Performance and return to sport after hip arthroscopy for femoracetabular impingement syndrome in National Hockey League players

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ABSTRACT

Femoroacetabular impingement (FAI) syndrome is a common cause of hip pain in National Hockey League (NHL) players that may lead to decreased performance. The purpose of this study was to determine the (i) return to sport (RTS) rate in NHL players following hip arthroscopy for FAI, (ii) post-operative career length and games per season, (iii) pre- and post-operative performance and (iv) post-operative performance compared with control players. NHL athletes who underwent hip arthroscopy for FAI and matched controls were identified based on position, age (±1 year), years of experience (±1 year) and performance data prior to the surgery date. Demographic and performance data were collected. RTS was defined as playing in at least one NHL game after surgery. A Bonferroni correction was used to control for multiple comparisons with statistical significance defined by a \( P \)-value \( \leq 0.007 \). Seventy players (77 surgeries) were analysed (mean age 29.4 ± 4.5 years; mean 8.8 ± 4.7 years NHL experience at the time of surgery). Sixty-three players (70 surgeries, 90.9%) RTS at an average of 6.8 ± 4.1 months. The 1-year NHL career survival rate for players undergoing surgery was 84.4%. Players in the control group (4.4 ± 2.7 years) had longer careers (\( P = 0.00002 \)) than players that underwent surgery (3.3 ± 2.5 years). There was no significant (\( P > 0.007 \)) decrease in post-operative performance compared with pre-operatively and with matched controls. The RTS rate for NHL athletes after hip arthroscopy for FAI is above 90% at less than 1 year. Following surgery, if a player returns to the NHL, then their post-operative performance is similar to pre-operatively and controls, but their careers are approximately one season less than controls.

INTRODUCTION

Femoroacetabular impingement (FAI) syndrome is a common cause of hip pain due to abnormal joint morphology leading to aberrant contact between the proximal femur (cam) and acetabular rim (pincer) [1–4]. This can lead to pain, decreased function and underperformance in elite athletes [4, 5]. Hockey players are at particular risk with these players 15 times more likely to develop FAI compared with the general population [6–11]. Previous studies have examined the epidemiology and outcomes of corrective surgery for FAI syndrome in elite athletes including hockey players [12–17]. The return to sport (RTS) rate in these high-level hockey players has been reported to range from 82% to 100% at up to 6.1 months post-operatively with significant improvement in several patient-reported outcome measures [13, 14, 17–19]. However, there are few studies investigating RTS and performance in National Hockey League (NHL) players following hip arthroscopy for FAI. It is important to understand the surgical outcomes in these patients given the professional status, monetary consequences and increased skill level required to play professional hockey.

The purpose of this study was to determine the (i) RTS rate in NHL players following hip arthroscopy for FAI, (ii) post-operative career length and games per season, (iii) pre- and post-operative performance and (iv) post-operative performance compared with control players matched by position, age, years of experience and performance. Based
on previously reported RTS data following hip arthroscopy for FAI, the authors hypothesized that NHL players who underwent hip arthroscopy for FAI would have (i) a greater than 85% RTS rate, (ii) no significant difference in post-operative career length and games per season compared with matched controls, (iii) no significant difference in post-operative performance compared with pre-operative and (iv) no significant performance difference post-operative when compared with matched controls.

**MATERIALS AND METHODS**

Athletes from the NHL who underwent hip arthroscopy for FAI syndrome between 2000 and 2016 were identified through team websites, publicly available internet-based injury reports, player profiles and biographies, and press releases. The search was manually conducted by two orthopedic surgery residents in January 2018. Searches were performed for all professional teams. This method of data collection has been used successfully in multiple prior studies of professional athletes including NHL [20–29].

All players identified were included in this study as it related to RTS rate. A player was deemed to have RTS if he played in any regular season game after surgery. A player did not RTS if he did not play in any NHL game after surgery. Inclusion criteria were any player on an active roster prior to hip arthroscopy for FAI. Players were included if they were found to have undergone hip arthroscopy for FAI as reported by at least two separate sources. Information from these databases was verified against each other and through independent web-based searches of team press releases that confirmed the date of surgery for each player. If this information was unclear, unverified or unable to be obtained, then the athlete was excluded. Athletes who were injured and underwent procedures before completing their first regular season were excluded from analysis because no pre-operative data would be available for comparison. Players who underwent hip arthroscopy for FAI in the 2017–2018 season were excluded from analysis because they had less than a 1-year opportunity to RTS and to obtain post-operative statistics.

