



Efficacy of the use of sterile plastic to cover the surgical field against infection in orthopedic operations

Ortopedi ameliyatlarında cerrahi sahanın örtülmesinde steril poşet kullanımının enfeksiyon açısından etkinliği

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Abstract

Introduction: Surgical site infections (SSI) are situations with difficult treatment processes for patients and clinicians. Though the precautions are taken to reduce this risk, they continue to occur. One of the most important sources of SSI is known to be the individual's own flora. The tables that contaminated with the patient's own flora lies under the sterile covers. This study simulated surgical conditions to research the efficacy of the use of sterile plastic against the incidence of surgical site infections.

Methods: Total of 18 surgical areas were imitated in 3 different groups by using full blood in the tables covered in real operating theater conditions. Each table was contaminated with a healthy individual's forearm flora. All tables used 3 sterile re-usable surgical drapes spread one on top of the other. The difference between the groups was using a sterile plastic or non-sterile plastic below sterile re-usable surgical drapes and no using of plastic. So groups were defined as no sterile plastic group, non-sterile plastic group and sterile plastic group. Additionally the cost of using a sterile plastic was calculated. The Fisher exact test used to calculate the propability of infection development.

Results: The use of sterile plastic was found to statistically reduce the possibility of infection development. The cost of using sterile plastic was about 2,5 tl (0,8 \$) when the study performed. The probability of infection development was statistically significantly lower in the sterile-plastic group.

Discussion and Conclusion: After skin preparation with an appropriate antiseptic agent, we recommend covering the table with sterile nylon plastic and then re-usable surgical drapes to reduce the possibility of SSI development.

Keywords: Bacterial penetration; re-usable surgical drape; skin flora; sterile plastic; surgical site infection.

Özet

Amaç: Cerrahi alan enfeksiyonları (CAE) hastalar ve hekimler için tedavi süreci zorlu durumlardır. Bu riski azaltmak için birçok tedbir alınmasına rağmen maalesef CAE görülmeye devam etmektedir. CAE'lerinin en önemli kaynaklarından birinin hastanın kendi florası olduğu bilinmektedir. Ameliyatlarda steril örtülerin hemen altında hastanın kendi florası ile kontamine olan masa bulunmaktadır. Bu çalışmada ameliyat şartlarına benzer şartlar oluşturularak steril yeşil örtülerin altında steril poşet kullanımının cerrahi alanda enfeksiyon görülmesi üzerine etkinliğinin olup olmadığı araştırıldı.

Gereç ve Yöntem: Bunun için ameliyathane şartlarında, tam kan kullanılarak 3 ayrı grupta toplam 18 adet cerrahi alana benzer ortam oluşturuldu. Her ameliyathane masası sağlıklı bir bireyin önkol florası ile kontamine edildi. Tüm masalarda üstüste 3 adet tekrar kullanılabilen steril yeşil örtü serildi. Gruplar arasındaki tek fark, tekrar kullanılabilen steril yeşil örtülerin altına bir grupta hiç poşet serilmemesi, bir grupta nonsteril poşet serilmesi ve bir grupta da steril poşet serilmesi idi. Bu nedenle gruplar poşet serilmeyen grup, steril olmayan poşet serilen grup ve steril poşet serilen grup olarak isimlendirildi. Ayrıca steril yeşil poşet kullanımının maliyeti de hesaplandı. Enfeksiyon gelişme ihtimali The Fischer Exact propability test ile değerlendirildi.

Bulgular: Steril poşet kullanımının istatistiki olarak enfeksiyon gelişme ihtimalini azalttığı tespit edildi. Steril poşet kullanım maliyeti çalışma yapıldığında yaklaşık olarak 2,5 tl (0,8 \$) idi. Enfeksiyon gelişme olasılığı steril poşet grubunda istatistiksel olarak anlamlı derecede düşüktü.

Sonuç: Sonuç olarak ekstremitte antisepsisini takiben steril yeşil örtülerin serilmesi öncesinde steril poşet serilmesinin enfeksiyon gelişme ihtimalini azaltacağını düşünmekteyiz.

Anahtar Sözcükler: Bakteriyel göç; tekrar kullanılabilen cerrahi örtüler; cilt florası; steril poşet; cerrahi saha enfeksiyonu.



