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Original Research Article

Glove Perforation in Arthroscopic Anterior Cruciate Ligament Reconstruction: A Silent Culprit of Infection

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ABSTRACT

With the growing popularity of sports, the number of arthroscopic anterior cruciate ligament (ACL) reconstructions has steadily increased. Although postoperative infection rates after arthroscopy are relatively low (0.28–1.0%), they can cause significant complications, particularly in young and active patients. One overlooked factor is glove perforation, which may contaminate the surgical field and allow infection to pass between the surgical team and the patient. This study aimed to determine the incidence of glove perforation during arthroscopic ACL reconstruction.

A prospective single-center study was conducted between August 2 and October 1, 2024. Gloves used by the primary surgeon, assistant surgeon, and scrub nurse were collected after ACL reconstruction procedures. All operations employed the anatomical single bundle technique with hamstring tendons. Perforations were detected by filling the gloves with water mixed with food coloring and applying pressure to reveal leaks.

In total, 43 surgeries were evaluated. Glove perforation was identified in 44.2% of procedures. The second surgeon had the highest perforation rate (68.7%), while scrub nurses demonstrated the greatest overall incidence (52.6%). The most frequent stage for glove perforation occurred during the opening of bone tunnels (47.4%).

In conclusion, glove perforation is common in arthroscopic ACL reconstruction, largely due to the use of sharp surgical instruments. Routine glove changes after 90 minutes and careful handling of penetrating tools are recommended to minimize infection risks and prevent septic arthritis.

ÖZET

Sporun giderek artan popülaritesi ile birlikte artroskopik ön çapraz bağ (ACL) rekonstrüksiyonlarının sıklığı da artmaktadır. Enfeksiyon oranları düşük olmakla birlikte (%0,28–1,0), bu komplikasyon genç ve aktif hastalarda önemli sosyal ve ekonomik sorunlara yol açabilmektedir. Eldiven perforasyonu, cerrahi alanın kontaminasyonuna ve enfeksiyonun hem hasta hem de cerrahi ekip arasında taşınmasına neden olabilecek, sıklıkla göz ardı edilen bir risk faktörüdür. Bu çalışmada artroskopik ACL rekonstrüksiyonu sırasında cerrahi ekipte eldiven perforasyonu insidansı araştırılmıştır.

Çalışma, 2 Ağustos–1 Ekim 2024 tarihleri arasında tek merkezde prospektif olarak yürütülmüştür. Primer cerrah, asistan cerrah ve steril hemşirenin ameliyat boyunca kullandıkları eldivenler incelenmiştir. Perforasyonlar, eldivenlerin su ve gıda boyası ile doldurulup basınç uygulanması ile tespit edilmiştir. Toplam 43 ameliyat değerlendirilmiş, bunların %44,2'sinde eldiven perforasyonu saptanmıştır. En yüksek perforasyon oranı ikinci cerrahta (%68,7) gözlenmiş, perforasyonların en sık görüldüğü aşama kemik tünellerinin açılması olmuştur (%47,4). Ayrıca, steril hemşire %52,6 ile en yüksek perforasyon oranına sahiptir.

Sonuç olarak, artroskopik ACL rekonstrüksiyonları sırasında eldiven perforasyonu önemli bir risk oluşturmaktadır. Penetran cerrahi aletlerin dikkatli kullanımı ve ameliyatın 90. dakikasında eldivenlerin rutin olarak değiştirilmesi enfeksiyon riskini azaltmada etkili olabilir.

Introduction

Arthroscopic procedures for the knee are mostly low morbidity and outpatient surgeries(1). The annual incidence of arthroscopic anterior cruciate ligament reconstructions(ACLR) is increasing in parallel with the increasing interests in sports(2,3). Post-operative complications may occur due to surgical or patient-related reasons as with any surgery. Vascular and neurological complications are rare after arthroscopy. Infection, which is the first among preventable complications, can be seen in 0.28% and 1.0% and even 1.8% according to registry-based cohort studies(4,5). Postoperative complications may cause social or economic problems because the patients undergoing reconstruction surgery are mostly young and active patients(6). Knee septic arthritis is a condition with high morbidity because it causes prolonged rehabilitation, poor surgical outcomes, and repeated revision surgeries that lead to psychological problems in patients. Although the risk of infection is statistically low, frequent arthroscopic surgeries lead to frequent complications.

