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Conservative management of an elite ice hockey goaltender with femoroacetabular impingement (FAI): a case report

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Objective: *To detail the presentation of an elite male ice hockey goaltender with cam-type femoroacetabular impingement (FAI) and acetabular labral tears. This case will outline the prevalence, clinical presentation, imaging criteria, pathomechanics, and management of FAI, with specific emphasis on the ice hockey goaltender.*

Clinical Features: *A 22-year old retired ice hockey goaltender presented to a chiropractor after being diagnosed by an orthopaedic surgeon with MRI confirmed left longitudinal and chondral flap acetabular labral tears and cam-type femoroacetabular impingement (FAI). As the patient was not a candidate for surgical intervention, a multimodal conservative treatment approach including manual therapy,*

Objectif : Décrire *la présentation d'un gardien de but de hockey sur glace d'élite souffrant d'un conflit fémoro-acétabulaire (CFA) de type came et de déchirures du labrum acétabulaire. Ce cas présentera la prévalence, la présentation clinique, les critères d'imagerie, la pathomécanique et la prise en charge du CFA, en mettant l'accent sur le gardien de but de hockey sur glace.*

Caractéristiques cliniques : *Un gardien de but de hockey sur glace à la retraite de 22 ans a consulté un chiropraticien après avoir reçu, de la part d'un chirurgien orthopédique, un diagnostic, confirmé par IRM, de déchirures du labrum acétabulaire chondrales et longitudinales du côté gauche et d'un conflit fémoro-acétabulaire (CFA). Comme le patient n'était pas candidat à une intervention chirurgicale, une approche thérapeutique conventionnelle multimodale comprenant*

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electroacupuncture and rehabilitation exercises were implemented.

Summary: *FAI is prevalent in ice hockey players, particularly with goaltenders. Both skating and position-dependent hip joint mechanics involved in ice hockey may exacerbate or contribute to acquired and congenital forms of symptomatic FAI. As such, practitioners managing this population must address sport-specific demands in manual therapy, rehabilitation and physical training, to improve functional outcomes and prevent future injury.*

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KEY WORDS: chiropractic, case report, femoroactebular impingement, FAI, intra-articular hip injuries, acetabular labral tear, ice-hockey, goaltenders

la thérapeutique manuelle, l'électroacupuncture et des exercices de réadaptation a été *mise en* œuvre.

Résumé : *Le CFA est prévalent chez les joueurs de hockey sur glace, en particulier chez les gardiens de but. Les pas de patinage et le mécanisme dépendant de la position de l'articulation de la hanche utilisés dans le hockey sur glace peuvent exacerber les formes congénitales ou acquises du CFA symptomatique, ou y contribuer. Ainsi, les praticiens prenant en charge cette population doivent traiter les demandes propres au domaine sportif en ayant recours à la thérapeutique manuelle, à la réadaptation et à l'exercice physique, afin d'améliorer les résultats fonctionnels et de prévenir les lésions futures.*

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MOTS-CLÉS : chiropratique, étude de cas, conflit fémoro-acétabulaire, CFA, lésions de la hanche intra-articulaires, déchirure du labrum acétabulaire, hockey sur glace, gardiens de but

Introduction

Femoroacetabular impingement (FAI) is a mechanism that clinically leads to pain and has been associated with several intra-articular injuries including acetabular labral tears and early-onset osteoarthritis of the hip.[1-3] The morphological characteristics associated with FAI have helped define subtypes that include cam impingement when there is overgrowth of the femoral head; pincer impingement when the acetabulum excessively covers the femoral head; and a combined impingement involving both cam and pincer characteristics.[1,2,4] Diagnostic imaging is necessary to confirm the presence and severity of the deformity and is used to predict symptomatic impingement.[5] The alpha angle is used quantitatively to evaluate the degree of femoral head deformity for cam-type FAI, while evaluation of acetabulum morphology allows for the determination of pincer-type FAI (Figure 1).[5-7] A review by Emary[8] highlights these pertinent radiographic findings in a clinical context for use in chiropractic practice.

