature on hip arthroscopy. Several of the findings were novel at the time of publication. The literature has been limited by small studies and retrospective designs. We have countered these issues by reporting on large series of patients and constructing prospective comparative studies to contrast the outcomes in different groups of patients. The fluid extravasation study which is not the main part of the thesis, but included in the appendix (appendix 9), looks at a unique outcome that has been recognised in case reports in the literature but not measured in any publications preceding this study. We have been able to perform survival analyses of hip arthroscopies over a period of eight years in a large number of patients, which is crucial information both for surgeons and for patients with FAI. The thesis is a compilation of the results of surgery in a highly specialised practice, performed in the hands of a high output and experienced surgeon and also reflects on the outcome in the hands of the wider group of orthopaedic surgeons with varying levels of experience. This would be a true measure of the efficacy of the procedure in general hands in standard secondary level practice.

However, the evolving nature of the science surrounding FAI and hip arthroscopic intervention imposes certain restrictions on study design, including the limited length of follow-up. These limitations have been detailed in the relevant papers. All the studies described here are rooted in the positivistic paradigm and are quantitative analyses of the data collected. Some opportunities that would be afforded by a qualitative approach may have been missed. One of the outcome measures that we have used (MHHS) may suffer from a ceiling effect (162); thus limiting its application for people engaging in sporting activities, but we have overcome this problem by combining MHHS with NAHS and a sports module questionnaire, that details return to high output activity after surgery. We have been able to present a survival analysis on conversion to THR from the national database study but we have not been able to link it with causation. The threshold for surgery differs between surgeons and it may be that the hip arthroscopy revealed advanced OA, necessitating hip replacement, and surgery may not be a true reflection of failure of the procedure. The strengths and limitations of individual papers have been elaborated in the individual papers and also in the critique included in the methods.

8.3 Future direction

There may well be a role for non-operative treatment for FAI (73). There is a dearth of well-constructed, randomised controlled trials to prove the efficacy of surgery versus non-operative treatment for patients with FAI and the next stage should be to perform a multi-centred trial comparing the two regimens. At the time of writing, there were four randomised controlled trials ongoing; the results of which should become available within the next five years (123). Three of the four ongoing studies compare hip arthroscopy with non-operative care. The fourth study is designed to compare hip arthroscopy with a placebo arthroscopic hip procedure. These trials could provide evidence for the benefit and safety of arthroscopic hip surgery in the future. Northumbria Healthcare NHS Foundation Trust is a part of one of these (FASHIoN trial) trials and I am the principal investigator for the trust.

The best approach for dealing with labral tears is still open to debate and the literature is undecided as to whether labral repair or labral debridement gives the better outcome (60, 91). A randomised controlled trial, comparing the outcomes in this select group, would also add to the literature but, because of the nature of the pathology it would need to compare groups that had only cam type pathology. Long term follow-up of these patients to see if intervention delays the need for THR would be the cornerstone research for this group. Qualitative research to look at employment outcomes/athletes' expectations and the results of surgery is another issue that needs further exploration to determine whether intervention meets the ultimate goal of improving the employability and performance of the patients. This would involve in-depth interview of both patients, GPs, orthopaedic surgeons and/or healthcare commissioners.

Chapter Nine: Conclusion and recommendation

Arthroscopic surgery for FAI improves QoL, is beneficial for non athletes as well as athletes, enables athletes to return to their professional level of function and may delay the need for total hip replacement. These papers have helped, not only in establishing the outcome of surgery but also in identifying the patients who would benefit from intervention. This information is critical to the clinicians' understanding of both the success of the intervention and the limitations of the technique. Important information has been generated from this work that will be helpful during preoperative counselling, when it is imperative to obtain properly informed consent.

Based on my original work, critical review of the literature and personal experience of more than 500 hip arthroscopic surgeries, following would be my recommendation to surgeon and patients

Who would be a candidate to have surgery for FAI?

An ideal candidate would be a physiologically young patient under 50 years of age with well-preserved joint space (< Tonnis grade1 OA).

When should the operation be performed?

The surgery should be reserved for symptomatic individuals where physiotherapy or modification of activity has not helped in relieving pain.

What should be the aim of the procedure?

The surgical goals should be complete excision of impingement lesions, labral preservation and repair of labrum in cases of unstable tear.

How should the outcome be assessed?

A hip specific outcome measure (NAHS), iHOT-12 and a generic QoL outcome measure EQ-5D would capture most relevant information required.

References

1. Ito K, Minka MA, 2nd, Leunig M, Werlen S, Ganz R. Femoroacetabular impingement and the cam-effect. A MRI-based quantitative anatomical study of the femoral head-neck offset. The Journal of bone and joint surgery British volume. 2001 Mar;83(2):171-6.

2. Ganz R, Parvizi J, Beck M, Leunig M, Notzli H, Siebenrock KA. Femoroacetabular impingement: a cause for osteoarthritis of the hip. Clin Orthop Relat Res. 2003 Dec(417):112-20.

3. Tanzer M, Noiseux N. Osseous abnormalities and early osteoarthritis: the role of hip impingement. Clinical orthopaedics and related research. 2004 Dec(429):170-7.

4. Laborie LB, Lehmann TG, Engesaeter IO, Eastwood DM, Engesaeter LB, Rosendahl K. Prevalence of radiographic findings thought to be associated with femoroacetabular impingement in a population-based cohort of 2081 healthy young adults. Radiology. 2011 Aug;260(2):494-502.

5. Frank JM, Harris JD, Erickson BJ, Slikker W, 3rd, Bush-Joseph CA, Salata MJ, et al. Prevalence of Femoroacetabular Impingement Imaging Findings in Asymptomatic Volunteers: A Systematic Review. Arthroscopy : the journal of arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association. 2015 Jan 28.

6. Ochoa LM, Dawson L, Patzkowski JC, Hsu JR. Radiographic prevalence of femoroacetabular impingement in a young population with hip complaints is high. Clinical orthopaedics and related research. 2010 Oct;468(10):2710-4.

7. Ng VY, Arora N, Best TM, Pan X, Ellis TJ. Efficacy of surgery for femoroacetabular impingement: a systematic review. Am J Sports Med. 2010 Nov;38(11):2337-45.

8. Burman MS. Arthroscopy or the direct visualization of joints: an experimental cadaver study. 1931. Clinical orthopaedics and related research. 2001 Sep(390):5-9.

9. Kieser CW, Jackson RW. Eugen Bircher (1882-1956) the first knee surgeon to use diagnostic arthroscopy. Arthroscopy : the journal of arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association. 2003 Sep;19(7):771-6.

10. Griffiths EJ, Khanduja V. Hip arthroscopy: evolution, current practice and future developments. International orthopaedics. 2012 Jun;36(6):1115-21.

11. Aignan M. Arthroscopy of the hip. In: Proceedings of the International Association of Arthroscopy. Rev Int Rheumatol. 1976;33:458.