Surgical site infections (SSI) are a very significant and severe problem due to increasing mortality, morbidity, hospital stay and hospital costs.^[1] Infections observed within one year of the operation in cases with implants and infections observed within the first month for cases without implants are defined as SSIs.^[2,3]

Until the middle of the nineteenth century, the incidence of SSI was above 90%. In 1867 with the definition of antiseptic principles by Joseph Lister and later development of aseptic-antiseptic methods and discovery of antibiotics, the incidence of SSI began to reduce.^[4,5]

Many methods are applied to the surgical team and patient to reduce the risk of SSI. Hand-washing by the surgical team, prophylactic antibiotherapy, patient skin cleaning before surgery, use of surgical masks and caps, covering the surgical field with aniodophore impregnated plastic adesive drape and laminar flow ventilation of the operating room may be includehüsed among these methods.^[2,6-11]

In spite of all these precautions, full sterilization of the skin is not possible in terms of SSI.^[12-14] Despite these precautions infections are observed.^[15,16]

In clinical practice after skin preparation with an appropriate antiseptic agent during the sterilization process before surgery, many orthopedic surgeries used prepared cover sets if they are in the hospital inventory, or if not manufactured nylon plastic bags, and spread the sterile re-usable surgical drapes above the plastic (Fig. 1).

Thus the aim is to prevent both potential bacterial migration from other extremities, and potential bacterial migration from the table. However, in our literature search we could not access any data on the use of sterile plastic before covering



Figure 1. Covering with sterile plastic before sterile re-usable surgical drapes.

with sterile re-usable surgical drapes and so this study was planned. This study planned to assess the correlation of sterile plastic use during surgical draping with bacteria in the surgical field and the duration to proliferation in culture.

Materials and Method

This study obtained permission from the clinical ethics committee (15-KAEK-198). The surgeries where the study was completed had laminar flow ventilation systems. During the study, operating room temperature was 16-18 °C and humidity was between 30-60%. Full blood was used to simulate the surgical field in the study. All surgical tables used in the study had routine cleaning performed a half hour before the study began. After routine cleaning, each table was contaminated with the forearm flora of an individual with no skin or infectious diseases (Fig. 2). Blood obtained from the blood center was negative on screening tests and 6 pouches of full donor blood past the use-by date by a mean of 2 days (1-3 days) was used. The study comprised 3 groups. In each group 6 surgical fields were simulated. In total 18 surgical fields were recreated. All tables used 3 sterile re-usable surgical drapes spread one on top of the other.

In the first group, no plastic was spread below the sterile re-usable surgical drapes. In the second group non-sterile plastic was spread below sterile re-usable surgical drapes. In the third group sterile plastic was spread below the sterile re-usable surgical drapes (Fig. 3).

Spreading the sterile plastic and re-usable surgical drapes was completed by 2 nurses and 1 orthopedic surgeon washed according to surgical conditions, wearing cap, mask, sterile box apron and sterile surgical gloves to imitated surgical conditions. After covering with the sterile re-usable surgical drapes, 150 ml full blood was spilled onto the re-usable surgical drapes on each table separately until a pool formed with the aim of simulating surgical conditions (Figure 4a and 4b).

Additionally the cost of using sterile plastic was learned from the hospital administration.



Figure 2. Contaminating of tables with forearm by an individual with no skin or infectious diseases.



Figure 3. Operation table. Areas covered with sterile plastic, non-sterile plastic and no plastic areas.

Sampling

In the 0, 10th and 30th minutes and after the 1st, 2nd, 3rd, 4th and 6th hours after covering with sterile re-usable surgical drapes, swab sticks were used to take samples by an expert microbiologist (ŞD) wearing box, cap and mask appropriate to surgical conditions (Fig. 4b). Samples were also taken from forearm and also from the tables before spreading sterile re-usable surgical drapes. Additionally during the study the surgery door was kept closed and apart from the expert microbiologist taking samples no one entered the surgery. Samples were cultured on blood agar plates and eosin methylene blue (EMB) agar plates within 10 minutes and incubated at 37°C for 48 hours in a incubator.