There is a growing body of evidence to suggest that FAI may be more prevalent in athletes, specifically sports which require end-range movements of hip flexion, adduction, and internal rotation.[9,10] Although involvement in sport was once thought to merely expose or self-select those with these congenital anomalies, increasing evidence has suggested these lesions may be due to sport-specific acquired adaptations over time.[9] Given the demands of the sport, ice hockey players are particularly susceptible to symptomatic FAI, with the cam and combined deformity being the two most common subtypes.[9-12] Furthermore, hockey goaltenders are exposed to a series of unique mechanical positions, particularly movements utilized in the butterfly technique, which may increase their risk of FAI.[9] The butterfly style for ice hockey goaltenders is popular, especially with younger, developing players. It is defined as a technique where the goaltender drops to their knees and internally rotates the hips to 90° with the intention of guarding the bottom portion of the net.[9,13,14] Recently, there has been much interest and controversy surrounding this topic with respect to position-specific demands in ice hockey players. There has

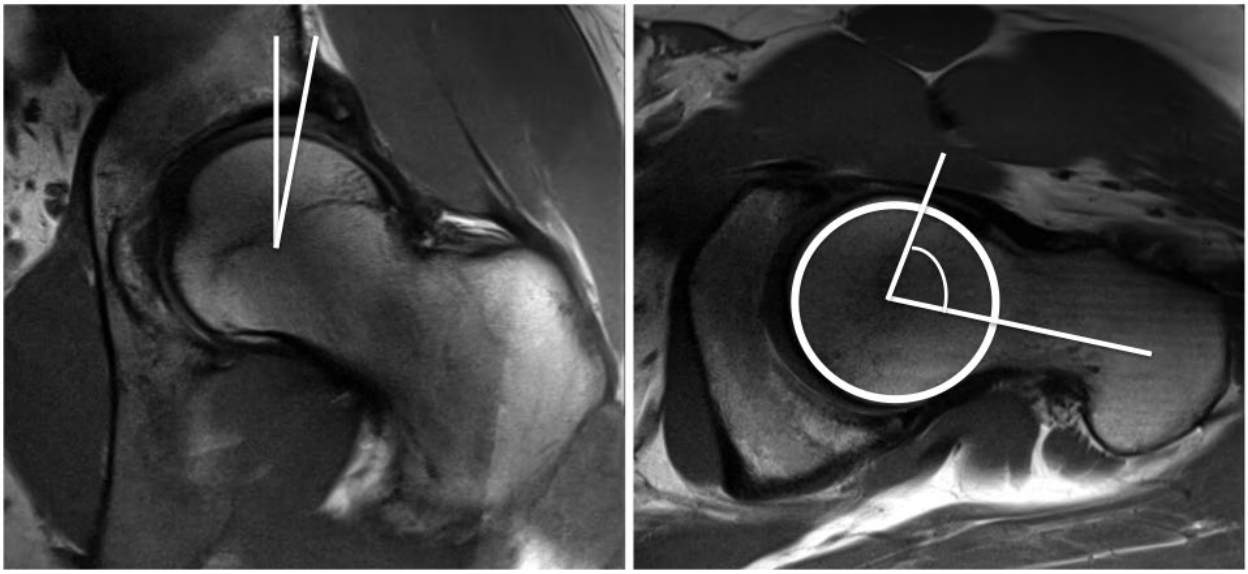

Figure 1.
T1-weighted coronal (left) and axial (right) MR images of the left hip. The coronal image on the left is demonstrating the measurement of the lateral centre edge angle. The axial image on the right is demonstrating measurement of the alpha angle.

been an increasing number of professional, junior and collegiate ice hockey goaltenders who have undergone surgery to treat symptomatic FAI, and media attention towards this sports phenomenon has become prevalent.[13] In a recent surveillance study of National Hockey League (NHL) players from 2006 to 2010, goaltenders had significantly higher hip and groin injury rates (1.84 per 1000 appearances) when compared with positional players (0.34-0.47 per 1000 appearances).[14] Interestingly, when analyzing intra-articular hip injuries, acetabular labral tears were most prevalent. With respect to positions, these injuries present more frequently in goaltenders in comparison to both forwards and defencemen.[14]

Since ice hockey is a Canadian national sport and it is common for clinicians to treat this population, there must be an increased awareness of sport-specific movements and injury patterns to optimize patient management. It is therefore critical to understand the pathomechanics at work and apply these principles to patient care, such as physical therapy and rehabilitation. The purpose of this case report is to detail the presentation of a male competitive hockey goaltender with symptomatic cam-type FAI and subsequent labral tears. This case will explore FAI with specific emphasis on athletes and ice hockey players, outlining the prevalence, clinical presentation, and management options. It will also expand on the importance of understanding sport-specific biomechanics to employ a thorough, non-surgical approach to aid in the treatment in FAI cases.