12. Eriksson E. Hip arthroscopy. Knee surgery, sports traumatology, arthroscopy : official journal of the ESSKA. 2006 Jul;14(7):591.

13. Eriksson E, Arvidsson I, Arvidsson H. Diagnostic and operative arthroscopy of the hip. Orthopedics. 1986 Feb;9(2):169-76.

14. Gross RH. Arthroscopy in hip disorders in children. Orthop Rev. 1977;6:43-9.

15. Shifrin LZ, Reis ND. Arthroscopy of a dislocated hip replacement: a case report. Clinical orthopaedics and related research. 1980 Jan-Feb(146):213-4.

16. Vakili F, Salvati EA, Warren RF. Entrapped foreign body within the acetabular cup in total hip replacement. Clinical orthopaedics and related research. 1980 Jul-Aug(150):159-62.

17. Holgersson S, Brattstrom H, Mogensen B, Lidgren L. Arthroscopy of the hip in juvenile chronic arthritis. Journal of pediatric orthopedics. 1981;1(3):273-8.

18. Johnson LL. Hip joint. In: Johnson LL, editor. Diagnostic and Surgical Arthroscopy, the knee and other joints. 2nd ed. St. Louis: Mosby; 1981. p. 405-11.

19. Eriksson E, Sebik A. Arthroscopy and arthroscopic surgery in a gas versus a fluid medium. Orthop Clin North Am. 1982 Apr;13(2):293-98.

20. Glick JM, Sampson TG, Gordon RB, Behr JT, Schmidt E. Hip arthroscopy by the lateral approach. Arthroscopy : the journal of arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association. 1987;3(1):4-12.

21. Byrd JW. Hip arthroscopy utilizing the supine position. Arthroscopy : the journal of arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association. 1994 Jun;10(3):275-80.

22. Hawkins RB. Arthroscopy of the hip. Clinical orthopaedics and related research. 1989 Dec(249):44-7.

23. Dvorak M, Duncan CP, Day B. Arthroscopic anatomy of the hip. Arthroscopy : the journal of arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association. 1990;6(4):264-73.

24. Villar RN. Hip arthroscopy. Oxford: Butterworth-Heinemann; 1992.

25. Keene GS, Villar RN. Arthroscopic anatomy of the hip: an in vivo study. Arthroscopy : the journal of arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association. 1994 Aug;10(4):392-9.

26. Byrd JW, Pappas JN, Pedley MJ. Hip arthroscopy: an anatomic study of portal placement and relationship to the extra-articular structures. Arthroscopy : the journal of arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association. 1995 Aug;11(4):418-23.

27. Elsaidi GA, Ruch DS, Schaefer WD, Kuzma K, Smith BP. Complications associated with traction on the hip during arthroscopy. The Journal of bone and joint surgery British volume. 2004 Aug;86(6):793-6.

28. Dorfmann H, Boyer T. Hip arthroscopy utilizing the supine position. Arthroscopy : the journal of arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association. 1996 Apr;12(2):264-7.

29. Dienst M, Godde S, Seil R, Hammer D, Kohn D. Hip arthroscopy without traction: In vivo anatomy of the peripheral hip joint cavity. Arthroscopy : the journal of arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association. 2001 Nov-Dec;17(9):924-31.

30. Dienst M, Seil R, Kohn DM. Safe arthroscopic access to the central compartment of the hip. Arthroscopy : the journal of arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association. 2005 Dec;21(12):1510-4.

31. Lyon T, Koval KJ, Kummer F, Zuckerman JD. Pudendal nerve palsy induced by fracture table. Orthopaedic review. 1993 May;22(5):521-5.

32. Rodeo SA, Forster RA, Weiland AJ. Neurological complications due to arthroscopy. The Journal of bone and joint surgery American volume. 1993 Jun;75(6):917-26.

33. Funke EL, Munzinger U. Complications in hip arthroscopy. Arthroscopy : the journal of arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association. 1996 Apr;12(2):156-9.

34. Griffin DR, Villar RN. Complications of arthroscopy of the hip. The Journal of bone and joint surgery British volume. 1999 Jul;81(4):604-6.

35. Dorfmann H, Boyer T. Arthroscopy of the hip: 12 years of experience. Arthroscopy : the journal of arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association. 1999 Jan-Feb;15(1):67-72.

36. Clarke MT, Arora A, Villar RN. Hip arthroscopy: complications in 1054 cases. Clinical orthopaedics and related research. 2003 Jan(406):84-8.

37. Ilizaliturri VM, Jr. Complications of arthroscopic femoroacetabular impingement treatment: a review. Clinical orthopaedics and related research. 2009 Mar;467(3):760-8.

38. Ilizaliturri VM, Jr., Acosta-Rodriguez E, Camacho-Galindo J. A minimalist approach to hip arthroscopy: the slotted cannula. Arthroscopy : the journal of arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association. 2007 May;23(5):560 e1-3.

39. Kelly BT, Williams RJ, 3rd, Philippon MJ. Hip arthroscopy: current indications, treatment options, and management issues. The American journal of sports medicine. 2003 Nov-Dec;31(6):1020-37.

40. Beck M, Leunig M, Parvizi J, Boutier V, Wyss D, Ganz R. Anterior femoroacetabular impingement: part II. Midterm results of surgical treatment. Clin Orthop Relat Res. 2004 Jan(418):67-73.

41. Murphy S, Tannast M, Kim YJ, Buly R, Millis MB. Debridement of the adult hip for femoroacetabular impingement: indications and preliminary clinical results. Clinical orthopaedics and related research. 2004 Dec(429):178-81.

42. Crawford JR, Villar RN. Current concepts in the management of femoroacetabular impingement. The Journal of bone and joint surgery British volume. 2005 Nov;87(11):1459-62.

43. Kelly BT, Weiland DE, Schenker ML, Philippon MJ. Arthroscopic labral repair in the hip: surgical technique and review of the literature. Arthroscopy : the journal of arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association. 2005 Dec;21(12):1496-504.

44. Crawford K, Philippon MJ, Sekiya JK, Rodkey WG, Steadman JR. Microfracture of the hip in athletes. Clinics in sports medicine. 2006 Apr;25(2):327-35, x.

45. Philippon MJ, Schenker ML, Briggs KK, Maxwell RB. Can microfracture produce repair tissue in acetabular chondral defects? Arthroscopy : the journal of arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association. 2008 Jan;24(1):46-50.

46. Guanche CA, Bare AA. Arthroscopic treatment of femoroacetabular impingement. Arthroscopy : the journal of arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association. 2006 Jan;22(1):95-106.

47. Sampson TG. Arthroscopic treatment of femoroacetabular impingement: a proposed technique with clinical experience. Instructional course lectures. 2006;55:337-46.

