



Cohort Study

Analysis of postoperative complications following elective arthroscopic surgeries of the knee- a retrospective cohort study



Ranjith Sreekumaran Nair^a, Rajiv Ramachandran Nair^a, Sandeep Munshi^c, Sriganesh Walkay^b,
Niranj Ganeshan Radhamony^{b,*}

^a Speciality Doctor in Trauma and Orthopaedics, University Hospitals of Morecambe Bay NHS Foundation Trust - Furness General Hospital, Barrow in Furness, Cumbria, UK

^b Senior Training Fellow in Trauma and Orthopaedics, Royal Stoke University Hospitals, Stoke on Trent, UK

^c Associate Specialist in Trauma and Orthopaedics, University Hospitals of Morecambe Bay NHS Trust, Furness General Hospital, Barrow in Furness, Cumbria, UK

ARTICLE INFO

Keywords:

Complications
Arthroscopy
Anterior cruciate ligament reconstruction
Effusion
Physiotherapy

ABSTRACT

Background: Since their introduction, arthroscopic procedures have been increasingly utilized for the treatment of knee pathologies, especially Anterior Cruciate Ligament (ACL) reconstruction. Reduction of post-operative morbidity, shortened hospital stay and recovery period have all been identified as the benefits of arthroscopy. However, despite tremendous increase in the number of these procedures done, the postoperative complications associated have been infrequently analyzed. Hence, we performed this study to analyze the perioperative complications of arthroscopic ACL reconstruction.

Materials & methods: We performed a retrospective case control study from our hospital database from the cases performed in July 2015 to December 2016. We included 20 cases who developed postoperative complications within 30 days of the procedure and 60 controls operated during the same period who did not have any complications.

Results: The complications noted in the cases were surgical site infection (SSI), deep vein thrombosis (DVT), effusion and superficial infection. The risk factors associated with each complication were compared with the cases and analyzed.

Conclusions: It was found that the lack of specialist physiotherapy, surgical prophylaxis and prolonged post-operative antibiotics were the major risk factors in the development of complications among our patients who underwent arthroscopic ACL reconstruction.

1. Introduction

Arthroscopic surgeries have become the norm for most sports injuries, and the rate of arthroscopic procedures has increased tremendously in the last decade with about 3 out of 10 elective orthopedic surgeries in the US performed by arthroscopy [1]. These surgeries, mainly the ACL reconstruction, are minimally invasive procedures, and serious complications following them are uncommon. Moreover, the benefits of the surgery, in general, far outweigh the risk of complications [2]. However, due to the rarity of such occurrences, very little is reported about the associated complications, their rates and risk factors. This study aims to shed light on such events.

Previous studies conducted on the post-operative complications following arthroscopic procedures have listed the weight of the patient

or body mass index (BMI) as a potential risk factor. Sing et al. (2016) identified that 40% of knee arthroscopy patients in their population sample were obese, and concluded that other than obesity, factors like American Society of Anesthesiologists (ASA) grade, local or remote infection and renal function are also related to postoperative complications [3]. Marecek et al. (2010) provided an in depth analysis of all common complications following arthroscopic shoulder surgeries barring failed treatment and post operative stiffness. They attributed a low rate of deep infections following surgeries to the use of preoperative antibiotics. The paper also describes in detail the importance of surgical site preparation and proper antisepsis as effective measures to reduce the risk of surgical site infections which is a serious complication that needs consideration [4].

With this background, the current study aims to identify the

* Corresponding author. 18 Sharman Close, Hartshill Road, Stoke on Trent, ST4 7LS, UK.

E-mail address: niranj.gr@gmail.com (N.G. Radhamony).

<https://doi.org/10.1016/j.amsu.2022.103546>

Received 17 February 2022; Received in revised form 17 March 2022; Accepted 26 March 2022

Available online 6 April 2022

2049-0801/Crown Copyright © 2022 Published by Elsevier Ltd on behalf of IJS Publishing Group Ltd. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

complications associated with arthroscopic ACL reconstruction surgeries at our institution and analyze the risk factors most commonly associated.