Case Presentation

A 22-year old male retired Ontario Junior Hockey (OHL) goaltender presented to a chiropractor at a sports clinic after being advised by an orthopaedic surgeon to seek conservative management for his symptomatic FAI. The patient had a 4-year history of recurrent left hip pain that had forced him to retire from competitive play. Six-months prior to presenting to the sports clinic, an orthopaedic surgeon had diagnosed him with left chondral flap and longitudinal acetabular labral tears with morphologic features of a cam-type femoroacetabular impingement (Figures 2-3). The patient was told he was not a surgical

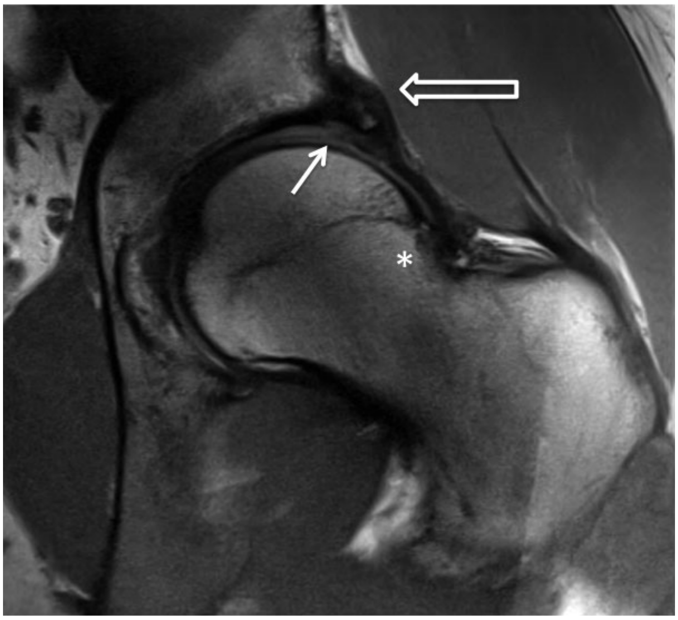

Figure 2.
T1-weighted coronal (left) MR image of the left hip demonstrating a mild cam-type morphology (white asterisk) with an acetabular labral tear (solid white arrow). The image also depicts a large os-acetabuli adjacent to the superolateral portion of the femoral head and acetabulum (hollow arrow).

candidate at the time since he had no previous attempts at conservative care, such as exercise and physical therapy. Furthermore, the patient was apprehensive to undergo surgery due to time constraints and fear of complications. As a result, the patient made a career choice to leave the sport of hockey and pursue further education to preserve future hip function. Since his left hip pain started to complicate other activities of daily living, such as long sitting and jogging, he felt that physical therapy was now warranted. The pain was described as a local, deep dull sensation that would present with intermittent bouts of sharp pain and catching that could radiate into the proximal anteromedial thigh. The pain was rated a 7/10 on a visual analogue scale (VAS) and his medical history revealed previous bilateral adductor strains and a left shoulder dislocation. When asked about his goals, the patient wanted to alleviate his consistent hip pain and improve his function for daily activities. He felt that he would never be able to play ice hockey competitively again considering the reported 'damage' to his left hip, but his ability to play at some level in the future was a long-term goal.

Physical examination revealed a 20% limitation and pain in both active and passive hip flexion and internal rotation. There was pain on palpation in several left hip girdle muscles, most notably the distal capsular portion of

