# The Plastic Surgical Adhesive Drape:

## An Evaluation of Its Efficacy as a Microbial Barrier

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**A microbial evaluation was made of adhesive plastic surgical drapes and cloth surgical drapes. These studies were done both during surgery and in the laboratory. The plastic drape does not allow bacterial penetration, lateral migration does not occur, skin bacteria do not multiply under the drape within the time periods studied and the patient drapes are held in place with their use. When wet, cloth drapes showed profuse bacterial penetration. Dry cloth showed less bacterial penetration as compared to wet cloth. Lateral migration under cloth drapes was not possible to assess due to a high level of penetration. The surface of cloth showed a higher level of bacterial contamination during the surgical procedures. Deep wound cultures collected just prior to closing showed 60% contamination when cloth was used compared to 6% when plastic was employed. The microorganisms recovered from the various sites sampled were identified. Finally, in addition to the positive aseptic benefits afforded by plastic adhesive drapes, aesthetic features such as a more delineated operative field and elimination of towel clips make this product a useful adjunct to the surgeon's armamentarium.**

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A VARIETY of techniques is used to prevent bacteria from entering the surgical wound. However, those microorganisms harbored by the patients skin are particularly troublesome in that the anatomy of the skin makes it virtually impossible to maintain the area in a sterile state. Bacteria harbored in the hair follicles invariably rise to the surface, thus contaminating the area previously prepared. The use, therefore, of plastic adhesive drapes which would immobilize those bacteria rising from deeper skin layers would appear to be very logical.

Several investigators[2,8] have evaluated and reported on bacterial permeability, or lack thereof, of a variety of surgical drapes. Most studies, however, have centered on laboratory experiments only or on wound contamination studies which were limited in number or were not rigidly controlled.[1,7]

This study was undertaken to compare a plastic surgical drape to a cloth drape when used under actual surgical conditions. In addition, *in vivo* laboratory experiments were conducted in order to gain further assessment as to the potential for bacterial build-up and/or migration under plastic adhesive drapes as well as cloth drapes. The overall objectives were as follows: 1) Do bacteria penetrate plastic or cloth surgical drapes? 2) Do bacteria multiply under plastic adhesive surgical drapes or under cloth drapes? 3) Does lateral migration of bacteria occur under plastic adhesive drapes or under cloth drapes? 4) Do surgical gloves become contaminated when surgical drapes are removed? 5) Are there differences in the level of wound contamination when plastic adhesive drapes or cloth drapes are used? 6) Are there differences in the level of surface contamination between plastic drapes and cloth drapes?

### Materials and Methods

*Surgical Studies*

Total hip replacements were employed in a comparative study of the microbial barrier properties of adhesive

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plastic drapes* and cloth drapes. To further assess the microbial properties of plastic adhesive drapes, a series of total knee arthroplasties were performed. The surgical procedures were performed in an operating room meeting Hill-Burton standards. In addition the room was equipped with horizontal laminar air flow† and the surgical team used an aspiration exhaust system. Fifty total hip replacement cases were performed with plastic drapes and 15 cases were done with cloth. The surgical procedures ranged from 45 to 90 minutes in duration. One surgeon performed all the operative procedures and the remaining surgical team was essentially unchanged from case to case in order to minimize variables.

Baseline skin counts at the surgical sites were established by sampling each patient with two Rodac plates[5] containing 5% sheep blood agar (Fig. 1). The Rodac sampling was done using a holding device previously described.[6] The surgical site was preoperatively prepared with an iodophor scrub,‡ dried with a sterile towel and painted with an iodophor solution‡ and allowed to dry.

Post preparation swab samples of the prepared site were collected using sterile cotton swabs moistened in Dey/Engley Broth.[3] Two samples were taken from the same area, the first removing the iodophor. Following the second swabbing, two side by side Rodac impressions were made over the swabbed area.

Using 70% isopropyl alcohol on a sterile gauze flat, the proposed incision site was wiped until the brown color of the iodophor was gone. The alcohol treated area was wiped with a sterile towel and the skin was allowed to dry completely. Swab and Rodac samples were again collected as previously described.

The sterile plastic adhesive drape was applied as directed by the manufacturer. Immediately after the incision was made, swab samples were collected by rubbing a swab around the edge of the wound twice. This was repeated every 15 minutes and at the end of the case just prior to closure.

Rodac impressions were made on the surface of the drape, one above and one below the site of the incision. This was done immediately after the drape was applied, and every 15 minutes thereafter until the end of the procedure.