2. Material and methods

2.1. Patient selection

The study was conducted as a retrospective case-control analysis between July 2015 and December 2016. After obtaining Institutional Review Board approval [IRB: AH009839], patients were selected from the hospital database and only the ones who had undergone arthroscopic ACL reconstruction surgeries were included. The work has been reported in line with the STROCSS criteria [5]. A power analysis was performed and based on it 20 patients who encountered complications within the first 30 days of the procedure were included as cases. Sixty cases were selected as controls to get a 1:3 ratio of cases and controls. The total number of cases performed during that period was 121. From this group, we excluded revision procedures and patients who were treated for complaints related to previous procedures. All the cases and controls were within the age group of 20–65.

The relevant data for the study was then collected from the patients' surgical charts and inpatient admission files. The parameters for which data was collected were the file number, age, gender, date of admission, date of surgery, Length of hospital stay (in days), duration and type of preoperative and postoperative antibiotic prophylaxis.

2.2. Statistical analysis

We used logistic regression analysis to analyze the risk factors associated with post-operative complications following arthroscopic ACL reconstruction surgeries. The primary risk factors that were analyzed were type and timing of pre-operative antibiotic prophylaxis, ASA score > II, obesity (BMI), diabetes, duration and intensity of post-operative physiotherapy.

The Odds ratio for each of the risk factors was then analyzed against the corresponding parameters from the control group along with 95% confidence intervals. P value and z statistics were calculated for each parameter using logistic regression analysis to identify the significance of each result.

3. Results

A total of 20 cases, patients who had developed complications following arthroscopic surgery, were identified from the 121 patients. 60 controls, patients with no complications following arthroscopic surgery, were then selected from this group on a 1:3 ratio. All cases and controls were males and belonged to the age between 20 and 65. The mean age of the total population (cases and controls) was 42.3 years.

Of the identified cases, 2 patients had developed DVT (10%, n = 2), 11 patients had effusions (55%, n = 11), 8 patients were diagnosed with superficial infection (40%, n = 8) and 4 patients developed deep surgical site infections (20%, n = 4). The risk factors were identified for the complications based on the analysis of patient records, and were used as exposure factors for statistical analysis. Barring DVT, due to low incidence, we have computed the odds ratio and 95% confidence intervals for each complication based on the risk factors.

The overall incidence per risk factor for patients who developed complications is computed in Table 1. Results are tabulated as cases versus controls to indicate the number of each category that did or did not have exposure to the risk factor.

The odds ratio and confidence intervals for the overall statistics from Table 1 has been computed in Table 2. Also computed are the P value and z statistic based on logistic regression analysis following the odds ratio in order to determine statistical significance.

Each type of complication was then further analyzed against the

Table 1

Distribution of Case and Control statistics as per exposure to risk factor.

Risk Factor	Case with exposure (n = 20)		Case without exposure		Control with exposure (n = 60)		Control without exposure	
Diabetes	8	40%	12	60%	28	46.7%	32	53.3%
Obesity	4	20%	16	80%	14	23.3%	46	77.7%
ASA > II	7	35%	13	65%	18	30%	42	70%
Antibiotic prophylaxis	17	85%	3	15%	54	90%	6	10%
Physiotherapy	13	65%	7	35%	49	81.7%	11	18.3%
Post-operative Antibiotics	18	90%	2	10%	42	70%	8	30%

Table 2

Odds of complication risk following exposure to risk factors.