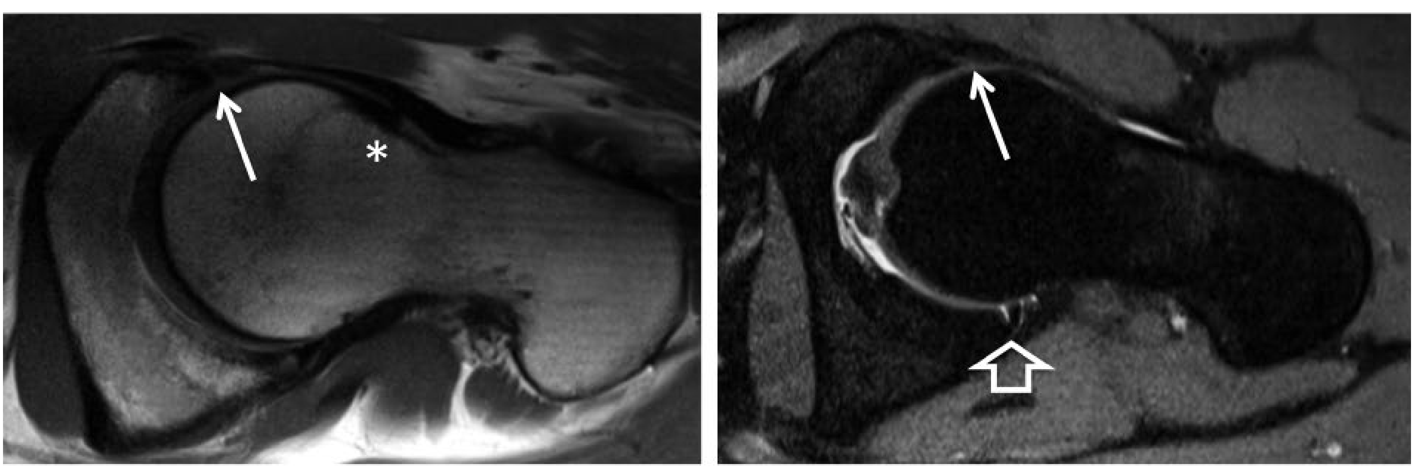

Figure 3.
T1-weighted (left) and T2 fat-suppressed (right) axial MR images of the left hip. An anterior acetabular labral tear is demonstrated on both images (white arrows). On the left T1-weighted image, the mild osseous cam-type deformity is visualized (white asterisk). A normal posterior labral recess is highlighted in the T2 fat-suppressed image on the right (arrow head).

the iliopsoas, proximal myotendinous junctions of the adductor longus and rectus femoris, and bellies of the pectineus, adductor magnus, and gluteal complex. Resisted left hip flexion and adduction were rated 4/5 with manual muscle testing (MMT), in which the patient was asked to meet the applied force of the practitioner at a fixed position.[15,16] Left hip abduction was rated 5/5 using the same MMT technique with pain reported during sustained contraction.[16] The hip scour and flexion-adduction-internal rotation (FADIR or FADDIR) tests[3,17] recreated the chief complaint, produced a palpable non-painful click, and had a hard end-feel. The left FABER (flexion-abduction-external rotation) test was positive, in which the vertical distance from the lateral knee to the examination table was increased on the symptomatic hip in comparison to the unaffected hip.[3] When the concurrent battery of testing is positive, clinical anterior hip impingement should be considered with a heightened suspicion for intra-articular hip pathology (including FAI).[17] Active straight leg raise (SLR), lumbar Kemp's, thigh thrust, and both sacroiliac joint compression and distraction tests were negative. Painful restriction was noted locally at the right sacroiliac joint with posterior-anterior joint challenge. Hip log roll, hip axial loading, resisted trunk flexion (sit-up), and valsalva tests were negative. These tests were implemented to rule out competing differential diagnoses (Table 1).

Table 1.
Differential diagnosis for persistent hip and thigh injuries in hockey players.

- Hip flexor or adductor strain
- Osteitis pubis
- Sports hernia/athletic pubalgia
- Inguinal or femoral hernia
- Femoroactebular impingement (FAI) or capsular impingement
- Acetabular labral tear
- Femoral neck stress fracture
- Degenerative osteoarthritis
- Referred pain: low back or genitourinary
- Infection

In addition to the imaging-confirmed diagnosis provided by the orthopaedic surgeon, a clinical diagnosis of left anterior hip impingement with associated tendinopathies of the left hip flexors and adductors was rendered. Treatment consisted of a conservative multimodal approach to address the secondary neuromusculoskeletal deficits associated with the underlying intra-articular hip joint pathology. The goals of the plan of management were to decrease pain, improve hip function (i.e. range of motion, strength, endurance, proprioception), and build more active lumbopelvic stability to allow participation in sport. The treatment was delivered at a frequency of 1-2 times per week over a 6-week period. Active Release Technique (ART)® and instrument-assisted soft tissue therapy was directed to the affected muscles and fascial planes. Spinal manipulative therapy was used to improve the range of motion and affect the overlying tissues of the right sacroiliac joint to optimize lumbopelvic function. Hip capsule distraction and release was delivered to the affected left hip using the Mulligan Mobilizations with Movement (MWM) concept.[18] Contemporary medical electroacupuncture was also incorporated into the plan of management. Spinal inputs included L2-L5 bilaterally and local inputs to the left hip muscles and nerves (SP-12, LR-10, GB-29, BL-53, BL-54) at a low (2 Hz) frequency stimulation. Rehabilitation exercises were used to increase muscle coordination, strength, endurance, and improve lumbopelvic stability. These were implemented in progressive phases: neuromuscular facilitation, functional training and sport specific training (Table 2).

After 6 weeks of treatment (total of 8 treatments) the patient was pain free at rest, during daily activities (including exercise), and with all stress tests used in the initial physical exam. Despite having less pain, the hip scour and FADIR tests still provided a hard end-feel and palpable click at extreme ROM. The patient was able to complete more taxing, sport-specific rehabilitation that incorporated both complex movement patterns and explosive plyometric training. At 8 weeks the patient was able to return to the ice with no further hip pain in a men's recreational hockey league at a frequency of once per week. Currently, he plays for 2 competitive men's hockey teams in both the winter and summer seasons at a frequency of 3 games per week. Although the underlying hip morphology and acetabular labral tears are irreversible with conservative care, this case demonstrates the importance of

Table 2.
Rehabilitation program utilized with the case patient over a period of 8 weeks.