Good sterilization of the surgical materials, laminar air flow in the operating rooms, use of prophylactic antibiotics, and use of strict aseptic techniques are preventions to reduce the risk of septic arthritis(7).

Among the major and well-known causes of infection, glove perforation is one of the overlooked causes of septic arthritis. Glove perforation causes contamination of the surgical field, as well as infection transmission between the patient and the surgical team.

The aim of our study is to determine the incidence of perforation in the gloves used by the surgical team after arthroscopic anterior cruciate ligament reconstruction (ACLR). The secondary aim of our study is to determine at which stage glove perforation is more common during ACLR and to reveal the surgical steps that the surgical team should be more careful about. Our hypothesis is that due to the use of more penetrating surgical instruments in anterior cruciate ligament reconstruction surgeries compared to other arthroscopic knee surgeries, we think that being more careful in the stages where glove perforation may develop will reduce the risk of septic arthritis

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Materials and Methods

Our investigation constitutes a single-center prospective study in which gloves worn by three distinct members of the surgical team (primary surgeon, assistant surgeon, and scrub nurse) during ACL reconstruction surgery were systematically collected. The study period spanned from August 2, 2024, to October 1, 2024. All ACL reconstruction surgeries were executed utilizing the anatomical single bundle technique with hamstring tendons. Gloves utilized by the assistant surgeon and scrub nurse during patient draping were excluded from the study. Throughout the procedure, the primary surgeon, assistant surgeon, and scrub nurse employed double-layer gloves. Non-latex nitrile gloves were chosen, particularly for individuals with latex allergies (8). To ensure ease for the surgical team with latex allergies, it was determined that the inner gloves would be non-latex nitrile. The entire surgical team utilized non-latex nitrile gloves as inner gloves and latex gloves as outer gloves to maintain standardization and eliminate bias, given that non-latex gloves exhibit 2-3 times greater resistance to puncture compared to latex or vinyl gloves (9). Measures were implemented to prevent contact between the outer glove and the skin for personnel with latex allergies. Adequate information about the study was provided to the personnel, and informed consent was obtained. Institutional Review Board approval was secured for the study.

Instances necessitating glove changes, such as contamination or glove tightening, were documented, along with the corresponding stage of the surgery. For cases involving glove perforation, the stage of the surgery at which the glove change occurred was specifically noted. The evaluation for this study encompassed the gloves utilized by three different surgeons and their respective teams throughout the surgical procedures. At the conclusion of each operation, an impartial evaluator, unaware of the study's details, examined the gloves used by the surgical team for potential perforations. The water infusion method, as outlined in the American Society for Testing and Materials guideline, was employed to render perforations visible on the gloves.(10). Perforation was defined as a "small continuous stream of water" or "dripping" of water from the fingers or other parts of the glove(11). The gloves underwent a procedure in which they were filled with 1000 ml of non-sterile tap water. To enhance visibility, food coloring was introduced, contrasting with the blue nitrile glove and the light cream-colored latex glove, thereby facilitating the identification of perforated areas. A drop of red food coloring was incorporated into the water to ensure that even minute leaks, potentially overlooked, could be readily discerned, aligning with recommendations from the guideline. A waiting period was observed to allow for the complete integration of the food coloring into the water. Subsequently, colored pressurized water was applied to the glove, causing it to exit from the perforated holes. The presence of perforations was ascertained by applying pressure to the glove for a duration of 2-3 minutes.

Results

The examination encompassed the gloves utilized by three distinct surgeons and their respective surgical teams, who conducted ACLR surgeries between August 2, 2021, and October 1, 2021. Specifically, the first surgeon performed 15 surgeries, the second surgeon performed 16 surgeries, and the third surgeon performed 12 surgeries within the study period. The cumulative evaluation involved 43 surgeries, revealing glove perforation in 19 cases, constituting a prevalence of 44.2%.