48. Philippon MJ, Stubbs AJ, Schenker ML, Maxwell RB, Ganz R, Leunig M. Arthroscopic management of femoroacetabular impingement: osteoplasty technique and literature review. Am J Sports Med. 2007 Sep;35(9):1571-80.

49. Larson CM, Giveans MR. Arthroscopic management of femoroacetabular impingement: early outcomes measures. Arthroscopy. 2008 May;24(5):540-6.

50. Ilizaliturri VM, Jr., Orozco-Rodriguez L, Acosta-Rodriguez E, Camacho-Galindo J. Arthroscopic treatment of cam-type femoroacetabular impingement: preliminary report at 2 years minimum follow-up. J Arthroplasty. 2008 Feb;23(2):226-34.

51. Bardakos NV, Vasconcelos JC, Villar RN. Early outcome of hip arthroscopy for femoroacetabular impingement: the role of femoral osteoplasty in symptomatic improvement. J Bone Joint Surg Br. 2008 Dec;90(12):1570-5.

52. Botser IB, Smith TW, Jr., Nasser R, Domb BG. Open surgical dislocation versus arthroscopy for femoroacetabular impingement: a comparison of clinical outcomes. Arthroscopy. 2011 Feb;27(2):270-8.

53. Matsuda DK, Carlisle JC, Arthurs SC, Wierks CH, Philippon MJ. Comparative systematic review of the open dislocation, mini-open, and arthroscopic surgeries for femoroacetabular impingement. Arthroscopy. 2011 Feb;27(2):252-69.

54. Lynch TS, Terry MA, Bedi A, Kelly BT. Hip arthroscopic surgery: patient evaluation, current indications, and outcomes. Am J Sports Med. 2013 May;41(5):1174-89.

55. Larson CM, Giveans MR. Arthroscopic debridement versus refixation of the acetabular labrum associated with femoroacetabular impingement. Arthroscopy : the journal of arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association. 2009 Apr;25(4):369-76.

56. Schilders E, Dimitrakopoulou A, Bismil Q, Marchant P, Cooke C. Arthroscopic treatment of labral tears in femoroacetabular impingement: a comparative study of

refixation and resection with a minimum two-year follow-up. The Journal of bone and joint surgery British volume. 2011 Aug;93(8):1027-32.

57. Philippon MJ, Briggs KK, Hay CJ, Kuppersmith DA, Dewing CB, Huang MJ. Arthroscopic labral reconstruction in the hip using iliotibial band autograft: technique and early outcomes. Arthroscopy : the journal of arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association. 2010 Jun;26(6):750-6.

58. Sierra RJ, Trousdale RT. Labral reconstruction using the ligamentum teres capitis: report of a new technique. Clinical orthopaedics and related research. 2009 Mar;467(3):753-9.

59. Boykin RE, Patterson D, Briggs KK, Dee A, Philippon MJ. Results of arthroscopic labral reconstruction of the hip in elite athletes. The American journal of sports medicine. 2013 Oct;41(10):2296-301.

60. Haddad B, Konan S, Haddad FS. Debridement versus re-attachment of acetabular labral tears: A review of the literature and quantitative analysis. Bone Joint J. 2014 Jan;96-B(1):24-30.

61. Tzaveas AP, Villar RN. Arthroscopic repair of acetabular chondral delamination with fibrin adhesive. Hip international : the journal of clinical and experimental research on hip pathology and therapy. 2010 Jan-Mar;20(1):115-9.

62. Byrd JW, Jones KS. Prospective analysis of hip arthroscopy with 10-year followup. Clin Orthop Relat Res. 2010 Mar;468(3):741-6.

63. ArthritisResearchUK. Osteoarthritis in General Practice. 2013; Available from: http://www.arthritisresearchuk.org/arthritis-information/data-and-statistics/osteoarthritis.aspx.

64. Kurtz SM, Lau E, Ong K, Zhao K, Kelly M, Bozic KJ. Future young patient demand for primary and revision joint replacement: national projections from 2010 to 2030. Clin Orthop Relat Res. 2009 Oct;467(10):2606-12.

65. NICE. Osteoarthritis - Care and management in adults. 2014; Available from: guidance.nice.org.uk/cg177.

66. Vendittoli PA, Lavigne M, Roy AG, Lusignan D. A prospective randomized clinical trial comparing metal-on-metal total hip arthroplasty and metal-on-metal total hip resurfacing in patients less than 65 years old. Hip Int. 2006;16 Suppl 4:73-81.

67. Palmer KT, Milne P, Poole J, Cooper C, Coggon D. Employment characteristics and job loss in patients awaiting surgery on the hip or knee. Occup Environ Med. 2005 Jan;62(1):54-7.

68. NJR. National Joint Registry for England and Wales 10th Annual Report. 2013 [cited 2013 05/02/2014]; Available from: http://www.njrcentre.org.uk/njrcentre/Portals/0/Documents/England/Reports/10th_annual_report/NJR 10th Annual Report 2013 B.pdf.

69. Liang MH, Cullen KE, Larson MG, Thompson MS, Schwartz JA, Fossel AH, et al. Cost-effectiveness of total joint arthroplasty in osteoarthritis. Arthritis Rheum. 1986 Aug;29(8):937-43.

70. SwedishJointRegistry. Swedish hip arthroplasty register- Annual Report 2012. 2012 [cited 2014 10.10.2014]; Available from: http://www.shpr.se/Libraries/Documents/AnnualReport_2012_Eng_WEB.sflb.ashx.

71. Gerhardt MB, Romero AA, Silvers HJ, Harris DJ, Watanabe D, Mandelbaum BR. The prevalence of radiographic hip abnormalities in elite soccer players. The American journal of sports medicine. 2012 Mar;40(3):584-8.

72. Kapron AL, Anderson AE, Aoki SK, Phillips LG, Petron DJ, Toth R, et al. Radiographic prevalence of femoroacetabular impingement in collegiate football players: AAOS Exhibit Selection. The Journal of bone and joint surgery American volume. 2011 Oct 5;93(19):e111(1-10).

73. Wall PD, Fernandez M, Griffin DR, Foster NE. Nonoperative treatment for femoroacetabular impingement: a systematic review of the literature. Pm R. 2013 May;5(5):418-26.

74. Lavigne M, Parvizi J, Beck M, Siebenrock KA, Ganz R, Leunig M. Anterior femoroacetabular impingement: part I. Techniques of joint preserving surgery. Clin Orthop Relat Res. 2004 Jan(418):61-6.

75. Emara K, Samir W, Motasem el H, Ghafar KA. Conservative treatment for mild femoroacetabular impingement. J Orthop Surg (Hong Kong). 2011 Apr;19(1):41-5.

76. Hunt D, Prather H, Harris Hayes M, Clohisy JC. Clinical outcomes analysis of conservative and surgical treatment of patients with clinical indications of prearthritic, intra-articular hip disorders. Pm R. 2012 Jul;4(7):479-87.