Phase	Exercises/Stretches	Reps	Sets	Time
Phase 1	Posterior hip capsule stretching	15	2	30 sec
	Dynamic hip capsule stretching	15	2	30 sec
	Potato squat with 5lb medicine ball	12	2	
	Modified curl-up	12	3	
	Side bridge track	2	3	45 sec
	Bird dog track	12	3	
	Pelvic (supine) bridge with theraband at knees	12	3	
	Side-lying hip abduction	15	2	
	Deadbug with isolated single limb movement	15	3	
	Single leg balance on disc/pillow		3	60 sec
	BOSU squats	15	2	
	Goblet Squat with 20lb dumbbell	12	2	
Phase 2	Deadbug (contralateral movement + exercise ball)	15	3	
	Standing Pallof press	15	3	
	Exercise ball plank to stir-the-pot	2	3	15 sec
	Single leg squat (BOSU)	15	3	
	Step ups & lateral cross-over step up	15	3	
	Multi-angle lunge (clock lunge)	15	3	
	Multi-plane monster walks	15	3	
	Split squats	10	2	
Phase 3	Slideboard multi-angle lunges	15	3	
	Slideboard lateral slides	15	3	
	Single leg box squat	12	3	
	Pallof press on BOSU/stability disc	15	3	
	Zigzag bounds	10	3	
	Front & lateral shuffles (ladder agility drills)	Max	3	5 min
	Tuck jumps to tuck holds on BOSU	10	3	
	On-ice lunges	Max	3	5 min
	On-ice post-to-post recovery drills	15	3	

soft tissue structures that can be contributing sources of hip pain and dysfunction. Addressing these biomechanical limitations with a patient-centred approach can contribute to the overall integrity and function of the hip and lumbopelvic joints.

Discussion

Epidemiology

The prevalence of FAI has been shown to vary based on age, gender, and the type of activities one predominantly performs.[3,19] The cam-type deformity accounts for approximately two-thirds to three-quarters of all FAI cases, while the pincer-type deformity accounts for the remaining one-quarter of cases.[19] There is evidence suggesting that FAI is not as rare as once thought among the asymptomatic population. Jung et al.[20] retrospectively examined anterior-posterior (AP) pelvic CT scout views of 419 randomly selected patients, looking for the prevalence of cam-type deformity and evaluating alpha angle measurements. Among asymptomatic adults, 215 male hips were assessed revealing 13.5% as pathological, 14.88% as borderline and 71.16% as normal. Among 204 asymptomatic female hip joints, 5.56% were pathological, 6.11% were borderline, and 83.33% were deemed normal.[20] Hack et al.[21] further demonstrated that in asymptomatic volunteers with no prior hip issues, 28% showed either a cam deformity or an elevated alpha angle, predisposing them to FAI.

FAI has been anecdotally reported to have a higher incidence in athletic populations compared to non-athletic populations. FAI is reported with an estimated prevalence of 24% to 67% in asymptomatic athletes.[22,23] In comparing a group of 22 semi-professional soccer players to 22 amateur soccer players, it was found that the semi-professional group had a significantly higher mean alpha angle, which predisposes impingement.[23] In a systematic review and meta-analysis it was found that high-level male athletes (participating in basketball, soccer, hockey, and running) are 1.9 to 8.0 times more likely to develop a cam-type deformity than male controls.[24] While many studies have reported on male athletes, it is important to distinguish the prevalence of FAI in female athletes due to their unique hip anatomy. Kapron et al.[25] analyzed 63 female collegiate athletes who participated in volleyball, soccer, and track and field, assessing for radiographic evidence of FAI. Cam-type deformities were found in 48% of all hips with track and field athletes having significantly higher alpha angles compared to soccer and volleyball athletes.[25] Additionally, several main sexual dimorphisms have been observed with FAI, in which males are significantly more likely than females to have both radiographic and symptomatic bilateral cam-type FAI.[26] Other differences include smaller alpha angles and greater hip anteversion observed in females with symptomatic FAI. Despite these morphological differences, it has been demonstrated clinically that subjective hip function outcome scores are lower in females with symptomatic FAI in comparison to male counterparts.[26]

With specific reference to hockey players, Ayeni et al.[11] demonstrated that elite ice hockey players had significantly greater alpha angles than non-athletes. Even some of the youngest hockey players when compared to skiers of the same age (10-18 years) showed significantly greater alpha angles, and were 4.5 times more likely to have an alpha angle associated with cam impingement.[12] Siebenrock et al.[27] further displayed that elite-level youth hockey players had greater alpha angles with a closed femoral physes versus open physes, as well as higher alpha angles in symptomatic athletes when compared to asymptomatic counterparts. In addition, Ross et al.[13] revealed that 90% of butterfly goaltenders had an elevated alpha angle greater than 50°, resulting in a higher prevalence of FAI when compared to positional players. As is the focus of this case study, athletes appear to have a higher prevalence of FAI, and specifically hockey players, even at young ages, show a higher prevalence of FAI than participants in other sports. While the exact causation for such prevalence cannot be attributed to sports participation alone, it is important for the clinician to be aware of these differential diagnoses for persistent hip pain in these populations.