Risk Factor	Odds Ratio	95% CI		z statistics	P value
		Lower Limit	Upper Limit		
Diabetes	0.769	0.272	2.13	0.518	0.604
Obesity	0.821	0.236	2.862	0.309	0.757
ASA > II	1.256	0.43	3.67	0.417	0.676
Antibiotic prophylaxis	1.714	0.331	8.881	0.642	0.521
Physiotherapy	0.417	0.135	1.288	1.520	0.128
Post-operative Antibiotics	0.629	0.142	2.792	0.609	0.543

observed risk factors to identify the individual significance against exposure. Table 3 shows the distribution of patients who developed effusions following surgery and with exposure to risk factors against controls that were and were not exposed to the risk factors. Table 4 shows odds ratio and 95% CI for occurrence of effusion per risk factor.

The distribution of cases to controls for occurrence of superficial infection has been computed in Table 5 followed by the odds ratio and 95% CI in Table 6.

Of the 20 cases 4 patients had developed surgical site infections secondary to the arthroscopic surgery. Risk factors for surgical site infection are computed as diabetes, lack of surgical prophylaxis administration, and post-operative antibiotics for more than 48 h.

4. Discussion

The primary purpose of this study was to identify the most statistically relevant risk factor associated with occurrence of complications following arthroscopic ACL reconstruction procedure. Based on the data following a case to control analysis on the overall population (Table 1), we identified that the distribution of patients without a specialist physiotherapist's advice was much higher in both cases and controls as compared to patients who performed exercises without a specialist physiotherapist's input. Furthermore, we also observed that a large number of cases and controls, (90% and 70% respectively) received

Table 3

Distribution of Cases and Controls with Effusion and exposure to risk factors.

Risk Factor	Case with exposure (n = 11)		Case without exposure		Control with exposure (n = 33)		Control without exposure	
Diabetes	5	45%	6	55%	12	36.3%	21	63.7
Obesity	4	36%	7	64%	14	42.4%	19	58.6%
ASA > II	4	36%	3	64%	18	54.5%	15	45.5%
Antibiotic prophylaxis	10	90.9%	1	9.1%	32	96.9%	1	3.1%
Physiotherapy	6	54.5%	7	45.5%	32	96.9%	1	3.1%
Post-operative Antibiotics	11	100%	0	0%	31	93.9%	2	6.1

Table 4
Odds of effusion following exposure to risk factors.

Risk Factor	Odds Ratio	95% CI		Z statistic	P
		Lower Limit	Upper Limit		
Diabetes	1.458	0.366	5.812	0.535	0.593
Obesity	2.714	0.529	13.917	1.197	0.231
ASA > II	0.312	0.018	5.464	0.797	0.426
Antibiotic prophylaxis	4.111	0.214	5.764	0.125	0.902
Physiotherapy	1.825	0.003	0.259	3.126	0.002
Post-operative Antibiotics	0.027	0.081	4.952	0.379	0.704

Table 5
Distribution of Cases and Controls with Superficial infection and exposure to risk factors.

Risk Factor	Case with exposure (n = 8)		Case without exposure		Control with exposure (n = 24)		Control without exposure	
	n	%	n	%	n	%	n	%
Diabetes	5	62.5%	3	37.5%	8	33.3%	16	66.7%
Obesity	2	25%	6	75%	5	20.8%	19	79.2%
ASA > II	1	12.5%	7	87.5%	3	12.5%	21	87.5%
Antibiotic prophylaxis	8	100%	0	0%	23	95.8%	1	4.2%
Physiotherapy	6	75%	2	25%	7	29.2%	17	70.8%
Post-operative Antibiotics	2	25%	6	75%	4	16.7%	20	83.3%

Table 6
Odds of superficial infection following exposure to risk factors.

Risk Factor	Odds Ratio	95% CI		Z statistic	P
		Lower Limit	Upper Limit		
Diabetes	3.333	0.631	17.603	1.418	0.156
Obesity	1.267	0.193	8.295	0.547	0.805
ASA > II	1	0.089	11.24	0	1
Antibiotic prophylaxis	1.085	0.04	2.285	0.049	0.961
Physiotherapy	1.123	0.776	1.626	2.131	0.033
Post-operative Antibiotics	1.667	0.243	11.449	0.520	0.603

postoperative antibiotics for over 48 h without a clinical indication. Similarly, a large number of cases and controls (85% and 90% respectively) received preoperative antibiotic prophylaxis beyond the half-life of the antibiotic and were found to be higher generation cephalosporins unlike the recommendation for antibiotic surgical prophylaxis by Society for Healthcare Epidemiology of America (SHEA) and American Society of Health-System Pharmacists (ASHP) [6–8]].