Notably, the second surgeon exhibited the highest rate of glove perforation at 68.7%, followed by the third surgeon at 41.7%, and the first surgeon at 33.3%. However, statistical analysis indicated that the observed differences in perforation rates among the three surgeons were not statistically significant (p=0.55). (Table 1).

Table 1. Glove perforation rates by surgeon

Surgeon	**Number of surgeries**	**Number of perforations**	**Perforation rate (%)**
1	15	5	33.3
2	16	11	68.7
3	12	5	41.7
Total	**43**	**19**	**44.2**

Table 2 presents the quantity and percentage of observed glove perforations at various stages of arthroscopic ACLR surgery. Among the 43 surgeries assessed, 19 instances (44.2%) exhibited glove perforation. Notably, the most prevalent stage of surgery for perforation was during the opening of bone tunnels, accounting for 47.4%. Perforations were also noted during other stages, including tibial and femoral tunnel preparation, graft passage, and knot tying. Utilizing the Chi-square test to assess potential differences in the rates of glove perforation across different stages of surgery, the results were found to be statistically insignificant (p=0.682). Concerning the distribution of glove perforations among members of the surgical team, the scrub nurse demonstrated the highest rate at 52.6%, followed by the primary surgeon at 31.6% and the assistant surgeon at 15.8%.

Table 2. Stages of surgery at which glove perforation occurred

Stage of surgery	Number of perforations	Perforation rate (%)
Opening of bone tunnels	9	47.4
Tibial and femoral tunnel preparation	4	21.1
Passing of the graft	3	15.8
Knot tying	3	15.8
Total	19	100

Discussion

The utilization of surgical gloves establishes a mechanical barrier that serves to prevent the transmission of microorganisms between the surgeon's hands and the patient, mitigating the risk of infection in both directions. The efficacy of this barrier can be influenced by various factors, including the proper handling of surgical instruments, the quality of the gloves employed, the duration for which the gloves are worn, the overall duration of the surgical procedure, the specific type of surgery conducted, and the individual habits of the surgeon. Each of these elements contributes to the overall integrity of the surgical gloves and, consequently, their ability to fulfill their protective function.(9).

Our observations revealed that glove injuries were prevalent, primarily attributable to the penetrating nature of instruments employed in ACLR surgery. A significant contributor to glove perforation was identified as the handling of penetrating surgical instruments. Direct penetration effects stemming from activities such as drills, insertion of tibial guide wires, or reaming for femoral tunnel creation were noted as potential causes of guide wire penetration.

In our investigation, we systematically assessed glove perforation at five distinct stages of ACLR surgery: 1) arthroscopic examination, 2) hamstring harvesting, 3) opening of femoral and tibial tunnels, 4) graft placement, and 5) graft fixation. Notably, our findings indicated that perforations were observed in the gloves of both the primary surgeon and the assistant surgeon, with a notable frequency during the opening of the tibial and femoral tunnels (Table 2).

Emphasizing the specificity of our study, we employed the anatomical single bundle reconstruction technique utilizing hamstring tendons in ACLR procedures. Given this focused approach, it is imperative to acknowledge the need for future research endeavors, specifically comprehensive and comparative studies, aimed at discerning and comparing the incidence of glove injuries across various ACLR techniques. Such investigations hold the potential to provide valuable insights into the nuanced aspects of glove perforations associated with different surgical approaches in ACLR procedures.