Clinical Presentation and Imaging

The literature describing clinical history and physical examination findings in patients with FAI is limited with considerable heterogeneity in population characteristics. Considering the vast amount of competing injuries that can occur at the hip, specifically in athletes such as ice hockey players, several important differential diagnoses must be evaluated and ruled out (Table 1). Patients with FAI will often present with groin pain, pain with prolonged sitting or walking, and pain during athletic activities requiring end-range motion, such as deep squatting.[22,28-30] Several clues in the clinical history include sharp or deep intermittent hip pain. With potential osteochondral or labral injuries, patients may report catching, locking, or give-way (instability) sensations.[3,28] A classic physical examination finding is a positive anterior impingement or FADIR test whereby the patients hip is passively flexed to 90°, followed by full adduction and internal rotation, with the presence of hip pain indicating a positive test.[3,17] In a study by Philippon et al.[3], the anterior impingement test was positive in 99% of patients with radiographic confirmed FAI. Ganz et al.[28] also reported that this test is almost exclusively positive in FAI-confirmed patients. Another common finding in FAI patients is a positive FABER test with reduced range of motion on the affected side or a less commonly reported positive posterior impingement test.[3,17] Common subjective measures used in FAI cases include the modified Harris hip score, the non-arthritic hip score, and the hip outcome score.[3] Although these clinical tests may allude to potential hip pathology if positive, both FAI and intra-articular injuries are imaging-based diagnoses.[28-31]

Conventionally, there are two imaging procedures used to diagnose and guide treatment in FAI cases; radiographic examination and MRI, with MR arthrography remaining the gold standard to evaluate the labrum and articular cartilage.[8,31,32] Regarding radiographs, a supine AP pelvis and cross-table lateral are used with assessment of the lateral center edge angle (to assess pincer deformity) and the alpha angle, which is the most frequently cited parameter for the assessment of cam deformity.[8,31,32] The lateral center edge angle is formed by a vertical line and a line connecting the femoral head centre with the lateral edge of the acetabulum (Figure 1).[32] This measurement is used to assess lateral coverage of the acetabulum. The normal range is stated to be 25-39°, with angles greater than 39° indicating over coverage.[31,32] On an axial view, the alpha angle is defined as the angle between a line from the center of the femoral neck to a line connecting the center of the femoral head to the point at which excess bone deviates the normal spherical shape of the femoral head (Figure 1).[7,8,32] An alpha angle greater than 50° is present when defining a cam deformity.[7] A previous narrative review has discussed these findings in detail for use in chiropractic practice.[8]

Ross et al.[13] set out to characterize radiographic deformity between butterfly goaltenders and positional players with symptomatic FAI who were surgical candidates. They found that butterfly goaltenders had a higher prevalence of acetabular dysplasia and significantly greater maximum alpha angles when compared to positional players. They also demonstrated that there were significant differences in the location of the cam deformity among hockey positions, with a more lateral offset found in butterfly goaltenders.[13] Although firm clinical implications cannot be drawn from this study, it does highlight potential adaptations that are unique to the positional demands of the ice hockey goaltender.

Pathomechanics

FAI is becoming a more predominant and detectable condition and is currently regarded as the most common cause of osteoarthritis in the non-dysplastic hip.[9,30,31] As previously discussed, FAI is a condition that has two distinctive biomechanical categories: cam and pincer impingement.[3-6, 24-32] Regardless of which impingement is occurring, the morphological changes and the subsequent inability to properly transmit forces efficiently will lead to future joint damage or insufficiency.[2,7,9]

The cam impingement is an abnormality with regards to the proximal femoral structures presenting unusually large or misshapen (often aspherical). This abnormal structural formation causes an unusual articular interaction to occur in the hip, particularly in the anterosuperior portion of the acetabulum.[26,28] Abutment occurs between the abnormal proximal femur and acetabulum, inflicting most of their effect to the cartilaginous structures and rarely to the labrum.[2,24,28] Alternatively, the pincer impingement is the result of an acetabulum abnormality where the proximal femur is partially, or fully engulfed by the bony protuberance of the acetabular rim. In cases of coxa profunda or protrusion, over coverage of the proximal femur leads to more insult on the labrum versus the cartilagenous portions of the joint.[2,26,28] With mixed impingement, both the articular cartilage and labrum are subject to injury.[32-34] The muscles most commonly affected with symptomatic FAI are the adductor longus, proximal hamstrings, hip abductors, and hip flexors (such as the iliopsoas).[33] As the body attempts to adapt to impingement, these muscles are often mechanically affected due to altered joint motion.[33,35]