At the conclusion of the surgical procedure and prior to removal of the drape (plastic or cloth), the surgeon put on a new pair of gloves. Impressions of each hand were made onto 150 mm bacteriological plates containing trypticase soy agar with 5% sheep blood. The top surface of the drapes above and below the incision were sampled with two Rodac plates. The drape was removed and sampled again with 2 Rodac plates on the under surface of the drapes. The skin that had been covered with the drape was sampled with two Rodac plates. The gloved hands were then sampled as described before. Microbial air samples were collected at the wound site and instrument table as previously described.[4]

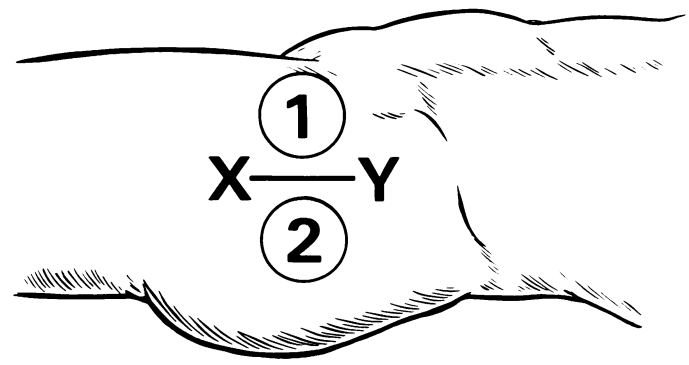


FIG. 1. Total Hip replacement incision and skin surface sampling sites. X —— Y represents the incision and swab, and Rodac sampling sites. One represents the area above the wound site for Rodac sampling and two the area below the wound site for Rodac sampling.

Swab and tissue samples were removed from the depth of the wound at the beginning and at the end of the case and tested for both aerobic and anaerobic microorganisms.

Rodac plates and swab cultures were incubated at 35–37 C for 48 hours. The air settle plates (ASP) were incubated at 35–37 C for 24 hours and 6 additional days at room ambient temperature.

*Laboratory Studies*

To further assess lateral bacterial migration, bacterial penetration, and bacterial build-up, studies were conducted on human volunteers.

The backs of volunteers were scrubbed with 70% isopropyl alcohol for 5 minutes and allowed to dry for 10 minutes. Rodac plates containing trypticase soy agar with 5% sheep blood were used to sample the skin after the alcohol skin preparation. A 2 × 2 inch adhesive drape template with a 14 mm hole in the center was applied at the test sites on the backs (Fig. 2). Five one hundredths ml of a 24-hour ATCC 12228 *Staph. epidermidis* culture was applied into each 14 mm template area and spread evenly (final concentration per 14 mm area was $2 \times 10^4$ organisms). The inoculum was allowed to dry for 10 minutes, and the 14 mm circle was outlined with a sterile ball point pen, and the adhesive template removed. Wearing sterile surgical gloves and using sterile hemostats, 12, 22 or 28 mm pieces of sterilized drape materials were centered over the 14 mm inoculum. The drape materials tested were adhesive plastic drape, dry cloth and wet cloth. Dry cloth was moistened by touching

* (Steri-Drape®) Surgical Drape, Minnesota Mining and Manufacturing Co., St. Paul, Minnesota.

† Agnew-Higgins, Inc., Garden Grove, California.

‡ Purdue Frederick, Yonkers, New York.

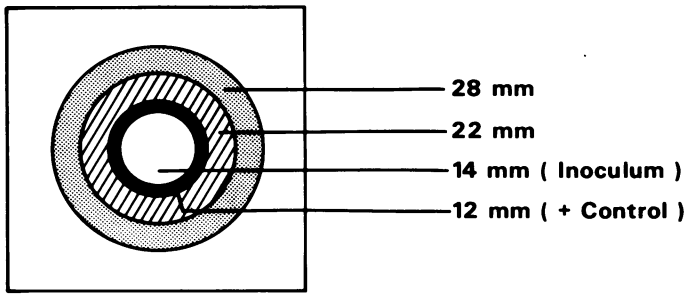


FIG. 2. Plastic adhesive drape template used for penetration and lateral movement studies of *Staph. epidermidis* on skin.

the edge of the material to sterile physiological saline until the cloth was wet.

The cloth drapes were held in place with sterile 1 mm wide strips of adhesive. The test sites were covered with several layers of sterile 4 × 4 inch gauze to prevent environmental contamination. The wet linen patches were kept moist by adding 0.1 ml of sterile saline each hour.

Rodac impressions were made of each test site after 4 hours. Also, Rodac samples were collected from the bottom side of each drape and of the skin under the drape.

The Rodac plates were read for lateral bacterial movement by observing growth around the edge of each applied drape. Penetration of bacteria through the drapes was determined when growth appeared on the surface where the drape had been applied. Bacterial build-up was determined by observing for growth of microorganisms under the uninoculated areas of surgical drape.

## Results

### *Surgical Studies: Total Hip Replacements*

Rodac surface samples of the wound site prior to cleansing displayed an average of 77.99 colony forming units/Rodac plate (CFU/Rodac plate). Samples collected after the area had been prepared, rinsed with alcohol, and wiped dry with a sterile towel, displayed an average of 8 CFU/Rodac plate.