On analyzing the odds ratio of occurrence of complications following exposure to the risk factors, we observed that patients with a higher ASA score had greater odds of complications following the surgery than those with an ASA score of I or II (1.256). As higher ASA scores are usually indicative of a systemic disease, we observed an overlap between these patients and patients with obesity and diabetes. Furthermore, the analysis of odds ratio also indicated greater odds for patients to acquire post-op complications (1.714) after receiving an antibiotic with half life running out earlier than the start of the procedure. It must be noted that all the patients in cases and controls received either third or fourth generation Cephalosporins as surgical antimicrobial prophylaxis.

Heyer et al., in his study including 21,143 patients of arthroscopic rotator cuff repair identified that 0.70% of them had complications within a 30-day postoperative period. They performed an univariate analysis which showed that age >65(p = 0.0028), ASA class >2 (p <

0.0001), male gender (p = 0.0053), elevated BMI (p = 0.0054), history of chronic obstructive pulmonary disease (p < 0.0001),dyspnea (p < 0.0001), hypertension (p < 0.0002), steroid use (p = 0.0350), and operative time >90 min (p = 0.0316) were the associated risk factors [9].

In Table 3, we analyzed the case to control distribution of patients who developed effusions post-op and their correlation with exposure to each of the primary risk factors. We observed that all the patients with postoperative effusion (100%) and 93.9% of the controls were given post-operative antibiotics for over 48 h without clear indication. However, based on the odds ratio analysis (Table 4), the low ratio of 0.027 and the P value of 0.704 indicate that this is statistically insignificant and there was no actual correlation between the duration of post-operative antibiotics and incidence of effusion. The odds ratios does however indicate high odds of developing effusion in patients who have received higher generation Cephalosporins as surgical prophylaxis and with coverage beyond the half-life. These patients showed the largest odds of developing effusion, indicating that preoperative antibiotics, their type and timing play a key role in prevention of effusions. Odds of effusion were also high in patients with obesity and diabetes as patients with comorbidities had odds ratio of 2.714 and 1.458 respectively. Given the large confidence interval for obesity, it is possible to reject it as a risk factor, but for the purpose of our study we have decided to include it due to the low P value. Of highest significance were the odds of effusion occurring in patients who did not undergo the recommended physiotherapy. Odds for such patients were 1.825 with a P value of 0.002, making it one of the strongest risk factors for consideration in cases of postoperative effusion. Small et al., in his analysis of post-operative complications in 10,262 arthroscopic procedures noted that hemarthrosis was the most frequent complication amounting to 60.1% of the complications. Moreover, in knee arthroscopies, hemarthrosis was encountered in just over 1% of the cases [10].

We also analyzed the distribution of cases and controls for development of postoperative superficial infection and their exposure to the risk factors. Based on the distribution, we observed that all of the patients who developed superficial infection had received higher Cephalosporins as surgical prophylaxis and these drugs were administered past the half-life period. Furthermore, we looked at all patients who developed a surgical site infection in the 30-day post-operative period. As per the National Healthcare Safety Network (NHSN) criteria, we included one patient with a deep infection in the primary incisional site who developed the infection within the 90 day postoperative period [11]. We observed from Table 7 that all patients with surgical site infections had received prolonged antibiotic prescriptions for over 48 h following surgery and 75% of patients with surgical site infections had received delayed administration of higher generation Cephalosporins as surgical prophylaxis. Following this, the odds ratios (Table 8) also indicated greater odds of developing surgical site infections following arthroscopic surgeries in patients who receive higher generation Cephalosporins as surgical prophylaxis followed by prolonged postoperative antibiotics. Hagino et al., in his analysis of postoperative complications in 2,623 knee arthroscopies found that only one patient developed superficial infection and 2 patients developed septic arthritis. The very low percentage of infection has been attributed to optimal antibiotic prophylaxis both in the preoperative and postoperative period. They used a

Table 7
Distribution of Cases and Controls with surgical site infections and their exposure to risk factors.