77. NICE. Arthroscopic femoro–acetabular surgery for hip impingement syndrome. 2011; Available from: http://www.nice.org.uk/guidance/ipg408/resources/guidance-arthroscopic-femoroacetabular-surgery-for-hip-impingement-syndrome-pdf.

78. Guyatt GH, Feeny DH, Patrick DL. Measuring health-related quality of life. Ann Intern Med. 1993 Apr 15;118(8):622-9.

79. Testa MA, Simonson DC. Assesment of quality-of-life outcomes. N Engl J Med. 1996 Mar 28;334(13):835-40.

80. Harris-Hayes M, McDonough CM, Leunig M, Lee CB, Callaghan JJ, Roos EM. Clinical outcomes assessment in clinical trials to assess treatment of femoroacetabular

impingement: use of patient-reported outcome measures. The Journal of the American Academy of Orthopaedic Surgeons. 2013;21 Suppl 1:S39-46.

81. Beaule PE, Le Duff MJ, Zaragoza E. Quality of life following femoral head-neck osteochondroplasty for femoroacetabular impingement. J Bone Joint Surg Am. 2007 Apr;89(4):773-9.

82. Sink EL, Fabricant PD, Pan Z, Dayton MR, Novais E. Results of treatment of femoroacetabular impingement in adolescents with a surgical hip dislocation approach. Clinical orthopaedics and related research. 2013 Aug;471(8):2563-9.

83. Impellizzeri FM, Mannion AF, Naal FD, Hersche O, Leunig M. The early outcome of surgical treatment for femoroacetabular impingement: success depends on how you measure it. Osteoarthritis and cartilage / OARS, Osteoarthritis Research Society. 2012 Jul;20(7):638-45.

84. Shearer DW, Kramer J, Bozic KJ, Feeley BT. Is hip arthroscopy cost-effective for femoroacetabular impingement? Clin Orthop Relat Res. 2012 Apr;470(4):1079-89.

85. Clement ND, MacDonald D, Gaston P. Hip arthroscopy for femoroacetabular impingement: a health economic analysis. Hip international : the journal of clinical and experimental research on hip pathology and therapy. 2014; 24(5):457-64

86. Byrd JW, Jones KS. Arthroscopic femoroplasty in the management of cam-type femoroacetabular impingement. Clin Orthop Relat Res. 2009 Mar;467(3):739-46.

87. Clohisy JC, St John LC, Schutz AL. Surgical treatment of femoroacetabular impingement: a systematic review of the literature. Clin Orthop Relat Res. 2010 Feb;468(2):555-64.

88. Dippmann C, Thorborg K, Kraemer O, Winge S, Palm H, Holmich P. Hip arthroscopy with labral repair for femoroacetabular impingement: short-term outcomes.

Knee surgery, sports traumatology, arthroscopy : official journal of the ESSKA. 2014 Apr;22(4):744-9.

89. Ben Tov T, Amar E, Shapira A, Steinberg E, Atoun E, Rath E. Clinical and functional outcome after acetabular labral repair in patients aged older than 50 years. Arthroscopy : the journal of arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association. 2014 Mar;30(3):305-10.

90. Philippon MJ, Briggs KK, Yen YM, Kuppersmith DA. Outcomes following hip arthroscopy for femoroacetabular impingement with associated chondrolabral dysfunction: minimum two-year follow-up. J Bone Joint Surg Br. 2009 Jan;91(1):16-23.

91. Byrd JW, Jones KS. Primary repair of the acetabular labrum: outcomes with 2 years' follow-up. Arthroscopy : the journal of arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association. 2014 May;30(5):588-92.

92. Tranovich MJ, Salzler MJ, Enseki KR, Wright VJ. A review of femoroacetabular impingement and hip arthroscopy in the athlete. Phys Sportsmed. 2014 Feb;42(1):75-87.

93. Alradwan H, Philippon MJ, Farrokhyar F, Chu R, Whelan D, Bhandari M, et al. Return to preinjury activity levels after surgical management of femoroacetabular impingement in athletes. Arthroscopy. 2012 Oct;28(10):1567-76.

94. Lovett Carter D, Kennedy N. What Are Athletes' Perceptions of Rehabilitation Outcome One Year Post Hip Arthroscopy? J Sport Rehabil. 2013 Oct 23.

95. Amenabar T, O'Donnell J. Return to sport in Australian football league footballers after hip arthroscopy and midterm outcome. Arthroscopy : the journal of

arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association. 2013 Jul;29(7):1188-94.

96. Philippon M, Schenker M, Briggs K, Kuppersmith D. Femoroacetabular impingement in 45 professional athletes: associated pathologies and return to sport following arthroscopic decompression. Knee Surg Sports Traumatol Arthrosc. 2007 Jul;15(7):908-14.

97. Philippon MJ, Weiss DR, Kuppersmith DA, Briggs KK, Hay CJ. Arthroscopic labral repair and treatment of femoroacetabular impingement in professional hockey players. Am J Sports Med. 2010 Jan;38(1):99-104.

98. Byrd JW. Femoroacetabular Impingement in Athletes, Part II: Treatment and Outcomes. Sports Health. 2010 Sep;2(5):403-9.

99. Byrd JW. Femoroacetabular impingement in athletes, part 1: cause and assessment. Sports Health. 2010 Jul;2(4):321-33.

100. Byrd JW, Jones KS. Arthroscopic management of femoroacetabular impingement in athletes. Am J Sports Med. 2011 Jul;39 Suppl:7S-13S.

101. Nho SJ, Magennis EM, Singh CK, Kelly BT. Outcomes after the arthroscopic treatment of femoroacetabular impingement in a mixed group of high-level athletes. Am J Sports Med. 2011 Jul;39 Suppl:14S-9S.

102. Fabricant PD, Heyworth BE, Kelly BT. Hip arthroscopy improves symptoms associated with FAI in selected adolescent athletes. Clin Orthop Relat Res. 2012 Jan;470(1):261-9.

103. Philippon MJ, Schroder ESBG, Briggs KK. Hip arthroscopy for femoroacetabular impingement in patients aged 50 years or older. Arthroscopy. 2012 Jan;28(1):59-65.

104. Gupta A, Redmond JM, Hammarstedt JE, Schwindel L, Domb BG. Safety Measures in Hip Arthroscopy and Their Efficacy in Minimizing Complications: A

Systematic Review of the Evidence. Arthroscopy : the journal of arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association. 2014 Jul 10.

105. Harris JD, McCormick FM, Abrams GD, Gupta AK, Ellis TJ, Bach BR, Jr., et al. Complications and reoperations during and after hip arthroscopy: a systematic review of 92 studies and more than 6,000 patients. Arthroscopy. 2013 Mar;29(3):589-95.

106. Papavasiliou AV, Bardakos NV. Complications of arthroscopic surgery of the hip. Bone Joint Res. 2012 Jul;1(7):131-44.