Athletes who partake in rigorous sporting movements are more likely to experience impingement, especially if internal rotation of the hip and axial loading are frequent.[2,9,36,37] Cam impingement is most symptomatic in sports requiring excessive hip flexion while the pincer impingement can limit athletes in multiple planes.[23,24,27] Ice hockey players have been reported to undergo more FAI-related corrective surgery than athletes from other sports.[37,38] When analyzing essential movements of the hockey stride, propulsion requires forceful extension, external rotation, and abduction of the hip (posterior impingement mechanism); while stride recovery requires the components of the anterior hip impingement mechanism: flexion, adduction, and internal rotation.[9,10,24] Stull et al.[10] confirmed these two at-risk positions during the skating stride in a population of youth hockey players with a mean age of 10.8 years. They noted that the push-off phase required an average of 11.5° of external rotation with concurrent 13.2° of abduction and 13.8° of extension. During the swing phase (or recovery period), a mean of 5.6° of internal rotation was measured with 44.2° of concurrent hip flexion.[9] Although the magnitude of these values are smaller then those measured during preoperative FAI resection, the repeated use of these hip positions throughout an ice-hockey players career may be a contributing mechanism in cases of acquired or congenital symptomatic hip impingement.[9]

The demands of ice hockey goaltenders require unique movements when compared to positional hockey players and other athletes. Some of these movements include dropping into and rising from the butterfly position, lateral push-offs, and sprawling movements.[9,13,14,39] It has been previously hypothesized that the butterfly movement performed by ice hockey goaltenders involves combined flexion, internal rotation, and axial load at the hip, leading to a higher risk of developing FAI.[13,14] Whiteside et al.[9] set out to quantify hip mechanics during a "long rebound sequence" task, composed of three movements: skating and decelerating to a stop, dropping into a butterfly save, and pushing laterally from the butterfly position using the skate blade (recovery). Interestingly, none of the aforementioned movements involved concomitant hip flexion, adduction, and internal rotation in adequate ranges of motion that replicate those achieved in the FADIR test.[9] Internal rotation of the hip was found to be 21.2° at maximum and 11.5° at peak axial loading (femoral shock) during the butterfly save, while the deceleration movement had internal rotation values of 32.6° at maximum and 29.5° at peak femoral shock.[9] As confirmed by Stull et al.,[10] end-range hip internal rotation alone may be the primary mechanism behind anterosuperior impingement in the hip. When comparing other sport-specific movements where cam-type FAI is prevalent, such as the side-splits in dance (38°), golf swing (35°), and taekwondo kick (31°), they experience similar internal ranges of motion as witnessed in on-ice deceleration movements.[9,40-42] Although the hip internal rotation experienced in the deceleration phases of the skating stride are not unique to goaltenders, future research may provide more clinical insight as to mechanisms resulting in more symptomatic FAI in this population.[9]

Management

When considering the treatment options for patients diagnosed with FAI and possible hip labrum complications, it is important to note the age, level of sport/activity, and physical findings.[37,43] Both conservative and surgical treatment aim to restore normal hip function, while decreasing pain, and enabling the individual or athlete to return to their previous level of activity or sport.[2-4] A systematic review on FAI corrective surgery stated the main indications for surgery were an imaging-confirmed diagnosis of FAI accompanied by persistent pain and impaired function that has not resolved from conservative management.[44] Indications for hip labrum reconstruction constitute young, active patients, without arthritis, along with findings of instability, pain, and hip dysfunction.[45] It is generally agreed that a trial of conservative care is initiated first in the absence of red flags or surgical indications mentioned previously, in an attempt to manage symptoms and improve function.[44-46] This was the scenario in the case presented as the patient was not a surgical candidate despite having acetabular labral tears and associated cam-type FAI. Previous literature detailing the role of chiropractic care for FAI is consistent with the approaches used in this case.[8,39] It is important to note that conservative approaches can only address secondary functional neuromusculoskeletal issues attributing to pain and do not modify the osseous abnormality.[8]

Currently, FAI surgery is generally based on an open or closed (arthroscopic) technique. The open technique allows for a fully exposed view of the femoral head and acetabulum, as the hip is openly dislocated.[2,17,44,47] For cam-type FAI, the aspherical head is corrected via resection osteoplasty, while the acetabulum is trimmed or reoriented via periacetabular osteotomy.[2,47] However, the open technique comes with inherent risks and slower recovery time when compared to the closed technique (arthroscopy), which allows for a less invasive and reduced exposure during the surgery as well as a quicker recovery time.[2,44] The surgical intervention of choice for FAI with associated labrum pathology is labral debridement and repair.[45] Ayeni et al.[45,46] revealed that labral repair resulted in superior outcomes when compared to labral debridement. When considering return to play for high-level athletes with FAI, it is important to note the success surgical intervention can have. Naal et al.[48] found that in professional athletes undergoing FAI surgery with hip dislocation (14

Table 3.
Goals in FAI arthroscopic post-operative rehabilitation (Adapted from Pierce et al.[39]).