Demographic variables including a player’s age, position, prior professional experience and date of surgery were recorded. Players were categorized by their positions, including offense (including center, left wing, right wing) ‘O’, defense ‘D’ and goalie ‘G’.

Due to the possible benefits or detriments of aging and/or experience on player performance and number of games played, matched control players were selected to use for comparison with post-surgery performance in the surgically treated players. A control was selected for every surgical case. Controls were matched to study cases based on position, age (±1 year), years of experience (±1 year) and performance data prior to the surgery date. Each control was given an index date which matched the case player’s surgery date to compare post-operative or post-index performance. For example, if a player had surgery 3 years into his career, the control’s index date was 3 years into his career.

Performance statistics were collected from http://www.hockey-reference.com for each player identified before and after FAI surgery. Statistics were collected for regular season NHL games only with pre-season and playoff games excluded. There were no players for whom performance data could not be identified. Player statistics for cases pre-operative and post-operative and controls pre-index and post-index were collected and aggregated. The performance score was calculated using the number of goals, assists, penalty minutes and shots on goal divided by the games played to account for discrepancies in the number of games played per season for offensive and defensive positions. The performance score for goalies was calculated using the number of wins, losses, ties, shutouts and goals against divided by games played. Performance was compared as described previously [27].

A Kaplan–Meier survivorship curve with ‘retirement’ as the endpoint was constructed post-operatively for cases and post-index for controls. The continuous variables of each cohort were compared using a two-tailed paired samples Student’s t-test for normally distributed data. Chi-square \( (\chi^2) \) was used to analyse categorical data. A Bonferroni correction was used to control for multiple \((n = 7)\) comparisons with statistical significance defined by a P-value \( \leq 0.007 \).

**RESULTS**

Seventy players (77 surgeries) underwent hip arthroscopy for FAI from 2000 to 2017 (Fig. 1). The mean age was 29.4 ± 4.5 years and the mean experience in the NHL was 8.8 ± 4.7 years at the time of surgery. Thirty-one players (57.4%) shot left handed while 23 (42.6%) shot right handed. Thirty-nine surgeries (50.6%) were performed in the offseason. Six players had bilateral surgery and one player underwent revision surgery. Offensive players \((n = 44)\) represented the largest proportion of players that underwent FAI surgery (57.1%) (Table I). Thirty-four (44.2%) of the surgeries were performed from 2000 to 2009 and 43 (55.8%) were performed from 2010 to 2016. There were no significant \((P > 0.007)\) differences in demographic, performance and games per season data between cases and matched controls pre-surgery and pre-index (Table II).

**RTS and career length**

Sixty-three players (70 surgeries, 90.9%) were able to RTS in NHL at an average of 6.8 ± 4.1 months. There was no significant difference in RTS rates or RTS time between
positions ($P > 0.007$). The overall 1-year NHL career survival rate of players undergoing FAI surgery was 84.4% (Fig. 2). Players in the control group (4.4 ± 2.7 years) had longer careers ($P = 0.00002$) than players that underwent surgery (3.3 ± 2.5 years).

Table I. Time to RTS by position

| Position | n   | RTS (%) | Months to RTS |
|----------|-----|---------|---------------|
| Offense  | 44  | 90.9    | 6.5 ± 4.4     |
| Defense  | 17  | 88.2    | 5.3 ± 1.9     |
| Goalie   | 16  | 93.8    | 7.8 ± 4.4     |
| Overall  | 77  | 90.9    | 6.8 ± 4.1     |

$n$, number of surgeries.

Games and performance outcomes after surgery
Cases and controls had similar age, years of experience and performance scores pre-operatively (Table II). There was no significant ($P > 0.007$) decrease in performance scores pre-operatively compared with post-operatively and between post-operative cases and post-index controls (Tables III and IV).

DISCUSSION
The study hypotheses were partially confirmed with a 90.9% RTS rate following hip arthroscopy for FAI. NHL players in the control group had approximately 1 year longer career lengths post-operatively compared with matched controls, without any significant difference in post-operative performance for all position groups compared with...
both matched controls. There was no significant difference in pre-operative versus post-operative performance.