Evaluation of Cultures

At 24 and 48 hours, cultures were evaluated and proliferating bacteria identified by an expert microbiologist (ŞD). In addition to evaluating the relationship of contamination risk

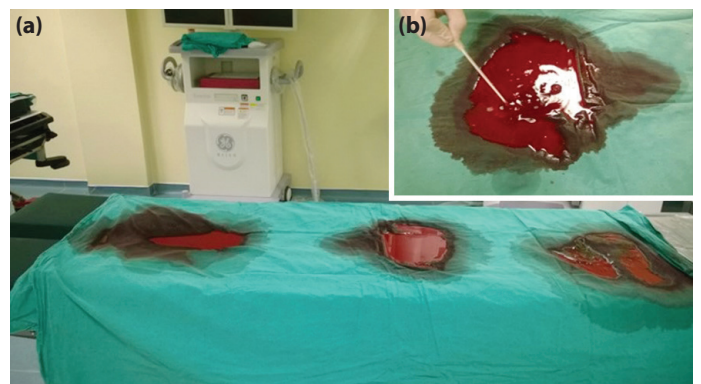


Figure 4. Full blood spilled areas (a), full blood spilled to form a puddle and culture sampling (b).

during surgery with the use of sterile plastic, an attempt was made to assess the time interval when contamination may be encountered after covering with sterile re-usable surgical drapes.

Cost Calculation

The items for calculation of the sterile plastic was the purchase cost of the prepared plastic and the cost of medical waste.

Statistics

Statistical analysis was completed with the Fisher Exact Propability Test (bilateral, 95% confidence interval). Comparisons were made between true results of experiments and expected results (for example, 100% infection). A p value below 0.05 was determined as a statistically significant high risk of infection occurrence.

Results

After draping all tables with sterile re-usable surgical drapes, there was proliferation observed on two tables in the no-plastic group, four tables in the non-sterile plastic group and one table in the sterile plastic group (Table 1). When the time interval samples were taken are investigated, all proliferation was observed to occur after the 2nd hour. Proliferation or lack of it according to time interval for all groups with sterile draping and sampling after full blood spillage is given in Table 2. Proliferation was seen in all forearm and table samples of non-sterile plastic and without plastic group. There was any proliferation at the samples those

Table 1. Total number of tables with proliferation in groups and statistical table of possibility of infection in groups according to the Fisher exact test

	Proliferation	No proliferation	Infection rate (%)	P (possibility of infection)
Group 1 no plastic	2	4	33.3	<0.05
Group 2 non-sterile plastic	4	2	66.7	<0.05
Group 3 sterile plastic	1	5	16.7	>0.05

Table 2. Infection development in blood after sterile covering of the table according to time

	Table number	0 min	10th min	30th min	1st hour	2nd hour	3rd hour	4th hour	6th hour
No	1								
	2								
	3							Proliferation	
	4								
	5								Proliferation
	6								
Non-sterile	1								Proliferation
	2								
	3					Proliferation			
	4								
	5					Proliferation			
	6							Proliferation	
Sterile	1								
	2								
	3								
	4								
	5							Proliferation	
	6								

taken from the sterile plastic group. Proliferating colonies were assessed and bacterial colonies were identified using classic methods. According to colony morphology, gram staining, catalase, and coagulase tests, all were determined to be coagulase negative staphylococci. The proliferations of the samples from forearm, tables and simulated surgical area were same morphology.

The cost of using a sterile plastic and the medical waste cost was about 2.5 tl (0.8 \$).

Statistical Result

According to the Fisher Exact Propability Test, the probability of developing SSI was significantly lower at sterile plastic group ($p>0.05$) (Table 1).

Discussion

In situations with infection after orthopedic surgery, implants may need to be removed making infection control for orthopedic surgery more important compared to infections in other regions.^[1,16]

As the majority of orthopedic surgeries use implants, and infections observed in the first year after implant are accepted as SSI, and due to the cost, long duration and difficult process involved in treating orthopedic infections, in clinical practice great care is taken to prevent development of infection.^[2,3,16] The treatment cost for an infected prosthesis is about 50,000 US dollars.^[17] To reduce this risk, a variety of precautions like sterilization of the surgical field, brush-washing the hands of personnel, textiles worn in the surgery and masks are taken.^[2,6-11] However, in spite of all these precautions there is always a risk of infection.^[18-20] It is known that the air in the surgery may be contaminated.^[21] The most significant source of SSI is the patient's own skin flora.^[22-24] It is

known that skin flora bacteria are mobile and may pass through damp re-usable surgical drapes. Bacteria above the drapes are significant potential causes of wound contamination.^[11] Drapes used repeatedly are easily permeable to skin flora. Single-use drapes have been shown to prevent bacterial passage.^[5] Due to the high cost of single-use drape sets, we choose to use sterile nylon plastic under sterile re-usable surgical drapes in our clinic.