Risk Factor	Case with exposure (n = 4)		Case without exposure		Control with exposure (n = 12)		Control without exposure	
	n	%	n	%	n	%	n	%
ASA > II	1	25%	3	75%	10	83.3%	2	17.7%
ASP	3	75%	1	25%	7	58.3%	5	41.7%
Post abx	4	100%	0	0%	10	83.3%	2	17.7%

Table 8
Odds of surgical site infections following exposure to risk factors.

Risk Factor	Odds Ratio	95% CI		Z statistic	P
		Lower Limit	Upper Limit		
ASA > II	0.067	0.004	1.017	4.948	0.052
ASP	2.142	0.169	2.104	0.589	0.556
Post-op Abx	2.143	0.085	54.225	0.462	0.644

first generation cephalosporin or a wide spectrum penicillin in the immediate preoperative period and then to cover 2 days in the post-operative period amounting to a total of 6 doses [12].

Upon analysis of the odds ratio (Table 6), we observed that the odds ratio for patients with ASA scores higher than II was exactly 1. In this case we concurred that the ASA score of the patient had no impact whatsoever on the chances that a patient develops postoperative superficial infection. We also excluded post-operative antibiotics, obesity and diabetes as potential risk factors in spite of the higher odds of 3.33 and 1.267 due to the large confidence intervals which made them statistically insignificant. Sing et al., in his study about adverse events following knee arthroscopy found that independent risk factors for complications in knee arthroscopies included ASA (class 4 versus ASA class 1 had an odds ratio of 5.39 [95% confidence interval: 3.11–9.33] and $P < 0.001$) [3].

Of significance in the analysis of superficial infection are surgical prophylaxis and physiotherapy as risk factors. We observed that patients with irregular physiotherapy and patients who did not keep up with regular physiotherapy appointments following surgery were much more likely to develop superficial infection (odds ratio: 1.123). With a low P value of 0.033, this is the most significant statistical value. Additionally, patients with 3rd and 4th generation Cephalosporins as surgical prophylaxis also had greater odds (1.085) of developing superficial infection in the postoperative period as compared to the controls. Given the low z statistic of 0.049 in this case, we considered surgical prophylaxis to be a significant risk factor as well. Following surgery, specialist physiotherapy is important and will help to restore movement of the hip or knee and strengthen the surrounding muscles. Strengthening the muscles not only helps with movement, but it will also protect the joints against future injury.

The limitations of the study include the small sample size, and subsequently we only analyzed the major risk factors related to ASA score, surgical prophylactic antibiotics and post-operative antibiotic prescriptions.

5. Conclusion

Based on the results, we identified lack of physiotherapy, improper preoperative antibiotic prophylaxis and over prescription of post-operative antibiotics to be the major risk factors in the development of complications in patients undergoing arthroscopic procedures. We believe that postoperative complications can be avoided with thorough review of antibiotics for each patient and modifying prescriptions based on the clinical indication for each patient. Patients undergoing supervised high repetitive physiotherapy had reduced pain, quick recovery and increased knee function as compared to postoperative patients who did not participate in a professionally guided rehabilitation program.

Declaration of interests

✓The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT statement

Ranjith Sreekumaran Nair- Conceptualization, Methodology, Formal

analysis and investigation. Rajiv Ramachandran Nair- Writing - original draft preparation, Writing - review and editing, Funding acquisition, Supervision. Sandeep Munshi-conceptualization, formal analysis, methodology, project administration, resources, supervision, validation, writing-review & editing. Sriganesh Walkay - conceptualization, formal analysis, methodology, project administration, resources, supervision, validation, writing-review & editing. Niranj Ganeshan Radhamony-Writing - original draft preparation, Writing - review and editing, Formal analysis and investigation.