107. Oak N, Mendez-Zfass M, Lesniak BP, Larson CM, Kelly BT, Bedi A. Complications in hip arthroscopy. Sports medicine and arthroscopy review. 2013 Jun;21(2):97-105.

108. Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg. 2004 Aug;240(2):205-13.

109. Sink EL, Leunig M, Zaltz I, Gilbert JC, Clohisy J. Reliability of a complication classification system for orthopaedic surgery. Clinical orthopaedics and related research. 2012 Aug;470(8):2220-6.

110. Bartlett CS, DiFelice GS, Buly RL, Quinn TJ, Green DS, Helfet DL. Cardiac arrest as a result of intraabdominal extravasation of fluid during arthroscopic removal of a loose body from the hip joint of a patient with an acetabular fracture. J Orthop Trauma. 1998 May;12(4):294-9.

111. DiStefano VJ, Kalman VR, O'Malley JS. Femoral nerve palsy after arthroscopic surgery with an infusion pump irrigation system. A report of three cases. Am J Orthop (Belle Mead NJ). 1996 Feb;25(2):145-8.

112. Fowler J, Owens BD. Abdominal compartment syndrome after hip arthroscopy. Arthroscopy : the journal of arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association. 2010 Jan;26(1):128-30.

113. Haupt U, Volkle D, Waldherr C, Beck M. Intra- and retroperitoneal irrigation liquid after arthroscopy of the hip joint. Arthroscopy : the journal of arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association. 2008 Aug;24(8):966-8.

114. Ladner B, Nester K, Cascio B. Abdominal fluid extravasation during hip arthroscopy. Arthroscopy : the journal of arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association. 2010 Jan;26(1):131-5.

115. Sharma A, Sachdev H, Gomillion M. Abdominal compartment syndrome during hip arthroscopy. Anaesthesia. 2009 May;64(5):567-9.

116. Siegel MG. Irrigation fluid complications. Arthroscopy : the journal of arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association. 2010 May;26(5):576; author reply -7.

117. Verma M, Sekiya JK. Intrathoracic fluid extravasation after hip arthroscopy. Arthroscopy : the journal of arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association. 2010 Sep;26(9 Suppl):S90-4.

118. Larson CM, Giveans MR, Taylor M. Does arthroscopic FAI correction improve function with radiographic arthritis? Clin Orthop Relat Res. 2011 Jun;469(6):1667-76.

119. Javed A, O'Donnell JM. Arthroscopic femoral osteochondroplasty for cam femoroacetabular impingement in patients over 60 years of age. J Bone Joint Surg Br. 2011 Mar;93(3):326-31.

120. Gedouin JE, May O, Bonin N, Nogier A, Boyer T, Sadri H, et al. Assessment of arthroscopic management of femoroacetabular impingement. A prospective multicenter study. Orthop Traumatol Surg Res. 2010 Oct 27.

121. McCarthy JC, Jarrett BT, Ojeifo O, Lee JA, Bragdon CR. What factors influence long-term survivorship after hip arthroscopy? Clin Orthop Relat Res. 2011 Feb;469(2):362-71.

122. Laude F, Sariali E, Nogier A. Femoroacetabular impingement treatment using arthroscopy and anterior approach. Clin Orthop Relat Res. 2009 Mar;467(3):747-52.

123. Wall PD, Brown JS, Parsons N, Buchbinder R, Costa ML, Griffin D. Surgery for treating hip impingement (femoroacetabular impingement). Cochrane Database Syst Rev. 2014;9:CD010796.

124. Domb BG, Stake CE, Botser IB, Jackson TJ. Surgical dislocation of the hip versus arthroscopic treatment of femoroacetabular impingement: a prospective matched-pair study with average 2-year follow-up. Arthroscopy. 2013 Sep;29(9):1506-13.

125. MacFarlane R, Konan S, El-Huseinny M, Haddad F. A review of outcomes of the surgical management of femoroacetabular impingement. Ann R Coll Surg Engl. 2014 Jul;96(5):331-8.

126. Wright JG, Swiontkowski MF, Heckman JD. Introducing levels of evidence to the journal. The Journal of bone and joint surgery American volume. 2003 Jan;85-A(1):1-3.

127. Malviya A, Stafford GH, Villar RN. Impact of arthroscopy of the hip for femoroacetabular impingement on quality of life at a mean follow-up of 3.2 years. J Bone Joint Surg Br. 2012 Apr;94(4):466-70.

128. Malviya A, Stafford GH, Villar RN. Is hip arthroscopy for femoroacetabular impingement only for athletes? Br J Sports Med. 2012 Nov;46(14):1016-8.

129. Malviya A, Paliobeis CP, Villar RN. Do Professional Athletes Perform Better Than Recreational Athletes After Arthroscopy for Femoroacetabular Impingement? Clin Orthop Relat Res. 2013 Mar 1;471:2477-83.

130. Malviya A, Raza A, Jameson S, James P, Reed MR, Partington PF. Complications and Survival Analyses of Hip Arthroscopies Performed in the National Health Service in England: A Review of 6,395 Cases. Arthroscopy : the journal of arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association. 2015 Feb 7;31:836-42.

131. Khanduja V, Villar RN. Arthroscopic surgery of the hip: current concepts and recent advances. J Bone Joint Surg Br. 2006 Dec;88(12):1557-66.

132. Byrd JW, Jones KS. Hip arthroscopy in the presence of dysplasia. Arthroscopy. 2003 Dec;19(10):1055-60.

133. Christensen CP, Althausen PL, Mittleman MA, Lee JA, McCarthy JC. The nonarthritic hip score: reliable and validated. Clin Orthop Relat Res. 2003 Jan(406):75-83.

134. Brokelman RB, Haverkamp D, van Loon C, Hol A, van Kampen A, Veth R. The validation of the visual analogue scale for patient satisfaction after total hip arthroplasty. Eur Orthop Traumatol. 2012 Jun;3(2):101-5.

135. Brokelman RB, van Loon CJ, Rijnberg WJ. Patient versus surgeon satisfaction after total hip arthroplasty. The Journal of bone and joint surgery British volume. 2003 May;85(4):495-8.

136. Chan CL, Villar RN. Obesity and quality of life after primary hip arthroplasty. J Bone Joint Surg Br. 1996 Jan;78(1):78-81.

137. Norman-Taylor FH, Palmer CR, Villar RN. Quality-of-life improvement compared after hip and knee replacement. J Bone Joint Surg Br. 1996 Jan;78(1):74-7.

138. Papavasiliou AV, Villar RN. Quality of life in different age groups after metal-on-metal hip resurfacing arthroplasty. Hip Int. 2008 Oct-Dec;18(4):307-12.

139. Rosser RM, Watts VC. The measurement of hospital output. Int J Epidemiol. 1972 Winter;1(4):361-8.

140. Gudex C, Kind, P. The QALY Toolkit. University of York: Centre for Health Economics. 1988;Discussion paper 38.

141. Beaton DE. Simple as possible? Or too simple? Possible limits to the universality of the one half standard deviation. Med Care. 2003 May;41(5):593-6.