Statistical evaluation of the total proliferation amount according to group of samples taken after draping with sterile-re-usable surgical drapes identified that in sterile plastic Group, the possibility of infection development was statistically not significant ($p>0.05$) (Table1).

SSI are frequently caused by gram positive cocci.^[2] In the early period after orthopedic surgery, the most frequently observed bacteria are staphylococci.^[24] In our study all the proliferating bacteria were identified as coagulase negative staphylococci. Similar studies in the literature generally use bacterial suspension with the aim of standardization. However, as there is no such suspension in the real surgical environment and as the patient's skin flora is one of the greatest risk factors, in this study we decided to use tables contaminated with skin flora instead of a bacterial suspension to better represent the surgical environment.^[5,11,25]

In the 30-160 minutes after antiseptic application to skin, flora bacteria begin to recolonize.^[24] As a result to prevent colonization drapes are used. The use of drapes does not allow water to pass, however it may allow bacterial transfer to the surgical field; additionally iodophore impregnated plastic adhesive drape use is stated to reduce bacterial recolonization.^[5,20] A study using drapes observed that proliferation occurred after the 2nd hour, similar to our study.^[26]

A study using a single drape found that bacteria passed the re-usable surgical drapes in 30 minutes and that due to the

risk of bacterial migration, multiple drapes should be used for surgical draping.^[11] In our study, on the tables without sterile plastic (no-plastic and non-sterile plastic groups) proliferation was observed on half the tables (Table 2). It appears the use of sterile plastic prevents infection.

As is known due to the infection risk of blood stored in blood banks, preservatives are used. One unit of full blood contains 450 mL of blood and 63 mL of anticoagulants and preservatives. For anticoagulation for each 100 mL of blood 14 mL of citrate is used.^[27] A reason for the low proliferation in cultures is that the full blood we used was obtained from a blood bank and contained preservatives. We believe that the observation of colonies in the medium generally on secondary and tertiary lines where full blood density is less supports this hypothesis. The bacterial source may be said to be contamination of air in the surgery. However, the statistical differences between groups in our study make this hypothesis less likely to be the case.

However, the low number of samples, lack of comparison with single-use sterile drapes, lack of a real surgical environment, and our use of skin contamination to simulate the real surgical environment while in the literature bacterial suspensions are used may be considered limitations of the study.^[5,11,25] Another limitation of our study is not to add a single-use drape group for comparing the bacterial reproduction and the cost of using single-use drape.

Conclusion

In conclusion; knowing all risk factors causing SSI and taken necessary precautions will reduce the incidence of these infections. In this study, we recommend that in clinics those do not use single-use drape sets, after skin preparation with an appropriate antiseptic agent, the surgical area should be covered with sterile plastic, that is put under re-usable products made of textile. The cost of sterile plastic is very low when compared with single-use drapes.