Furthermore, the variation in the quality of surgical gloves among different brands underscores the importance of evaluating their performance in a systematic manner. In a separate study, participants were surveyed, and the surgical sterile gloves they utilized were scrutinized based on criteria such as perforation rate, ventilation, allergic reactions, elasticity, thickness, powder content, and overall satisfaction properties. This comprehensive evaluation aims to contribute to a more nuanced understanding of the diverse attributes and performance metrics associated with different surgical glove brands, thereby informing and improving the choices made by surgical practitioners (12). The examination of two specific glove brands revealed that they exhibited significantly inferior characteristics in terms of ventilation, thickness, and elasticity compared to other brands. Another study highlighted the impact of surgical gloves on the psychomotor performance of surgeons. Notably, in surgeries involving fine motor muscles, such as hand surgery, factors like psychomotor performance, tactile sensation, and overall comfort of the glove become crucial. Thin gloves, while potentially addressing security concerns related to perforation, may introduce issues, whereas thicker gloves might compromise tactile feedback and manual dexterity. Striking a balance between these considerations is essential to ensure optimal surgical performance while maintaining necessary safety measures during intricate procedures. The findings from such studies contribute valuable insights into the nuanced relationship between surgical glove characteristics and their impact on surgical outcomes (13). Units responsible for the supply of gloves to healthcare institutions should take responsibility for monitoring glove quality in order to select safe and comfortable gloves. Due to the increased need for non-sterile gloves during the Covid pandemic period, it may be another subject to study on whether there is a decrease in the quality of non-sterile but especially sterile surgical gloves compared to the pre-pandemic period.
In an experimental study, it was observed that subjects who were asked to wear gloves for a long time (6 h/day for 14 days) had a marked deterioration in the skin barrier function at the end of the study and were open to infections(14). In another study conducted on nurses who had to use gloves for a short time in intensive care units, they reported that using short-term gloves did not have an effect on the skin barrier, but sweaty hands would increase the deterioration of the skin barrier(15).

In the short survey conducted with the surgical team participating in the study, it was concluded that wearing double gloves increases sweating in the hand. Increased sweating may cause the skin barrier to deteriorate and may result with an easier transmission of microorganisms from the patient to the surgical team if the glove is perforated. We think that this hypothetical conclusion should be supported by further studies.

In another study, the use of surgical gloves for 90 minutes or less resulted in micro perforation 15.4%, 18.1% with 91-150 minutes, and 23.7% with more than 150 minutes(16,17). Changing the outer gloves of the surgical team after 90 minutes may be beneficial in preventing micro perforation.
Pathogens can be transmitted from the surgical team to the patient or vice versa after any surgery due to the invasive nature of surgery. Glove perforation can be seen in all surgical branches besides orthopedic surgeries are considered to be high risk in terms of perforation due to sawing, drilling or contact with sharp objects(18). Although it is related to the type and aggressiveness of the surgery performed, it should not be forgotten that perforation is also related to the duration of glove use, the quality or elasticity of the glove.
Our study showed that there is a considerable risk of glove perforation during ACLR surgeries, with a rate of 20.9%. Although there was no statistically significant difference in perforation rates among the three surgeons, the 1st surgeon had a higher perforation rate compared to the 2nd and 3rd surgeons. It is essential to take preventive measures, such as changing gloves every 90 minutes, to reduce the risk of infection transmission to the surgical team and patients. The most common stage of surgery at which glove perforation occurred was during the opening of bone tunnels. Perforations also occurred during other stages of surgery, such as tibial and femoral tunnel preparation, passing of the graft, and knot tying. The scrub nurse had the highest rate of glove perforations, followed by the primary surgeon and assistant surgeon, indicating the need for all members of the surgical team to be vigilant in preventing contamination and infection.

Conclusion

Glove perforation is an inherent risk across various surgical procedures, and its occurrence is particularly pronounced in orthopedic surgeries due to the prevalent use of penetrating surgical materials. Arthroscopic anterior cruciate ligament reconstruction (ACLR) surgeries, in particular, exhibit a higher frequency of glove perforations, notably during the critical phase of opening bone tunnels. Prudent measures, such as exercising caution when employing perforating surgical instruments, coupled with the routine change of outer gloves 90 minutes into the surgical procedure, can significantly contribute to preventing potential complications, including the risk of septic arthritis. Such preventative actions underscore the importance of vigilance and adherence to established protocols in minimizing the likelihood of glove perforation-associated complications in orthopedic surgeries, especially in the context of arthroscopic ACLR procedures.

Declaration of conflicting interests

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Ethical approval

The study was approved by the Institutional Review Board

Institutional Review Board

Information about the study was given to the personnel and informed consent for this study was obtainee

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