Location of the study

Apollo Hospital Muscat, Al Hamriya, Ruwi, PO Box 1097, PC 131, Muscat, Sultanate of Oman.

Sources of funding

There were no sources of funding received for the current study.

Provenance and peer review

Not commissioned, externally peer-reviewed.

Declaration of competing interest

The authors do not have any conflicts of interest to disclose.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.amsu.2022.103546>.

References

- [1] W.E. Garrett Jr., M.F. Swiontkowski, J.N. Weinstein, J. Callaghan, R.N. Rosier, D. J. Berry, et al., American board of orthopaedic surgery practice of the orthopaedic surgeon: part-II, certification examination case mix, *JBJS* 88 (3) (2006) 660–667 [2].
- [2] M.A. Bohensky, R. Desteiger, C. Kondogiannis, V. Sundararajan, N. Andrianopoulos, A. Bucknill, et al., Adverse outcomes associated with elective knee arthroscopy: a population-based cohort study, *Arthrosc. J. Arthrosc. Relat. Surg.* 29 (4) (2013) 716–725.
- [3] D.C. Sing, T.F. Luan, B.T. Feeley, A.L. Zhang, Is obesity a risk factor for adverse events after knee arthroscopy? *Arthrosc. J. Arthrosc. Relat. Surg.* 32 (7) (2016) 1346–1353.
- [4] G.S. Marecek, M.D. Saltzman, Complications in Shoulder Arthroscopy, *J. Title Orthop.* 33 (7) (2010).
- [5] G. Mathew, R. Agha, for the STROCSS Group, StrocSS 2021: strengthening the Reporting of cohort, cross-sectional and case-control studies in Surgery, *Int. J. Surg.* 96 (2021) 106165.
- [6] D.M. Shlaes, D.N. Gerding, J.F. John Jr., W.A. Craig, D.L. Bornstein, R.A. Duncan, et al., Society for Healthcare Epidemiology of America and infectious diseases society of America joint committee on the prevention of antimicrobial resistance: guidelines for the prevention of antimicrobial resistance in hospitals, *Clin. Infect. Dis.* 25 (3) (1997) 584–599.
- [7] E.L. Beard Jr., The American society of health system pharmacists, *JONA's Healthc. Law, Ethics, Regul.* 3 (3) (2001) 78–79.
- [8] M. Rybak, B. Lomaestro, J.C. Rotschafer, R. Moellering, W. Craig, M. Billeter, et al., Therapeutic monitoring of vancomycin in adult patients: a consensus review of the American society of health-system pharmacists, the infectious diseases society of America, and the society of infectious diseases pharmacists, *Am. J. Health Syst. Pharm.* 66 (1) (2009) 82–98.
- [9] J.H. Heyer, X. Kuang, R.L. Amdur, R. Pandarinath, Identifiable risk factors for thirty-day complications following arthroscopic rotator cuff repair, *Physician Sportsmed.* 46 (1) (2018) 56–60.
- [10] N.C. Small, Complications in arthroscopic surgery performed by experienced arthroscopists, *Arthrosc. J. Arthrosc. Relat. Surg.* 4 (3) (1988 Jan 1) 215–221.
- [11] J.R. Edwards, K.D. Peterson, M.L. Andrus, J.S. Tolson, J.S. Goulding, M.A. Dudeck, et al., National Healthcare safety Network (NHSN) report, data summary for 2006, issued June 2007, *Am. J. Infect. Control* 35 (5) (2007) 290–301.
- [12] T. Hagino, S. Ochiai, Y. Watanabe, S. Senga, M. Wako, T. Ando, et al., Complications after arthroscopic knee surgery, *Arch. Orthop. Trauma Surg.* 134 (11) (2014) 1561–1564.