Phase	Goals
Phase 1 (2-10 weeks)	Protection Maintain constant passive range of motion Decrease inflammation Prevent muscle inhibition
Phase 2 (weeks 4-12)	Normalize gait Restore full range of motion Enhance neuromuscular control
Phase 3 (weeks 5-16)	Restore endurance and fitness Progress to more unilateral movements Restoration of balance
Phase 4 (16+ weeks)	Restore power and strength Return to play

of which were ice hockey players), 21 of 22 patients were still competing professionally 12-79 months post-surgery, and showed favourable satisfaction with the hip surgery and their athletic ability. Another method using an iliotibial band autograft produced similar patient satisfaction and returning to a similar level of competition in elite athletes.[49] A recent systematic review showed that all studies with various surgical techniques all reported significant improvements in patient pain, function, and satisfaction rate, as well as improved range of motion and a high return to sport rate of 98.2%.[44]

Regardless if a patient or athlete with FAI is involved in a non-surgical or operative plan of management, rehabilitation is the cornerstone of treatment and must address any lumbopelvic and lower kinetic chain deficiencies.[39,50] The rehabilitation process is similar after open or arthroscopic hip surgery and is broken down into four phases (Table 3).[39] The end goal of any rehabilitation program is to return the athlete to play at their previous level of competition. With respect to the hip, it is imperative to restore full range of motion (ROM), mobility, and build both endurance and strength.[39] When assessing the hip complex after corrective FAI surgery, the gluteal muscles, most notably gluteus medius, must be addressed as a priority since they are weakened and inactivated.[39,50] By restoring the strength, endurance, and dynamic control of the gluteal muscles through progressive exercises as demonstrated in the case (Table 2), patients can reintegrate proper hip function and lower limb kinematics.[39] A well-designed post-operative rehabilitation program for the hip should limit excessive hip flexion, or over-activation of the iliopsoas muscle short-term, which may cause irritation and prolong recovery.[39] Stationary hip abduction exercises are recommended for the activation of gluteus medius, while maintaining a relaxed iliopsoas. An over-aggressive exercise program should be avoided as it can lead to hip flexor irritation, muscle weakness, failure of a labral repair, and intra-articular adhesions.[39] When initiating sport-specific exercises for ice hockey goaltenders after post-arthroscopic hip surgery, progression should begin with normalizing skating mechanics without equipment. Once skating mechanics are attained without pain or functional issues, adding equipment and moving to light goalie specific movements (post-to-post lateral glide) can begin.[39] Once these goals are achieved, adding speed, incorporating butterfly-specific positions, and utilizing explosive movements should be initiated. The final stage prior to returning a goaltender to play is to integrate all components in game-like situations with a conditioning component.[39]

Summary

FAI has been observed to be more prevalent in athletic populations, and ice hockey goaltenders may be a specific at-risk athletic population.[9,13,14] Although the exact causes for this prevalence are unknown, recent literature has shown increasing evidence that acquired changes from sport demands over time may be a contributing factor. It is still important to consider the exposure of pre-existing congenital bone features and the potential of self-selection to occur given this morphology for success in sport. As demonstrated by the case presentation, elite-level hockey goaltenders can present with morphological characteristics such as FAI or associated soft-tissue adaptations that may be further exposed or aggravated with their unique sport-specific demands. The butterfly technique was previously thought to be the main precipitating factor for FAI development in hockey goaltenders, but recent research suggests that skating mechanics, specifically decelerating to a stop repetitively, may impose the greatest at-risk hip biomechanics leading to future intra-articular injury.[9] Conservative management utilizing a multimodal approach, as described in the case, should be first line treatment.[44-46] Surgery with a comprehensive post-operative rehabilitation program is warranted with failed conservative care, severe functional limitations, or complications from associated labral damage.[44,45] While surgery has very positive outcomes and a high return to play rate for athletes, it is imperative that rehabilitation maintain range of motion, endurance, strength, and power in the hip complex if the athlete wishes to return to the previous level of competition.[14,40,43-46]

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