Rodac impression samples of the skin under the plastic adhesive drape, collected after completion of the operation, showed 6.72 CFU/Rodac plate above the incision site and 15.94 CFU/Rodac plate below the incision site. Results obtained when the adhesive portion of the plastic drape was sampled yielded identical bacterial counts, thus giving a "mirror image" of those bacteria obtained from the skin. Impression samples of the skin under the cloth drape, collected after completion of the operation, showed 5.7 CFU/Rodac plate above the incision site and 17.4 CFU/Rodac plate below the incision site. The overall count for cloth and plastic are similar to those counts observed after the alcohol rinse.

Rodac impression samples of the surface of the plastic drape taken at 0, 15, 30, and 45 minutes, and the end of the surgical procedure revealed low microbial contamination, 0.1 CFU to 3.9 CFU (Table 1). Cloth drapes on the other hand showed increasing contamination with time, 0.1 CFU to 31.8 CFU, with the cultures taken below the wound edge showing the greatest overall contamination.

The microorganisms recovered from the surfaces of both types of drapes consisted of *Staph. epidermidis*. *Staph. aureus* was isolated from the skin under the plastic drape at the end of the case in one procedure, but was neither recovered from the surface of the drape nor the wound itself.

Prior to removal of the drape, a sterile pair of surgical gloves was put on. Hand impressions were made onto 5% sheep blood agar plates. All gloves tested were sterile, however, when the drapes were removed and the gloved hands immediately resampled, they were found to be contaminated with an average of 13.8 CFU/hand impression. The microorganisms recovered from gloves consisted mainly of *Staph. epidermidis* and *Micrococcus sp.*

The edge of the wound next to the plastic adhesive drape and the cloth drape was sampled to determine whether or not there was microbial migration from the skin under the drape to the wound. The results of swab samples collected at 15 minute intervals are shown in Table 2. Cultures were taken out of the deep areas of the wound after the incision had been made and just prior to closure. Results from these cultures are also shown in Table 2.

The isolates recovered from the wound prior to closure consisted mainly of *Staph. epidermidis*. However, *Pepto-*

TABLE 1. *Contamination Levels of Surfaces of Plastic and Linen Drapes Obtained During Actual Surgery*

| Time of Sampling (Min) | Site Sampled | Colony Forming Units/Rodac Plate (4 in.²) | | |
|---|---|---|---|---|
| | | Plastic | | Linen |
| | | Knees | Hips | Hips |
| $T_0$ | 1* | .46 | .04 | 0 |
| | 2† | 0 | .14 | 0 |
| $T_{15}$ | 1 | 0 | 1.3 | 0 |
| | 2 | .05 | .58 | .27 |
| $T_{30}$ | 1 | .05 | 3.98 | .4 |
| | 2 | 0 | .72 | 10.3 |
| $T_{45}$ | 1 | 0 | .97 | 1.4 |
| | 2 | 0 | .77 | 27.7 |
| End of case | 1 | 0 | 2.4 | 1.5 |
| | 2 | 0 | 1.56 | 30.3 |

* Area above incision site.
† Area below incision site.

*coccus sp.*, alpha hemolytic streptococci, diphtheroids and *Propionibacterium acnes* also were recovered from the wound draped with cloth.

Sterile air settle plates (150 mm) containing 5% sheep blood agar were placed proximally from the wounds to determine the shedding rate of aerobic microorganisms near the wound site. The results of this study showed that shedding of 24.7 CFU/ft²/hr occurred.

The microflora of the air consists of *Staph. epidermidis*, *Micrococcus sp.*, alpha hemolytic streptococci, diphtheroids, *Bacillus sp.*, and a few fungi.

### *Surgical Studies: Total Knee Replacements*

The sampling techniques and operating room conditions were the same for the total knee replacements as those employed for the total hip replacements. Twenty-two total knee replacement surgical cases were used to evaluate the effectiveness of the adhesive plastic drape. The skin at the wound site prior to cleansing showed 84 CFU/Rodac plate and 1.9 CFU/Rodac plate after scrubbing with an iodophor. The area showed no surface contamination after the scrubbed area was rinsed with alcohol and wiped dry with a sterile towel.

The surface of the plastic drape showed extremely low contamination when sampled at 15-minute intervals (Table 1). The underside of the drape (adhesive side) and skin under the drape produced 0.0 CFU/Rodac plate in both instances.

Sterile gloves donned for removal of the drape were found to be sterile by the hand impression technique. An average of only 0.7 CFU/hand impression was recovered from the gloves after the drape had been removed.

Wound edge swab samples collected at 15-minute intervals, opening deep wound cultures and closing deep wound culture data are shown in Table 2.