The most common position undergoing hip arthroscopy for FAI was offense (n = 44, 57.1%) with the defense and goalie positions having fewer players undergoing surgery. Similar demographics were seen in previous studies with forwards being the most common position to have surgery [14, 17]. This positional breakdown is likely due to three athletes playing the forward positions at a time while only two defenders and one goalie are on the ice during game play. Adjusting for this, goalies undergo hip arthroscopy for FAI at a higher rate than other positions. This is likely due to goaltender-specific hip positioning as goaltenders must flex and internally rotate their hips frequently (butterfly technique, among others) while making a save. This technique places significant stress across their hips leading to increased impingement and resultant increased symptoms [30, 31].

The RTS rate in NHL players has been previously reported to range from 91.8% to 100% at 3.4–6.1 months post-operatively [17–19]. The present study had a similar RTS rate of 90.9% at 6.8 months. This is why studies such as these, using publicly available performance data, mandates the use of a matched control group to ensure if any change occurs following surgery, it may or may not be a natural performance history decline that occurs with age in professional sports. Thus, the current investigation differs from all previous studies without control groups that demonstrated significantly worse performance following surgery [18, 19].

Table II. Pre-surgery and pre-index statistics for cases and controls by position

| Statistic | Offense | Controls | P   | Offense | Controls | P   | Offense | Controls | P   |
|-----------|---------|----------|-----|---------|----------|-----|---------|----------|-----|
| Age       | 29.2 ± 4.6 | 29.0 ± 4.6 | 0.518 | 28.4 ± 4.2 | 28.6 ± 4.6 | 0.572 | 31.0 ± 4.5 | 31.0 ± 3.7 | 0.926 |
| Exp       | 9.2 ± 4.9  | 9.1 ± 4.8  | 0.571 | 7.3 ± 4.6  | 7.3 ± 4.6  | 1.000 | 9.3 ± 4.6  | 9.0 ± 4.1  | 0.217 |
| Score     | 0.83 ± 0.88 | 0.77 ± 0.61 | 0.720 | 0.60 ± 0.53 | 0.61 ± 0.48 | 0.937 | 1.53 ± 0.37 | 1.67 ± 0.27 | 0.247 |

P-values as determined by two-tailed paired Student’s t-test. Exp = seasons in NHL and score = performance score.

Fig. 2. Kaplan–Meier survival analysis for cases and controls. Zero (0) signifies year of surgery for cases and index year for controls.

rate in shorter time (3.4 months; range, 1–5 months) reported by Philippon et al. is likely due defining RTS as return to skating and/or hockey drills while the current study only considered a player to RTS if they played in a regular season NHL game following surgery [17]. In the current study, only nine players were able to RTS in the same season as their surgery and 18.6% of NHL players were in the offseason when they were expected to return. Therefore, the RTS time is likely longer than it would have been if the players were not in the offseason when expected to return.

The average post-operative career length for players undergoing hip arthroscopy for FAI in the present study was 3.3 years. This is similar to previous studies with reported post-operative career lengths ranging from 2.1 to 3 years following hip arthroscopy [13, 14, 18, 19]. However, the control group in the present study had significantly longer careers compared with matched players undergoing surgery. Only the study by McDonald et al. compared players undergoing surgery to matched controls and found no significant difference in career lengths between groups [13]. This study included American Hockey League (AHL) players in addition to NHL players. The AHL allows players an additional league to prolong their professional careers and likely contributes to the similar career lengths in both groups compared with the present study.

Despite the significant decrease in career lengths following surgery, there was no significant decrease in post-operative performance scores compared with pre-operatively and between post-operative cases and post-index controls for all positions. This is why studies such as these, using publicly available performance data, mandates the use of a matched control group to ensure if any change occurs following surgery, it may or may not be a natural performance history decline that occurs with age in professional sports. Thus, the current investigation differs from all previous studies without control groups that demonstrated significantly worse performance following surgery [18, 19].
By not using controls, these studies are unable to account for the career-based performance decline that likely plays a large role in their results. However, in the study by McDonald et al. with controls, there was no significant difference in performance following surgery for goalies and non-goalies [13]. Without surgery, their decline may have been accelerated and their career lengths even shorter. However, there is no control group including patients with FAI syndrome that were treated non-operatively to compare against.