142. Costa ML, Achten J, Parsons NR, Edlin RP, Foguet P, Prakash U, et al. Total hip arthroplasty versus resurfacing arthroplasty in the treatment of patients with arthritis of the hip joint: single centre, parallel group, assessor blinded, randomised controlled trial. BMJ. 2012;344:e2147.

143. Devlin NJ, Krabbe PF. The development of new research methods for the valuation of EQ-5D-5L. Eur J Health Econ. 2013 Jul;14 Suppl 1:S1-3.

144. NICE. Guide to the methods of technology appraisal. London2013.

145. Herdman M, Gudex C, Lloyd A, Janssen M, Kind P, Parkin D, et al. Development and preliminary testing of the new five-level version of EQ-5D (EQ-5D-5L). Qual Life Res. 2011 Dec;20(10):1727-36.

146. Ware JE, Jr. SF-36 health survey update. Spine (Phila Pa 1976). 2000 Dec 15;25(24):3130-9.

147. Bryan S, Parkin D, Donaldson C. Chiropody and the QALY: a case study in assigning categories of disability and distress to patients. Health Policy. 1991 Jul;18(2):169-85.

148. Coast J. Reprocessing data to form QALYs. BMJ. 1992 Jul 11;305(6845):87-90.

149. Williams A. Economics of coronary artery bypass grafting. Br Med J (Clin Res Ed). 1985 Aug 3;291(6491):326-9.

150. Lodhia P, Slobogean GP, Noonan VK, Gilbart MK. Patient-reported outcome instruments for femoroacetabular impingement and hip labral pathology: a systematic review of the clinimetric evidence. Arthroscopy : the journal of arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association. 2011 Feb;27(2):279-86.

151. Griffin DR, Parsons N, Mohtadi NG, Safran MR. A short version of the International Hip Outcome Tool (iHOT-12) for use in routine clinical practice. Arthroscopy : the journal of arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association. 2012 May;28(5):611-6; quiz 6-8.

152. Klassbo M, Larsson E, Mannevik E. Hip disability and osteoarthritis outcome score. An extension of the Western Ontario and McMaster Universities Osteoarthritis Index. Scand J Rheumatol. 2003;32(1):46-51.

153. Nilsdotter AK, Lohmander LS, Klassbo M, Roos EM. Hip disability and osteoarthritis outcome score (HOOS)--validity and responsiveness in total hip replacement. BMC musculoskeletal disorders. 2003 May 30;4:10.

154. Lieberman JR, Dorey F, Shekelle P, Schumacher L, Thomas BJ, Kilgus DJ, et al. Differences between patients' and physicians' evaluations of outcome after total hip arthroplasty. The Journal of bone and joint surgery American volume. 1996 Jun;78(6):835-8.

155. McGrory BJ, Morrey BF, Rand JA, Ilstrup DM. Correlation of patient questionnaire responses and physician history in grading clinical outcome following hip and knee arthroplasty. A prospective study of 201 joint arthroplasties. J Arthroplasty. 1996 Jan;11(1):47-57.

156. Hetaimish BM, Khan M, Crouch S, Simunovic N, Bedi A, Mohtadi N, et al. Consistency of reported outcomes after arthroscopic management of femoroacetabular impingement. Arthroscopy : the journal of arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association. 2013 Apr;29(4):780-7.

157. Colvin AC, Harrast J, Harner C. Trends in hip arthroscopy. The Journal of bone and joint surgery American volume. 2012 Feb 15;94(4):e23.

158. Bozic KJ, Chan V, Valone FH, 3rd, Feeley BT, Vail TP. Trends in hip arthroscopy utilization in the United States. J Arthroplasty. 2013 Sep;28(8 Suppl):140-3.

159. Palmer AJR, al e. Past and projected temporal trends in arthroscopic hip surgery in England between 2002 and 2013. BMJ Open Sport Exerc Med. 2016;2(e000082).

160. Agricola R, Waarsing JH, Arden NK, Carr AJ, Bierma-Zeinstra SM, Thomas GE, et al. Cam impingement of the hip: a risk factor for hip osteoarthritis. Nat Rev Rheumatol. 2013 Oct;9(10):630-4.

161. Stafford GH, Malviya A, Villar RN. Fluid extravasation during hip arthroscopy. Hip Int. 2011 Nov-Dec;21(6):740-3.

162. Wamper KE, Sierevelt IN, Poolman RW, Bhandari M, Haverkamp D. The Harris hip score: Do ceiling effects limit its usefulness in orthopedics? Acta Orthop. 2010 Dec;81(6):703-7.

Appendices

Appendix 1 – Modified Harris Hip Score

Appendix 2 – Non-arthritic Hip Score

Appendix 3 – Visual analogue scale for patient satisfaction

Appendix 4 – Rosser Index

Appendix 5 – Rosser Index Matrix

Appendix 6 – Sports Module Questionnaire

Appendix 7 – Level of evidence table

Appendix 8 – Service evaluation statement

Appendix 9 – Fluid extravasation paper

Appendix 10 – Declaration form

Appendix 1

Modified Harris Hip Score

Side: L R

Please answer the following questions as they pertain to your hip:

Pain:

☐None/Able to ignore it
☐Slight, occasional, no compromise in activity
☐Mild, no effect on ordinary activity, pain after usual activity, use aspirin/ibuprofen/Tylenol
☐Moderate, tolerable, makes concessions, occasional narcotic
☐Marked, serious limitations
☐Totally disabled

Function: Gait

Limp

☐None
☐Slight
☐Moderate
☐Severe
☐Unable to walk

Support

☐None
☐Cane for long walks
☐Cane all the time
☐Crutch
☐2 canes
☐2 crutches
☐Unable to walk

Distance Walked

☐Unlimited
☐6 blocks
☐2-3 blocks
☐Indoors only
☐Bed and chair

Functional Activities

Stairs

☐Can go up/down normally
☐Can go up/down normally with banister
☐Any method
☐Unable

Socks/Shoes

☐With ease
☐With difficulty
☐Unable

Sitting

☐Any chair, 1 hour
☐High chair, ½ hour
☐Unable to sit, ½ hour, any chair

Public Transportation

☐Able to enter public transportation
☐Unable to use public transportation (such as bus, or airport transportation)

For Internal Use:

Score___________
Initials__________

Appendix 2

Non-arthritic Hip Score

INSTRUCTIONS: The following 5 questions concern the amount of pain you are currently experiencing in the hip that you are having evaluated today. For each situation, please circle the response that most accurately reflects the amount of pain experienced in the past 48 hours. Please circle one answer that best describes your situation.