The air settle plate placed at the knee wound edge collected 7.4 CFU/ft²/hr.

### *Laboratory Studies*

Rodac impressions of the skin following prepping and prior to bacterial inoculation demonstrated a lack of bacterial growth. This indicated that the prep had been effective in removing all surface contamination.

Bacterial penetration did not occur with the plastic adhesive drape. However, excessive bacterial penetration occurred with dry linen drapes. It was difficult to quantitatively assess overall bacterial strikethrough with the linen drape since Rodac impressions demonstrated confluent growth indicating that bacteria penetrated the entire surface area.

Migration studies demonstrated a lack of lateral movement of bacteria underneath the plastic adhesive drape. None of the 22 mm or 28 mm samples demonstrated a zone of bacterial growth at the periphery. The positive control (12 mm) sample did exhibit a complete zone of growth at the periphery on all subjects.

TABLE 2. *Microbial Contamination of Total Hip and Knee Replacement Wounds Employing Plastic and Linen Drapes*

| Sampling Site of Swab Culture | Time of Culturing (In Min) | Per Cent Positive Swab Cultures | | |
|---|---|---|---|---|
| | | Hips | | Knees |
| | | Plastic | Linen | Plastic |
| Wound edge* | 0 | 0 | 0 | 0 |
| | 15 | 16 | 6.7 | 4.6 |
| | 30 | 24 | 6.7 | 4.6 |
| | 45 | 20 | 11.1 | 0 |
| | End of case | 16.3 | 26.7 | 5 |
| Deep wound | Opening | 2 | 26.7 | 0 |
| | Closing | 6.1 | 60.0 | 0 |

* Swab rubbed around wound edge twice.

Rodac impressions of the linen samples yielded positive results with all sizes and all subjects. Therefore, it was not possible to determine if lateral migration had occurred under the cloth linen drapes since so many bacteria did penetrate to the top surface. It would seem logical, however, that bacteria would move laterally or at least follow the linen particles contained in such a drape. More than likely a "wicking action" did occur.

Bacteria were not detected on the noninoculated area under the 28 mm Steri-Drape samples, indicating a lack of bacterial proliferation. It was not possible to determine bacterial proliferation under the wet linen because of profuse strikethrough which encompassed virtually the entire top surface of the samples.

## Discussion

In the introduction 6 questions concerning surgical drapes were asked. Based on data collected in this study, the following summarizes the answers to those questions:

1. Bacteria do not penetrate plastic adhesive drapes whether wet or dry. Bacterial penetration does occur with cloth drapes, particularly when wet.
2. Bacteria do not multiply under plastic adhesive drapes within time periods studied. It was not possible to accurately determine whether bacterial build-up occurs with cloth since penetration occurs so readily.
3. Lateral migration of bacteria does not occur under plastic adhesive drapes. Again an accurate assessment of migration under cloth could not be made because of penetration.
4. Surgical gloves do become contaminated when surgical drapes, whether plastic or linen, are removed.
5. A significantly higher level of wound contamination

occurs with use of cloth linen drapes as compared to plastic adhesive drapes.

6. A significantly higher level of surface contamination below the wound site occurs with linen as compared to plastic drapes.

As can be seen from the above, there is little doubt that plastic adhesive drapes do play an important role in surgical asepsis. Plastic adhesive drapes contain any skin bacteria which may rise to the surface following skin antisepsis and subsequent carryover into the surgical wound. Both laboratory and surgical studies determined that bacterial build-up does not occur under the adhesive plastic drape within the time periods studied.

Contrasting the above with data generated on standard cloth linen drapes, it was found that bacterial migration readily occurs through the drape to the surface. The linen drape was sterile when first applied, but gradually became increasingly contaminated. The top side of the wound site showed low levels of contamination. The drape above the wound edge was dry while beneath the wound edge the drape was always wet and bloody. Rodac samples collected below the wound site after 30 minutes, 45 minutes, and at the end of the case showed 10.3, 27.7, and 30.3 CFU/Rodac plate respectively.

Deep wound cultures collected just prior to closing showed 60% contamination when cloth was used as compared to 6% when plastic was employed. This latter difference is probably due in part to the higher level of surface contamination observed with cloth drapes.

In addition to reducing the incidence of wound contamination, plastic adhesive drapes afford other desirable attributes. They do help to delineate the surgical field. Since plastic drapes are held in place with adhesive, towel clips are eliminated. Wound irrigation can be more readily performed since the plastic drape allows for easy fluid run off.

## Acknowledgment

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## Erratum

In the study "Aspiration Pneumonia: Experimental Evaluation of Albumin and Steroid Therapy" appearing in Volume 183, pages 179 to 184, 1976, the concentration of hydrochloric acid used was erroneously stated as 0.1 N. The concentration of hydrochloric acid used was 1.0 N.