There are limitations to this study and other studies of similar methodology. The use of publicly available data to identify players that underwent hip arthroscopy for FAI may be prone to selection, reporting and observer bias. However, this method of data acquisition has been used in multiple previous studies [20–23, 25, 26]. By only including the highest level of professional players, this data may only apply to elite-level male athletes. Professional players may seek to have the ‘top’ surgeons and ‘top’ therapists which may lead to a higher rate of return to play than non-professional players following hip arthroscopy [15]. This is believed to be due to the inherently higher motivation for return (e.g. financial income potential, skill, reputation, talent, grit, toughness, etc.) [14]. Additionally, players may retire due to other non-performance-related reasons that are not able to be accounted for in this type of study. As such, counting return to a single regular season game as RTS may not give the complete picture. The authors attempted to mitigate this by including performance data and career length following surgery compared with matched controls. The authors may not have been able to identify all previous hip surgeries for the included players which has been shown to have an effect on the outcomes of hip arthroscopy for FAI [32, 33]. Also, career length and performance were not adjusted for ‘time missed’ players who underwent hip arthroscopy for FAI. Inherent to this type of study, there are multiple unknown confounding variables such as no direct physical contact, patient-reported outcomes or medical records access to corroborate diagnosis and treatment. The use of public data limits the ability to determine the chronicity and severity of the injury. It was also unable to be determined reliably the surgeon who performed the operation or exact operative procedure used in each hip arthroscopy (labral debridement versus repair versus reconstruction, degree of cam/pincer correction/undercorrection/overcorrection, chondral treatments for variable degrees of articular cartilage pathology/arthritis or capsular closure/repair/plication/shift; periarticular extra-articular peritrochanteric, deep gluteal space or athletic pubalgia/core muscle injury). Heterogeneity of surgeons or surgeon experience is also a limitation. Other limitations include the absence of patient-reported outcomes and incomplete follow up and career length for players still in the NHL.

**Table III. Performance scores for pre-and post-surgery for cases and pre-and post-index for controls by position**

| Position | Cases | Controls | P | Cases | Controls | P |
|----------|-------|----------|---|-------|----------|---|
| Offense  | 0.83 ± 0.88 | 0.36 ± 0.99 | 0.017 | 0.77 ± 0.61 | 0.64 ± 0.55 | 0.061 |
| Defense  | 0.60 ± 0.53 | 0.20 ± 0.68 | 0.025 | 0.61 ± 0.48 | 0.55 ± 0.44 | 0.585 |
| Goalie   | 1.53 ± 0.37 | 1.25 ± 0.60 | 0.035 | 1.67 ± 0.27 | 1.60 ± 0.45 | 0.563 |

*P*-values as determined by two-tailed paired Student’s *t*-test between pre-and post-surgery and pre-and post-index.

**Table IV. Post-surgery and post-index statistics for cases and controls by position**

| Statistic | Cases | Controls | P | Cases | Controls | p | Cases | Controls | P |
|-----------|-------|----------|---|-------|----------|---|-------|----------|---|
| Seasons   | 3.2 ± 2.7 | 3.9 ± 2.7 | 0.022 | 3.0 ± 2.2 | 4.6 ± 3.0 | 0.021 | 3.8 ± 2.2 | 5.4 ± 2.2 | 0.006 |
| Score     | 0.36 ± 0.99 | 0.64 ± 0.55 | 0.089 | 0.20 ± 0.68 | 0.55 ± 0.44 | 0.111 | 1.25 ± 0.59 | 1.60 ± 0.45 | 0.045 |

*P*-values as determined by two-tailed paired Student’s *t*-test. Seasons = years in the NHL after surgery/index and score = performance score.
CONCLUSION
The RTS rate for NHL athletes after hip arthroscopy for FAI is above 90% at less than 1 year. Following surgery, if a player returns to the NHL, then their post-operative performance is similar to pre-operatively and controls, but their careers are approximately one season less than controls.

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CONFLICT OF INTEREST STATEMENT
All the authors have been actively involved in the planning and enactment of the study, and have also assisted with the preparation of the submitted article. The manuscript has been read and approved by all the authors.

The authors confirm that this is original work and has not been submitted, presented or published elsewhere.

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