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References

1. Enstone JE, Humphreys H. Monitoring Infective Complications Following Hip Fracture. *J Hosp Infect* 1998;38:1–9.
2. Ozer MT, Sinan H, Saydam M, Kilic A, Akyol M, Coskun AK, et al. Effectiveness of N-Butyl Cyanoacrylate-Based Microbial Skin Sealant on the Prevention of Surgical Site Infections. *Surgical Infections* 2014;15:14–7.
3. Mangram AJ, Horan TC, Pearson ML, Silver LC, Jarvis WR. Guidelines for prevention of surgical site infection. *Hospital Infection Control Practices Advisory Committee. Infect Control Hosp Epidemiol* 1999;20:250–78.
4. Mangram AJ, Horan TC, Pearson ML, Silver LJ, Jarvis WR. Guideline For Prevention of Surgical Site Infection. *AJIC* 1999;27:97–134.
5. Blom AW, Estela CM, Bowker KE, MacGowan AP, Hardy J. The Passage of Bacteria Through Surgical Drapes. *Ann Roy Coll Surg* 2000;82:405–7.
6. Woodhead K, Taylor EW, Bannister G, Chesworth T, Hoffman P, Humphreys H. Behaviours and Rituals in the Operating Theatre. *Journal of Hospital Infection* 2002;51:241–55.
7. Kaiser AB, Kernodle DS, Barg NL, Petracek MR. Influence Of Preoperative Showers on Staphylococcal Skin Colonization: A Comparativetrial of Antiseptic Skin Cleansers. *Ann Thorac Surg* 1988;45:35–8.
8. Hardin WD, Nichols RL. Hand Washing And Patient Preoperative Skin Preparation. In: Malangoni MA, Ed. *Critical Issues in Operating Room Management*. Philadelphia: Lippincott-Raven 1997;133–49.
9. McLure HA, Tallboys CA, Yentis SM, Azadian BS. Surgical Face Masks and Downward Dispersal of Bacteria. *Anaesthesia* 1998;53:624–6.
10. Chosky SA, Modha D, Taylor GJ. Optimisation of Ultra Clean Air. The Role of Instrument Preparation. *J Bone Joint Surg Br* 1996;78:835–7.
11. Blom AW, Gozzardy C, Heal J, Bowkerand K, Estela CM. Bacterial Strike-Through of Re-usable Surgical Drapes: The Effect of Different Wetting Agents. *J Hosp Infect* 2002;52:52–5.
12. Dohmen PM1, Weymann A, Holinski S, Linneweber J, Geyer T, Konertz W. Use of an Antimicrobial Skin Sealant Reduces Surgical Site Infection in Patients under Going Routine Cardiac Surgery. *Surg Infect (Larchmt)* 2011;12:475–81.
13. von Eckardstein AS1, Lim CH, Dohmen PM, Pêgo-Fernandes PM, Cooper WA, Oslund SG, et al. A Randomized Trial of Skin Sealant to Reducethe Risk of Incision Contamination in Cardiac Surgery. *Ann Thorac Surg* 2011;92:632–7.
14. Dohmen PM. Antibiotic Resistance in Common Pathogens Reinforces the Need to Minimise Surgical Site Infections. *J Hosp Infect* 2008;70:15–20.
15. Trampuz A, Widmer AF. Infections Associated with Orthopedic Implants. *Curr Opin Infect Dis* 2006;19:349–56.
16. Thomas C, Cadwallader HL, Riley TV. Surgical-Site Infections After Orthopaedic Surgery: State Wide Surveillance Using Linked Administrative Data Bases. *J Hosp Infect* 2004;57:25–30.
17. Trampuz A, Zimmerli W. Prosthetic Joint Infections: Update in Diagnosis and Treatment. *Swiss Med Wkly* 2005;135(17-18):243–51.
18. Wilson SE. Microbial Sealing: A New Approach to Reducing Contamination. *J Hosp Infect* 2008;70:11–4.
19. Kuhme T, Isaksson B, Dahlin LG. Wound Contamination in Cardiac Surgery. A Systematic Quantitative and Qualitative Study of the Bacterial Growth in Sternal Wounds in Cardiac Surgery Patients. *APMIS* 2007;115:1001–7.
20. Falk-Brynhildsen K, Söderquist B, Friberg O, Nilsson UG. Bacterial Recolonization of the Skin and Wound Contamination During Cardiac Surgery: A Randomized Controlled Trial of the Use of Plastic Adhesive Drape Compared with Bare Skin. *J Hosp Infect* 2013;84:151–8.

21. Kırbaş C. Hastanelerde Mimari-Mekanik Proje Tasarımı ve Uygulama Esasları. Tesisat Mühendisliği 2012;127:15–30.
22. Uzunköy A. Cerrahi alan infeksiyonları: Risk faktörleri ve önleme yöntemleri. Ulus Travma Derg 2005;11:269–81.
23. Occhipinti LL, Hauptman JG, Greco JJ, Mehler SJ. Evaluation of Bacterial Contamination on Surgical Drapes Following use Of the Bair Hugger® Forced Air Warming System. Can Vet J 2013;54:1157–9.
24. Ersöz G. Ortopedik Protez İnfeksiyonları. Klimik Dergisi 2013;26:84–93.
25. Blom AW, Barnett A, Ajitsaria A, Noel A, Estela CM. Resistance of Disposable Drapes to Bacterial Penetration. Journal of Orthopaedic Surgery 2007;15:267–9.
26. Mazurek MJ, Rysz M, Jaworowski J, Nowakowski F, Krajewski R, Starościk S, et al. Contamination of the Surgical Field in Head and Neck Oncologic Surgery. Head&Neck 2014;36:1408–12.
27. Altıntaş F. Kan ve Kan Bileşenlerinin Genel Özellikleri. Yoğun Bakım Derneği Dergisi 2005;3:6–13.