QUESTION: How much pain do you have-

1. Walking on a flat surface?
   4 = none
   3 = mild
   2 = moderate
   1 = severe
   0 = extreme
2. Going up or down stairs?
   4 = none
   3 = mild
   2 = moderate
   1 = severe
   0 = extreme
3. At night while in bed?
   4 = none
   3 = mild
   2 = moderate
   1 = severe
   0 = extreme
4. Sitting or lying?
   4 = none
   3 = mild
   2 = moderate
   1 = severe
   0 = extreme
5. Standing upright?
   4 = none
   3 = mild
   2 = moderate
   1 = severe
   0 = extreme

INSTRUCTIONS: The following 4 questions concern the symptoms that you are currently experiencing in the hip that you are having evaluated today. For each situation, please circle the response that most accurately reflects the symptoms experienced in the past 48 hours. Please circle one answer that best describes your situation.

QUESTION: How much trouble do you have with-

1. Catching or locking of your hip?
   4 = none
   3 = mild
   2 = moderate
   1 = severe
   0 = extreme
2. Your hip giving out on you?
   4 = none
   3 = mild
   2 = moderate
   1 = severe
   0 = extreme
3. Stiffness in your hip?
   4 = none
   3 = mild
   2 = moderate
   1 = severe
   0 = extreme
4. Decreased motion in your hip?
   4 = none
   3 = mild
   2 = moderate
   1 = severe
   0 = extreme

INSTRUCTIONS: The following 5 questions concern your physical function. For each of the following activities, please circle the response that most accurately reflects the difficulty that you have experienced in the past 48 hours because of your hip pain. Please circle one answer that best describes your situation.

QUESTION: What degree of difficulty do you have with-

1. Descending stairs?
   4 = none
   3 = mild
   2 = moderate
   1 = severe
   0 = extreme
2. Ascending stairs?
   4 = none
   3 = mild
   2 = moderate
   1 = severe
   0 = extreme
3. Rising from sitting?
   4 = none
   3 = mild
   2 = moderate
   1 = severe
   0 = extreme
4. Putting on socks/stockings?
   4 = none
   3 = mild
   2 = moderate
   1 = severe
   0 = extreme
5. Rising from bed?
   4 = none
   3 = mild
   2 = moderate
   1 = severe
   0 = extreme

INSTRUCTIONS: The following 6 questions concern your ability to participate in certain types of activities. For each of the following activities, please circle the response that most accurately reflects the difficulty that you have experienced in the past month because of your hip pain. If you do not participate in a certain type of activity, please estimate how much trouble your hip would cause you if you had to perform that type of activity. Please circle one answer that best describes your situation.

QUESTION: How much trouble does your hip cause you when you participate in-

1. High demand sports involving sprinting or cutting (for example, football, basketball, tennis, and exercise aerobics)
   4 = none
   3 = mild
   2 = moderate
   1 = severe
   0 = extreme
2. Low demand sports (for example, golfing and bowling)
   4 = none
   3 = mild
   2 = moderate
   1 = severe
   0 = extreme
3. Jogging for exercise?
   4 = none
   3 = mild
   2 = moderate
   1 = severe
   0 = extreme
4. Walking for exercise?
   4 = none
   3 = mild
   2 = moderate
   1 = severe
   0 = extreme

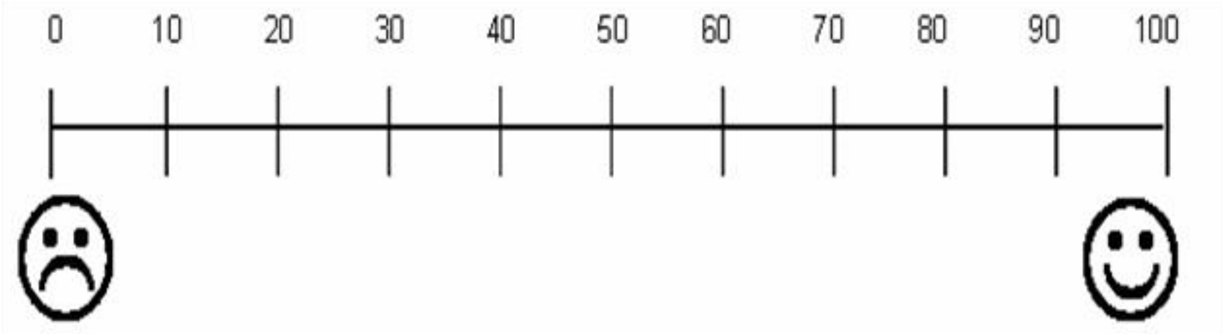
5. Heavy household duties (for example, lifting firewood and moving furniture)?
   4 = none
   3 = mild
   2 = moderate
   1 = severe
   0 = extreme

6. Light household duties (for example, cooking, dusting, vacuuming, and doing laundry)?
   4 = none
   3 = mild
   2 = moderate
   1 = severe
   0 = extreme

INSTRUCTIONS: Please add the numbers associated with each of your 20 answers to arrive at the raw score, Multiply the raw score by 1.25 to obtain your hip score.

Appendix 3

Visual analogue scale of patient satisfaction



Worst pain **Pain relief**

Appendix 4

Rosser Index

The Rosser Index (Rosser and Watts 1972)	
Disability	
I	No disability
II	Slight social disability
III	Severe social disability and/or slight impairment of performance at work
IV	Choice of work or performance at work severely limited Housewives and old people able to do light housework only, but able to go shopping
V	Unable to undertake any paid employment Unable to continue any education Old people confined to home except for escorted outings and short walks and unable to do any shopping
VI	Confined to chair or wheelchair or able to move around in the house only with support from an assistant
VII	Confined to bed
VIII	Unconscious
Distress	
A	No distress
B	Mild
C	Moderate
D	Severe

Appendix 5

Rosser index matrix

The Rosser Index Matrix (Gudex and Kind, 1988) showing a Quality of Life (QoL) score for each disability/distress combination

Disability	Distress			
	A	**B**	**C**	**D**
I	1.000	0.995	0.990	0.967
II	0.990	0.986	0.973	0.932
III	0.980	0.972	0.956	0.912
IV	0.964	0.956	0.942	0.870
V	0.946	0.935	0.900	0.700
VI	0.875	0.845	0.680	0.000
VII	0.677	0.564	0.000	-1.486
VIII	-1.028			

Appendix 6 Sports module questionnaire

Sports Assessment Module: ***Name:***

The following questions relate to the impact of your hip problem on playing your sport. Please record in the box the main sport in which you participate and note your answers relating to this sport in the column of the following table (fill-in or circle, as appropriate). If you play more than one sport please answer with respect to that activity which is most important to you.

Please record *the one* sport which is most important to you: .

1. Does your hip condition involve one or both hips?	One/ Both
2. Is the impact of the hip on your sport the main reason why you saw an orthopaedic surgeon?	Yes / No
3. With 100% being your performance the day before symptoms began, at what percentage would you presently rate yourself?	
4. Is your sport a source of income? (Options: ***A: only source. B: additional source. C: no income received***)	A/ B/ C
5. What is your level of competition? (Options: ***A: representing country. B: representing region, e.g. county(ies)/state(s). C: representing local club. D: no affiliation***)	A/ B/ C/ D
6. How many hours per week did you *train* for your sport in the last 3 months?	
7. How many hours per week did you *compete* in your sport in the last 3 months?	
8. How many competitive events were you attending per year before hip symptoms started?	
9. What percentage of the competitions you had planned for this year have you missed as a result of your hip condition?	
10. Have you stopped or reduced exposure to your sport because of your hip condition?	Yes / No
11. Have you changed your style in your sport to accommodate your hip condition?	Yes / No

Appendix 7

Levels of Evidence for Primary Research Question[a]

[This chart was adapted from material published by the Centre for Evidence-Based Medicine, Oxford, UK. For more information, please see www.cebm.net.]

Types of Studies

Level	Therapeutic Studies—Investigating the Results of Treatment	Prognostic Studies—Investigating the Effect of a Patient Characteristic on the Outcome of Disease	Diagnostic Studies—Investigating a Diagnostic Test	Economic and Decision Analyses—Developing an Economic or Decision Model
I	• High quality randomized trial with statistically significant difference or no statistically significant difference but narrow confidence intervals • Systematic review[b] of Level I RCTs (and study results were homogenous[c])	• High quality prospective study[d] (all patients were enrolled at the same point in their disease with $\geqslant$80% of enrolled patients) • Systematic review[b] of Level I studies	• Testing of previously developed diagnostic criteria on consecutive patients (with universally applied reference "gold" standard) • Systematic review[b] of Level I studies	• Sensible costs and alternatives; values obtained from many studies; with multiway sensitivity analyses • Systematic review[b] of Level I studies
II	• Lesser quality RCT (eg, < 80% followup, no blinding, or improper randomization) • Prospective[d] comparative study [e] • Systematic review[b] of Level II studies or Level I studies with inconsistent results	• Retrospective[f] study • Untreated controls from an RCT • Lesser quality prospective study (eg, patients enrolled at different points in their disease or <80% followup) • Systematic review[b] of Level II studies	• Development of diagnostic criteria on consecutive patients (with universally applied reference "gold" standard) • Systematic review[b] of Level II studies	• Sensible costs and alternatives; values obtained from limited studies; with multiway sensitivity analyses • Systematic review[b] of Level II studies
III	• Case control study[g] • Retrospective[f] comparative study[e] • Systematic review[b] of Level III studies	• Case control study[g]	• Study of nonconsecutive patients; without consistently applied reference "gold" standard • Systematic review[b] of Level III studies	• Analyses based on limited alternatives and costs; and poor estimates • Systematic review[b] of Level III studies
IV	Case series[h]	Case series	• Case-control study • Poor reference standard	• Analyses with no sensitivity analyses
V	Expert opinion	Expert opinion	Expert opinion	Expert opinion

[a] A complete assessment of quality of individual studies requires critical appraisal of all aspects of the study design.
[b] A combination of results from two or more prior studies.
[c] Studies provided consistent results.
[d] Study was started before the first patient enrolled.
[e] Patients treated one way (eg, cemented hip arthroplasty) compared with a group of patients treated in another way (eg, uncemented hip arthroplasty) at the same institution.
[f] The study was started after the first patient enrolled.
[g] Patients identified for the study based on their outcome, called "cases" eg, failed total arthroplasty, are compared with patients who did not have outcome, called "controls" eg, successful total hip arthroplasty.
[h] Patients treated one way with no comparison group of patients treated in another way.

Appendix 8

Service evaluation statement

VILLARBAJWA
PRACTICE

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www.villarbajwa.com

RV/LL

8 April 2015

Dear To whom it may concern

Re: **Dr Ajay Malviya**

This is to confirm that all the data used in the published papers for this thesis from the Richard Villar Practice were collected as part of a service evaluation. The database is confidential, anonymised and held in a secure place. It is not possible to identify any subjects from the studies. The data are collected and maintained in accordance with standard governance and ethical principles.

With best wishes

Yours sincerely

Mr R N Villar, MS FRCS
Consultant Orthopaedic Surgeon

The Richard Villar Practice Ltd c/o Spire Cambridge Lea Hospital, 30 New Road, Impington, Cambridge, CB24 9EL.

Registration Number 05916824

Appendix 10

Research Student Declaration Form
RC/DEC

NAME: Ajay Malviya

DEGREE FOR WHICH THESIS IS SUBMITTED: PhD

THESIS TITLE: “The role of hip arthroscopic intervention for femoroacetabular impingement on the quality of life and deferring the need for hip replacement”

1 * Material submitted for award

(a) I declare that I am the sole author of this thesis.

(b) I declare that all verbatim extracts contained in the thesis have been identified as such and sources of information specifically acknowledged.

(c) I certify that where necessary I have obtained permission from the owners of third party copyrighted material to include this material in my thesis.

(d) **Please tick one of the following options**

☐ I declare that no material contained in the thesis has been used <u>by me</u> in any other submission for an academic award.

☐ *I declare that the following material contained in the thesis formed part of a submission for the award of ……………………………………………………… *(state the award and awarding body and list the material below):*

(e) I agree that a copy of the thesis be held in The University of Sunderland Electronic Thesis repository with full public access, that a paper copy (if available) be held in The University of Sunderland Library, and that The University of Sunderland supplies the British Library with a copy of the thesis in paper or electronic format for further distribution and inclusion in a central electronic repository with full public access, with the following status:

Please tick one of the following options

☐ *Release the entire thesis immediately for access worldwide

☐ *Restrict access to the thesis, as approved by Research Committee for <u>2</u> years after the date of deposit.

If restricting access, please indicate the reason for this:

Please tick one of the following options

☐ The material is due for publication, or the author is actively seeking to publish this material.

☐ The release of the material would prejudice substantially the commercial interests of any
Person

☐ The material includes information that was obtained under a promise of confidentiality.

☐ other. *Please specify the reason for exemption in accordance with the Freedom of Information Act:*

I retain the ownership rights to the copyright of my work. I retain the right to use all or part of this thesis in future works (such as books and articles).

I hereby grant to The University of Sunderland the non-exclusive right to archive and make accessible my thesis, in whole or in part in all forms of media. I agree that for purposes of preservation file format migration may be carried out should this be necessary.

2 Concurrent registration for two or more academic awards
Please tick one of the following options

☐ *I declare that while registered as a research student for the University of Sunderland's research degree, I have not been a registered research student for another award of the University or other academic or professional institution.

☐ *I declare that while registered for the University of Sunderland's research degree, I was, with the University's specific permission, a registered student for the following award:

Signature of research student ……

Date …………10.01.2016

ADDRESS: 10 East Brunton Wynd

Newcastle upon Tyne

NE13 7 BR